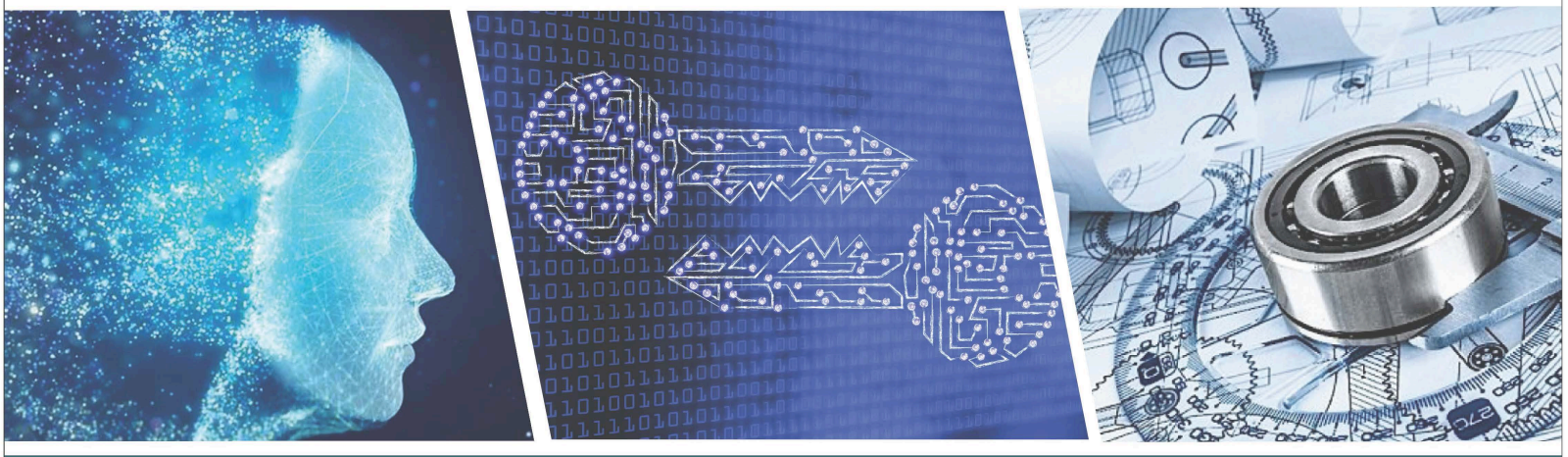
Volume 3, Issue 2

ISSN: 2706-7351

Foundation University Journal of Engineering and Applied Sciences

Volume 3 Issue 2



Foundation University Journal of Engineering and Applied Sciences
E-mail:- editor.fujeas@fui.edu.pk

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Biannual

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Foundation University Journal of Engineering and Applied Sciences
Vol. 3, Issue 2, 2022.
DOI: 10.33897/fujeas.v3i2.565

Research Article

Heart Diseases Prediction and Diagnosis using Supervised Learning

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Abstract:

The existing data for clinical diagnosis are often enlarged, but available tools are not efficient enough for decision making. Data mining techniques provide a user-oriented approach for clinical diagnosis and reduce risk factors. To improve clinical diagnosis, particularly for Cardiovascular diseases, nine different data mining techniques have been applied for classification and clustering. We compare all these techniques for better prediction. Despite all recent research efforts, the literature lacks the application of multiple techniques on multiple data sets for Cardiovascular disease prediction, which helps in decision making. In particular, this study is the augmentation of techniques for multiple data analysis by comparing four datasets with 14 attributes and a different number of instances. Another challenge is how to increase the accuracy of the decision-making process. Our research findings predict the better accuracy by using SMO and classification via regression for all data sets which shows the significant difference. Consequently, this research further helps to integrate the clinical decision support, thereby reducing medical errors, enhance patient safety, decrease unwanted practice variation, and improve patient recovery.

Keywords: Data mining; Classification techniques; Cardiovascular disease prediction

1. Introduction

Data is generally gathered from various sectors like e-business, marketing, health and other industries to predict useful information for future assessments (El-Hasnony et al., 2022). Given that, raw data have been usually heterogeneous and thus difficult to understand. The available data is quite enriched and analysis tools are not efficient enough for decision making. Since data mining techniques are used to extract meaningful information for future estimates, therefore, important for research and development process (*EBSCOhost | 124636309 | A Descriptive Study of Predictive Models of MERS-CoV Outbreak.*, n.d.). The process of automatic creation of useful information from large data repository is called data mining. A term KDD (Knowledge discovery in databases) is generally used in data mining for decision making, where raw data is transformed into useful information (Palaniappan & Awang, 2008). The artificial intelligence, machine learning, databases, statistics, and pattern recognition are also the core of data mining (*An Overview of Knowledge Discovery Database and Data... - Google Scholar*, n.d.). Nonetheless, data mining involves multiple methods to accomplish different tasks. Intelligent methods are being utilized as an essential data mining process to extract data patterns and knowledge discovery (*EBSCOhost | 124636309 | A Descriptive Study of Predictive Models of MERS-CoV Outbreak.*, n.d.). All these methods attempt to fit a data into the model using different algorithms. The closer model is determined using these algorithms according to the charachteristics of data that are being examined (P. C. Chen et al., 2010). Medical predictors also use KDD to improve the quality of health services. Data mining techniques provide a user-oriented approach to discover hidden patterns that are further used for clinical diagnosis to reduce risk

factors (*EBSCOhost | 124636309 | A Descriptive Study of Predictive Models of MERS-CoV Outbreak.*, n.d.). Clinical diagnosis is viewed as an essential, but a complex job that should be executed precisely and legitimately. Developing an application to predict the outcome of diseases is the most interesting and challenging task in data mining. There is also a field in medical prognosis called survival analyses where various applications are used to deal with historical data in order to predict the survival of a particular patient suffering from a disease over a particular time period (J. Chen et al., 2009).

Other studies have been conducted for decision making on different diseases, which include Hepatitis, Lung Cancer, Liver Disorder, Breast Cancer, Diabetes and Thyroid disease etc. (*Cluster Analysis - Basic Concepts and Algorithms - Google Scholar*, n.d.). Despite all these researches, particularly for Cardiovascular disease prediction, literature lacks the implementation of multiple techniques which help in decision making (Soni Ujma Ansari Dipesh Sharma & Associate Professor, 2011), (Zhang et al., 2014), (Jindal et al., 2021). However, as far as recent literature is concerned, the available studies are limited in accordance with the comparison of multiple techniques on multiple data sets for better prediction. The major challenge is concerned with the accuracy of the decision-making process. In addition, according to the world health organization seventeen million deaths happen globally due to Cardiovascular diseases. Nevertheless, application of data mining techniques is still needed to be focused for Cardiovascular disease prediction. Therefore, our study, particularly focused on Cardiovascular diseases predictions and compared nine approaches; Decision trees J48, Naïve Bayes, REPTree, Decision table, Bayes net, classification via regression, bagging, Sequential Minimal Optimization (SMO) and K-means clustering using four data sets including Cleveland, Hungarian, VA Long Beach and Switzerland. This study is designed to compare all these methods against performance parameters for better prediction. Research findings predict the better accuracy by using SMO and classification via regression on all data sets.

The rest of the paper is organized as follows: Section 2 presents the proposed methodology along with summary of different techniques from the literature. Section 3 describes the results and discussion while Section 4 concludes the work.

2. Methodology

This section presents the extraction of significant patterns from the Cardiovascular disease data warehouse. The clinical data is the screening of patients affected by different heart problems (*World Health Organization: Death and Disability Due... - Google Scholar*, n.d.). Primarily the data are considered to improve the health standards and services. We took data from the UCI repository to ensure the efficient and explicit processes for mining, which is already preprocessed excluding VA Long Beach dataset. This study comprises three important phases: data understanding, data modeling, and results evaluation.

Data understanding identifies the preliminary insights about attributes and their definitions. In the modeling phase above, mentioned techniques are applied to the data sets to produce optimal values by using WEKA 3.8.1. In evaluation phase, results against performance parameters are compared. Figure 1 shows the proposed methodology framework.

2.1 Dataset

Our dataset contains the statistics of two major cities of Italy: Hungarian and Cleveland from the UCI machine learning repository. The first phase of methodology involves the understanding of preprocessed data which includes the attribute characteristics. Details of datasets are listed in Table 1. We implemented nine different models: eight models for classification and one for clustering. These models are specifically

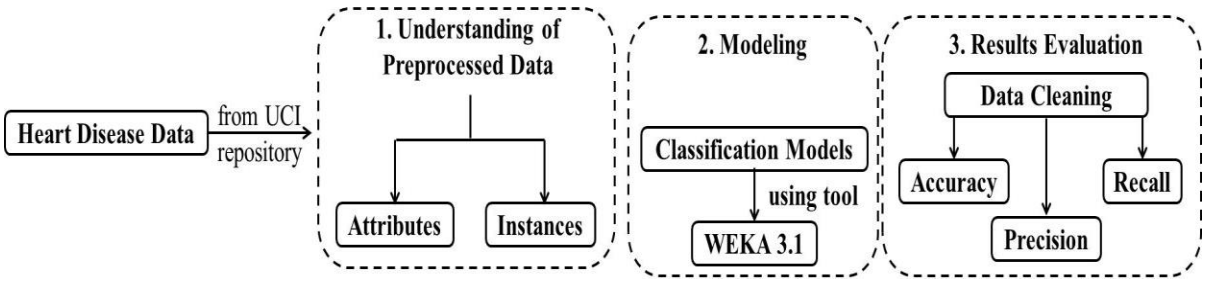


Figure 1: Proposed methodology

Table 1: Dataset details

Datasets	No of Attributes	No of instances
Cleveland	14	219
Hungarian	14	219
VA Long Beach	14	200
Switzerland	14	124

selected for their popularity and they also produce better average performance, according to the comparative studies that have been recently published in the literature (J. Chen et al., 2009). The classifiers, we used in this study evaluates that how good it is to predict the class of instances for which it is trained on. We applied classifiers on the training set by using Weka.

2.2 Summary of Techniques

Following is the detailed description of the mentioned techniques to seek deeper knowledge which is further applied in this study.

2.2.1 Naïve Bayes

Feature selection is a vital preprocessing technology to improve the efficiency, accuracy, and scalability of classifiers specifically in text classification. Usually, domain and algorithm characteristics are considered important for better feature selection. Feature selection is quite simple and efficient in a Naïve Bayes classifier, as it is highly sensitive to the results generated by using this technique for feature selection is highly significant (Ali et al., 2021). It provides fast and easy implementation, so it is used as a baseline for text classification. It suits best specifically when inputs have higher dimensions. The Naïve Bayes model uses the maximum likelihood criteria for parameter inference and performs better in complex real-world situations (El-Hasnony et al., 2022).

As a statistical classifier, the Naïve Bayes does not assume any dependency between attributes. It can work without using any Bayesian methods and can also produce better classification accuracy as compared to other algorithms (*EBSCOhost | 124636309 | A Descriptive Study of Predictive Models of MERS-CoV Outbreak.*, n.d.). The formula used for Naïve Byes (Augusto Gonçalves & Geraldo Pereira Barbosa, 2017) is described below:

$$\boldsymbol{P(c|x) = \frac{P(x|c)\,P(c)}{P(x)}} \qquad \textbf{(1)}$$

Where $P(c|x)$ is the posterior probability of *class* (*target*) given *predictor* (*attribute*), $P(c)$ is the prior probability of *class*, $P(x|c)$ is the probability of *predictor* given *class*, $P(x)$ is the prior probability of the *predictor*.

2.2.2 REPTree

The basic principle of the REPTree algorithm is to calculate the information gain with entropy and use variance to reduce the occurrence of an error. REPTree algorithm helps to reduce the complexity of the decision tree model by using "reduced error pruning method" so the occurrence of error will be reduced from the variance. REPTree only sorts numeric attributes and builds a fast decision tree by using information gain (Platt, 1998).

2.2.3 Decision Tree

Decision Tree is the most widely used classifier which is easy to understand and configure as compared to other algorithms (Chaurasia & Pal, 2014). It uses divide and rule approach to form a data structure in the form of a tree. It uses supervised learning to structure a model with the set of divisions where local regions found recursively.

The general equation used for decision tree is given below where the information gain of X is calculated when Y is the conditional entropy:

$$\begin{aligned} &\boldsymbol{(Y) = -\Sigma(Y = yi)\; logP(Y = yi) k\; i = 1} \\ &\boldsymbol{(Y|X) = -\Sigma(X = xi)\;(Y|X = xi) l\; i = 1} \\ &\boldsymbol{(Y; X) = (Y) - (Y|X)} \end{aligned} \qquad \textbf{(2)}$$

There are two types of pruning in decision tree: pre-pruning and post-pruning. In contrast to each other pre-pruning produces faster trees and post-pruning produce more successful tree (Platt, 1998). Decision Tree stills have a problem of redundancy so necessary steps should be taken to resolve the replication and repetition (Mathuria, 2013).

2.2.4 Decision Tree J48

Decision tree J48 is developed by WEKA team and implemented by ID3 (Iterative Dichotomiser 3) algorithm. Derivation of rules, decision tree pruning, and missing values are the additional features of J48. This algorithm can be used for precision in case of overfitting pruning. Usually, the classification algorithm performs pruning until the best possible classification of data is done. The objective of this algorithm is to generate rules for data identification and generalize the decision tree until it meets the accuracy.

The disadvantage of the J48 algorithm is that the size of the tree increases linearly with the number of examples which increases the complexity. Consequently, tree depth is linked with tree size which cannot be greater than the number of attributes. When the depth of tree increases; space complexity, occurs to stores the values in the array and rules get slow down for large and noisy datasets (Alam & Pachauri, 2017).

$$\textbf{Entropy } \boldsymbol{E(S) = \sum_{i=1}^{c} -p_i \log_2 p_i} \qquad \textbf{(3)}$$

$$\textbf{Information gain Gain } \boldsymbol{(T, X) = Entropy(T) - Rntropy(T, X)} \qquad \textbf{(4)}$$

2.2.5 Bayes Network

Probabilistic models for the variables of interest can be encoded graphically by using Bayesian networks. It is more efficient when multiple statistical techniques are merged to model graphically. Bayesian network provides an adequate graphical model even though some data entries are missing and variables have dependencies among each other.

The Bayesian network helps to seek a better understanding of difficult domains and casual relationships. This model gives the best representation of data by combining data and prior knowledge by using probabilistic semantics. Over fitting of data can be avoided efficiently by combining Bayesian networks and Bayesian statistical methods. The formula that is commonly used for the Bayes network is defined below:

$$\boldsymbol{P(C=T|A=T)} = \frac{\boldsymbol{(P(C=T,\ A=T)}}{\boldsymbol{P(A=T)}} \qquad \textbf{(5)}$$

2.2.6 Classification via Regression

The Classification via Regression comprises of three major levels that involve encoding, linear regression and decoding. Multivariate adaptive regression splines and kernel tricks are the strategies for conventional adaptive non-parametric regression to apply on the nonlinear extension. To encode class label, the particular scoring scheme is used in literature named as optimal scoring. Average of squared regression residuals can be minimized by optimal scoring. This regression technique is efficient to extract low dimensional features (Chaurasia et al., n.d.).

2.2.7 Bagging

Bagging is basically a meta-algorithm which is designed to improve the accuracy and scalability of machine learning algorithms. It is mostly used in statistical classification and regression which helps to avoid over fitting and reduces variance. It can be used with any type of technique, but mostly applied to decision tree technique. It is also called Bootstrap aggregating (Sankar et.al, 2014).

It is an alternate to cross-validation method which is the mixture of different models. The results are generated in the form of different combinations of training data based on the Bootstrap method after learning weak training data. Bagging is a voting method which helps to generate multiple instances from a single sample. It uses the displacement method to produce multiple instances from the original sample (Platt, 1998). The formula for bagging is formulated as follows:

$$\underbrace{\boldsymbol{E}[[\boldsymbol{h_D}(\boldsymbol{x})-\boldsymbol{y})^2]}_{\textbf{Error}} = \underbrace{\boldsymbol{E}\left[\left(\boldsymbol{h_D}(\boldsymbol{x})-\overline{\boldsymbol{h}}(\boldsymbol{x})\right)^2\right]}_{\textbf{Variance}} + \underbrace{\boldsymbol{E}\left[\left(\overline{\boldsymbol{h}}(\boldsymbol{x})-\overline{\boldsymbol{y}}(\boldsymbol{x})\right)^2\right]}_{\textbf{Bias}} + \underbrace{\boldsymbol{E}[(\overline{\boldsymbol{y}}(\boldsymbol{x})-\boldsymbol{y}(\boldsymbol{x}))^2)]}_{\textbf{Noise}} \qquad \textbf{(6)}$$

2.2.8 SMO

Sequential Minimal Optimization (SMO) is an iterative algorithm used to solve problems of Quadratic Programming (QP), where QP problems occurred during the training process of a support vector machine. John Platt proposed this algorithm to resolve constraint optimization problems (Nirve et.al, 2013). The algorithm of SMO is described below:

$$\sum_{i=1}^{n} \boldsymbol{a_i} - \frac{1}{2}\sum_{i=1}^{n}\sum_{j=1}^{n} \boldsymbol{y_i y_j K(x_i, x_j) a_i a_j}\ ,$$

$$\textbf{Subject to}$$
$$0 \leq a_i \leq C, for\ i = 1.2, \ldots n,$$
$$\sum_{i=1}^{n} y_i a_i = 0 \qquad (7)$$

Where C is an SVM hyper-parameter and $K(x_i, x_j)$ is the kernel function, both supplied by the user; and the variables are Lagrange multipliers.

2.2.9 K-means Clustering

K-means is an unsupervised learning where available data have no specified groups or categories. This algorithm assigns data point to each K in the group, according to the features decided iteratively. Data points are decided according to the similarity of data which are in the form of clusters. Clustering allows finding and analyzing the groups that are formed spontaneously rather than assuming the groups before observing the data. The resulting groups are defined by the clusters and each cluster has a centroid which shows the collection of feature values. These feature values are used as the weights for centroids which further interpret the quality of cluster represented in the group (Www et al., 2008).

Given a set of observations ($\mathbf{x}_1$, $\mathbf{x}_2$, …, $\mathbf{x}_n$), where each observation is a d-dimensional real vector, k-means clustering aims to partition the n observations into k ($\leq n$) sets. Formally, the objective is to find:

$$argmin_s \sum_{i=1}^{k} c \sum_{x \in S_i} ||x - \mu_i||^2 = argmin_s \sum_{i=1}^{k} |S_i| Var S_i \qquad (8)$$

Where μ_i is the mean of points in S_i.

3. Results and Discussion

Third phase of the study involves the evaluation of results for all cities, after applying mentioned techniques for classifications and clustering. Following are the performances of all data sets with their summaries, evaluation criteria and confusion matrix.

3.1 Performance Study of Cleveland City

Table 2 shows the performance summary of these techniques for Cleveland city.

Table 2: Performance summary of classifiers for Cleveland city

Evaluation Criteria	Bayes Network	Naïve Bayes	SMO	Bagging	Classification via Regression	Decision Table	J48	REPTree
Correctly Classified Instances	205	199	219	175	219	141	177	121
Incorrectly Classified Instances	14	20	0	44	0	78	42	98
Kappa Statistics	0.898	0.854	1	0.667	1	0.339	0.665	0
Mean Absolute Error	0.050	0.074	0.24	0.131	0.038	0.241	0.107	0.2541
Root Mean Squared Error	0.140	0.173	0.315	0.2359	0.095	0.329	0.231	0.3565
Relative Absolute Error (%)	19.680	29.11	93.899	51.237	15.228	94.449	42.04	99.424
Root Relative Squared Error (%)	39.313	48.518	88.489	66.169	26.693	92.411	65.03	99.993
Predictive Accuracy (%)	93.607	90.87	100	79.908	100	64.383	80.82	55.251
Time to Build Model (sec)	0	0.01	0.08	0	0.02	0	0.02	0

Table 3 shows the evaluation criteria for Cleveland City after applying all techniques.

Table 3: Comparison of estimates under certain evaluation criteria for Cleveland city

Evaluation Criteria	Bayes Network	Naïve Bayes	SMO	Bagging	Classification via Regression	Decision Table	J48	REPTree
TP Rate	0.936	0.909	1	0.799	1	0.644	0.808	0.553
FP Rate	0.050	0.069	1	0.155	1	0.303	0.193	0.553
Precision	0.936	0.908	1	0.797	1	0.565	0.823	0.305
Recall	0.936	0.909	1	0.799	1	0.644	0.808	0.553
F-Measure	0.935	0.907	1	0.793	1	0.575	0.793	0.393
MCC	0.890	0.849	1	0.677	1	0.404	0.698	0.000
ROC Area	0.989	0.979	1	0.955	1	0.810	0.905	0.500
PRC Area	0.983	0.964	1	0.890	1	0.615	0.811	0.365

3.2 Performance Study of Hungarian City

Table 4 shows the performance of different techniques on Hungarian city dataset.

Table 4: Performance summary of classifiers for Hungarian city

Evaluation Criteria	Bayes Network	Naïve Bayes	SMO	Bagging	Classification via Regression	Decision Table	J48	REPT ree
Correctly Classified Instances	191	180	219	180	217	149	180	141
Incorrectly Classified Instances	28	39	0	39	2	70	39	78
Kappa Statistics	0.768	0.661	1	0.657	0.983	0.253	0.625	0
Mean Absolute Error	0.070	0.090	0.24	0.115	0.040	0.191	0.110	0.219
Root Mean Squared Error	0.189	0.221	0.315	0.220	0.105	0.304	0.235	0.331
Relative Absolute Error (%)	31.929	40.766	108.06	52.200	18.430	86.414	49.819	98.993
Root Relative Squared error (%)	57.202	66.865	95.252	66.418	31.688	91.897	70.932	99.988
Predictive Accuracy (%)	87.214	82.191	100	82.191	99.086	68.036	82.191	64.383

Table 5 shows the evaluation criteria for Hungarian city.

Table 5: Comparison of estimates under certain evaluation criteria for Hungarian city

Evaluation Criteria	Bayes Network	Naïve Bayes	SMO	Bagging	Classification via Regression	Decision Table	J48	REPTree
TP Rate	0.872	0.822	1	0.822	0.991	0.680	0.822	0.644
FP Rate	0.108	0.183	1	0.184	0.001	0.453	0.252	0.644
Precision	0.874	0.820	1	0.823	0.992	0.525	0.826	0.415
Recall	0.872	0.822	1	0.822	0.991	0.680	0.822	0.644
F-Measure	0.872	0.817	1	0.815	0.991	0.590	0.803	0.504
MCC	0.762	0.665	1	0.672	0.986	0.309	0.676	0
ROC Area	0.971	0.954	1	0.964	1	0.734	0.841	0.500
PRC Area	0.959	0.924	1	0.909	0.998	0.594	0.768	0.450

3.3 Performance Study of VA Long Beach City

Table 6 shows the performance of these techniques on VA Long Beach data set.

Table 6: Performance summary of classifiers for VA Long Beach

Evaluation Criteria	Bayes Network	Naïve Bayes	SMO	Bagging	Classification via Regression	Decision Table	J48	REPTree
Correctly Classified Instances	162	152	199	165	196	72	59	59
Incorrectly Classified Instances	38	48	1	35	4	128	141	141
Kappa Statistics	0.753	0.686	0.993	0.771	0.974	0.113	0	0
Mean Absolute Error	0.096	0.125	0.222	0.133	0.054	0.251	0.256	0.256
Root Mean Squared Error	0.211	0.241	0.310	0.226	0.121	0.352	0.358	0.358
Relative Absolute Error (%)	37.287	48.86	86.38	51.976	21.018	97.771	99.76	99.762
Root Relative Squared Error (%)	58.908	67.25	86.60	63.285	33.764	98.363	99.99	99.996
Predictive Accuracy (%)	81	76	95.5	82.5	98	36	29.5	29.5
Time to Build Model (sec)	0.03	0.03	0.08	0.13	1.19	0.11	0.01	0

Table 7 shows the evaluation criteria for VA Long Beach after applying all techniques:

Table 7: Comparison of estimates under certain evaluation criteria for VA long beach

Evaluation Criteria	Bayes Network	Naïve Bayes	SMO	Bagging	Classification via Regression	Decision Table	J48	REPTree
TP Rate	0.810	0.760	0.995	0.825	0.980	0.360	0.295	0.295
FP Rate	0.058	0.075	0.002	0.054	0.005	0.248	0.295	0.295
Precision	0.831	0.780	0.995	0.825	0.980	0.197	0.087	0.087
Recall	0.810	0.760	0.995	0.825	0.980	0.360	0.295	0.295
F-Measure	0.815	0.762	0.995	0.824	0.980	0.252	0.134	0.134
MCC	0.761	0.695	0.993	0.773	0.974	0.104	0.000	0.000
ROC Area	0.962	0.936	0.998	0.969	0.999	0.593	0.500	0.500
PRC Area	0.916	0.873	0.998	0.890	0.998	0.286	0.230	0.230

3.4 Performance Study of Switzerland City

Table 8 shows the performance of these techniques on data set of Switzerland.

Table 8: Performance summary of classifiers for Switzerland

Evaluation Criteria	Bayes Network	Naïve Bayes	SMO	Bagging	Classification via Regression	Decision Table	J48	REP Tree
Correctly Classified Instances	105	99	122	82	118	56	49	49
Incorrectly Classified Instances	19	25	2	42	6	68	75	75
Kappa Statistics	0.781	0.710	0.977	0.515	0.931	0.157	0	0
Mean Absolute Error	0.114	0.146	0.240	0.175	0.080	0.283	0.285	0.285
Root Mean Squared Error	0.208	0.241	0.316	0.281	0.159	0.372	0.377	0.377
Relative Absolute Error (%)	39.964	51.026	83.988	61.318	28.178	99.023	99.528	99.53
Root Relative Squared Error (%)	55.314	63.998	83.845	74.593	42.310	98.580	99.990	99.99
Predictive Accuracy (%)	84.677	79.838	98.387	66.129	95.161	45.161	39.516	39.52
Time to Build Model (sec)	0.04	0.07	0.02	0.17	2.04	0.34	0.4	0.13

Table 9 shows the evaluation criteria for Switzerland after applying all the techniques:

Table 9: Comparison of estimates under certain evaluation criteria for VA long beach

Evaluation Criteria	Bayes Network	Naïve Bayes	SMO	Bagging	Classification Via Regression	Decision Table	J48	REPTree
TP Rate	0.810	0.760	0.995	0.825	0.980	0.360	0.295	0.295
FP Rate	0.058	0.075	0.002	0.054	0.005	0.248	0.295	0.295
Precision	0.831	0.780	0.995	0.825	0.980	0.197	0.087	0.087
Recall	0.810	0.760	0.995	0.825	0.980	0.360	0.295	0.295
F-Measure	0.815	0.762	0.995	0.824	0.980	0.252	0.134	0.134
MCC	0.761	0.695	0.993	0.773	0.974	0.104	0.000	0.000
ROC Area	0.962	0.936	0.998	0.969	0.999	0.593	0.500	0.500
PRC Area	0.916	0.873	0.998	0.890	0.998	0.286	0.230	0.230

3.5 K-means Clustering

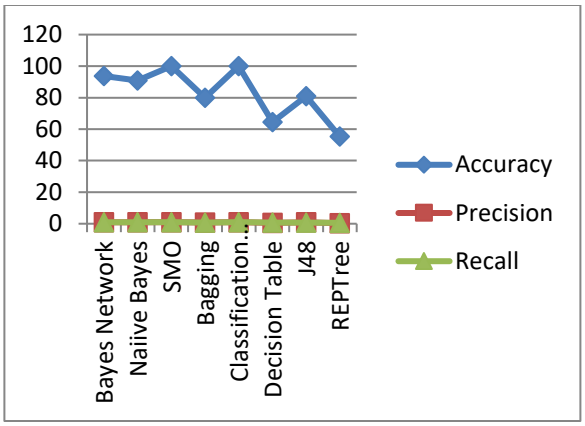
The clustering model describes the statistics assigned to different centroids of the cluster which includes the number and percentage of instances. The characteristics of cluster depend on the values represented by each centroid which includes mean vectors and dimension values (Kapoor et al., 2017). Every new cluster has cluster instances which describes what number of instances are generated in that cluster. Table 10 shows the summary of cluster centroids and cluster instances of all datasets including Cleveland, Hungarian, VA Long Beach, and Switzerland.

Table 10: Final summary of cluster centroids.

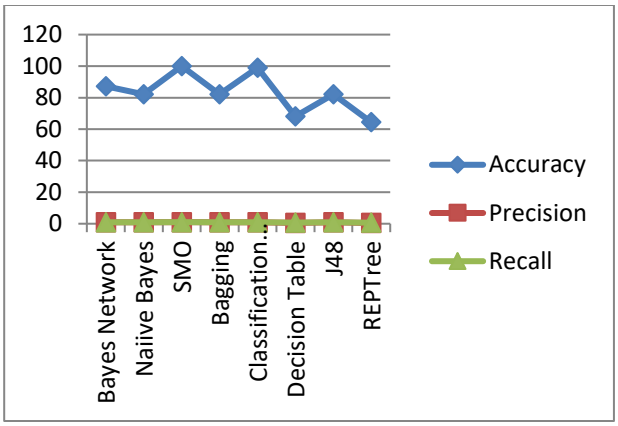
K-mean Clustering	Cleveland	Hungarian	VA Long Beach	Switzerland
Number of Iterations	3	3	7	3
Within Cluster Sum of Squared Error	1651.0	1179.0	1273.0	642.0
Time to Build Model	0.01 sec	0.01 sec	0.22	0.07
Clustered instances at 0	139 (63%)	74 (34%)	118 (59%)	97 (78%)
Clustered Instances at 1	80 (37%)	145 (66%)	82 (41%)	27 (22%)

3.4 Comparison

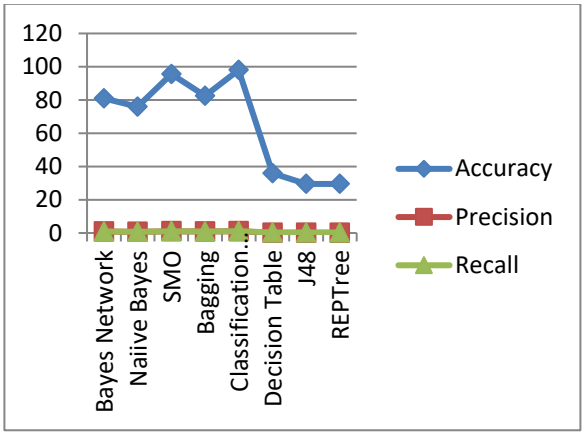
Figure 2 shows the performance of all four cities with respect to parameters including accuracy, precision, and recall after applying classification techniques.



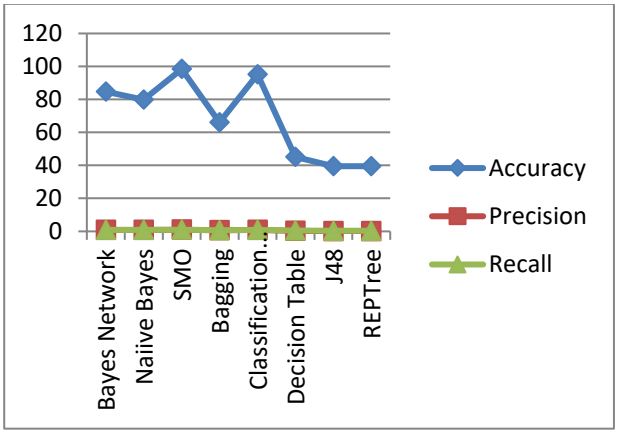
(a) Cleveland



(b) Hungarian



(c) VA Long Beach



(d) Switzerland

Figure 2: Performance visualization of all datasets (Cleveland, Hungarian, VA Long Beach and Switzerland).

4. Conclusion

The objective of this study is to compare all these methods against performance parameters including precision, recall, and accuracy for better prediction of Cardiovascular disease. Existing techniques are limited in accordance with the comparison of multiple techniques on multiple data sets. Our study is the augmentation of techniques for multiple dataset analysis where nine multiple techniques are applied to a greater number of instances and attributes. We use multiple instances on all four datasets--Cleveland, Hungarian, VA Long Beach, and Switzerland to evaluate the precision, recall, and accuracy of these techniques.

Results depict that the accuracy of all cities by using SMO and classification via regression is more than 95%. Accuracy by applying SMO shows the dramatic difference as no other research shows this kind of difference using SMO. While Byes Network and Naïve Bayes are around 80% to 90% in all cities. Whereas accuracy J48 and REPTree are showing approximately the same results for all cities. Bagging is about 80% for all cities, whereas Decision Tree shows poor performance in the whole scenario. Precision and recall are approaching to 1 for SMO, while REPTree shows the lowest for all. Furthermore, a comparison of all

these techniques helps to integrate the clinical decision support that could reduce medical errors, enhance patient safety, decrease unwanted practice variation, and improve patient recovery.

In future, this study can be enhanced by adding the automatic prediction of other diseases instead of the heart. Other data mining techniques can be incorporated using the same data set such as time series, fuzzy sets, and rule-based association. In addition, we want to look at how various preprocessing methods affect clustering algorithms. Also, producing datasets with a missing values rate of more than 20% will be taken into consideration to identify the optimal preprocessing methods to use for such datasets.

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Foundation University Journal of Engineering and Applied Sciences
Vol. 3, Issue 2, 2022.
DOI: 10.33897/fujeas.v3i2.689

Research Article

Multiple Eye Disease Detection Using Deep Learning

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Abstract:

Human eyes are susceptible to various abnormalities due to aging, trauma, and diseases like diabetes. Glaucoma, cataracts, macular degeneration, and diabetic retinopathy are the leading causes of blindness worldwide. It is crucial to detect and diagnose these eye diseases early to provide timely treatment and prevent vision loss. Multiple eye disease detection through the analysis of medical images can aid in this process. The steps involved in the detection of multiple eye diseases using deep learning include image acquisition, region of interest extraction, feature extraction, and disease classification or detection. In this study, we proposed a model using deep learning algorithms, ResNet and VGG16, to detect eye diseases such as uveitis, glaucoma, crossed eyes, bulging eyes, and cataracts. We achieved a 92% accuracy rate using ResNet50 and 79% accuracy using the VGG16 model. By automating the detection process, we can save time for doctors and increase the accuracy and detection rate. The proposed model can be integrated into the healthcare system to assist in early diagnosis and effective treatment of eye diseases.

Keywords: Deep learning; Eye diseases prediction; Convolutional neural network

1. Introduction

Physical disorders of the eyes can have a significant impact on an individual's confidence, self-esteem, and productivity. These disorders not only affect a person's overall health by indicating the presence of serious underlying diseases, but they can also cause shame and bullying, particularly in children. Bulging eyes, cataracts, crossed eyes, glaucoma, and uveitis are major diseases that can affect both the appearance and health of an individual. Eyes that protrude or bulge from their normal position can be a sign of a serious medical condition. This condition is known as proptosis or exophthalmos in medical terms. If there is a visible white part of the eye between the upper eyelid and the iris, then there may be symptoms of abnormal bulging. Hyperthyroidism is a major cause of bulging eyes. The thyroid gland controls metabolism by releasing hormones, and in hyperthyroidism, the gland releases an excess of these hormones. Graves' disease, an autoimmune disorder, is a major cause of bulging eyes and hyperthyroidism. In hyperthyroidism, the tissues surrounding the eyes become swollen, which causes the bulging effect. There may be an underlying infection, thyroid issue, or some other medical problem associated with bulging eyes. Therefore, it is important to identify and diagnose eye disorders like bulging eyes, cataracts, crossed eyes, glaucoma, and uveitis in their early stages to prevent them from affecting an individual's appearance, health, and overall well-being.

In cataracts, there is a blurring of the clear lens of the eye. In cataracts, seeing via cloudy lenses are like a blurred window. Blurred vision due to cataracts causes difficulty in reading, driving, and analyzing the world. Cataract is a common cause of blindness in developing countries. Approximately 37 million people were blind in 1990 and of these 40% were due to cataracts (McCarty, Keeffe, & Taylor, 1999). Cataracts develop gradually and do not affect eyesight at first but with time, cataracts disturb the vision. In Strabismus, eyes are not synchronized and deviate from their original place i.e. one eye deviates in an

opposite direction from the other. Strabismus occurs due to problems in the optic nerve, extraocular muscle, or brain (Rutstein et al., 2011). Normally, six muscles work together and control the movement of the eye due to which both eyes can point in the same direction. Patients having strabismus have problems controlling the movement of the eye and cannot maintain normal alignment. Crossed eyes are caused due to nerve damage or non-synchronization of eyes muscles. When different signals are sent to the brain, it ignores weaker eye signals. Patients having strabismus have problems controlling the movement of the eye and cannot maintain normal alignment. Crossed eyes are caused due to nerve damage or non-synchronization of eyes muscles. When different signals are sent to the brain, it ignores weaker eye signals. Glaucoma damages the optic nerve of the eyes. It becomes worse with time. It is linked to the creation of pressure inside the eye. Glaucoma can inherit in the offspring and diagnose in the later stage of life. The optic nerve which is responsible for sending images to the brain can be damaged by intraocular pressure. In worse conditions, vision can be permanently lost or complete blindness can occur within a few times. There are no early symptoms of glaucoma. Once vision is lost, it is impossible to recover it. But due to decreasing pressure of the eye further vision loss can be prevented.

Uveitis is a severe condition characterized by inflammation in the eyes. It affects the tissues of the uvea, which is the middle layer of the eye wall. The warning signs of uveitis can appear suddenly and can rapidly worsen over time. Symptoms include blurred vision, redness of the eye, and pain. This disease can harm one or both eyes, and people of all ages, including children, can be affected by it. The probable causes of uveitis include inflammatory disease, injury, or infection. However, in numerous cases, the root cause remains unidentified. It is crucial to diagnose and treat uveitis in its early stages to prevent permanent loss of vision.

1.2 Eye Disease Detection Using Deep Learning

Artificial Neural Networks are based on mathematical models that on a smaller scale copy mammalian neural structures. In neural networks, neurons are arranged in layers. ANN layers are fully connected having a non-linear 'activation function' that uses backpropagation for error reduction using gradient descent. The input layer recognizes patterns that are passed to the hidden layers for processing the pattern using weights adjustment. Hidden layers are linked to the output layer that apprehends patterns of retinal images. The weights of neurons are adjusted according to some learning rules and input patterns. But the conventional neural network doesn't analyze patterns in various places.

CNN is a special neural network type that has good performance in image classification. Convolution neural networks can recognize various objects after training on a large dataset. It uses correlations between the images. It can detect diseases within seconds that are difficult to recognize manually. Yet the selection of hyperparameters like the selection of layers, and the size of the CNN filter is important in this regard. Here we have used CNN for the detection of a particular disease in which we have used five convolution layers for the extraction of features and three dense layers for classification. Features are extracted using convolution layers but a large number of parameter requirements is problematic for training deep neural networks. Max-pooling summarizes the outputs of a particular layer and rescales them. Flatten layer performs the transition from convolution to dense layers. The dense layer learns nonlinear combinations from convolution layer outputs. Softmax has been used in the output layer as an activation function for classifying outputs.

A Convolutional Neural Network (CNN) recognizes the structural features of an image. CNN can capture the input pattern across the image by sliding the filter on the entire image to perform pattern matching.

Stride decides the movement of the window for matching the image pattern. CNNs are comprised of processing elements having self-learning biases and weights. Input is received by a neuron that performs the dot product of these inputs with weights, adding the result with bias and passing it to the activation function. The entire neural network uses a single score function from the input image pixels to class scores. The CNN takes images as input for encoding characteristics into architecture making forward function implementation efficient and reduction of network parameters. Unlike ANN, neurons in CNN layers are arranged in three dimensions (width, height, and depth). CNN is comprised of a minimum of 5 layers. Input 3D data is transformed into 3D output using a differentiable function. There are three components in CNN. The convolutional layer is the first one that is used for identifying patterns in the entire image. Secondly, the max-pooling layer is used for performing down sampling and thirdly the fully connected dense layer is used to output results.

Deep CNN and neural networks are different in the sense that in the neural network, all the image pixels are fed to a single layer and then it is connected with the next layer, this can cause overfitting if there are abnormal patterns at various positions of the retina. The edges and core can be detected by different neurons. These are moved to the whole image using the locality principle with a particular stride(steps) and it is ensured that different localization pattern data (abnormal patterns) is passed to different neurons. In this way, patterns are well learned than searching out the location as opposed to the ordinary neural network. A CNN model will be trained on a dataset for the classification of diseases. After training model will be able to classify multiple diseases. So the system will be able to detect the diseases when the image of a specific disease will be placed before the system. After analyzing the image, the system will predict the name of the disease. So multiclass classification will be performed. A disease detection architecture of CNN is shown in Figure 1.

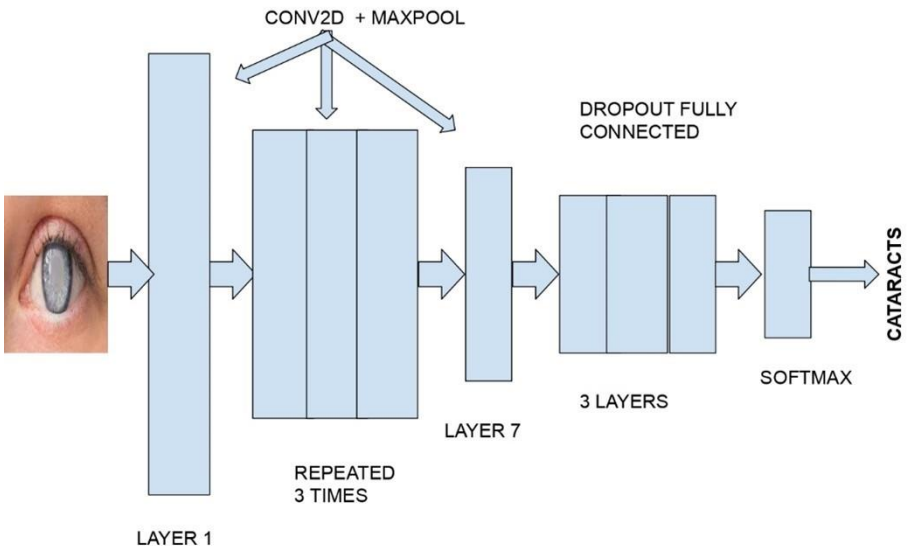

Figure 1: Disease detection CNN architecture

The rest of the paper is organized as follows. Section 2 discusses the related work. Material and methods are presented in Section 3. Results and related discussions are presented in Section 4. Lastly, Section 5 concludes the work.

2. Related Work

Krishna et al. (Prasad, Sajith, Neema, Madhu, & Priya, 2019) proposed multiple eye disease detection using deep learning. Diabetic Retinopathy (DR) and Glaucoma are the diseases that have been detected using the proposed method. Deep neural network models have been trained on datasets. This dataset has been obtained from Kaggle. The accuracy of the system is 80%. Aun et al. (Nazir et al., 2020) proposed a technique for diabetes-based eye diseases. Fast Region-based Convolutional Neural Network (FRCNN) algorithm is used for disease localization that is used for object detection. Fuzzy k-means (FKM) clustering is used for the segmentation of disease after detection. DIARETDB1, ORIGA, MESSIDOR, DR-HAGIS, and HRF datasets are used for performance evaluation.

Grassmann et al. (Grassmann et al., 2018) proposed a deep learning-based approach for age-related macular degeneration from color fundus photography. Classification of age-related diseases has been performed for analysis of fundus images. Thirteen classes have been trained over an independent dataset using a deep neural network. Overall classification of 94.3% healthy fundus images was performed successfully. Chen et al. (Chen, Xu, Wong, Wong, & Liu, 2015) proposed Glaucoma detection based on a deep convolutional neural network. Classification between glaucoma and non-glaucoma patterns has been performed. Strategies of data augmentation and dropout have been used for performance enhancement. A deep neural network is used for the segmentation and classification of diseases. Response-normalization layers and overlapping-pooling layers are used for the reduction of over fitting.

Chen et al. (Chen, Xu, Yan, et al., 2015) presented an approach for feature learning specifically for Glaucoma detection. In their work, CNN is used for feature learning. The micro neural network has been used to obtain the input. A deep learning structure is used for obtaining a hierarchical representation of fundus images. The authors used SCES and ORIGA datasets for the training of DNN. Sarkari et al. (Sarki, Ahmed, Wang, & Zhang, 2020) conducted a survey related to diabetic eye disease detection which covers several aspects like deep learning models, image processing techniques, available datasets, and performance evaluation metrics. A comprehensive synopsis of all the approaches has been presented.

Chelaramani et al. (Chelaramani, Gupta, Agarwal, Gupta, & Habash, 2020) used fundus images for three tasks relating to eye diseases. Firstly, the category of the disease has been detected then the subcategory of the disease has been detected, and at last textual diagnoses have been generated. ResNet models have been used for the detection of disease using multi-task learning. Experiments on the dataset with 40658 images of 3502 patients have been performed. Accuracy of 86% for category detection and 67% for subcategory have been achieved.

Nguyen et al. (Nguyen et al., 2020) explored a method for automating the screening process for diabetic retinopathy (DR) that can enhance the efficiency of detection and decision-making. They presented a classification system that uses deep learning models like VGG16 and VGG19 to analyze and categorize fundus images. The disease was classified into four categories based on its severity, and the system achieved an accuracy of 82%, with 80% sensitivity and 82% specificity. Mishra et al. (Nguyen et al., 2020) conducted a study using deep learning to analyze different stages of diabetic retinopathy (DR). They used the DenseNet model to classify 3662 fundus images obtained from the Kaggle (Aptos) dataset into five DR stages. The DenseNet model extracted features from the fundus images for classification, resulting in an accuracy of 96%. The study also compared the performance of VGG16 and DenseNet. Qummar et al. (Qummar et al., 2019) proposed an automatic approach for detecting DR disease. Manual detection of DR can be laborious and prone to errors; thus, computer vision-based techniques are used for the automatic detection of the disease from retinal images. They trained a classifier on the Kaggle dataset using CNN models such as ResNet50, Inception v3, etc. The system successfully detected all DR stages.

Ramanathan et al. proposed a model that detects cataract, glaucoma, and retinal diseases in patients. To achieve this, the system uses Logistic Regression, Random Forest, Gradient Boosting, and Support Vector Machine algorithms. By enabling early detection of these diseases, the proposed system can help people receive proper treatment and reduce the incidence of blindness. The system also evaluates the safety and effectiveness of cataract surgery in eyes with age-related degeneration, while detecting glaucoma and retinal diseases (Ramanathan, Chakrabarti, Patil, Rishipathak, & Kharche, 2021).

The early detection of diseases can increase the likelihood of a cure and prevent blindness. Medical professionals can diagnose retinal issues, such as diabetic retinopathy and retinitis pigments by examining retinal fundus images. Recently, machine learning research has focused on using feature extraction and image classification to diagnose diseases like diabetic retinopathy. Jain et al. classified retinal fundus images automatically, without explicit segmentation or feature extraction. This is achieved using a simple and fast deep-learning model that can classify any image as healthy or diseased. The model has been tested on two datasets, including real patient retinal fundus images from a local hospital, and has shown an accuracy range of 97% (Jain, Murthy, Patel, & Bansal, 2018).

Nazir et al. proposed an automated approach for disease localization and segmentation using the FRCNN algorithm combined with FKM clustering. The FRCNN algorithm is an object detection approach that requires bounding-box annotations to work, but these annotations are often not available in datasets. Therefore, ground-truth annotations were generated and used to train the FRCNN for localization, which was then segmented out using FKM clustering. The segmented regions were compared against the ground-truth annotations using intersection-over-union operations. The performance of the approach was evaluated on several datasets (Nazir et al., 2020). Adding too many layers to a deep neural network can lead to several potential issues, including:

Overfitting: Overfitting occurs when a machine learning model is trained too well on the training data, resulting in poor performance on unseen data. It happens when the model captures noise and idiosyncrasies in the training data, rather than learning the general patterns. Adding too many layers to a neural network can cause it to become too complex, leading to the overfitting of the training data. Overfitting occurs when the model learns the noise in the training data rather than the underlying patterns.

Vanishing gradients: Vanishing gradients are a problem that can occur when training neural networks. It happens when the gradients used to update the weights in the network during backpropagation become very small, making it difficult to optimize the network. As the number of layers in a neural network increase, the gradients used to update the weights during backpropagation can become very small. This can make it difficult for the model to learn the underlying patterns in the data.

Slow training: Slow training refers to the problem of long training times for machine learning models. This can be caused by a variety of factors, such as large amounts of data or complex models that require many iterations to converge. A deep neural network with many layers can take longer to train than a simpler network. This is because the backpropagation algorithm must propagate errors through many layers, which can be computationally expensive.

Gradient explosion: Gradient explosion is the opposite of vanishing gradients, where the gradients become too large during training, resulting in instability and difficulty in finding a good set of weights. In some cases, the gradients used to update the weights during backpropagation can become very large, leading to numerical instability and divergence during training.

Difficulty with hyperparameter tuning: Hyperparameters are parameters of a machine learning model that are not learned during training, but rather set manually. Tuning these hyperparameters is important for

achieving good performance, but it can be a challenging and time-consuming task. Adding more layers to a neural network increases the number of hyperparameters that must be tuned, making it more difficult to find the optimal combination of hyperparameters.

Decreased interpretability: As machine learning models become more complex, they can become harder to interpret. This can be a problem, as understanding how a model makes decisions is important for trust and accountability. Interpretability techniques can be used to help understand these models. As the number of layers in a neural network increases, it can become more difficult to interpret how the model is making predictions. This can make it challenging to diagnose and fix problems with the model.

3. Materials and Methods

Various eye diseases can cause vision impairment or blindness, including bulging eyes, cataracts, crossed eyes, glaucoma, and uveitis. Detecting these diseases in their early stages is crucial for effective treatment and prevention of further damage to the eyes. However, the current process of detection often involves subjective assessments by doctors, which can lead to errors and delays in diagnosis. Therefore, there is a need to develop an automated detection system for these diseases. Automating the detection process of eye diseases will provide several benefits. It will help doctors to make faster and more accurate diagnoses, and decrease the chances of human errors. By using computer algorithms, the detection process can be standardized, and objective measurements can be obtained, leading to more reliable and consistent results. Moreover, an automated detection system can handle a large number of patients simultaneously, which can reduce the waiting time for diagnosis and treatment. To develop an automated detection system for eye diseases, a multi-stage approach will be taken. Initially, the eyes will be detected in the images using the Haar Cascade classifier, which is a widely used computer vision technique. Then, the detected eyes will be fed to a deep neural network for the classification of diseases. The deep learning model will be trained on a large dataset that contains images of eyes with various diseases. After training, the model will classify the images of a particular disease, enabling the automated detection of eye diseases. Overall, the development of an automated detection system for eye diseases has the potential to revolutionize the way in which these diseases are diagnosed and treated, leading to improved health outcomes for patients.

3.1 Dataset

3.1.1 Class Label

The dataset consists of five classes labeled with disease names. These class labels will be used in training and testing the model. Class labels will be given to the classifier as the names of folders. Each folder will represent a separate disease and will contain images of that disease. These class labels will be represented as follow:

- Crossed eyes, also known as strabismus, is a condition where the eyes do not align properly. This can result in one eye looking straight ahead while the other eye turns inward, outward, upward, or downward.
- Cataracts are a common eye disease that affects the clarity of the eye's lens. It causes blurry vision and can make it difficult to see clearly. The condition develops slowly over time and is often associated with aging, but can also be caused by genetics, trauma, or certain medications.

- Uveitis is a condition that causes inflammation in the uvea, the middle layer of the eye. It can be a serious condition that can lead to vision loss if left untreated. Symptoms of uveitis include eye redness, pain, blurred vision, and sensitivity to light. It can affect people of all ages, but it is more common in those between the ages of 20 and 50.
- Glaucoma is a serious eye disease that can cause irreversible damage to the optic nerve, which is responsible for transmitting visual information from the eye to the brain. It is often associated with increased pressure inside the eye, which can lead to gradual loss of vision if left untreated.
- Bulging eyes, also known as proposes or exophthalmos, is a medical condition that causes one or both eyes to protrude from the eye socket. This can be due to various underlying medical conditions such as thyroid eye disease, orbital cellulitis, or a tumor behind the eye.

3.1.2 Images

Each class label contains approximately 100 train and 20 test images for training and testing the deep learning model respectively. These images will be given to the classifier for identification of the person and the folder containing these images will be named the same as the name of the student. A snapshot of the dataset is shown in Figure 2.

Figure 2: Dataset images of diseases

3.1.3 Training and Testing Module

There are separate modules for training and testing. Each module contains a separate dataset of images for training and testing the model. The training module will contain separate 100 images for training and the test module will contain separate 20 images for testing the model.

- Test
- Train

3.2. ResNet

Deep neural network (DNN) pre-trained models are widely used in machine learning due to their ability to solve complex problems. However, adding too many layers to a DNN can cause vanishing gradient problems, where the gradients become too small to update the weights in the initial layers using backpropagation. To solve this issue, Residual Networks (ResNets) were developed, which introduced identity connections to the architecture. Identity connections, also known as skip connections, allow gradients to move backward from later to initial filters in the network. This allows for the preservation of the gradient of error while backpropagating through the layers. The addition of these identity connections improved the performance of convolutional neural networks (CNNs) by reducing the effects of vanishing gradients and facilitating the training of deeper networks. The ResNet architecture consists of a backend that starts with a 7x7 convolution and a 3x3 max pool layer with strides of 2, which downsamples the input tensor (Conv1). This is followed by four residual blocks, with the stride of 1 used in all layers except the initial layer, where the stride of 2 is used for further downsampling of the input. To obtain a feature map of a single value, a global average pooling layer (GAP) is used, which is then passed to a fully connected layer with a sigmoid activation function for classification.

We have developed a DNN based on the ResNet architecture that takes input images of size 224x224x1. The model starts with a 7x7 convolution, followed by a 2x2 max pooling layer. A ResNet block is then used, which contains one convolution and three identity blocks. In the identity blocks, there are three layers and an identity connection. These consist of 1x1, 3x3, and 1x1 convolutions. The convolution block consists of three layers of 1x1 and 3x3 convolutions stacked on top of each other, with a kernel size of 1x1. The stride of 2 is used in a 3x3 convolution layer, which reduces the input size and prevents size mismatch. Finally, an average pooling layer, a flattened layer, and two fully connected layers are used respectively. This DNN model has been trained on a large dataset and has achieved high accuracy in image classification tasks. The use of the ResNet architecture with identity connections has enabled the model to learn complex features from the input images and improved its performance. Additionally, the use of a sigmoid activation function in the fully connected layers has helped to improve the model's ability to accurately classify the image. Overall, the ResNet architecture with identity connections has been a significant improvement in CNN architecture, particularly for solving complex problems. The addition of skip connections has allowed for the training of deeper networks, which was previously difficult due to vanishing gradients. The model we have developed based on the ResNet architecture has demonstrated the effectiveness of this approach in achieving high accuracy in image classification tasks. Future research may explore the use of ResNet in other areas of machine learning, such as natural language processing and time-series analysis. ResNet architecture is shown in Figure 3.

3.3 VGG16

At Oxford University, VGG16 has been proposed by K. Simonyan and A. Zisserman (Simonyan & Zisserman, 2014). As a convolutional neural network model, VGG16 achieved a remarkable test accuracy of 92.7% when tested on ImageNet, a large dataset that contains over 14 million images belonging to 1000 different classes. The model was submitted to the ILSVRC-2014 competition and has since become a popular choice for image recognition tasks. The VGG16 model improved upon the AlexNet architecture by using multiple 3×3 filters of kernel size in place of large kernel-size filters. The model was trained over several weeks using NVIDIA GPUs for processing. With its impressive accuracy and robustness, VGG16 has proven to be a valuable tool in the field of image recognition, particularly for large-scale datasets such

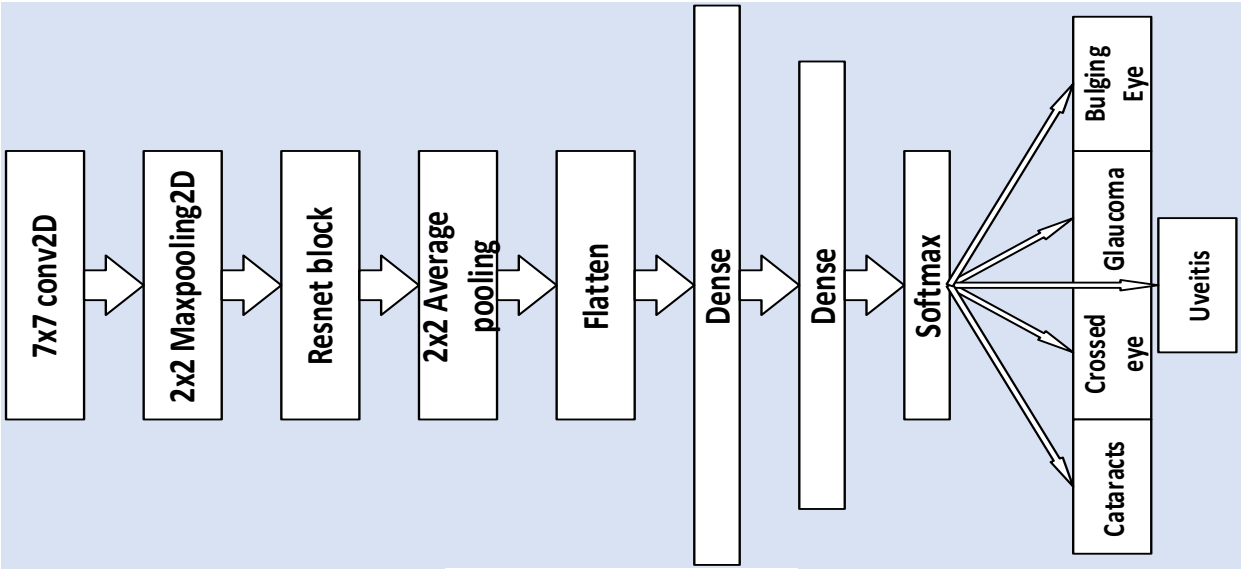

Figure 3: ResNet architecture

as ImageNet. Its success has also inspired the development of other deep convolutional neural network models that have achieved even greater accuracy in image recognition tasks. The architecture of VGG16 is shown in Figure 4.

3.3.1 ImageNet Dataset

The ImageNet dataset is a collection of over one million high-resolution images that have been labeled with over 22,000 categories. The labeling was done by human labelers and the images were gathered from the internet. In 2010, the ILSVRC (ImageNet Large Scale Visual Recognition Challenge) was held, where the ImageNet dataset was used with approximately 1000 categories, resulting in a total of around 1.2 million training images. To make the dataset compatible with the competition, the images were resized to 256×256 and the central 256×256 portion of the images were cropped and rescaled.

The VGG16 model was proposed at Oxford University by K. Simonyan and A. Zisserman in their paper "Very Deep Convolutional Networks for Large-Scale Image Recognition". The model is a convolutional neural network that achieved a test accuracy of 92.7% on the ImageNet dataset. The ImageNet dataset is a collection of over 14 million images that belong to 1000 classes and was submitted to the ILSVRC-2014 competition, making the VGG16 model one of the most popular models used in deep learning. The model improved on the AlexNet architecture by replacing large kernel-size filters with multiple 3×3 filters of kernel size. The VGG16 model was trained for several weeks using NVIDIA GPUs for processing.

The Conv1 layer of the VGG16 model takes input in a 224 x 224 size, and after passing through the convolutional layers, a receptive field filter of 3×3 is used. One of the configurations of the model utilizes 1×1 convolution filters as a linear transformation of the input channels. The convolution stride of 1 pixel is used to preserve spatial resolution after convolution, and spatial pooling is carried out by five max-pooling layers on a 2×2-pixel window with a stride of 2. The VGG16 model also utilizes three fully-connected convolutional layers, with 4096 channels used in the first two layers and 1000 channels used in the third layer for classification. The final layer of the model is the Soft-max layer, and the same configuration is used in all fully connected layers of the network. The hidden layers of the VGG16 model use Rectification

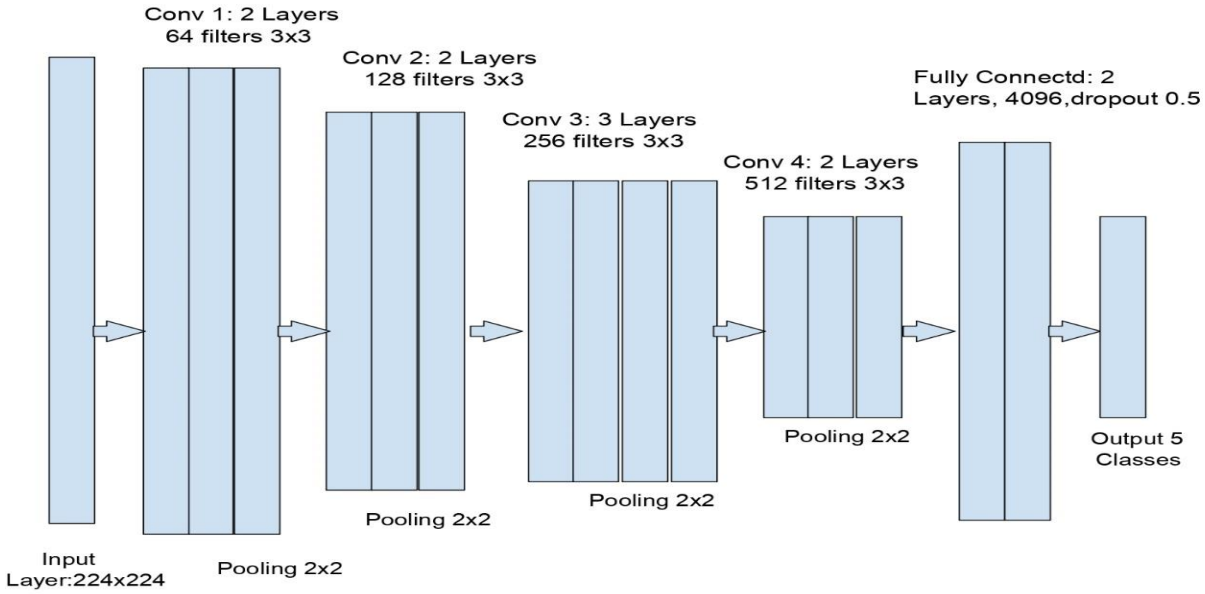

Figure 4: VGG16-Architecture

(ReLU) non-linearity, but Local Response Normalization (LRN) is not included, as the ILSVRC dataset showed that normalization did not improve performance and only increased computation time and memory consumption.

4. Results and Discussion

The testing of the system is done by inputting both the test images and the images that are taken live corresponding to multiple eye diseases. The output has been shown in form of accuracy. The results that are obtained for test images show that the image of the eye is affected. Experiments performed on images for crossed-eye detection is shown in Figure 5.

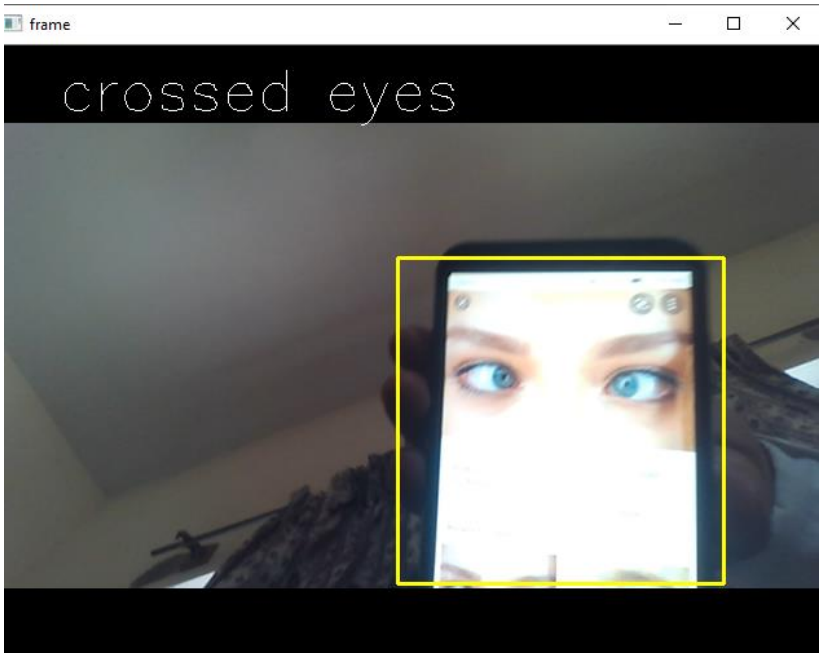

Figure 5: Detection of crossed eyes

The results show that the proposed system has successfully recognized particular diseases. However, the model has achieved 92% training accuracy and 89% validation accuracy. Training loss is 67% while validation loss is 69% as described in Table 1.

Table 1: Model evaluation results

Models	Train Accuracy	Train Loss	Validation Accuracy	Validation Loss
ResNet50	0.920	0.670	0.890	0.690
VGG16	0.798	0.495	0.821	0.840

4.1 Need for Multiple Eye Disease Detection

With the increase in the aging population worldwide, the incidence of eye diseases is also predicted to rise gradually. Early detection and appropriate treatment are crucial for preventing vision loss and promoting a better quality of life. However, conventional diagnosis approaches involving human judgment have a higher risk of misdiagnosis. To address this issue, automated detection of eye diseases using deep learning can greatly improve the accuracy and detection rate while saving doctors' time. Previous research has focused on the detection of single diseases such as strabismus in children using deep learning. However, in this study, we aim to detect multiple diseases such as crossed eyes, uveitis, glaucoma, and others using deep learning techniques. By training our deep learning model on a large dataset of labeled images, we have achieved promising results in accurately detecting these various eye diseases. This approach has the potential to revolutionize the field of ophthalmology by enabling the early detection of multiple diseases through an automated process. This will not only reduce the burden on doctors but also improve the accuracy of diagnoses, ultimately leading to better patient outcomes. With further research and development, deep learning-based approaches to ophthalmology could have a significant impact on the prevention and treatment of various eye diseases.(Yehezkel, Belkin, & Wygnanski-Jaffe, 2020). In this paper, we have performed the detection of multiple diseases like crossed eyes, uveitis, glaucoma, etc.

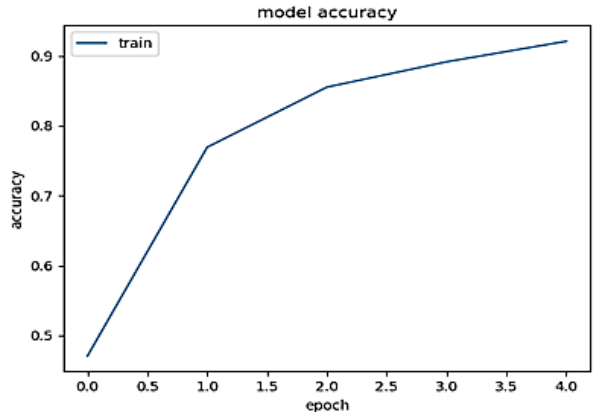

Figure 6: ResNet accuracy

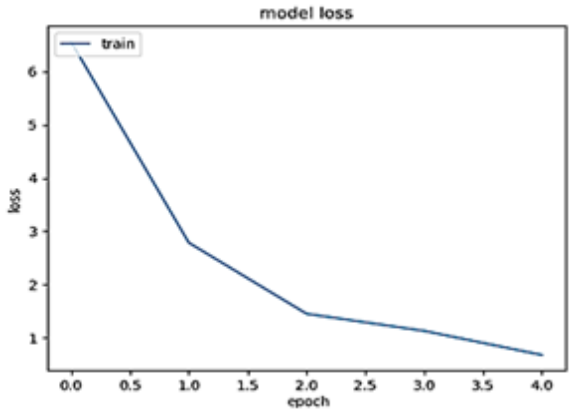

Figure 7: ResNet loss

We utilized the ResNet model on our dataset and achieved a training accuracy of 92%. However, we also obtained a loss of 0.67 during the training process, as shown in Figures 6 and 7 respectively. Our ResNet model was successful in making accurate predictions.

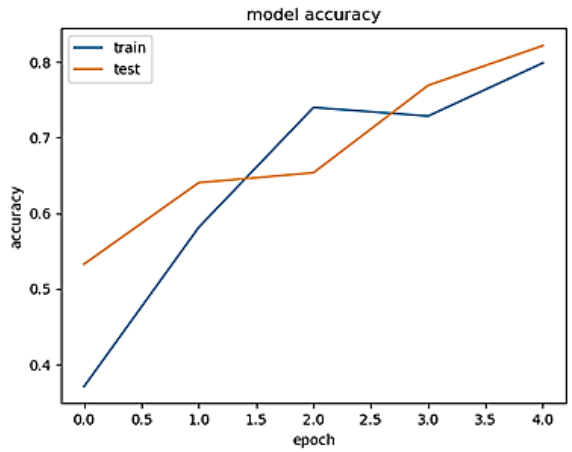

Figure 8: VGG16 accuracy

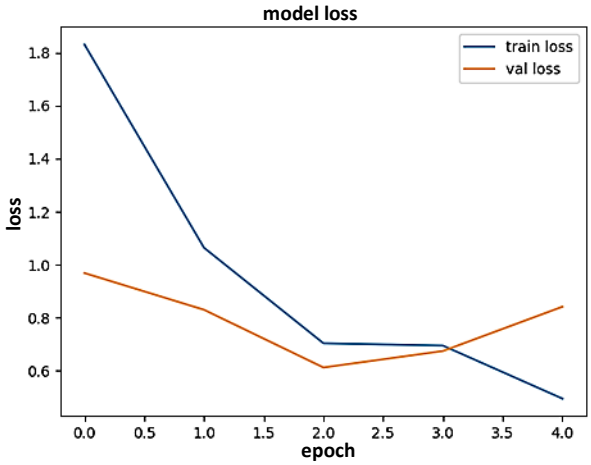

Figure 9: VGG16 loss

Using VGG16, we have achieved 79% train accuracy, and the accuracy we have obtained while testing is 82% as shown in Figure 8. The training and testing loss using the VGG16 model is 0.49 and 0.82 respectively as shown in Figure 9. So ResNet has performed better than VGG16 not only while making predictions but also during testing and training.

5. Conclusion

The eyes are one of the most important organs in the human body, and eye disorders can have a significant impact on a person's life. The early detection and treatment of eye diseases such as glaucoma, uveitis, cataracts, crossed eyes, and bulging eyes are crucial for maintaining good eye health and overall well-being. This paper has proposed an automated detection system that can aid in the diagnosis of these diseases using deep learning algorithms. Specifically, we have utilized ResNet50 and VGG16 models for the detection process. During the training process, ResNet50 demonstrated higher accuracy compared to VGG16. The automated detection system has the potential to revolutionize the way eye diseases are diagnosed and treated, as it can save time and increase the accuracy of detection. This system can also be utilized to aid medical professionals in their decision-making process, leading to better patient outcomes. Future research can be done to improve the accuracy of the detection system and to expand its capabilities to detect other eye disorders. Additionally, the integration of this technology into clinical settings can be explored to enhance the efficiency of eye disease diagnosis and treatment. Overall, the proposed system shows promise in improving the detection and treatment of eye diseases, ultimately contributing to better eye health and quality of life for individuals. In the future, we will extend this work for Optic neuritis disease.

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Foundation University Journal of Engineering and Applied Sciences
Vol. 3, Issue 2, 2022.
DOI: 10.33897/fujeas.v3i2.688

Research Article

Comparative Analysis of Fruits and Vegetables Quality Using AI Assisted Technologies: A Review

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Abstract:

Food quality is a major issue for society since it is a crucial guarantee not only for human health but also for society's progress and stability. Planting, harvesting, and storage through preparation and consumption, all aspects of food processing should be considered. One of the most important methods for managing fruit and vegetable quality is by using AI food quality evaluation techniques. Upcoming automation technologies like Artificial intelligence (AI) and Computer vision (CV) are thought to profit from the availability of massive data for active training and the generation of intelligent and operational equipment in real time and predictably. This paper review provides an overview of leading-edge Computer vision (CV) and Artificial Intelligence automation technologies can help farmers in food processing and Agriculture Sector. In addition, thereview presents some implications for the recommendations and provocations regarding the addition of automations in actual time agriculture, policies, and universal substantial investments. Furthermore, it addresses the 4th industrial revolution automation technologies of Computer Vision and Deep Learning, as well as robots, which are the key sustainability for production of food is also addressed in it.

Keywords: Computer vision; Advanced process control; Artificial neuronal networking; Fuzzy logic; Autonomous navigation; Artificial intelligence; Image processing; Food processing

1. Introduction

In today's top competitive trade quality is a critical aspect in the present food sector because top-quality products are the foundation for success. Manual inspection is still widely utilized in the food industry, but it is time-consuming, difficult, and expensive, and it is easily impacted by physiological conditions, resulting in irrational and inconsistent assessment outcomes. It is vital to enhance quality evaluation of food items to meet the rising awareness, sophistication, and expectations of customers (Brosnan & Sun, 2004). Production speed and efficiency may be enhanced by production values and sustainable techniques if quality evaluation is done automatically. With the world's population expanding, the United Nations Food and Agricultural Organization (FAO) estimate that population of world in 2050 will be over 9.1 billion (Godfray et al., 2010) . This estimate substantially eliminates the need to account for a rise of seventy percent in global food supply and an almost twofold rise in developing economies (*Population and Food in the Early Twenty-First Century: Meeting Future Food ... - Google Books*, n.d.). The undernourishment word still points out to the inefficiency to get sufficient food and the quantity of inadequate edibles absorption required to join the requirements of dietary energy.

The latest revolutions in the food industry have opened the door to new methods of food production and technological transformation. Over the last decades many types of food were in demand, which contains few of the specific types such as functional foods that have demonstrated to be a key component of a healthy and good lifestyle. (Health and Illness - Michael Bury, Mike Bury - Google Books, n.d.) To join market

demand and produce quickly, the industry of food produced a finite number of food processing methods. Latest agricultural and food processing technology was used, and they may be called innovative forerunners in the modernization of sector of food before being supplanted by smart machines and production lines (Edible Food Packaging: Applications, Innovations and Sustainability - Google Books, n.d.). Will these developments be able to feed the world's rapidly rising population, while avoiding the inevitable? Corresponding to the rise in technological breakthroughs and with the growth in need, it appears to be doable. With the increase of 4IR techniques Like AI, C.V robots during the last ten years, there has been a significant model change in investments and business models. In meeting future demand for a secure food supply, this cutting-edge technology might considered be a appropriate tool.

According to the FAO, Under the pandemic of COVID-19 most people impacted by worldwide hunger grew in 2020 and after maintaining nearly stable from 2014 to 2019, the prevalence of undernourishment (PoU) risen to nearly 9.9% in 2020, up from 8.4% in the past year. In terms of population, it is predicted that between 720 and 811 million people in the globe in 2020 will be hungry, considering additional statistical uncertainty. According to the midpoint of the estimated range (768 million), In 2020, 118 million more people will be hungry than in 2019 – or as many as 161 million if the upper end of the spectrum is considered. Food insecurity affects 793 million people, or one out of every nine people on the earth. The data from the FAO, as shown in Fig. 1B, shows that only a few Asian nations are still undernourished. The two largest nations, India, and China, are tied for top and second place, owing to their rapidly rising populations and economic achievements (*The Impact of Economic Shocks on Global Undernourishment - Sailesh Tiwari, Hassan Zaman - Google Books*, n.d.) .

Demographic estimations have a high degree of statistical accuracy, confirming the credibility of the food and agriculture organizations assertion based on population increase, as shown in Figure 1 worldwide heat map. Figure 3 shows greenhouse gas emissions on a global scale, saying that increased restoration linearizes the growth in environmental risks, and Figure 4 characterizes the value-added portion of GDP in terms of different portfolios on a global scale. Eventually, the records of uncertainty assessed based on a variety of aspects like high rising incomes in emerging nations and rising levels of economic inequity, among others, might lead to impartial worldwide estimations (*Rural Wage Employment in Developing Countries: Theory, Evidence, and Policy - Google Books*, n.d.) .

Finally, food supply remains a point of contention in the demand of supply chain, and the technique of selecting an acceptable technique from among continual latest practices that provide more desirable outcomes in terms of maintaining productivity while meeting demand. In comparison to other commercial sectors, the food industry is Conceptually developed and sluggish expanding, with advancement and essential research spending, in comparison to other business areas (*Agricultural Development and Economic Transformation: Promoting Growth with ... - John W. Mellor - Google Books*, n.d.) .

In Figure 1, the credibility of food and agriculture organization description positioned on increase population displayed as a worldwide heat map is supported by statistical demographic projections with a high degree of assurance. In a recent survey of food and agriculture organization 793 million people, or one out of every nine people on the planet, are insecure of food. The data from the food and agriculture organization, as shown in Figure 2, shows that only a few Asian countries are still undernourished. Intuitively, the two largest countries, India, and China, stand on first and second place, owing to their rapidly rising populations and economic achievements.

In Figure 3, Authors T. Reardon, J. E. Taylor, K. Stamoulis, P. Lanjouw and A. Balisacan represents

greenhouse gas emissions on a continental basis, stating that increased modernization linearizes increased environmental dangers. Figure 4 represents the value-added division of Gross domestic product in terms of various collections on a continental size. Record unreliability, on the other hand, is computed using a range of criteria such as growing high incomes in emerging nations and expanding economic disparity, among others. It's possible that this will lead to impartial global estimations.

In several ways AI techniques can be used to manage fruit and vegetable quality. AI techniques can play a

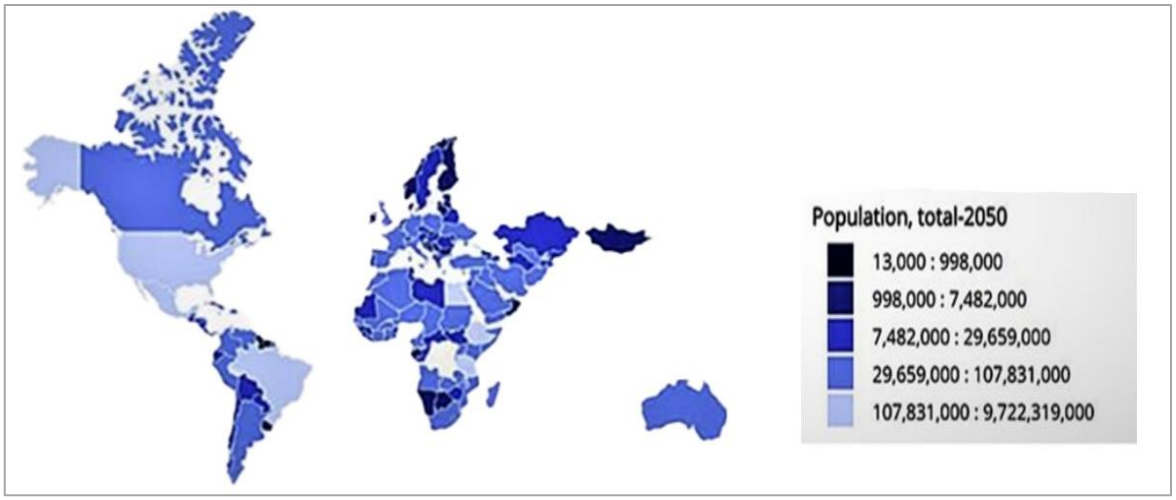

Figure 1: Various statistics illustrating food-based crisis global population growth heat map

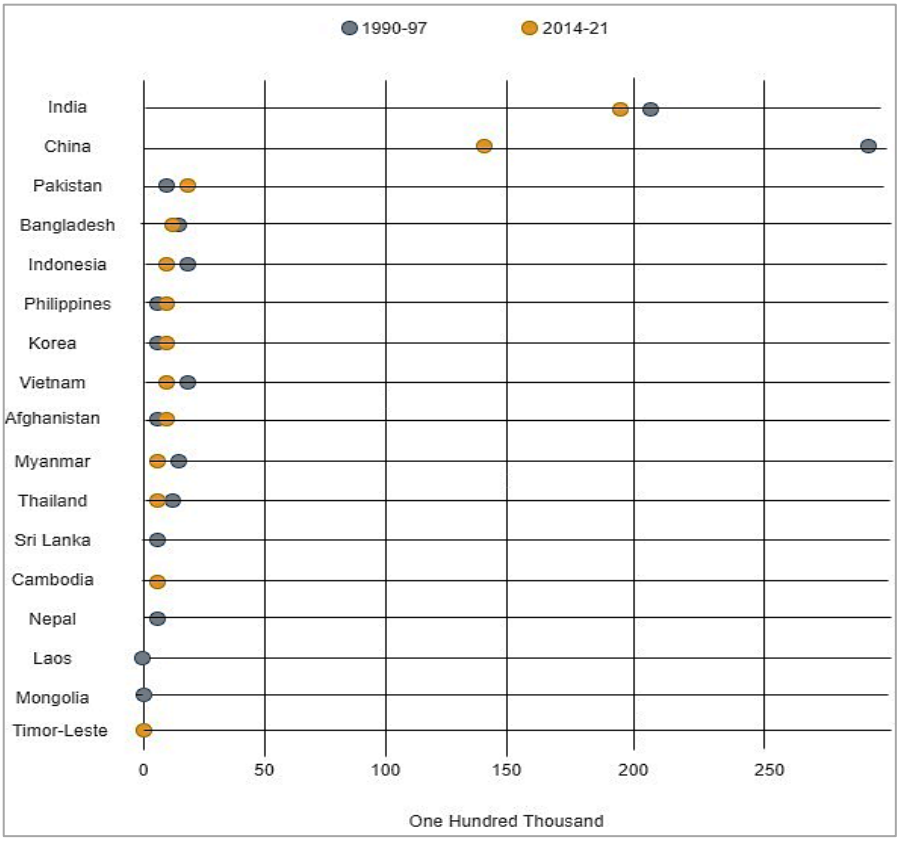

Figure 2: Undernourishment of food in Asian countries

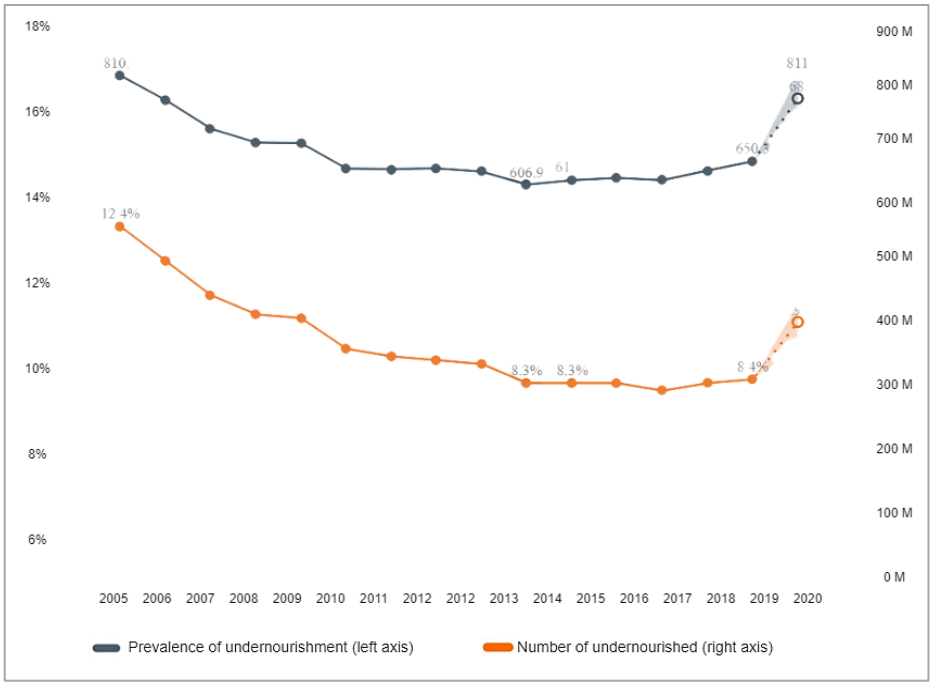

Figure 3: Gas emissions of greenhouse in agriculture

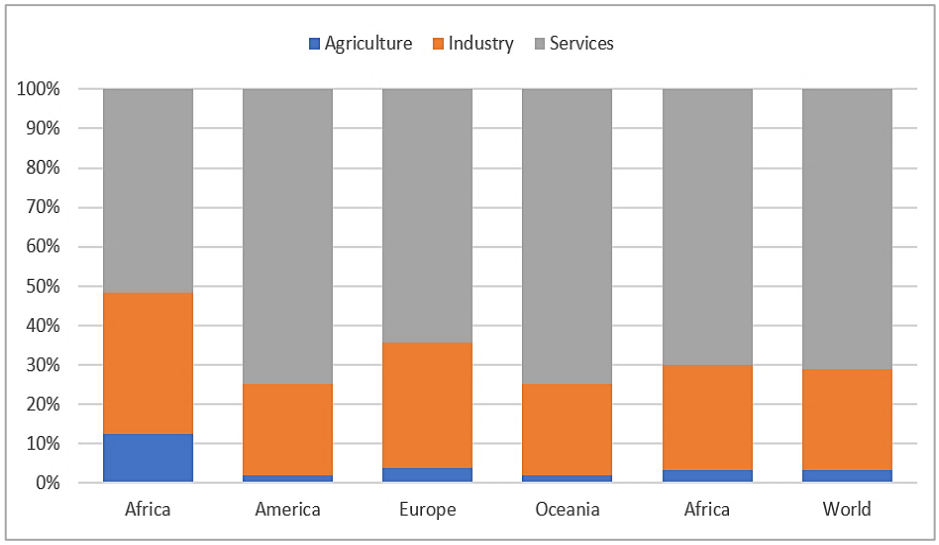

Figure 4: Value added share of GDP (2013)

crucial role in managing fruit and vegetable quality. Image recognition algorithms can be trained to identify different types of produce and evaluate their quality based on appearance, helping with sorting and grading. Predictive analytics can analyze data from various sources like weather forecasts, soil sensors, and crop yields to predict produce quality before harvesting, aiding in data-driven decision making on when to harvest, how much to harvest, and storage/transportation. Smart packaging with AI-powered sensors can monitor environmental factors like temperature and humidity during transportation and storage, adjusting storage conditions or alerting handlers when necessary. AI can also be used to monitor produce quality during processing and packaging, detecting defects or bruises that affect quality, reducing waste and ensuring only high-quality produce reaches consumers. Overall, AI techniques can improve product quality and consistency while reducing waste and ensuring high-quality produce is delivered to consumers.

Other than food management and processing in the food industry, the major sector that may affect a significant change in the food economy is the food business. According to data, several aspects like control quality, kind of food, present direction, customer psychology, and human well-being impact the food processing business (*Food Geographies: Social, Political, and Ecological Connections - Pascale Joassart-Marcelli - Google Books*, n.d.) (*Food Safety and International Competitiveness: The Case of Beef - John Spriggs, Grant Isaac - Google Books*, n.d.) .

Due to the limits imposed on the food processing business, solutions to increase values of production, havoc control, and market demand satisfaction is required (*Remaking the North American Food System: Strategies for Sustainability - Google Books*, n.d.-a). Market trends, as previously said, drive food processing technology, which in turn influences the food sector. Systematically, market trends are determined by client attitudes about the food or product, which may be influenced using certain tactics or marketing strategies (*Remaking the North American Food System: Strategies for Sustainability - Google Books*, n.d.-b).

According to Global Meals Technology, time restrictions, social events, stress alleviation, and indulgence have raised the merchandise need for the modular of food (*Food Authentication: Management, Analysis and Regulation - Google Books*, n.d.). Equivalently, factors like as increased need for awareness of health and wellbeing have resulted in a significant growth in adoption of useful foods. Saying like "Eat Worldwide Local," "Natural = Healthier," and "Gluten-free in more markets of Asian" highlight the significant impact of health and wellbeing knowledge of market trends. (Annunziata & Pascale, 2009).

With the advancement of machineries, the construction sector and contemporary corporation have reached new heights of productivity in a matter of decades. (AI) is a collection of several methodologies and developments, the most important of which are two main ideas known as Deep Learning and Neural Networks which are responsible for AI's tremendous progress (Rajakumari & Pradhan, 2023). This innovation was formerly unthinkable, but because of today's tremendous computer capacity of Graphics Processing Units, it is now conceivable (GPU). Because of this compute capacity, neural networks were able to simulate the components of the brain of human, allowing the Artificial intelligence to study complicated tasks using huge amounts of Training data (Macedonia, 2003).

This technique, which was revealed in 2014, demonstrated to the world how quickly robots can learn complicated jobs that humans took decades to perfect. Within a few years, DeepMind technology has advanced from simple jobs such as document review and spam email categorization to more complex ones like as object identification, context creation, and scene interpretation. (Moritz et al., 2015) (Mnih et al., 2015) . Even difficult sectors like remedies and pharmaceutics have encountered this type of AI through challenging tasks like anticipating problems of eye based only on retinal scans (Gulshan et al., 2016) .

The combination of NVIDIA and Google ushered in the age of self- driving automobiles Esther Francis. NVIDIA, a prominent GPU manufacturer, provided computing basics for self-driving AI training using Google's enormous data set of views of street and automotive glossaries. (Chen & Lin, 2014).

Figure 5 depicts use cases of AI application scenarios in a variety of disciplines like in agriculture, finance, pharmaceuticals, Automotive, Healthcare, Public/Social, Consumer, Manufacturing, Telecom, Energy, Media, Travel Transport etc.

a) Farmers may utilize artificial intelligence (AI) to gain real-time insights on their crops, allowing them to identify areas that require irrigation, fertilizer, or pesticide treatment. Furthermore, innovative agricultural techniques such as vertical agriculture may help to increase food output while decreasing resource usage.

b) Agriculture: AI can be used to optimize crop yields by analyzing soil and weather data to determine

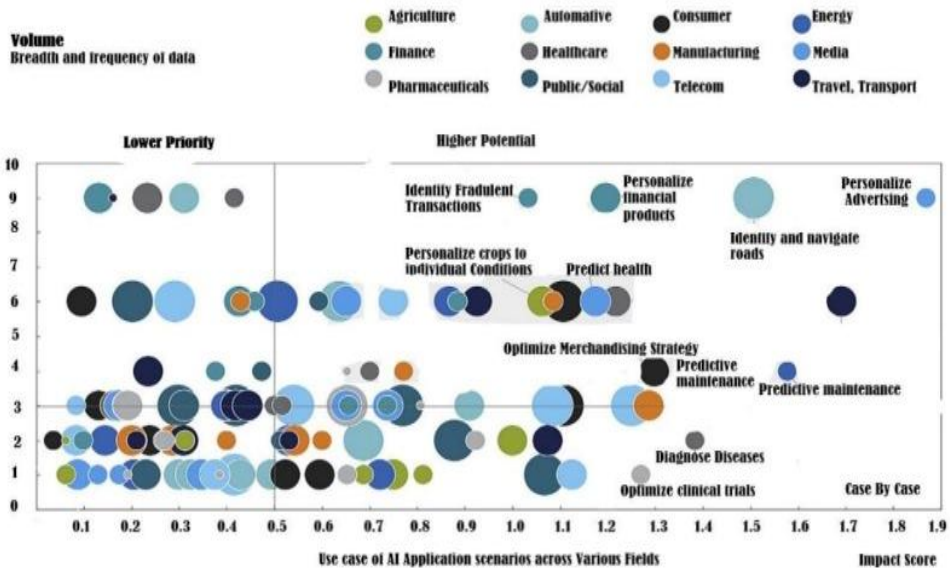

Figure 5: Use-cases of AI application

the best irrigation and fertilization strategies. AI can also be used to monitor plant health and detect diseases early, allowing for timely intervention and reduced crop loss. In addition, AI can be used to automate farm machinery, reducing labor costs and improving efficiency.

c) Finance: AI can be used for fraud detection by analyzing large amounts of financial data to identify patterns of fraudulent behavior. AI can also be used for credit scoring by analyzing credit history, income, and other relevant factors to determine the creditworthiness of individuals or businesses. In addition, AI can be used for trading algorithms to identify profitable investment opportunities.

d) Pharmaceuticals: AI can be used for drug discovery by analyzing large datasets to identify potential drug targets and design more effective treatments. AI can also be used to predict drug interactions by analyzing patient data to determine the most effective drug combinations. In addition, AI can be used for personalized medicine by analyzing genetic data to determine the best treatment options for individual patients.

e) Automotive: AI can be used for self-driving cars by analyzing sensor data to navigate roads and avoid obstacles. AI can also be used for predictive maintenance by analyzing vehicle data to identify potential issues before they occur. In addition, AI can be used for driver assistance systems to help drivers avoid accidents and improve overall safety. In Automation, artificial intelligence applications make it possible for machines to complete real human tasks.

f) Healthcare: AI can be used for medical image analysis by analyzing medical images to detect abnormalities and assist with diagnosis. AI can also be used for patient monitoring by analyzing patient data to detect changes in health and provide early warning of potential issues. In addition, AI can be used for drug discovery by analyzing large datasets to identify potential treatments for various diseases.

g) Public/Social: AI can be used for predicting and preventing crime by analyzing crime data to identify patterns and potential hotspots. AI can also be used for monitoring social media for potential threats by analyzing social media data to detect potential threats to public safety. In addition, AI can be used for analyzing public sentiment by analyzing social media and other data to determine public opinion on various issues. In Public Sector AI might aid citizens by answering their commonly asked questions through chatbots or virtual assistants, or AI could assist public employees by making welfare

payments and immigration decisions, identifying fraud, and designing new infrastructure projects

h) Consumer: AI can be used for personalized marketing by analyzing customer data to provide personalized recommendations and marketing messages. AI can also be used for chatbots to provide customer service and support. In addition, AI can be used for recommendation engines to suggest products and services to customers based on their past behavior and preferences.

i) Manufacturing: AI can be used for predictive maintenance by analyzing machine data to detect potential issues before they occur. AI can also be used for quality control by analyzing product data to detect defects and improve overall product quality. In addition, AI can be used for supply chain optimization by analyzing data to determine the most efficient and cost-effective supply chain strategies.

j) Telecom: AI can be used for network optimization by analyzing network data to improve performance and reduce downtime. AI can also be used for customer service chatbots to provide support and assistance to customers. In addition, AI can be used for fraud detection by analyzing call data to detect potential fraudulent behavior. In Telecom or telecommunications (SONs), Building self-optimizing networks isanother popular application of AI algorithms that detect and accurately forecast network anomalies automatically monitor such networks. 63.5 percent of telecom businesses are actively integrating AI to improve their network infrastructure, according to IDC.

k) Energy: AI can be used for energy demand forecasting by analyzing historical data and weather patterns to predict future demand. AI can also be used for optimizing energy usage by analyzing energy data to identify areas where energy usage can be reduced. In addition, AI can be used for predicting equipment failure by analyzing equipment data to detect potential issues before they occur. In Energy, Artificial intelligence has the potential to reduce energy waste, minimize energy costs, and expedite the implementation of clean renewable energy sources in power systems around the world. Power system planning, operation, and control can all benefit from AI.

l) Media: AI can be used for content recommendation by analyzing user data to provide personalized content recommendations. AI can also be used for automated news writing by analyzing news data to generate news articles automatically. In addition, AI can be used for video analytics by analyzing video data to identify potential issues and improve overall video quality. In Media creation workflows journalists can now include AI. In what is becoming known as 'automated journalism,' they can gather content and comprehend data pools, as well as generate and distribute media at the touch of a button. Algorithms are beingutilized to generate large-scale tales.

With the annual rise in AI startups, developments in industries across the public and commercial sectors will accelerate in the future decade, as seen in Fig. 2, which depicts a conceptual study conducted by McKinsey & Company Global Institute about the importance and possible opportunity of incorporating AI into various areas (Jones, 2017) (Jones, 2017). Since the most recent wave of AI advancements has skyrocketed, Analysts and advisors predict that by 2020 AI will be a major technology sustaining many corporations (Müller & Bostrom, 2016) . The fundamental logic for this is the rapid expansion of digital data, with the annuary rate of data production predicted to reach forty-four trillion gigabytes by 2020 (Batista & Marques, 1 C.E.) . With this big amount of data intact and smart AI companies, the fourth Industrial Revolution is on its way through novel approaches to current challenges in a variety of industries. Late developments in AI, CV, and Big Data, the symptoms of the Fourth Industrial Revolution might be seen in every industry. The food industry is one such industry that has recently seen a significant impact from AI on its procedures, equipment, and machines. With the introduction of AI-powered processes and

machines in agriculture and the sector of food, growing of crop, cultivation, production, and methods of processing have changed.

This paper focuses specifically on food quality evaluation techniques using different AI-based algorithms and computer vision techniques. An AI algorithm is a subset of machine learning that advises the computer on how to learn to function on its own. As a result, the device is always learning how to enhance processes and do jobs more effectively. Artificial intelligence (AI) refers to machine intelligence as opposed to natural intelligence displayed by animals such as humans. Algorithms for artificial intelligence are commonly classified into three types. There are three types of learning: supervised learning, unsupervised learning, andreinforcement learning. In the case of unsupervised learning, the goal output is not provided, and the model is intended to generate a template from the inputs provided. Reinforcement learning is a subset of supervised learning. In this learning example, you are given a rating that indicates how accurate the model's output is. The model is fed diverse data in the supervised learning approach, and the model's findings are compared to the real goal outputs. The model attempts to minimize the mistakes.

Computer vision technologies are processes for capturing, processing, analyzing, and comprehending digital pictures, as well as the extraction of high-dimensional data from the actual world to create numerical or symbolic information, such as judgments,are examples of computer vision tasks. To allow self-driving automobiles, computer vision is required. Volvo, Audi Tesla, and BMW, handle various cameras, radar, lidar, and ultrasonic sensors to capture images from the surroundings for their self-driving vehicles to distinguish, traffic signals, lane markings, signs and objects and drive safely.

Deep learning and computer vision robotics are being increasingly used in food production to enhance various aspects of the production process. For example, deep learning algorithms can be applied to analyze images of food products to detect defects such as discoloration, bruises, and other imperfections, allowing manufacturers to remove defective products before they reach consumers. In addition, computer vision systems can sort, and grade food products based on size, shape, color, and texture, which can be particularly useful in fruit and vegetable processing. Another application of deep learning and computer vision robotics is in packaging. By leveraging these technologies, manufacturers can ensure that products are packaged correctly, with the appropriate amount of food in each package. This can reduce waste and improve efficiency in the packaging process.

Incorporating AI technologies in real-time agriculture has the potential to revolutionize the industry by enhancing productivity, reducing costs, and improving sustainability. However, there are several challenges that need to be addressed to realize these benefits. Here are some challenges and recommendations for incorporating AI technologies in real-time agriculture and policies:

a) Data management: The use of AI in agriculture requires large amounts of data, including weather patterns, soil conditions, and crop information. One of the main challenges is the lack of standardization and interoperability of data from different sources. Policymakers can address this by encouraging the development of common data standards and protocols and supporting the development of data-sharing platforms.

b) Infrastructure: AI technologies in agriculture require high-speed internet access, which is not always available in rural areas. Policymakers should invest in broadband infrastructure to ensure that farmers can access AI technologies.

c) Adoption: Many farmers may be hesitant to adopt AI technologies due to the perceived complexity and cost. Policymakers can encourage adoption by providing financial incentives such as tax credits or subsidies to farmers who adopt AI technologies. Additionally, policymakers can invest in

training programs to help farmers understand the benefits and use of AI technologies.

d) Ethical considerations: AI technologies in agriculture raise ethical concerns such as privacy, ownership of data, and bias in decision-making. Policymakers should develop guidelines and regulations to address these concerns and ensure that AI technologies are developed and used in an ethical and responsible manner.

e) Standards and certification: AI technologies in agriculture require standards and certification to ensure that they are safe, effective, and reliable. Policymakers should develop and enforce standards and certification processes to ensure that AI technologies meet these requirements.

Overall, the adoption of AI technologies in real-time agriculture has the potential to enhance productivity, reduce costs, and improve sustainability. Policymakers should address challenges such as data management, infrastructure, adoption, ethical considerations, and standards and certification, and provide incentives and support to encourage the use of AI technologies in agriculture. Furthermore, computer vision systems can be used to monitor inventory levels and track the movement of products through the production process, which can help manufacturers optimize their production processes and reduce waste. Additionally, deep learning algorithms can identify potential food safety hazards, such as foreign objects or contaminants, in food products to ensure their safety for consumption.

In conclusion, the application of deep learning and computer vision robotics in food production has the potential to significantly enhance the efficiency, accuracy, and safety of the production process. The Fourth Industrial Revolution (4IR) refers to the current period of rapid technological progress, characterized by the integration of physical, digital, and biological systems. It has significant implications for a wide range of industries, including agriculture and food production, where it has the potential to improve sustainability.

In the context of food production, the 4IR can help improve sustainability in several ways. For instance, farmers can leverage technologies such as IoT, drones, and satellite imaging to collect and analyze real-time data on soil moisture, nutrient levels, and crop health, allowing for more targeted application of fertilizers and pesticides. This can reduce waste and increase crop yields.

Additionally, the use of blockchain technology, sensors, and other tracking systems can enhance transparency and traceability in the food supply chain. This can help reduce food waste, improve food safety, and ensure that products are sustainably sourced. Furthermore, vertical farming, which utilizes artificial lighting and controlled environments to grow crops, can help address the challenges of land scarcity and water use in traditional agriculture. This technology can also reduce the need for pesticides and fertilizers while reducing transport-related emissions. Finally, predictive analytics and machine learning algorithms can help food manufacturers and retailers optimize their production processes and reduce waste, which is a significant contributor to greenhouse gas emissions. Overall, the 4IR offers an opportunity to revolutionize the way food is produced, distributed, and consumed while increasing sustainability and reducing environmental impact.

A brief introduction of techniques with their performance is also given in the ending sections. This paper is structured as follows: Section II will be containing a literature review; Section III will be comparative analysis that we have done from recent and up-to-date research articles. A brief introduction of datasets, models, and algorithms will also be given. Finally, section IV will discuss the findings of our comparative study of computer vision and intelligence methodologies as they apply to a variety of agricultural applications of agriculture like processing of food, smart irrigation, applications that are based on agriculture, farming, next generation farming, and data of plant analysis.

2. Literature Review

In a recent study by (Singh et al., 2022) presented multiple approaches for reducing post-harvest loss (PHL) and improving quality control using various machine learning algorithms. The authors also demonstrate the effectiveness of integrating Internet of Things (IoT) sensors into a traceability system for the perishable food supply chain to minimize PHL. The analysis is supported by substantial data to showcase the impact of Deep Learning and IoT in precision agriculture and food processing, specifically in reducing PHL losses in fruits. The study critically reviews and discusses the accuracy outcomes of various machine learning models, including their recall, precision, and F1 score. The models utilize RBG images, infrared images, and hyperspectral images to develop training and testing data sets followed by feature extraction and classification. The proposed model achieved a classification accuracy of 93.33 percent. However, the results of MFC InceptionV3 based on MNet were even better, achieving 99.92 percent accuracy and reducing misclassification by 5.98 percent compared to the original InceptionV3 and 4.17 percent compared to FC InceptionV3. These findings demonstrate the effectiveness of deep learning models in reducing PHL losses in fruits.

The authors Al-Sammarraie, Gierz, Przybył (Al-Sammarraie et al., 2022) their aim of this article was to investigate the feasibility of utilizing artificial intelligence technology to predict the sweetness of oranges. The study accomplishes this by analyzing the correlation between the RGB values of orange fruits and their sweetness levels, utilizing the orange data mining tool. The study uses a dataset of orange fruit images and applies various machine learning algorithms to compare and identify the algorithm with the highest prediction accuracy. The results demonstrate that the red color value has a more significant impact on predicting orange fruit sweetness compared to the green and blue color values, as there exists a direct relationship between the value of the red color and the level of sweetness. Additionally, the logistic regression model algorithm was found to provide the highest degree of accuracy in predicting orange fruit sweetness.

In a recent study by (Sharma et al., 2022) their aim was to evaluate the nitrogen status of wheat crops using predictive computational intelligence techniques. This evaluation is based on analyzing crop images taken under varying lighting conditions in the field. The study involves HSI color normalization of the wheat crop, followed by an optimization process that utilizes genetic algorithm (GA) and artificial neural network (ANN) based prediction and crop precision status classification. This optimized approach based on ANN significantly distinguishes between wheat crops and other unwanted plants and weeds, while categorizing crop yield age into classes. The experimentation results in a validation accuracy of 97.75%, with a minimized error rate of 0.22 and a 0.28 decrease in loss value. Compared to other contemporary counterparts, the proposed ANN+GA mechanism provides improved performance outcomes while minimizing error rates

The authors (Wieme et al., 2022) demonstrated that hyperspectral imaging can be an effective tool for evaluating the quality parameters of fruits, vegetables, and mushrooms and analyzed both laboratory-measurable variables and more complex properties like maturity, ripeness, detection of biotic defects, physiological disorders, mechanical damages, and sensory quality. The article starts with an overview of quality concepts, measuring principles, and theory and analysis of hyperspectral imaging systems. Then, it described emerging techniques for monitoring and assessing quality parameters, pre- and post-harvest, and reviews and discusses their applications. Additionally, this review illustrated how artificial intelligence, particularly machine learning and deep learning, can be used for hyperspectral imaging analysis in horticulture. Lastly, the article highlighted some challenges and considerations for future research,

including improving data availability, finding solutions for better integrating artificial intelligence, and transferring knowledge from research parameters to those relevant for industrial stakeholders.

To evaluate the quality of fruits and vegetables, several parameters such as size, shape, and appearance are taken into consideration. Among these parameters, appearance plays a crucial role in determining the market value and consumer preference. To address this, authors (Tata et al., 2022) presented an application that has been developed to classify and grade fruits and vegetables based on their appearance. This proposed system utilizes image processing techniques to extract relevant features such as color, shape, and Histogram of Gradient (HOG) to classify the produce. Additionally, techniques such as data augmentation, normalization, Principle-Component Analysis (PCA), and Deep learning (CNN) are employed to improve the accuracy and reduce dimensions. To facilitate a faster and more efficient identification process, they have developed a high-performance Android application that can be easily deployed, in contrast to current manual grading systems that require more time and energy or embedded systems (sensors).

The authors of (Hassoun et al., 2023) provided an overview of the application of Traceability 4.0 in the fruits and vegetables sector, with a focus on the relevant Industry 4.0 enablers including Artificial Intelligence, the Internet of Things, blockchain, and Big Data. The study indicates that Traceability 4.0 has the potential to improve the quality and safety of many fruits and vegetables, increase transparency, reduce costs associated with food recalls, and decrease waste and loss. However, these advanced technologies are expensive to implement and are not easily adaptable to industrial environments, which has hindered their large-scale application. Thus, further research is required to overcome these limitations and enable the widespread use of Traceability 4.0.

The researchers (Kutyauripo et al., 2023) evaluated the use of artificial intelligence (AI) throughout the entire food production process, encompassing crop and livestock farming, harvesting, and slaughtering, post-harvest management, food processing, distribution, consumption, and waste management. Their main objective (Kutyauripo et al., 2023) was to investigate the implementation of AI systems at each stage of the food system. A systematic review was carried out, in which 110 articles were analyzed after screening 450 articles according to specific inclusion and exclusion criteria. The findings indicate that different AI algorithms are being utilized across all stages of the food system, from crop and livestock production to the management of food and agricultural waste.

In a study presented by (Das et al., 2022) utilized machine learning algorithms and computer vision (CV) techniques to identify the freshness quality of stored tomatoes. The assessment is based on a grading scale ranging from 1 (fresh) to 10 (rotten). To accomplish this, they combined image pre-processing, handcrafted feature extraction, and a shallow artificial neural network (ANN). Their proposed ANN model achieved better results than several state-of-the-art methods, including deep neural networks. For this study, they developed a large dataset that covers the degradation of tomatoes over 70 days, which can be valuable for future research in the field.

Authors (Jurkonis et al., 2023) presented a method to evaluate crop parameters by analyzing mechanical vibrations. The investigation was demonstrated on a cucumber crop grown vertically using a support system in the field. The study involved modeling the cucumber yield, with a focus on the natural oscillation frequencies. A numerical model of the support design was developed, and its natural frequencies were calculated using the finite element method (FEM). The accuracy of the results was verified by conducting a physical experiment that replicated the numerical model.

In central Mexico, vending machines, street vendors, and cafeterias are the primary sources of food in hospitals. While prior research conducted in other countries has shown that the majority of food offered in

these environments is unhealthy, there is a lack of information regarding the nutritional situation of hospitals in developing countries. Therefore, the purpose of authors (Murillo-Figueroa et al., 2023) study was to investigate the nutritional characteristics of food sold in hospitals and its compliance with the national Front-of-Pack Labeling Regulation (FOPLR). The findings revealed that the food available in and around hospitals contains high levels of calories, sodium, and saturated fats, and does not adhere to the nutritional guidelines set forth by FOPL.

Current evolutions in computer vision, Big Data, AI and, the symptoms of Fourth Industrial Revolution (4.0 IR), may be seen in each corporation (Sihlongonyane et al., 2020) . The food industry is one such industry that has lately seen a significant impact from AI on its procedures, equipment, and machines. With the advent of AI-driven processes and machines in agriculture and the food sector, crop growing, cultivation, production, and processing methods have altered.

Recently another work focused on that computer can now not only display photos of food, but also recognize and expose details about that item's nutritional content. (Pinel, 2015) Taking it a step further, International Business Machines Corporation (IBMAI)'sin 2016, Watson made history by becoming the first AI chef, offering innovative and imaginative dishes based purely on the ingredients. With its main feature of presenting modifications in a recipe with equivalent components, IBM's Watson silenced prominent chefs.

In a study presented by A. Singh. (*Singh, A. K. (2012). Mobile Technologies for Enriching... - Google Scholar*, n.d.) About Tech behemoths like Microsoft and Google are supplying these countries with technology and assisting in the formationof global economic stability. For example, Microsoft and ICRISAT collaborated to deploy Microsoft Cortana Intelligent Suite for agricultural data gathering and analysis by using machine learning techniques Through public, private partnerships and state investment, the Indian government developed 13 pilot areas for learning through soil laboratories on soil analysis, smart irrigation systems, and IMOD techniques to support farmers.

In a recent study (Kakani et al., 2020) work focus on worldwide scale increased population has a remarkable effect on the points like regime services and policies.With number of increasing populations, the important responsibility respecting this problem is to stabilize the supply and demand for food in emerging countries. The corresponding increase in technological progress paves the way for the country's good economic position, with this factor as a foundation-governments and privatized investors are running on inspiring AI and CV techniques into sectors like industry of Agriculture and food for resolving distinct issues and rising productivity.

The authors (Lecun et al., 2015) worked on AI principles like deep and machine learning enabled the processing of photos using a computer vision. Till 2012, image processing and vision of computer were areas that analyzed images and trained computers to interpret their contents, allowing them to perform actions on certain judgements. The introduction ofmachine and deep learning expanded the breadth of computer vision behind its limits, get to the pinnacle of scientific achievement in tasks such as device identification, recognition, facial recognition, and so on. Data, photos, movies, linguistic sequences, and so forth.

In (Becker-Reshef et al., 2010) the author told that as automations advanced, current inventions put back old gear, utmost often in wealthy nations where to reach the public R&D takes short time. Through frequent field surveys and data assessment, the integration of computer vision and robots created a new inventive way to farming. Unmanned aerial devices and drones for crop imaging, are among the most recent breakthroughs in site-specific crop management. These are outfitted with sensors like multispectral,

allowing farmers to examine their field, make decisions like the requirement for irrigation of water, and evaluate the soil fertility in areas throughout the land.

In a study presented by (Lele & Goswami, 2017) worked on the study of tech. Giant's sites that collect data from many variables like historical rainfall data ,water, soil, Prediction of weather , yield crops, and other features to construct a trained system that can forecast season and best time of crop production. It is delivered precisely to agriculturalist smartphones, by making it more user-friendly and ultimately increasing crop yields. ICRISAT picked one seventy farmers and urged them to postpone planting activities until pilot sites, tell them that it is safe to do so. On this year in June third week trial sites sent an SMS to all farmers using Microsoft's machine learning skills of inspecting meteorological data and training on numerous aspects. This strategy allows agriculturalist to grow their seeds closer to the time of year when it rains., increasing agricultural yields by 30–40 percent. Nearly 2000 farmersreceived assistance in the latter months of 2017 to help them boost output on their farms.

In a recent study presented by (Eaton et al., 2008), Udio, a California-based agricultural technology start-up, has been working on sustainable AI-driven agriculture to quadruple production by concentrating on water irrigation strategies. Their basic idea is to Combine meteorological data, farm data, irrigation, and characteristics of soil to produce insights on filed level as recommendations for farmers to nearly double their comprehensive generation rate.

Several approaches have been developed in the literature to measure size, shape, color,and textural aspects, which have been thoroughly examined by Du and Sun (2004) (Murillo-Figueroa et al., 2023). These characteristics are objective data that are used to represent food goods and may be utilized to create the training set. After obtaining the training set, the learning algorithm extracts the knowledge base required to make a judgement in an unknown scenario. An intelligent judgement is created as an output based on the information and is simultaneously fed back into the knowledge base, generalizing the process used by inspectors to perform their obligations. The two primary applications where learning techniques have been used for developing knowledge bases are artificial neural network (ANN) and statistical learning (SL). Decision trees, Fuzzy logic and evolutionary algorithms also been utilized for learning in the meanwhile.

3. Comparative Analysis

Computer vision systems and image processing are a rapidly increasing study topic in agriculture, and they are an important analytical technique for pre- and post- harvesting of crops. To the best of our knowledge, Figure 6 depicts the number of research articles published each year. The trend in this subject of research may clearly be noticed from this graph. Between 2011 and 2022 Table 1 describes the best paper of Food Science and technology category. The average number of publications each year was 262.36 in 2016, with the greatest value of 385 in 2020, while there is a half-year break in 2022. Each article in the WoS (Web of Science) is classified into one or more subject groups. In the science version, there are twenty-eight web of science subject classes, along with Food Science and Technology classes (total 254 categories), and 21 research areas. Food Science Technology (2,887 papers, 100 percent of 2,887 papers), Chemistry Applied (1051,36.417 percent), Nutrition Dietetics (821, 28.4 percent), Agriculture Interdisciplinary (201, 5.999 percent), and Toxicology (202, 6.999 percent) are the top five categories (96, 3.326 percent).

Food Science Technology (2,887 papers, 100 percent of 2,887 papers), Chemistry (1067, 37.937 percent), Nutrition Dietetics (823,29.482 percent), Agriculture (317, 10.019 percent), and Toxicology (318, 11.019 percent) are the top five research areas (96, 3.326 percent). The WoS allows for the classification of journals or publications into two or more classes, reflecting the interdisciplinary nature of this field of

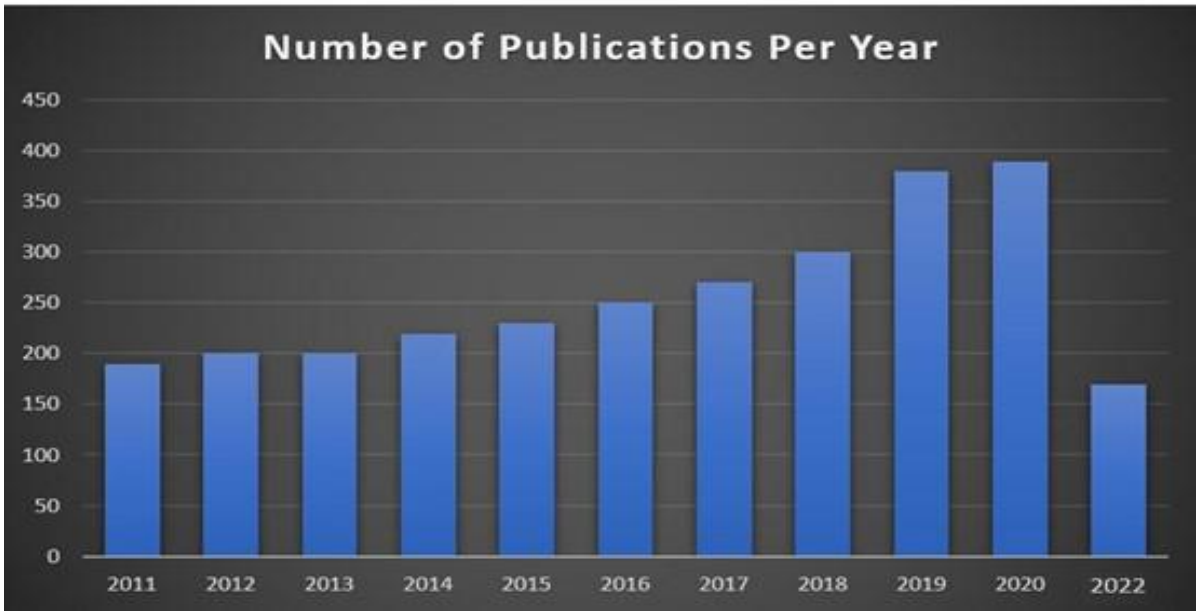

Figure 6: Publications of paper

research (Elango & Ho, 2017,2018). In web of science each document is assigned to one or more study categories. Publications are assigned areas, which are subsequently mapped to each document (paper) within them. As a result, publications can be categorized in several different ways. Despite its flaws, this broad database-specific mapping is often used in bibliometric analysis. Advertisements are also connected to web of science classes, that are major specific than fields in WoS (Stopar et al., 2021).

Table 1: From 2011 to 2021 Web of science areas of research and classes for food science and technology

WoS categories			**Research areas**		
Rank					
Categories No. papers	% Total papers	Areas	No. papers%	Total papers	
Dairy Animal	58	1.976	Biotechnology Applied	58	1.976
Science			Microbiology		
Food Science Technology	2887	101	Food Science Technology	2887	101
Agronomy	37	1.318	Business Economics	15	0.454
Applied, Chemistry	1051	36.4	Chemistry	1066	36.93
Toxicology	96	3.326	Toxicology	96	3.326
Nutrition, Dietetics	821	29.482	Nutrition, Dietetics	821	29.482
Agriculture Interdisciplinary	201	5.999	Agriculture	317	11.019
Biotechnology Applied	56	1.975	Pharmacy, Pharmacology	51	1.802
Microbiology					
Horticulture	35	1.213	Mycology	7	0.243
Analytical, Chemistry	14	0.51	Neurosciences Neurology	5	0.139
Behavioral Sciences	5	1.139	Public Environmental	2	0.03
			Occupational Health		

Molecular Biology, Biochemistry	91	4.119	Molecular Biology, Biochemistry	91	4.119
Microbiology	61	1.148	Microbiology	63	1.148
Pharmacy, Pharmacology	15	0.52	Physiology	4	0.139
Chemistry, Medicinal	37	0.282	Spectroscopy	15	0.485
Mycology	7	1.243	Ecology, Environmental Sciences,	2	0.035
Policy, Agricultural Economics	20	1.658	Entomology	6	0.173
Economics	17	1.554	Behavioral Sciences	5	0.13
Entomology	5	1.173	Plant Sciences	2	0.03
Spectroscopy	14	0.485	Immunology	2	0.069
Chemical. Engineering	94	3.257	Engineering	95	3.292

The parameters listed above the tables are related to various fields and disciplines in agriculture, animal science, and food production. Here is a brief explanation of each parameter:

a) Agriculture - This field is concerned with the study and practice of farming. It encompasses a wide range of topics, including crop production, soil management, land use, pest management, and agricultural engineering.

1. Dairy Science - This discipline is concerned with the biology, chemistry, and processing of milk and milk-derived products. Dairy scientists study topics such as animal nutrition, milk production, milk quality, and the development of dairy products.
2. Animal Science - This field encompasses the study of animal biology, breeding, nutrition, and management. Animal scientists may specialize in areas such as animal genetics, animal nutrition, animal behavior, and animal health.
3. Agronomy - This discipline is concerned with the study of crop production and soil management to optimize agricultural productivity. Agronomists study topics such as soil fertility, crop physiology, plant genetics, and sustainable agriculture.
4. Food Science Technology - This field is concerned with the physical, chemical, and microbiological properties of food, and how they relate to food processing, preservation, and safety. Food scientists may work on the development of new food products, food packaging, or food safety regulations.
5. Chemistry - This field encompasses the study of the composition, properties, and behavior of matter, including its interactions with other substances and energy. Chemists may work on topics such as chemical synthesis, materials science, or analytical chemistry.
6. Applied Nutrition Dietetics - This discipline is concerned with the role of food and nutrition in health and disease prevention, as well as the application of this knowledge in the development of dietary recommendations and interventions. Applied nutritionists and dieticians may work in fields such as public health, clinical nutrition, or food service management.
7. Agriculture Multidisciplinary - This field involves the study of agriculture from multiple disciplines, including agronomy, animal science, soil science, and horticulture. Multidisciplinary approaches may be used to address complex agricultural problems such as sustainable land use, crop productivity, or food security.

8. Toxicology - This field involves the study of the harmful effects of chemicals on living organisms, including their impact on human health and the environment. Toxicologists may work in fields such as environmental health, public health, or drug development.
9. Chemical Engineering - This field involves the application of chemical principles to the design and operation of chemical processes and systems. Chemical engineers may work on topics such as process design, process optimization, or process control.
10. Biochemistry Molecular Biology - This field involves the study of the chemical and biological processes that occur within living organisms, including the structure and function of proteins, nucleic acids, and other biomolecules. Biochemists and molecular biologists may work on topics such as genetics, protein engineering, or drug discovery.
11. Microbiology - This field involves the study of microorganisms, including bacteria, viruses, fungi, and parasites, and their role in health and disease, agriculture, and the environment. Microbiologists may work on topics such as microbial ecology, infectious disease, or food microbiology.
12. Biotechnology Applied Microbiology - This field involves the use of living organisms or their products to develop new products or processes, including the production of food, medicine, and biofuels. Biotechnologists and applied microbiologists may work on topics such as genetic engineering, fermentation, or bioremediation.
13. Medicinal Chemistry - This field involves the study of the design, development, and synthesis of drugs and other therapeutic compounds. Medicinal chemists may work on topics such as drug discovery, drug design, or drug delivery.
14. Horticulture: the science of plant cultivation, including the production of fruits, vegetables, and ornamental plants.
15. Agricultural Economics and Policy: the study of the economic principles that govern agricultural production, marketing, and trade.
16. Analytical Chemistry: the development and application of analytical techniques to analyze and measure chemicals and materials used in agriculture and food production.
17. Pharmacology and Pharmacy: the study of the effects of drugs on living organisms, including their therapeutic and toxic effects.
18. Spectroscopy: the use of electromagnetic radiation to analyze and measure the chemical and physical properties of materials, including those used in agriculture and food production.
19. Mycology: the study of fungi and their role in agriculture, food production, and medicine.
20. Entomology: the study of insects and their interactions with living organisms, including their role in agriculture, ecology, and disease transmission.
21. Behavioral Sciences: the study of human and animal behavior, including the biological, psychological, and social factors that influence behavior in agriculture and food production.
22. Biotechnology Applied Microbiology - Biotechnology is the application of technology to biology for the development of new products and processes. Applied microbiology is the use of microorganisms to develop new products or processes. Biotechnology applied to microbiology involves the use of microorganisms such as bacteria, yeast, and fungi to produce products such as vaccines, antibiotics, enzymes, and biofuels.

23. Business Economics - Business economics is the application of economic principles to the study of business activities such as production, marketing, and finance. It involves analyzing how businesses make decisions, allocate resources, and respond to changes in the market.
24. Food Science Technology - Food science technology is the study of the physical, chemical, and microbiological properties of food and how they relate to food processing, preservation, and safety.
25. Chemistry - Chemistry is the study of the composition, structure, properties, and behavior of matter. It includes the study of chemical reactions and the development of new materials and chemical compounds.
26. Nutrition Dietetics - Nutrition dietetics is the study of the role of food and nutrition in health and disease prevention. It involves the development of dietary recommendations and interventions to promote optimal health.
27. Agriculture - Agriculture is the science and practice of cultivating land, raising animals, and producing food, fuel, and other products. It includes crop production, soil management, animal science, and agricultural economics.
28. Toxicology - Toxicology is the study of the harmful effects of chemicals on living organisms, including their impact on human health and the environment. It involves the study of chemical exposure, toxicity, and risk assessment.
29. Engineering - Engineering is the application of science and mathematics to solve practical problems. In agriculture and food production, engineering is used to develop and improve technologies for crop production, food processing, and packaging.
30. Biochemistry Molecular Biology - Biochemistry is the study of the chemical processes and substances that occur within living organisms. Molecular biology is the study of the structure and function of biological molecules such as DNA and proteins. Biochemistry and molecular biology are closely related fields that are used to study the biological processes involved in agriculture, food production, and human health.
31. Microbiology - Microbiology is the study of microorganisms such as bacteria, viruses, fungi, and parasites. It is an important field in agriculture and food production as microorganisms play a vital role in food safety, fermentation, and soil health.
32. Pharmacology Pharmacy - Pharmacology is the study of drugs and their effects on living organisms. It involves the development and testing of new drugs, as well as the study of drug interactions and toxicology. Pharmacy is the science and practice of preparing and dispensing medications. Pharmacology and pharmacy are important fields in the development and distribution of drugs for human and animal health.
33. Spectroscopy - Spectroscopy is the study of the interaction of electromagnetic radiation with matter. It is used in agriculture and food production to analyze the chemical composition of samples, such as soil, crops, and food products.
34. Mycology - Mycology is the study of fungi and their role in ecology, agriculture, and medicine. Fungi are important organisms in agriculture and food production as they are used in fermentation, production of enzymes, and in the control of plant diseases.
35. Entomology - Entomology is the study of insects and their interactions with other organisms, including their role in agriculture, ecology, and disease transmission. Insects play an important

role in pollination, pest control, and food production.

36. Neurosciences Neurology - The study of the nervous system and its structure, function, and disorders. This field includes research on the brain, spinal cord, and peripheral nervous system.
37. Behavioral Sciences - Behavioral sciences are the scientific study of human and animal behavior. In agriculture and food production, behavioral sciences are used to study the behavior of animals, such as cows and chickens, to improve their health and productivity.
38. Physiology - The study of the normal functions of living organisms and their parts. This field encompasses research on the functions of cells, tissues, organs, and organ systems.
39. Immunology - The study of the immune system and its response to infectious agents, cancer, and other diseases. This field includes research on the biology of immune cells and their interactions with pathogens and other cells in the body.
40. Environmental Sciences Ecology - The study of the relationships between living organisms and their physical and biological environments. This field encompasses research on topics such as biodiversity, conservation, and ecosystem dynamics.
41. Plant Sciences - The study of plant biology, including the structure, growth, and reproduction of plants, as well as their interactions with the environment.
42. Public Environmental Occupational Health - The study of the impact of environmental factors on public health, including the effects of pollution, hazardous substances, and occupational exposures. This field includes research on the prevention and control of environmental health hazards.

By 2050 Ag Tech startups have chosen a specific Vision and AI Solutions to enhance productivity and achieve the target of maintaining food amount. Ag Tech Startupslike sky squirrel technologies, imaging of ceres and river blue use computer-assisted visual imagery technology in the form of spectral picture analysis, image capture by robots and drones.

Data of sensor can be a valuable aid in Farm-based experiments like Sen crop, centaur analysis and sponsor technologies use multicenter data for sensing anomalies in the crop productivity and deformity in product supply. Same method has been used by beginners like smart agriculture for sustainable food supply and better productivity, Benson hill Biosystems, agrilyst , trace genomics, agreeable, agrible, my ag data, Cuba, using innovations like plant data analytics and when it comes in term of animal raising and future generations farms for the greenhouse surroundings manipulate guided environment with the clever irrigation like ales a life, brilliant farms, farm note, modern animal diagnostics, crops aqua spy, hydro point data systems are using machine learning and computer recognition technologies for analysis, recording and anticipate the elements which can enhance productivity. Ag Tech Startups making use computer and AI.

In this comparative analysis P. Shah worked on robotics, drones Ceres imaging to identify nutrient deficiencies, establish management zones, enable variable rate applications, and water stress imaging. A. Gertisis worked on robotics drones sky squirrel technologies for the Crop health assessment using drone imagery and thistechnique applied on nova crop. E Waltz worked on robotics, drones, blue river which is based on AI They worked on Herbicide resistant weed control Robotic vehicle and cloud analytics for upgraded yields and these techniques are based on Data Collective, Innovation, and endeavors (Waltz, 2017). A. Guptill worked on sensors (AI) Centaur analytics by Using sensors to monitor each crop and reduce unnecessary usage of chemicals (Μπέλτσος, 2017) .

Caplan worked on Sensors (AI) Technologies by using Smart sensors for weed detection, estimation of great pests by using impending Modifications (Caplan et al., 2014) . B. Foubert worked on sen crop by Employing sensors such as wind gauge, rain gauge to precise and efficient prediction. The Sencrop weather stations require a global network that is universally accessible to assist farmers from anywhere on the planet. However, the coverage provided by Sigfox is inadequate for the purpose. Sigfox is only capable of handling a limited amount of regular monitoring data and is not equipped to support a complete firmware upgrade. Sencrop is a company that produces and markets weather stations that collect data autonomously. The purpose of these stations was to assist farmers in accurately predicting the weather, such as the risk of frost, and to make informed decisions during the crop cycle, including determining the required amount of water and fertilizer. The weather stations gather precise, parcel-specific weather-related data, such as temperature, humidity, pluviometry, and wind speed. (Foubert & Mitton, 2019) . Fraser uses Precision Agriculture and Predictive Analysis (Computer Vision) by using Wadsworth, easily Investments. Precision agriculture is a farming management approach that is focused on watching, measuring, and responding to crop inter- and intra-field variability. Precision farming is a method of increasing average yields by using exact amounts of inputs in comparison to traditional gardening approaches (Fraser, 2019) . N. N. Prescott worked on Precision Agriculture and Predictive Analysis (Computer Vision), forecasting harvest times and guiding planting cycles using data-driven systems to achieve high yields (Prescott, 2016). A. K Khulemann focused on precision agriculture and predictive analysis (computer vision) by utilizing data systems to assist producers in locating value in the supply chain and developing proprietary crop designs that can assist growers in streamlining operations. D. Knowler worked on plant data analysis (computervision) by using Machine learning is being used to learn information from agricultural soil. Vision Automations are completely described in Table 2.

The metadata summarizes basic information about data, making working and finding with instances to make data easier. It can be produced manually to be more efficient, or automatically and it consists of the more basic information (Knowler & Bradshaw, 2007). H. D Priest worked on plant data and analysis (computer vision) by using plant biology, cloud computing and big data analytics through predictive learning engine for the superior crops (Priest et al., 2014).

D.H. Sloane worked on smart irrigation (Computer vision) and aqua spy by Tracking crop behavior of both water and nutrients through profiling modeled using predicted parameters of soil moisture. In the beginning they collected data on the soil moisture levels in the field over time, as well as on the nutrient levels present in the soil. They have gathered data using a variety of techniques, such as soil sampling, remote sensing, or on-farm sensors. After the collection they have used to build a predictive model that takes into account the various factors affecting crop growth and nutrient uptake. Which shows that how different changes in soil moisture levels and nutrient availability will affect crop growth over time and this model was based on a number of factors, including soil type, climate conditions, and the specific crop being grown. Soil moisture is frequently forecasted using data from nearby weather stations and soil and crop factors using one of three methods: empirical, regression, and machine learning. (*AquaSpy - A Revolutionary New Soil Moisture Sensor*, n.d.).

There are various methods that are being used for forecasting soil moisture levels. Some examples include physical-based models that simulate the movement of water through soil layers and evapotranspiration, empirical models that rely on statistical relationships between past weather conditions and soil moisture, remote sensing techniques that use satellite or airborne sensors to indirectly measure soil moisture, machine learning algorithms that can predict soil moisture levels based on input data such as soil characteristics, climate data, and vegetation indices, and on-farm soil moisture sensors that provide real-time data to

Table 2: AgTech startups using computer vision and AI and automations: precision agriculture, drones, plant analysis, smart irrigation, robotics, sensors

Technological components	Organization	Founded	Use-cases	Shareholders
Robotics, Drones	Ceres Imaging	P. Shah [44] Established in 2014, California,USA	Find shortage in nutrients, set up. Management areas, allow applications of variable rate and image of water pressure.	Imagine H20, Lemnos Labs, Silicon Bada
Robots, Drones AI(Automations)	Sky Squirrel	A. Gertisis [45] Established in 2015,Halifax, Canada	To detect plants health with the help of drone imaging	In NOVA Crop
Robotics, Drones	Blue River	E Waltz [46]	Herbicide resistant weed control Robotic	Data Collective,
(AI) Technology		Established in 2017 Sunnyvale, CA, USA	Automobile and cloud analytics for progressed yields	Innovation Endeavors
Sensors (AI)	Centaur Analytics	A. Guptill [47] Established in 2017, Los Angeles, USA	Using sensors to see each plant and limit the use of unneeded chemical	Our Crowd, PJ Tech Catalyst
Sensors (AI)	Sensa Technologies	S. Caplan[48] Established in 2014, Great Lakes, USA	Intelligent sensors for weed detection, prediction upcoming of pests	Innovations
Sensors (AI)	Sen crop	B. Foubert [49] Established in 2019, Lille, France	Employing sensors like wind gauge, rain gauge to accurate and systematic estimation	Brega Capital, Enertech Gestion
Precision Agriculture and Predictive Analysis (CV)	My Ag Data	A. Fraser [50] Established in 2017, Great Lakes, USA	Using accurate agricultural data development tactics to bridge the gap between data collected and used by farmers, crop insurance firms	Adams Street Partners, Alpha Capital Partners, Don Wadsworth, Early Investments
Precision Agriculture and Predictive Analysis (CV)	Agrilyst	N. N Prescott [51] Established in 2016, Brooklyn, New York, USA	Harvest forecasting and guided planting cycles Using data-driven systems that result in high yields	Brooklyn Bridge Ventures, Metamorphic Ventures
Precision Agriculture and Predictive Analysis (CV)	Agrible	A.K Khuleman [52] Established in 2017, Great Lakes, USA	Uses data systems to assist producers in locating value in the supply chain and developing proprietary crop models to assist growers in streamlining operations.	Archer Daniels Midland Company, Flyover Capital, Serra Ventures
Data of Analysis (CV)	Trace Genomics	D. Knowler [53]	Machine Learning is used to learn metadata Illumina Ventures, from the farm soil	Fall Line Capital

optimize irrigation and fertilizer applications.

C.D. Hergert worked on smart irrigation (computer vision) and hydro points data system. They worked on leaked detection, smart irrigation solutions and technology. The hydro power data system does site

inspections, irrigation system efficiency audits, leak detection, weather analytics, installation or upgrading of existing systems, and continuing maintenance and training are all available through it. Gonçalves, J. L. Worked on Animal Data (Computer Vision) and enhanced animal diagnostics by utilizing precise animal care and on-site illness diagnosis via machine vision and pattern analysis. AAD develops and commercializes diagnostics for diagnosing and controlling disease conditions, reproductive, nutritional, and general health status of producing animals. (Gonçalves et al., 2017)

4. Conclusion and Future Directions

This review paper describes the technologies like artificial intelligence and computer vision in the branch of food and agriculture industry. Mainly the current review gives a complete knowledge of intelligence and computer vision technologies which manages many agricultural applications like data of plant analysis, agriculture-based applications, next generation farming, smart spraying, and food processing. More ever this paper focuses on the underlying plan of employing sustainable for industrial revolution technologies through which mankind can attain the essential foodsupply by 2050 in a user-friendly manner. The significance of the Agri Tech Industry, as well as financing based on Vision and AI automations, was explained with suitable sources and application examples. Startups based on AI and computer vision applied in the food and agriculture industries have been thoroughly analyzed and discussed in terms of many uses. Behind agriculture-based startups and food industry this paper describes a few other startups like animal data and next generation farms. With respect to the agriculture and food sector this paper provides a single window path for interdisciplinary material integrating Vision and AI strategies.

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Foundation University Journal of Engineering and Applied Sciences
Vol. 3, Issue 2, 2022.
DOI: 10.33897/fujeas.v3i2.691

Research Article

Country Level Social Aggression Using Computational Modelling

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Abstract:

Computational Modelling is emerging field to model the cognitive as well as social interactions between individual and society. Aggression is social evil which is instance response and its impact last for long time. Different societies have different norms and values based on ecological, environmental and cultural attributes so aggression level also varies among individuals and societies. Aggressive behavior is based on different factors, racism, hate violence self-control and education are the main factors. Racism is the idea that certain human groups have hereditary characteristics that correspond to particular behavioral features, and that these groupings can be split according to the superiority of one race over another. Current study is based on psychological and temporal aggressive behavior different individuals and societies in same habitat. In this paper we have proposed a frame work to model human social and psychological behaviors. Results are based on simulation which are according to our assumptions.

Keywords: Aggression; Tolerance; Hate; Violence; Racism

1. Introduction

Aggression is often harmful, social interaction with the intention of inflicting damage or other unpleasantness upon another individual or group (Anderson & Bushman, 2002). Human aggression is instant behavior to harm other individual where culprit suspect that behavior will harm the target, in response to which target will avoid (Anderson & Bushman, 2002; Berkowitz & emotion, 1993; Geen, 2001; Zak, Kurzban, & Matzner, 2004). Aggression is social as well as individual behavior which is composed of sequence of behavior, inflicting harm, escalation desecration (Andersson & Pearson, 1999). Findings of social learning theory about Aggression is that it is acquired by observations as well as direct experience by observational learning processes as other social behavior (Bandura & Walters, 1977; Greene & Abuse, 2005).

In many countries ethnically or culturally diverse population groups have lived and worked together peacefully for centuries. In others permanent conflict persist, often ending up in bloody civil wars. Often a seemingly insignificant incident escalates out of all proportion into armed conflict costing thousands of lives that must finally be stopped by external forces (Mischel, Shoda, & research, 1999). We are dealing with dynamic processes that can either amplify into dangerous conflict following an initial perturbation, or calmly settle down to some equilibrium state tolerated by sides.

There are many factors and processes that play a role in such aggression dynamics such as strengthens of another culture, the tolerance of people involved, the hate which gradually buildup, the inhibition threshold controlling actions harmful to others. These factors and processes interact and can set in motion an ominous dynamic but we can neither accurately describe the sequence of events nor reliably predict their outcome (Van Lange, Rinderu, Bushman, & sciences, 2017). These are the fundamental reasons for this:

- Important quantities for such dynamic developments like hate or tolerance can only be described

in terms of qualitative and subjective terms and cannot be measured in terms of quantification and are only indirectly measurable

- Relationships between factors and processes are vaguely identifiable and cannot be uniquely identified

Despite these reservations we can connect generally accepted concepts in logically correct manner quantify these approximations and use the computer model to compute possible developments. Simulation results depict that proposed model generate corresponding results.

2. Overall System Model

There are two major entities cognitive process of one entity depends on other entity and vice versa. Figure 1 illustrates over structure of all process.

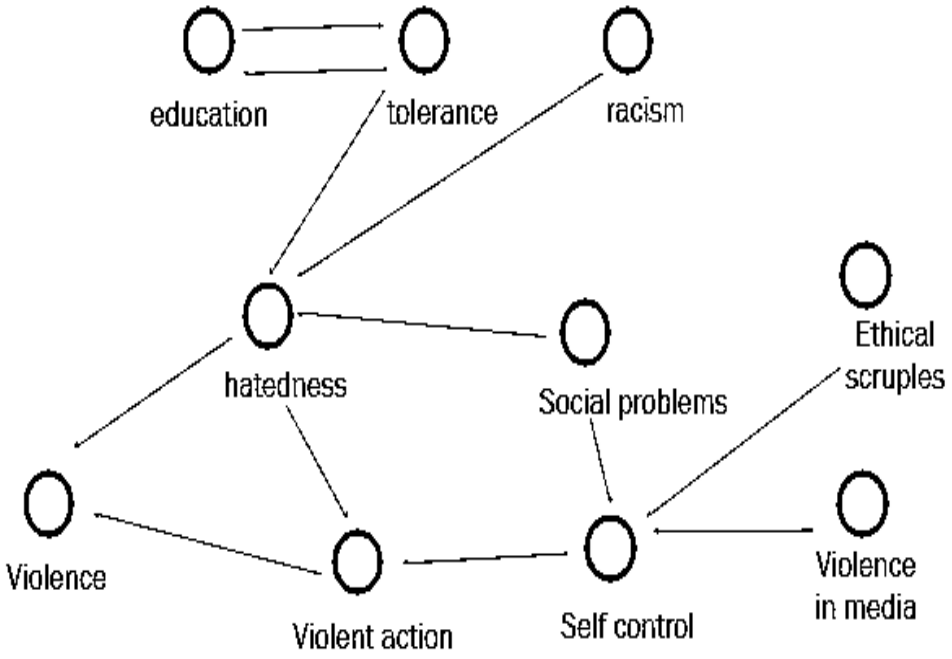

Figure 1: Overall structure of process

3. Proposed Model

The proposed model is shown in Figure 2. The details are provided in the following sections.

4. Analysis of Main Concepts

The model uses and connects four state variables tolerance, racism, hate and self-control.

4.1 Tolerance

Tolerance is the ability or willingness to tolerate the existence of opinions or behavior that one dislikes or

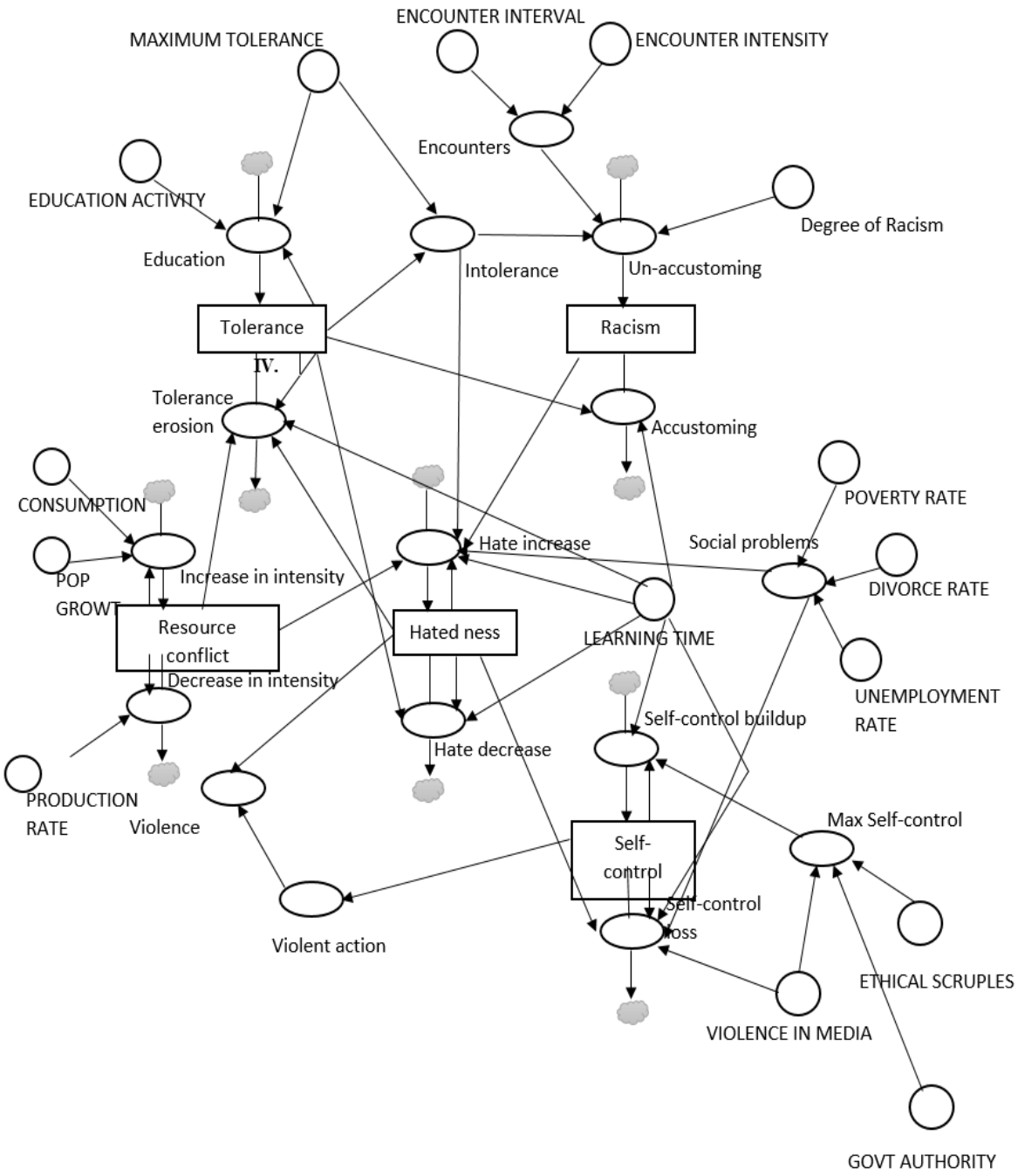

Figure 2: Proposed model

disagrees with. It is an essential aspect of living an ethical life. It is the wish to solve problems in the most ethical way, respecting the fundamental rights of all people. It's relatively easy to be tolerant of others' actions that don't affect other people.

4.2 Education

One of the fundamental roles that education plays is to increase tolerance which, in turn, underpins democracy and strengthens the bonds that hold peaceful communities and societies together.

4.3 Tolerance Erosion

Tolerance erosion refers to those factors which contribute to disintegrate tolerance from society and increase the feelings of discontentment among people or society.

4.4 Hate

Hate is a deep and extreme emotional dislike, especially invoking feelings of anger or resentment. It can be directed against individuals, groups, entities, objects, behaviors, or ideas. Hatred is often associated with feelings of anger, disgust and a disposition towards hostility. Hat is cause of aggression in which individual intent to harm target but it also serves instrumental functions for culprits (Cohen & psychology, 1998) Some causes of hate and violence are guns (O'Donnell, 1995), human activities e.g. global warming, child violence (Anderson, Bushman, Groom, & psychology, 1997).

4.5 Racism

Racism is presence of superior behavior and discrimination of one race over another. which often results in prejudice towards people based on their race or ethnicity (Hyman & Psychology, 1995). The term "racism" has been defined in a variety of ways by scholars working in a variety of fields of stud y. Racism, in general, is the idea that some races of people are naturally superior to others, and it frequent ly entails prejudice or discrimination based on race or ethnicity.
Racism is described by MerriamWebster as "belief that some races of humans are superior to others by bir th and nature". Racism is defined more specifically by Britannica as "the view that some races are fundam entally superior to others; that there is a causal relationship between inherited physical traits and attributes of personality, intellect, morality, and other cultural and behavioral features".

4.6 Self-control

It makes the people increase their self-control and decrease their feelings of hate or discontent towards the society or other individuals or groups .Self-control and aggression are interdependent, it is observed that aggression starts when self-control stops, forgiveness is key to enhance self-control and reduce aggression (Lentin, 2004).

4.7 Relationship Between Identified Concepts

The temporal relationships between identified concepts are as follow: Hated-ness is affected the amount of tolerance and racism. The racism is affected by unfamiliar experiences. The tolerance is affected by the education activity in a country. Self-control in a person is affected by the violence in media and ethnical scruples. Violence is affected by the amount of hateness and violent actions.

5. Concept Formalization

- Hate
- Tolerance
- Self-control
- Violence in media
- Ethical scruples
- Social problems

- Racism
- Intolerance
- Violent actions
- Education

Table 1: Concept formalization

Concept	***Formalization***
Educational Activities	$\text{Educational}_{\text{Activity}}$
Maximum Rate of Tolerance	$\text{Max}_{\text{Tolerance}}$
Hated ness	Hate
Tolerance	Tolerance
Racism	Racism
Self-control	$\text{Self}_{\text{Control}}$
Violence	Violence
Violence in media	$\text{Violence}_{\text{In.Media}}$
Erosion of tolerance	$\text{Tolerence}_{\text{Erosion}}$

5.1 Formalization of Concepts

$$Education = Educational_{Activity} \times Tolerance(t) \times \left(\frac{1 - Tolernce\ (t)}{Max_{Tolerance}}\right) \quad (1)$$

$$Tolerance_{Erosion} = \frac{Tolerance(t) \times Hate(t)}{Learning_{Time}} \quad (2)$$

$$Tolerance(t + \Delta t) = Tolerance\ (t) + \left(Education_{Tolerence_{Erosion}}\right) \times \Delta t \quad (3)$$

$$Intolerance = Max_{Tolerance} - Tolerance(t) \quad (4)$$

$$Unaccustoming = Intolerance \times degree_{of_{Racism}} \times Encounter_{Interval} \times Encounter_{intensity} \times Racism\ (t) \quad (5)$$

$$Accousting = \frac{Racism\ (t) \times Tolerance(t)}{Learning_{Time}} \quad (6)$$

$$Racism(t + \Delta t) = Racism(t) + (Unaccusstoming - Accousting\ ) \times \Delta t \quad (7)$$

$$Social_{Problems} = Unemployment_{Rate} \times Poverty_{Rate} \times Divorce_{rate} \quad (8)$$

$$Hate_{Increase} = \frac{Racism\ (t) \times Intolerence \times Social_{Problems} \times Hate(t) \times \left(\frac{Hate(t)}{Max_{Hate}}\right)}{Learning_{Time}} \quad (9)$$

$$Hate_{Decrease} = Hate(t) \times \left(\frac{Tolerance(t)}{Learning_{Time}}\right) \quad (10)$$

$$Hate(t + \Delta t) = Hate(t) + (Hate_{Increase} - Hate_{Decrese}) \times \Delta t \quad (11)$$

$$Max_{Self control} = Govt_{Authority} \times \left(1 - Violence_{in_{Media}}\right) + Ethical_{Scruples} \quad (12)$$

$$SelfControl_{Buildup} = \frac{Max_{Self control} \times Self_{COntrol}(t) \times \left(\frac{1 - Self_{Control}(t)}{Max_{Self_{Control}}}\right)}{Learning_{Time}} \quad (13)$$

$$Self_{control_{Loss}} = \frac{Hate(t) \times Social_{Problems} \times Violence_{in_{Media}} \times Self_{Control}(t)}{Learning_{Time}} \quad (14)$$

$$Self_{Control}\ (t + \Delta t) = Self_{Control}(t) + \left(Self_{Control_{Buildup}} - Self_{Control_{Loss}}\right) \times \Delta t \quad (15)$$

$$Violent_{Action} = 0\ if\ (Hate - Self_{Control}(t) < 0\ \ 1\ else \quad (16)$$

$$Violence(t + \Delta t) = Violent_{Action} \times Hate(t) \quad (17)$$

5.2 Formalizing the Relationships

The temporal relationships can be formalized in the following manner. Here the time t is taken in months.

Education_Activity	=	0.5;
Max_Tolerance	=	1;
Encounter_interval	=	2;
Encounter_Intensity	=	5;
Degree_of_Racism	=	0.5;
Unemployment_Rate	=	2.5;
Poverty_Rate	=	2;
Divorce_Rate	=	0.75;
Govt_Authority	=	0.6;
Ethical_Scruples	=	0.1;
Poverty_Rate	=	2;
Violence_In_Media	=	0.4;
Learning_Time	=	5;
Tolerance(1)	=	0.5;
Racism(0)	=	0.1;
Hate(0)	=	0.1;

Self_Control(0) = 0.5;
Violence(0) = 0.5;

If educational activities are zero the violence shows a linear increasing trend. Educational activities and violence are inversely proportional to each other. Intolerance increases the rate of hated-ness. When amount of hate is greater than the self-control, violent actions show a linear increasing trend. When amount of hate is less than the self-control, violent actions show a linear decreasing trend. Violence in media decreases the rate of self-control buildup.

6. Simulation Results

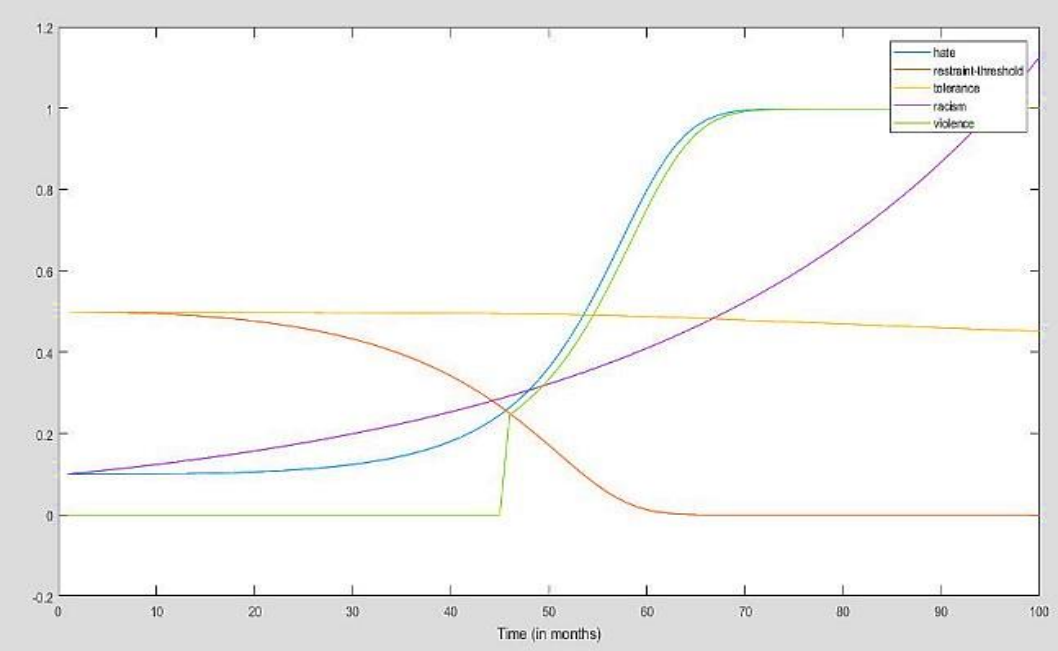

Figure 2: Aggression procedure

Figure 2 depicts temporal behavior of violence, hate, racism and tolerance. It is obvious that hate and violence increases as there is racism less tolerance. As tolerance depends on previous behavior of community, hate of people and learning time so multiple factors e.g., Racism, intolerance, social problems collectively decrease tolerance level and generate minimum threshold which results aggression.

Figure 3 shows that aggression between individuals and society decreases and remain minimum when there is reasonable increase in tolerance. Following figure depicts the temporal behavior of our proposed model.

Simulation results in Figure 4 depict temporal Behavior and monotonically decreasing relation between self-control and hate. There is maximum limit of hate when there is very less or minimum self-control present, when self-control increases hate become minimum.

Figure 5 shows that Racism and Hate are directly proportional to each other. When there is no Racism hate is not present at all. When we feel racism and racism increases ultimately hate will increases.

Figure: 6 depicts the behavior of self-control on violence both are reciprocal to each other. Violence is much aggressive than hate, it decreases when there is self-control and remain minimum when self-control increase at specific point.

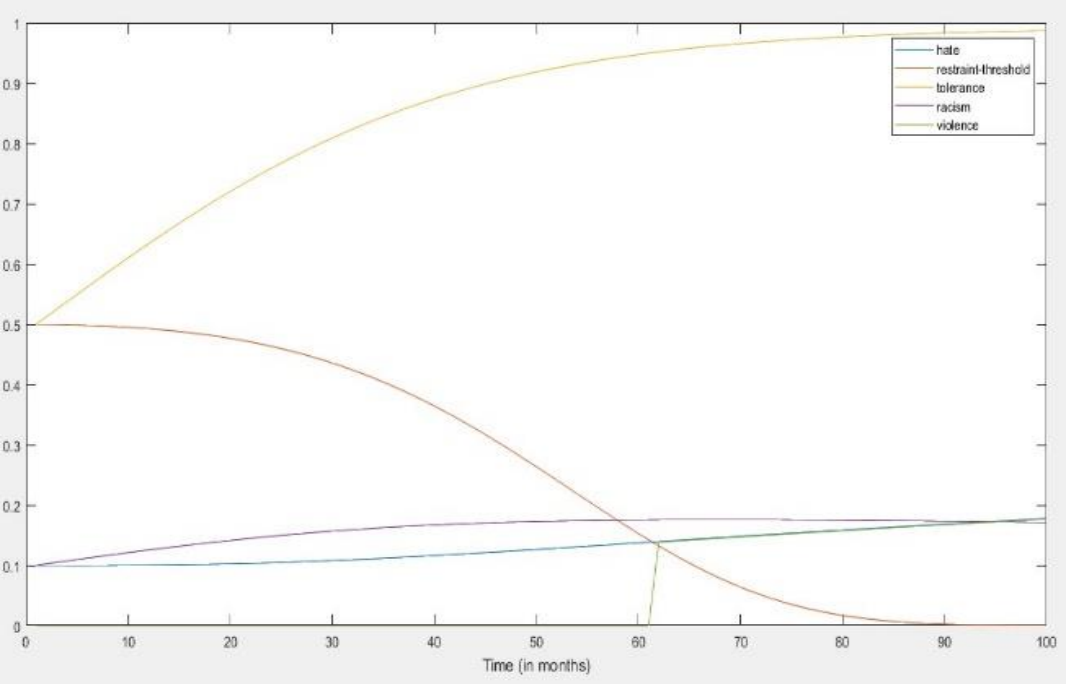

Figure 3: Decline of violence and hate

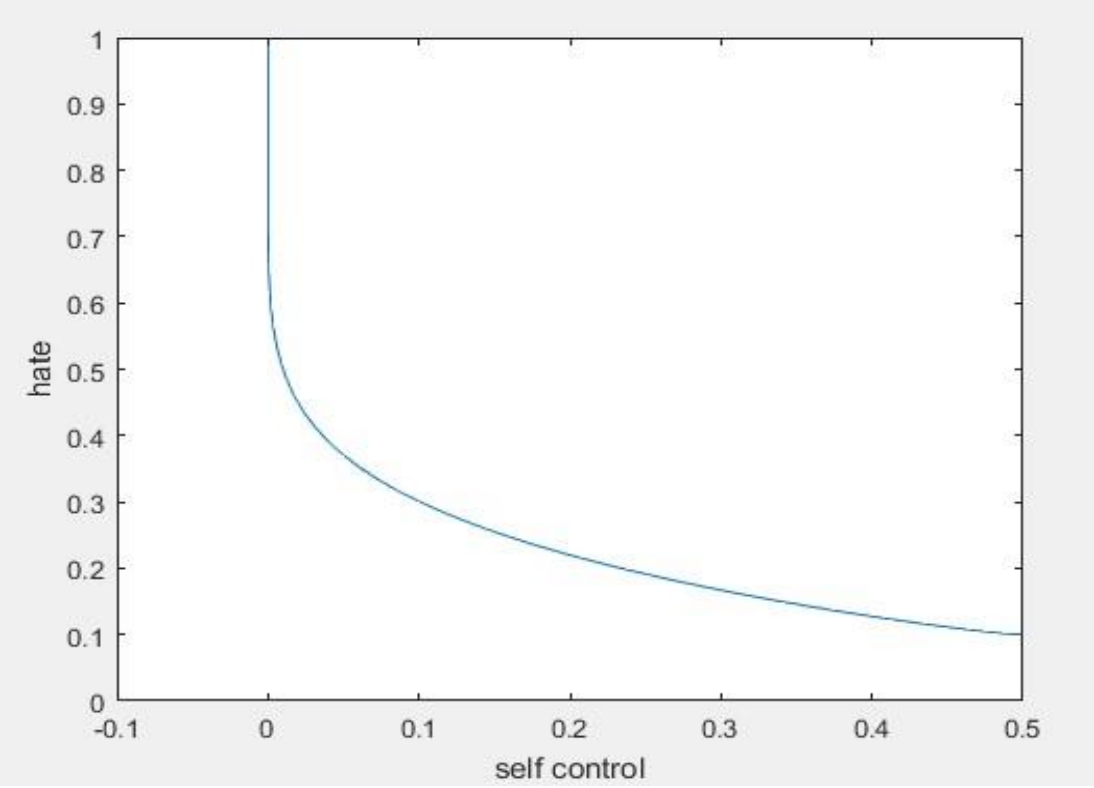

Figure 4: Relation between hate and self-control

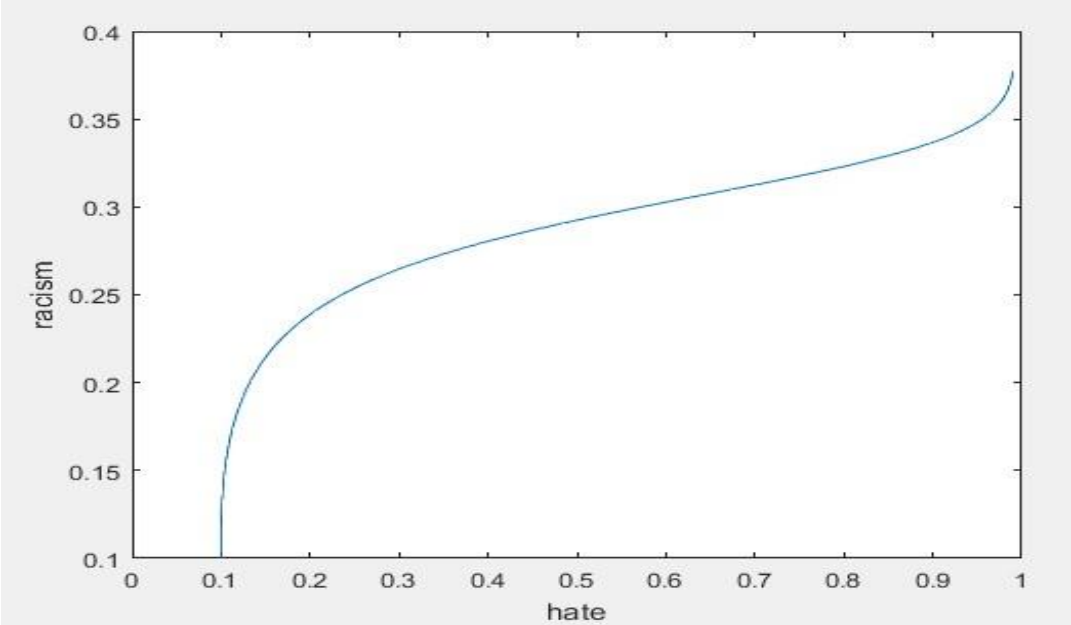

Figure 5: Racism verses hate

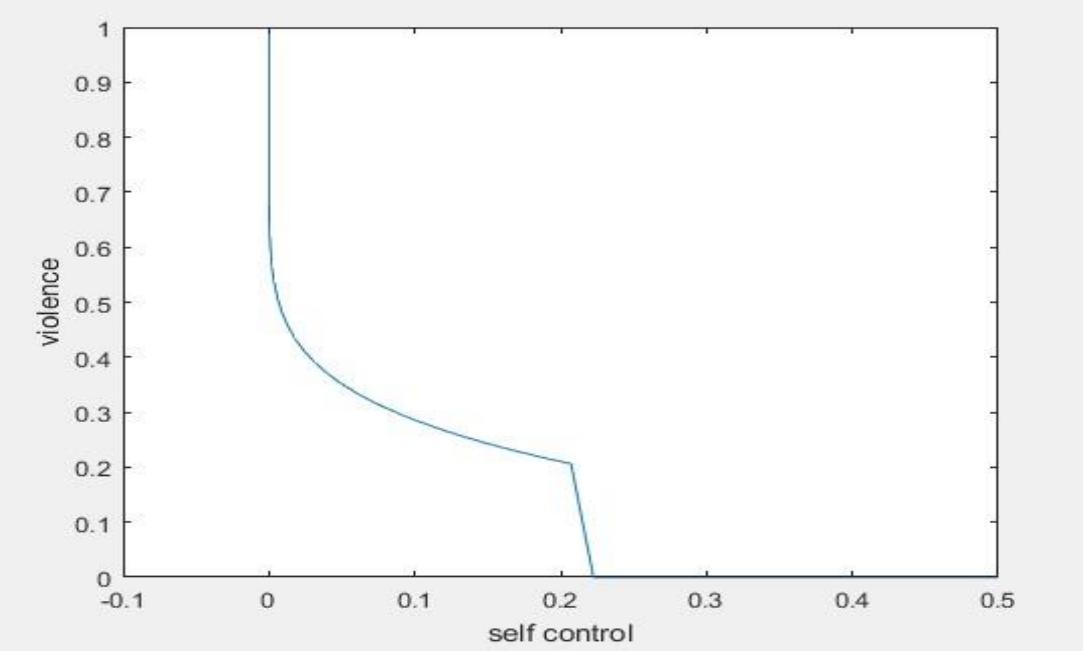

Figure 6: Effect of self-control on violence

- Assumptions behind the model:
- The time stamps of 0.01 month are taken.
- Rate of educational activities are considered content.
- Violent activity value will be either 0 or 1.
- Value of maximum tolerance is 1.

7. Discussion and Conclusion

Aggression at a habitat using computational modelling was presented in this article. Aggressive behavior depends on social, psychological and cognitive behavior of societies. Racial discrimination is described by the American Psychological Association (APA), as "a form of prejudice that argues that the members of racial categories have distinctive traits and that these differences result in some racial groupings being inferior to others".

Racism can also take the form of a system that structures opportunities and assigns value based on race, unfairly favoring some people and communities while unfairly disadvantaging others. In conclusion, racism refers to a wide range of ideas, attitudes, and actions that are motivated by the idea that some races are fundamentally superior to others. It can appear as bias, discrimination, or prejudice and have detrimental effects on both individuals and communities.

Aggression in educational activities can have various underlying causes and consequences. One factor that contributes to aggression in educational settings is violence against educators and school personnel, which has been identified as a global epidemic affecting Pre-K through 12 grades (Miles, 2004). Additionally, school-based aggression and violence are major concerns that require a comprehensive framework for understanding and responding to them, including implementing evidence-based programs and strategies to reduce violence (Greene & Abuse, 2005). In terms of individual factors that contribute to aggression, research has found that exposure to media violence, such as through television, can increase aggressive behavior in both males and females and can have long-term effects, as early childhood exposure to TV violence has been found to predict aggressive behavior in adulthood. However, there is debate surrounding the link between violent video games and aggression, with some studies finding a connection and others finding little to no connection.

Individual factors, such as genetic, neural, and biochemical influences, can also contribute to aggression, with the amygdala being one area of the brain that can be stimulated to increase rage in animals. Additionally, self-control is a key factor in reducing aggression and violence, as individuals with lower self-control are more likely to engage in violent behavior. Finally, the erosion of tolerance can contribute to aggression and violence in communities, with violence limiting business growth and prosperity, straining education, justice, and medical systems, and slowing community progress. America's youth and young adults are particularly vulnerable to community violence, which can further exacerbate the erosion of tolerance.

Relational or social aggression, such as gossip, social exclusion, or spreading rumors, can also contribute to the erosion of tolerance and social standing within peer groups. In conclusion, aggression in educational activities is a complex issue that can be influenced by individual factors, societal factors, and exposure to violence in various forms. Addressing these factors through evidence-based programs, strategies to reduce violence, and promoting self-control and tolerance can help reduce aggression and violence in educational settings and communities. Simulation results depicts that aggressive behavior of individuals become moderate with the passage of time.

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Foundation University Journal of Engineering and Applied Sciences
Vol. 3, Issue 2, 2022.
DOI: 10.33897/fujeas.v3i2.690

Research Article

Behavioral Authentication for Smartphones backed by "Something you Process"

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Abstract:

Authentication of smartphone devices has been never so important nowadays. Machine learning techniques are not far behind to touch the new milestones of the latest and ever updating world. However, totally depending on machine learning will give you the scenarios of false user being accepted as true one and a true user being rejected as the false one, which can be devastating in some cases. Fifth factor of authentication "Something You Process" eradicates most of the cases of the false acceptance and false rejection, if used with the mentioned techniques. The novel approach applied here is the fifth factor combined with machine learning system and Behavioral authentication. The fifth factor is anti-shoulder surfing since the arithmetic operation is hidden by hand placed on the screen. After placing hand on the screen in such a way that it hides the code from others, the system shows the arithmetic operation and the processed calculation is performed in user's mind. The pattern which is shown to the user is public, but machine learns the touch dynamics of the user along with his different postures including lying posture. The focus has been on the aspect of something that can be another layer or line of defense which can save the user's authentication process. It results in decrement of false acceptance or false rejection upon unlocking of a smartphone device. This study deals with the postures of standing, sitting, and lying. The data is collected and the features are extracted in all of these positions.

Keywords: Machine learning; Behavioral authentication; Smartphone devices; Smartphones; Pattern lock; Something you process; Shoulder surfing

1. Introduction

Human living standards have totally changed with the gadgets around them, amongst which the most impactful and life changing gadget is the smartphone. It has literally brought the whole world in our hand. The range of usage of smartphone is crossing the limits in all of the aspects of life. This importance also gives it a very huge responsibility of being safe and secure. The secure authentication of a mobile phone should be of the utmost value and strength which can pass the test of time from all types of threats and attacks. Nowadays various authentication methodologies are used by the smartphone users throughout the world which include passwords, PIN, biometrics and patterns. Every technique has its own advantages and disadvantages Bier, A, et al., (2017). Pattern techniques are very widely used in the smartphone users of different platforms.

Jose, T, et al., (2019) These techniques have been used and proposed since quite some time such as PassGo Tao, et al., (2008) and Graphical Password Design and Analysis Jermyn, A, et al., (1999) where the user registers and draws the graphical password for registration and authentication respectively. Any biometric-based authorization platform's core attribute is that the calculated qualities must be sufficiently unique to each person. Higher precision is associated with greater individuality or uniqueness. Morphological

attributes are thought to be more identifiable for both validation and recognition, while behavior patterns are only thought to be completely different for verification Yampolskiy, R, et al., (2008).

Studies have shown that the smartphones users opt for using pattern rather than other techniques of authentication like PIN, passwords or other biometrics for unlocking their cellphones Andriotis, G, et al., (2016), Ye, G, et al., (2017). Biometric techniques are also becoming popular and its usage is getting more and more but still patterns are widely used and they are also used as the backup of the biometric authentication. User who is using the biometric technique has to register a pattern as well, in case of too many invalid entries of the biometric authentication. The percentage of pattern authentication users for unlocking smartphones is about 40% Van, B, et al., (2014). In short, the pattern lock is one of the most widely used methods for unlocking smartphones.

According to daily life observations and studies performed on the security analysis of the pattern lock, it is quite clear that these techniques are rather vulnerable to attacks like shoulder surfing and other different sorts. This has been one of the oldest problems in the human performed authentication that users tend to make a simpler pattern or password which is easy to remember but liable to be cracked, guessed or shoulder surfed. In terms of pattern lock, user mostly opts for a simpler pattern Ullenbeck, S, et al., (2013), Cha, S, et al., (2017) and leaves the patterns lines enabled for the shoulder surfer to easily see and know it in the first go.

In the different choices and procedures of authentication one of the emerging techniques is of Behavioral Authentication which is based on the behavior of the user. This technique has been strengthened with the upgrade of machine learning. The machine learns through the behavioral biometrics such as touch sensor dynamics and gait etc. Different machine learning categories are shown in Figure 1. These biometric behaviors are measured by different sensors which are present in the

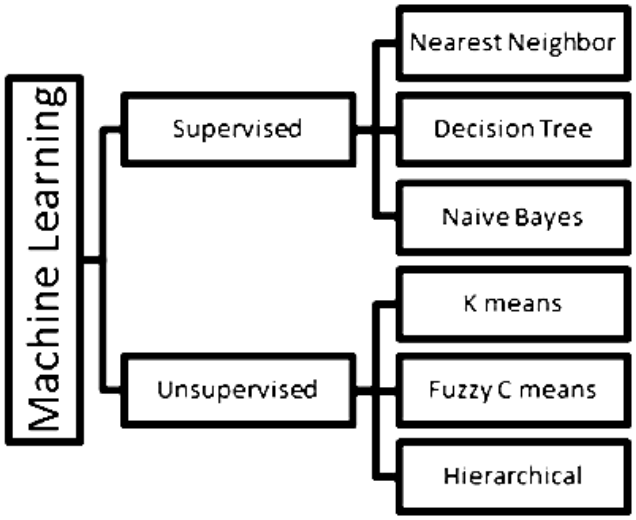

Figure 1: Machine learning categories

machine by default. Most of the time the touch dynamics which are recorded, need the user to draw a shape or a pattern on the screen of the smartphone. For the authentication to be accurate through behavior depends on the gesticulations and not all of them are suitable for authentication to be accurate for the legal user Song, Y, et al., (2015). The combination of behavior authentication with pattern has been an improvement in the aspect of security but along with the peak attack and other different attacks there is quite room for improvement. Along with the threats there has been another aspect which needs to be addressed which is the False Acceptance Rate and False Rejection Rate.

2. Background

There are millions of smartphones used all over the world and this number is increasing. Smartphones are not only used for just having calls or for messaging, but people are also carrying out their life activities like education, business, security, defense, awareness, socio political life, health etc. through them. It's obvious that there would be large amount of data of utmost importance which is to be secured through a strong authentication process. The machine-learning-based intelligent authentication approaches features in the multi-dimensional domain for achieving cost-effective, more reliable, and situation-aware device validation He, Fang, et al.

There are constant and real threats towards the authentication and unlocking of smartphones. These threats include Shoulder surfing attack, Phishing attack, Brute force attack, Guessing attack. Shoulder surfing is a type of attack where an adversary attempts to obtain sensitive information, such as passwords or PINs, by watching the victim enter it on their device. To perform shoulder surfing on a mobile device, an adversary may take the following steps:

1. Identify a potential target: The adversary may look for someone using their mobile device in a public place, such as a coffee shop or on public transportation.
2. Position themselves strategically: The adversary may position themselves behind or beside the target to get a clear view of the device screen while it is in use.
3. Observe the target's actions: The adversary may watch as the target enters sensitive information, such as a password or PIN.
4. Record the information: The adversary may use a camera or simply remember the information they observed to use later to access the device or sensitive information.

Behavioral Authentication is the technique which grants authentication through constant measure of behavior at the back of the biometric authentication system which will again put the burden on password or pattern system Aviv, J, et al., (2017), Khan, H, et al., (2018), Oakley, J, et al., (2018).

Biometric authentication involves analyzing physical or behavioral characteristics unique to an individual, such as their fingerprints, face, voice, or even their touch dynamics. For touch-based authentication, the system may capture data on how a user interacts with their device's touch screen, such as the pressure applied, the angle of touch, the duration of contact, and the frequency of taps. This data can then be used to create a unique profile for the user, which can be compared against future interactions to verify their identity.

2.1 Smartphone Pattern Lock

It is a graphical representation made by the user on the screen of the phone which makes a pattern by joining different points. Studies have shown that pattern is relatively more used than PIN or password Andriotis, G, et al., (2016), Ye, G, et al., (2017). Mostly it is a 3x3 setup resembling to the numbers from 1 to 9. A little bit more secure aspect of pattern is that if the user opts for the lines not to be shown. If it is shown, then the adversary can easily know the pattern by just giving a single peak. There are approximately close to 4 million possible patterns Aviv, J, et al., (2010), Cho, J, et al., (2017). Yeet al. (2018), which used an image processing algorithm to detect the fingertip activity on the video and is based on the security of android pattern lock. Zhou et al. (2018) converted sound waves as lock pattern using the defendant's device's speaker and microphone. Hong et al. (2015) presented a similar model which includes ten waving gestures for the process of authentication to be completed securely. The FAR and FRR of this system are 4% and 7% respectively.

Behavior Authentication – This mode of authentication relies upon the human behavior with the examples like touch dynamics, gait along with the postures and movement of the body. As smartphones have sensors present in them by default, so along with the touch screen this makes the behavior authentication practical.

2.2 Smartphone Authentication

The authentication mechanisms used commonly, have commonality of ease of use but can be compromised in threating scenario. Different types of authentication types are shown in Figure 2. PIN and passwords are notoriously set as weak which can be easily guessed, smudged or shoulder surfed. On the other hand, biometrics like fingerprint or face recognition are now regularly used but fingerprint

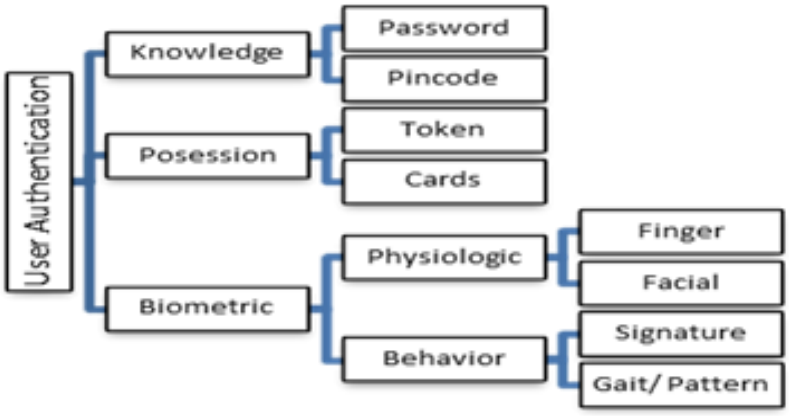

Figure 2: Type of authentications

recognition is unprotected against smudge attack Lee, H, et al., (2017). Face recognition gives problems with angles and lighting. There would always be another mode of authentication. The weaknesses shown in this mode of authentication are in terms of figure of the gesticulations Alpar, O, et al., (2017) and the False Acceptance and False Rejection cases. The proposed focuses on these grief weaknesses and aim to exterminate them by techniques like open pattern, operation hiding and something you process.

The valuable aspect of uniting behavioral authentication with pattern is to get rid of gesture problems, memorizing problems. While operation hiding with hand will prevent shoulder surfing and lastly something you process will provide the solution of any false acceptance or rejection case. Signatures and forms have been the better recognized movements, and signals were immune to shoulder surfing attacks, according to the research Yangt, Y, et al., (2016). It is also studied that smartphone users seem to visit certain locations at specific times on certain days in a week. It was also known that smartphone users are most likely to call or email a known number rather than an unfamiliar number, implying that the smartphone phones are in their hands Jakobsson, M, et al., (2009).

3. Hazard Model

The scenario is assumed where the adversary is in proximity presumably familiar or unfamiliar person. In both cases adversary can pose a threat. Non expert threat of shoulder surfing can be performed by naked eye while sitting near to the user or in the other case when authentication process is recorded. In such cases adversary procuring the mobile can easily lead to unlocking of it, as the pattern can be easily learned through abovementioned techniques.

The adversary is also well acquainted of the error rates while performing Behavioral authentication and knows that there would be chance of false acceptance so can keep on attacking. Such educated attempts not just only watch the pattern but in the recorded shoulder surfing attack, the behavior can also be impersonated. Applying the proposed system, such hazards can be easily avoided. An internet poll of 260 people was performed to help evaluate their authorization actions. They discovered that only 42.7 percent of participants activated authorization on their smartphones, and that 57 percent of those who could not install authorization stated discomfort as a justification who doesn't use a lock feature.

Moreover, 46.8% of those who locked the smartphone partially or fully admitted that activating them would be inconvenient Harbach, M, et al., (2014).

Another experiment was conducted with 28 individuals so to achieve a deeper understanding of users' behaviors and reactions regarding smartphone security. In order to substantiate their conclusions, they performed an online survey of 2,518 smartphone consumers to augment their individual studies. According to the findings of the poll, 42% of participants said they won't lock the devices. Furthermore, 33.6 percent of those who did not secure their phones did so due to the reason they thought it was uncomfortable Egelman, S, et al., (2014).

4. Related Work

Y. Sheng et al. (2005) used Decision Tree which is a method that uses pattern recognition and is a type of' Learning by Example' procedure. The algorithm used in this system was for the purpose of granting authentication to the users on the basis of keystroke patterns. This system can be implemented on mobile internet of thing devices. This system proposes that the only corresponding Decision Tree cannot be able to resolve the grant of authentication through keystroke patterns. They performed training with 43 users and allowed each user to type common combination of string having 37 characters. In results, their study attained 9.62 % FRR and 0.88% FAR.

A. Buriro et al. (2019)opted for a system of authentication named AnswerAuth in which the data was captured through the sensors of the smartphone which are already present in it. These sensors extract features from that data collected by the sensors. They tested their AnswerAuth system with compilation of data of more than 10,000 patterns. Amongst these patterns there were 120 extracted from each sensor from participants which were 85 in number. The procedures used for classification were 6 that are Bayes, Naïve Bayes, kNN, random forest, SVM and J48. The results gathered from these were Random Forest with the top scores in aspect of True Acceptance rate which was close to 100 percent.

L. Fridman et al. (2015) for continuous authentication through multi modal decision fusion proposed this system and used the classification of Naïve Bayes. As it is on the basis of Bayesian Theorem, this system came up with the FAR of 0.004 and FRR of 0.01 and the timeline of the user authentication given, was of 30 seconds. Identifying the user with Behavioral characters has also been used and X. Wang et al. (2017) showed through their study about the recognizing of a user with his Behavioral features and characters. It was proposed for numerous devices which would recognize a particular user but will not pinpointing the user as to keep the user anonymous.

Mario Frank et al. (2013) in this study showed the application of Behavioral Biometric in order to attain authentication with the data gathered from the touchscreens. The analytics of touch screen were gathered from the features like median velocity, mean length, trajectory length, velocity, direction, duration, phone orientation and finger orientation. The results showed that the recognition of user through very restricted usage of touch screen is also conceivable. The rejection chance of legal user is 0-4% and it is similar in the false acceptance.

Shakir Ullah Shah et al. (2009) presented the new factor of authentication, which was something you process, the factors that were there before this one was "Something you Know" (Password, Pin code), "Something You are", "Something you have". This factor was the first which involved the process of processing to enter the password, Pin code or pattern. This technique is said to be one of the formidable against shoulder surfing attack. As this method ensures the password or pin code is random and keeps on changing with the condition of user's ease. Crouse et al. (2015) previously presented same algorithms of multi - factor authorization methods commonly incorporate facial expression and voice methods.

Gait is a technique for identifying individuals based on how user walks Derawi, M, et al., (2010), Mantyjarvi, J, et al., (2005). In a few of the pioneering approaches, used an elevated accelerometer

attached to the individuals' belts at the back to test gait ways. Another gait-based authorization has recently been seen to work well on wrist wearing gadgets Cola, G, et al., (2016). It had a 2.9 percent ERR for 15 participants. Signature models demonstrate control of the ability users autograph with a stylus on smart phones. Among the first tries to create sign verification work on smartphone was by Narayanaswamy et al. (1999). They applied a mix of international and national characteristics. Signs' total spatial as well as temporal properties are captured by global characteristics.

Stroke and dimension pertaining functions make up the local characteristics. The database of 542 authentic and 325 fake signs, they obtained a 3 percent Equal Error Rate. There has been research in which approaches for authorizing clients dependent on the 3D sign formed in the space have also been proposed Ketabdar, H, et al., (2012), Ketabdar, H, et al., (2010). Sae-Bae et al. (2012) implemented a predetermined series of five-digit contact gestures and found that each recipient's touch gestures are unique (based on biometric qualities such as hand dimension and finger size). They evaluated their procedure and found that it was over 90% accurate, with high usable input from participants. Singh, Y, et al., (2012) combined the ECG data with facial and phalanges biometrics for authorization using revival-based rating combination. The equal error rate of the multifactor process was 0.22 percent, relative to 10.80 percent, 4.52 percent, and 2.12 percent for the ECG date, facial, and phalanges biometrics, respectively.

5. Proposed System

In this system the user must kick off the process of getting himself registered and acquainted with the mechanism. In order to get registered, the user has to enter his necessary credentials like username etc. after which the user will be shown a pattern which is to be drawn on the screen. The numbers at the nodes will guide user to draw the shown pattern. The user will keep on drawing same and other different patterns several times in order to let the system's mechanism recognize and extract the unique touch dynamics and features which user is having while drawing pattern. In the mean while the user would also be prompted to draw pattern in position like sitting, standing and walking. The sensors will extract and record uniquely recognizable data and features and save that with link to the user. This will be the information which device will learn along with the Behavioral changes. Figure 3 shows the proposed system with user registration and authentication.

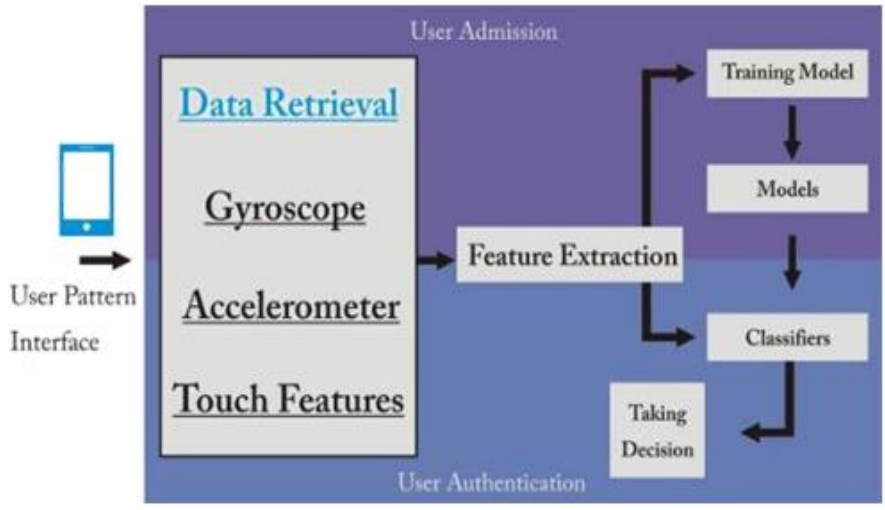

Figure 3: Overview of the proposed system with user registration & authentication

After letting the system know the unique touch dynamics and features of the user, the system will prompt user to put hand in the shape of the oval in the middle of the screen. This action allows the user

to perform mathematical operation. After this action the system will show user a number and arithmetic sign of either addition or subtraction randomly. The user will be advised to do the suggested arithmetic operation of the given number with a number of user's choice so as to choose the Registration Number or R-Number. For example, the suggested S-Number with arithmetic operator is shown as +3. The user wants the Registration number to be 5. So, the result would be 8, which user later will use in the final combination of the pattern and this process number is named as the Pattern number or P-number. Figure 4 shows the snapshot of the pattern.

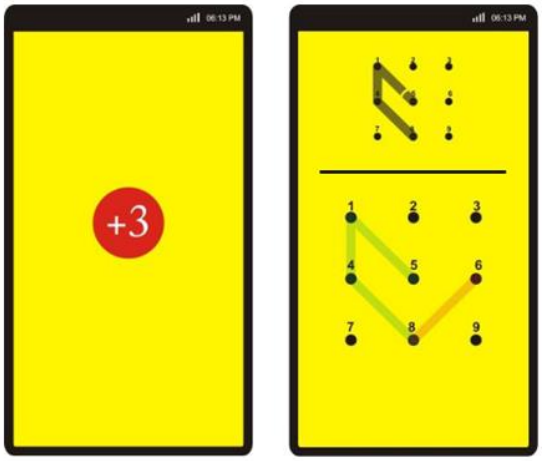

Figure 4: Pattern sample (top portion) Pattern made by user along with red line of the processed digit (bottom portion).

Due to the use of hand input on the screen, the R-number will never be shown to the adversary or any recording device nearby which records the process of registration. This method of concealing the R-number can be easily performed anywhere without the need of any special device or equipment. The P-number can result in negative, so the user has to just take the number into consideration if such case occurs, not the sign. This means the user always can subtract greater number from the lesser number which will always be an ease on the part of any user. Figure 5 shows authentication process.

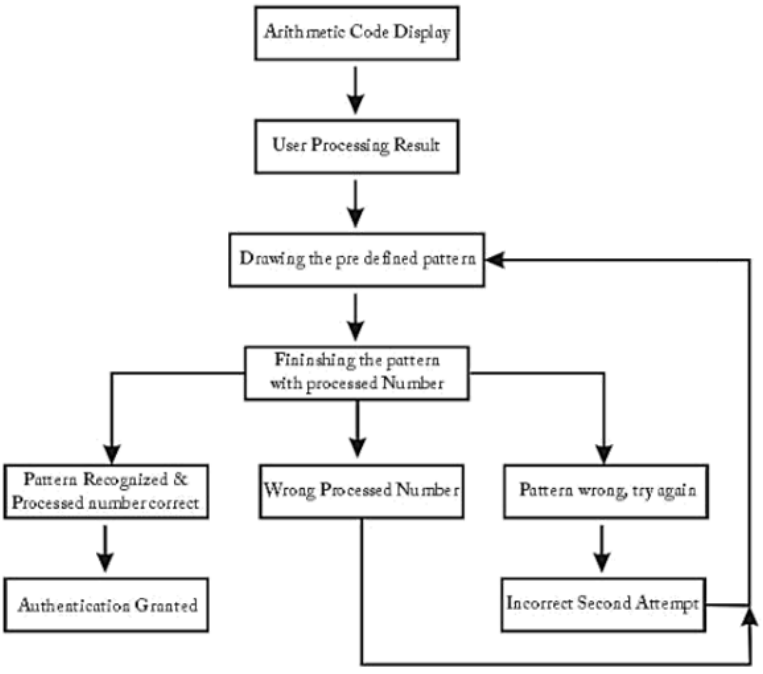

Figure 5: Diagram of login and registration process

For extraction of features while drawing pattern, the system uses the sensors which are present by default in the mobile phone. Most modern mobile phones have a range of sensors such as accelerometers, gyroscopes, and magnetometers. These sensors can be used to measure the movement and orientation of the phone in real-time. Table 1 shows touch proceedings which the corresponding sensors will be extracting while user draws the pattern.

Table 1: Touch events and their descriptions for feature extraction

Touch Proceedings	Description
amTP	Amount of Touch Proceedings of each section
avgTG	Touch Gravity average of each section
sdTG	Standard Deviation of Touch Gravity of each section
maxTG	Maximum Touch Gravity of each section
minTG	Minimum Touch Gravity of each section
avgTD	Average of Touch Dimension of each section
sdTD	Standard Deviation of Touch Dimension of each section
maxTD	Maximum Touch Dimension of each section
minTD	Minimum Touch Dimension of each section
avgSS	Average of Slide Speed of each section
stdSS	Standard Deviation of Slide Speed of each section
maxSS	Maximum Slide Speed of each section Minimum Slide Speed of each section
minSS	Slide Speed of each section from point A to point B

5.1 Algorithm

In order to grant user authentication using one of the aspects of the proposed system, Behavioral authentication pattern should be able to recognize the user's drawn pattern in a certain behavior or posture. For attaining this goal, the algorithm of Posture clustering or Posture bundling is used Rousseeuw, P. J, et al., (1987). This method has few steps in which the first one is that we use silhouette coefficient to get the value of the number of postures (K) along with K-means algorithm to get the posture predictor and projected tags of postures. Then we will be able to compute the threshold which will tell us that whether the posture of a feature trajectory belongs to an authorized user. Each user can normally have not that much of postures so similar postures can be bundles or clustered as a unit posture. Along with this method the threshold method is used which makes sure that the legal user's postures can be rightly recognized. The K bundles are renowned as the K posture of legal user. The detachments between all the trajectories are computed respectively.

Then their average and variance are calculated. This process is given by the Algorithm 1. Algorithm 2 on the other hand shows the pseudo code of SVM based classifier which takes the number of input vectors and output vectors into account along with the features and arrays, gives us the decision function outputs.

5.2 Pre-Processing

Before forwarding the original information to the classifier, it must be processed, sized, and normalized.

Algorithm 1 Posture Bundling Algorithm

Input:

User's portion of feature vector, T_{user} ;

Output:

Posture estimation evaluator, *pos_evt*;

Projected tags of posture, pro_pos_tag;

Limit, *limit;*

1. $T_{user\text{-}pos}$ = extract_posture _from (T_{user})
2. top_value= -1
3. for x = 2 to 6 do
4. (pos evt, pro pos tag) = K means(k, $T_{user\ pos}$)
5. S=sil coe f ($T_{user\ pos}$, pro pos tag)
6. If(s > top_value) then
7. top_value = s
8. pos_evt = tmp_pos_evt
9. pro pos tag = tmp pro pos tag
10. **end if**
11. **end for**
12. dis each trajectory = dis group pivot ($T_{user\ pos}$, pos evt)
13. Limit = 3 * mean(dis of each traj) + 7 * var(dis_of_each_traj)

The data is clearer during pre-processing. To obtain the necessary functionality, the pre-processing code is run on the entire raw data. The parts in the pre-processing procedure:

i. While deleting redundant timestamps from a certain account, the whole data will be displayed and ordered based on specific User IDs (UUID) and action timestamps.

ii. If the occurrence count is less than 2 attempts, use other instances under a particular threshold.

iii. If position data, such as latitude and longitude, is available, remove it. The raw data's variants and estimates are used to derive the functions.

iv. Locate contact activity records depending on the Button clicked and Action Type which is the pattern making touch features. The user is prone to making errors when entering the data. If a user makes the same error repeatedly, it is the user's typing habit. When estimating the right contact cases for a person, their perspective or behavior is taken into account.

v. For each button clicked and activity type case, create features from the raw information variables. The X and Y coordinate functions are derived from the distance formula through sensors of the smartphone. The derivatives are used to create the timestamps for the letters, and is shown in Table 2. Each letter has its own touch pressure and scale that correlates to a distinct attribute. The raw data was pre-processed, yielding 155 features for 25 consumers.

5.3 Feature Assortment

Feature Assortment, also known as variable or characteristic preference, is the process of selecting the

Table 2: Showing the last half of the data of the single user

Lat	Long	Touch Pressure	Touch Size	X-coordinate	Y-coordinate	X precision	Y precision	Action Timestamp
0	0	0.176589		105	1105	1	1	1615208011
0	0	0.176589		105	1105	1	1	1615208011
0	0	0.176589		125	1145	1	1	1615208011
0	0	0.176589		133	1098	1	1	1615208011
0	0	0.176589		197	645	1	1	1615208011
0	0	0.176589		344	654	1	1	1615208011
0	0	0.176589		525	755	1	1	1615208011
0	0	0.176589		224	811	1	1	1615208011
0	0	0.176589		88	1011	1	1	1615208011
0	0	0.176589		378	672	1	1	1615208011
0	0	0.176589		649	914	1	1	1615208011
0	0	0.176589		411	1149	1	1	1615208011
0	0	0.176589		289	788	1	1	1615208011
0	0	0.176589		344	951	1	1	1615208011
0	0	0.176589		186	917	1	1	1615208011
0	0	0.176589		78	816	1	1	1615208011
0	0	0.176589		307	873	1	1	1615208011
0	0	0.176589		68	1037	1	1	1615208011

most effective or important features for use in the classification algorithm. The data is minimized by overlooking unnecessary attributes, which reduces the model's runtime. It also improves performance indicators by focusing the classifier on the most important features. Feature selection can aid performance and minimize classification mistakes. It chooses a subset of the selected features to use in the classification model. There are three categories of feature selection algorithms, filtering procedure, wrapping procedure and embedding procedure.

5.4 Classification

The method of estimating a learning algorithm to map data points to output systems is called as classification. The mapping pattern defined as the model predicting the class for the dataset. Data points may be classified under one or greater classes whether they are re-valued or discreet. Multi-label classification strategies have several criteria that have to be configured as per the issue. The Python science kit library provides classification algorithms that can be adapted to the specific problem. The classification tools are developed in a classification class.

The authentication enactment of Behavioral authentication might rest on which classifier is performed and which blend of features is applied to the classifier. In this deference, we should be able to check which classifier and feature groups are operative in relations of user discernment. For the study that needed further experiments, we installed the system on a Samsung Galaxy S8 running Android OS. We used a Python-based machine learning library, to contrivance the six classifiers.

The classifier resilience impacts the time required to start deciding. This interpretation forms the different modules. For example, if only a few acts are needed to have an accurate classification, an attacker can be detected quicker and will do less harm. But for updating the device's security settings, it is possible to disable standard password protection in this situation. If the phone requires to track, say, an hour of use before classifying it, our suggested system might clearly support traditional security

features and act as an identity verification system, triggering GPS, sending SMS, or locking the smartphone.

5.5 The Dataset

The dataset which we applied in our tests is defined as it contains values for all the attributes that reflect a user's behavior. As previous studies have shown and proved that touch features are different while user is performing it in different positions which make recognition of the legal user more accurate. The data is being exported as an Excel spreadsheet from a local database table. The database is Microsoft SQL, and the whole table can be exported as an Excel spreadsheet. Any person who contributed to the data analysis has an instance in the Excel file. To suit the classifier and forecast it using the test data, it is necessary to register the users and gather several specimens from them. Since certain users did not enter data during the whole data analysis, the number of cases for each user varies. Whenever the user clicks any button of the smartphone screen, a record in the database is made, and that person added in the database. If a user's number of samples is very small, it will be skipped in the preprocessing phase.

Just 22 users are valid after pre-processing the dataset, which has 25 users who engaged in the data analysis. Clients for less than thirty occurrences are excluded from the study and are not used. There are 24 attributes in the raw data that can be used to classify a person. A total of 155 features are acquired during the feature extraction stage. While typing the password that appears on the phone, the occurrences are recorded. Daily, the user must launch the app and enter the code. The periods can be any duration, but the user must log in at least five times to input the password over the course of five days. The dataset across all clients is contained in an Excel file containing characteristics such as ID, Unique UserID (UUID), language, system model, SDK edition, make, pixel density, time zone, date time, country code, amount of CPU cores, country, location hemisphere, amplitude, button, touch force, touch density, action type, activity time stamp. To reflect all of the characteristics, the dataset was split into two pictures, as seen in the Tables 2 and 3.

5.6 Feature Extraction and Classification

Classification is a machine learning technique for distinguishing and categorizing entities as they are identified. Classification is a form of supervised learning in which the training samples is named so that it can be correctly categorized, as per machine learning notation. Clustering, on the other side, is an unsupervised learning method in which the training set is unlabeled, and classification is done using a resemblance or difference scale. Classification is the method of identifying data points and determining which group of groups they apply to base on training samples. After selecting features, the system can provide better output metrics, lower generalization mistake, mitigate training time, mitigate over-fitting, and prevent the dimensionality burden. The algorithm conducts an extensive investigation throughout the room to locate a new function subset and ranks them using a scoring metric. The target is to lower the error rate and improve the classification system's accuracy. If the dataset is huge and has many functions, it is highly scalable. There are some types of feature selection techniques Krishnamoorthy, S, et al., (2018).

5.7 Extraction

To properly represent the data, it must first be converted into functions. The raw data includes the identifiers from which the functions must be created to show the input trends' distinct characteristics. It generates new capabilities to differentiate between clients and improve classification mechanism. The method for determining the features is determined by the dataset and specific issue. The classification model tests whether the produced framework fits a saved model that was produced once the client was

Table 3: Dataset for a single user displaying the first half of the information

ID	UUID	Language	SDK VER.	Vendor	Time zone	Date/Time	Country code	CPU Cores
124384	SSRX1700559932194	English	21	Samsung	Pakistan/Kar	564789332	PK	4
124384	SSRX1700559932194	English	21	Samsung	Pakistan/Kar	564789332	PK	4
124384	SSRX1700559932194	English	21	Samsung	Pakistan/Kar	564789332	PK	4
124384	SSRX1700559932194	English	21	Samsung	Pakistan/Kar	564789332	PK	4
124384	SSRX1700559932194	English	21	Samsung	Pakistan/Kar	564789332	PK	4
124384	SSRX1700559932194	English	21	Samsung	Pakistan/Kar	564789332	PK	4
124384	SSRX1700559932194	English	21	Samsung	Pakistan/Kar	564789332	PK	4
124384	SSRX1700559932194	English	21	Samsung	Pakistan/Kar	564789332	PK	4
124384	SSRX1700559932194	English	21	Samsung	Pakistan/Kar	564789332	PK	4
124384	SSRX1700559932194	English	21	Samsung	Pakistan/Kar	564789332	PK	4
124384	SSRX1700559932194	English	21	Samsung	Pakistan/Kar	564789332	PK	4
124384	SSRX1700559932194	English	21	Samsung	Pakistan/Kar	564789332	PK	4
124384	SSRX1700559932194	English	21	Samsung	Pakistan/Kar	564789332	PK	4
124384	SSRX1700559932194	English	21	Samsung	Pakistan/Kar	564789332	PK	4
124384	SSRX1700559932194	English	21	Samsung	Pakistan/Kar	564789332	PK	4
124384	SSRX1700559932194	English	21	Samsung	Pakistan/Kar	564789332	PK	4
124384	SSRX1700559932194	English	21	Samsung	Pakistan/Kar	564789332	PK	4
124384	SSRX1700559932194	English	21	Samsung	Pakistan/Kar	564789332	PK	4
124384	SSRX1700559932194	English	21	Samsung	Pakistan/Kar	564789332	PK	4
124384	SSRX1700559932194	English	21	Samsung	Pakistan/Kar	564789332	PK	4
124384	SSRX1700559932194	English	21	Samsung	Pakistan/Kar	564789332	PK	4
124384	SSRX1700559932194	English	21	Samsung	Pakistan/Kar	564789332	PK	4
124384	SSRX1700559932194	English	21	Samsung	Pakistan/Kar	564789332	PK	4
124384	SSRX1700559932194	English	21	Samsung	Pakistan/Kar	564789332	PK	4
124384	SSRX1700559932194	English	21	Samsung	Pakistan/Kar	564789332	PK	4

recruited (training phase) into the method. The classification model then produces the final judgment based on the corresponding criterion. The people will be asked to reach the biometric technology if the ultimate verdict is yes. Alternatively, the user's authorization is refused. There are two kinds of biometric systems: identification and verification-based systems. In client authentication, a client's biometric is compared to other stored in the database to determine their identification. This is known as a 1-to-n match scheme, where n represents the number of clients in the database. For extraction of features while drawing pattern, the system uses the sensors which are present by default in the smartphone. Table 1 shows touch proceedings which the corresponding sensors will be extracting while user draws the pattern.

5.8 Posture Bundling

The features which are extracted and are of main significance are the ones which show the properties of time series like mean, variations, top and bottom numbers (n), assortment and span of time sequence (t). It also shows the features that show native properties of time sequence like initial position value (s_{init}), middle position value (s_{mid}), the relative location of maximum value ($s_{\max\_loc}$) and relative location of the minimum value ($s_{\min\_loc}$) along with usage of relative top location (i) and relative bottom location (j). Liu, Q, et al., (2016).

$$s_{init} = \frac{s_{t0} + s_{t1} + s_{t2}}{3}$$

$$S_{mid} = \frac{st_{\left[\frac{n}{2}-1\right]} + st_{\left[\frac{n}{2}\right]} + st_{\left[\frac{n}{2}+1\right]}}{3}$$

$$S_{end} = \frac{st_{[n-3]} + st_{[n-2]} + st_{[n-1]}}{3}$$

$$S_{\max\_loc} = \frac{i}{n}$$

$$S_{\min\_loc} = \frac{j}{n}$$

The features are extracted based on the postures as well as the touch dynamic features are also considered for a precise and unique extraction. The posture predictor and projected tags are the main features which will be able to calculate the threshold if the user's features match with the unique set already present.

6. Performance Assessment

These experiments and evaluation were done to get the accuracy of the system and different values and score of various classifiers in different postures like sitting, walking or lying. It was also checked that whenever the instance of false rejection or acceptance occurs then the tier of fourth factor stops that false assumption by the system.

6.1 Data Collection

To get the results, we performed experiments with 25 volunteers who participated without any charges. There were 17 male participants and 8 female participants who belonged to different fields and all of them were users of smartphones.

The proposed system was described to them along with the basic theme of work. All of them were provided by same model smartphone Samsung A50 with the proposed system installed and checked. They all were guided to make open patterns 25 times while sitting, walking, and lying. Mats and pillows were provided in the vicinity to perform the authentication while lying. We told the participants to use the smartphone and postures in a normal daily life way. A total of 3750 samples were acquired to perform experiments.

6.2 Top Performing Classifier

The result of the experiments while evaluating authentication through behavior depends upon the used classifier and the features which are used. The evaluation was done with the technique of one feature one time. Recursive feature elimination was applied to select the most suitable feature set for each classifier. This procedure was applied until the entire feature set became null. The procedure of selection of the feature set was done for six classifiers and three postures.

There are three postures along with the accuracy and F score. It can be seen from the table that the best performing classifier is GNB. It had the highest accuracy in the postures of sitting, walking, and lying**.** Figure 9 shows different postures feature set and their corresponding F-score.

6.3 Resultant Perentage (Rp) in Terms of EER

The proposed system contains two levels of percentages which combines and gives the resultant percentage. This resultant percentage can be derived by the concept of Percentage of a Percentage. To find this, first percentage P1 and the second percentage P2 both are divided by 100. These two results give us the derivatives which are then multiplied to give the Resultant Percentage Rp.

First Derivative (N1) = P1/100

Table 4: Touch events and their descriptions for feature extraction

Classifier	Sitting		Walking		Lying	
	Acc.	F Score	Acc.	F Score	Acc.	F Score
DT	93.39	93.53	74.12	73.91	83.76	83.45
SVM	96.71	96.65	86.94	86.23	92.88	92.74
KNN	96.31	96.22	70.01	68.45	86.79	86.35
GNB	98.06	97.31	96.22	95.64	96.42	95.88
RF	96.85	96.45	91.71	90.77	95.55	94.09
LR	97.33	97.30	89.34	89.19	91.88	92.69

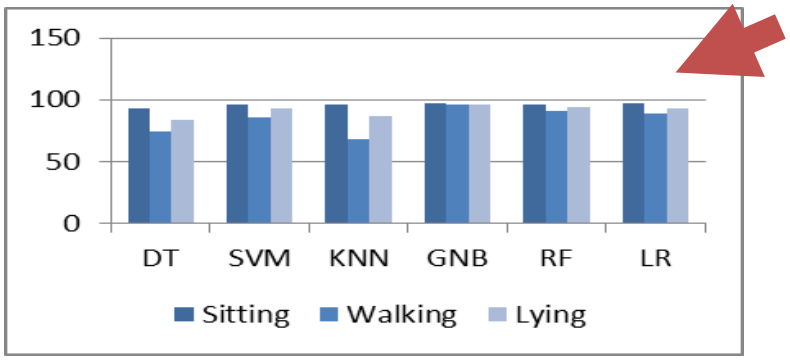

Figure 7: F-score of the three postures in different classifiers used

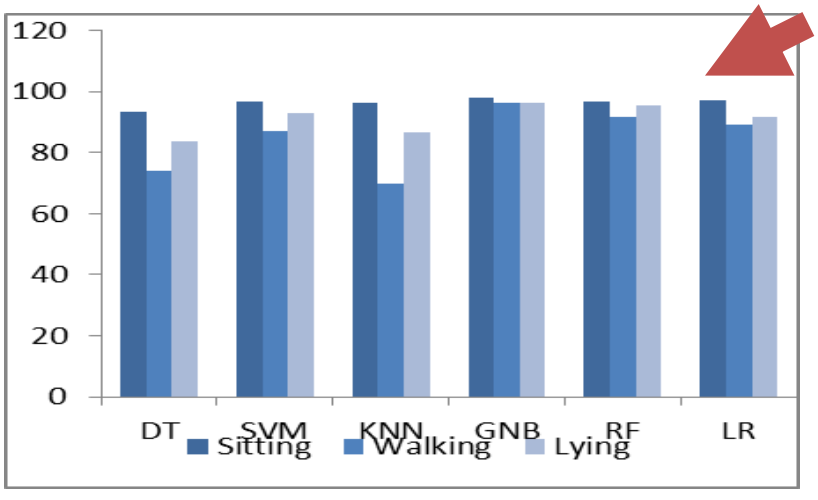

Figure 8: All of the classifiers accuracy in the three postures proposed in the system, i.e., Sitting, Walking, and Lying

Second Derivative (N2) = P2/100

Resultant Percentage (Rp) = N1 * N2

In this scenario the first percentage (P1) is EER and the second percentage (P2) is derived from the guessing chance of a number from the nine numbers of the grid while doing the arithmetic operation to get the processed result. As there are nine numbers so the guessing percentage would be found out using the following values.

P1= 3.5%

P2 = 1/9*100=11.11%

First Derivative (N1) = P1/100 = 3.5/100 = 0.035

Second Derivative (N2) = P2/100 = 11.11/100 = 0.11

Resultant Percentage (Rp) = N1 * N2

Resultant Percentage (Rp) = 0.035 * 0.11 = **0.0039%**

Table 5 shows comparison between the EER and Resultant Parentage between different technologies which clearly shows the marked difference between the EER scores and no change in the resultant percentage due to no other tier.

Table 5: Comparison between the EER and Resultant Parentage

Scheme	EER	Resultant	
		Exist	%
Proposed System	**3.50%**	**YES**	**0.0039%**
Shahzad et al. (2018)	**4.80%**	**No**	**4.80%**
Xu et al. (2014)	**10%**	**No**	**10%**
Sitova et al. (2015)	**7.16%**	**No**	**7.16%**
Alpar et al (2017)	**4.10%**	**No**	**4.10%**

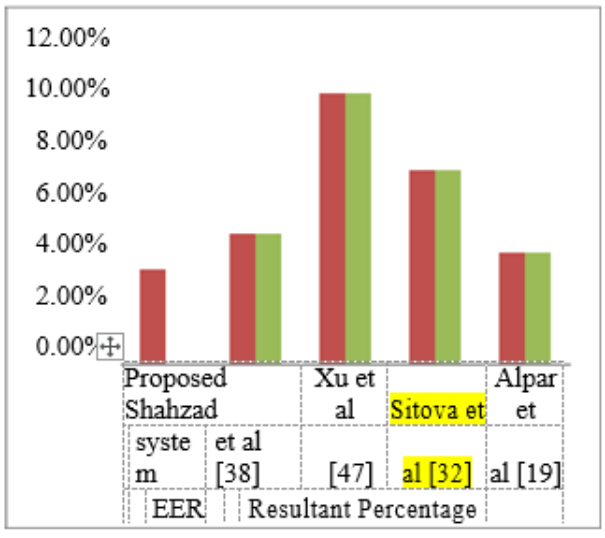

Figure 6: EER and Resultant Percentage of different systems with the proposed system with the only least Resultant Percentage

The graph shown in Figure 6 is from the very fact that values of the EER in a normal scenario are almost quite similar and there is not bigger difference amongst most of the systems. But when the resultant percentage criteria is applied then the EER decreases in the proposed system but others lack that change.

Table 6: This table compares and shows the availability of two technology's presence in different modern schemes along with the proposed one

Schemes	Behavioral Auth	Something you process	Both
Proposed system	Yes	Yes	Yes
Liu et al. (2016)	Yes	No	No
L. Lu et al. (2015)	Yes	No	No
Kayacık et al. (2014)	Yes	No	No
Shakir et al. (2009)	No	Yes	No

6.4 Evaluation

In Figure 6, it can be clearly seen that the resultant percentage is way less than other relevant methodologies. There is Shahzad et al. (2018) whose EER is 4.80 which in comparison to other systems is a good number but when another tier of defense is applied which others lack then there is a big difference significantly. Shahzad el al. (2018) mechanism was gesture based but along with other systems, they all lack the other layer, which can be acting as a part of the system but would add that extra edge and would be clearly shown in the numbers. The other schemes mentioned are based on touch and typing based respectively but have the same story. There were values of the schemes in sitting and walking postures, but we only considered lower one. Table 4 evidently specifies that modern system of authentication which use Behavioral authentication only are dependent on that particular scheme while the systems which used the factor, "Something you process" has not used it with Behavioral authentication.

7. Security Analysis

7.1 Against Shoulder Surfing

In this instance the 10 participants were given the task of being an attacker. While others were performing the authentication process, they attackers were allowed to peak from near or to record the session of the authentication. The attackers were fully guided on how to get maximum efficiency out of the authentication. These included postures, gait, arithmetic code, and processed result. Attackers were given the freedom of re-watching the video as many times as they want to get authentication. A total of 704 samples were used and free lunch was provided to the student who finds success in his attack. It was observed that none of the attacker was able to get authentication. The same experiment was performed without the usage of the 2nd tier of something you process. It was that time when there was success (3.7%) got by the attackers as shown in Table 7.

Another comparative experiment was done with simple pattern lock and the proposed system. The attackers were easily able to know the right pattern through peak and recording attack. The attacker success rate was 90 %.

7.2 Analysis of Usability

We assess our mechanism's usefulness in 2 aspects: by determining what other patterns are required to train the classifier to produce meaningful authentication precision, as well as using the basic System Usability Scale to collect user feedback on our possible framework. We also put effort to get the minimal sample collection time as shown in Table 8.

8. Discussion

8.1 Implications

While the thought process of most of the people would be that the pattern lock is getting outdated in this ever-growing era but there would be no two ways about it that it is one of the most used authentication processes till date. This system not only has used this well-known procedure but also has combined it with modern day machine learning mechanism. In addition, this has been backed up by the fourth factor.

Table 7: Three different entries showing success rate of shoulder surfing attack involving Pattern Entry

Scheme	Entry type	Shoulder Surfing
Proposed System	**With behavioral auth. And Something You Process**	**0.00%**
Pattern Entry 1	With Behavioral Authentication	3.5%
Pattern Entry 2	Without Behavioral Authentication	90%

This system has been made in such a way so that it can firstly identify the links between the patterns and their conciseness which are to be used in pattern recognition. Even till date the biometric sources of authentication like fingerprint is still backed up by pattern, pincode or password. Whenever in any mobile a user gets the authentication wrong using his fingerprint then the user is asked that he has exceeded the limit of invalid tries now the user has to enter the pattern or the password. This scenario makes the patterns and password very relevant and significant in today's modern ever evolving world.

Afterwards in the second stage the server generation of the number with arithmetic operation plays an important role to let user uses that only to comply the processing step. The pattern drawing system

Table 8: Sample collection timing comparison with proposed system and other system

System	Sample Collection time (s)
Proposed System	3.8
PIN	3.9
Password	8.01
Voice	5.35
Face	5.78
Gesture	8.11
Face + Voice	8.03
Gesture + Voice	10.11

grants user the opportunity to input the pattern as well as the final processed code. In this way the system not only makes this super easy for the user to just draw a pattern nonetheless protects this easy procedure. The system eases off the user by removing the burden of making and remembering difficult patterns and always trying to keep it away from close sitting people.

Machine learning based authentication is educating day by day but needs quite some input even after which there can be occasions where the scenario of False Acceptance or False rejection can occur. This problem which may look small, but it needs to be dealt with. The need of fourth factor of authentication is clearly awaited to seal and strengthen the security of the machine learning Behavioral authentication. It is to be anticipated that this system can eradicate the existing susceptibilities, which present parallel methods have. Many of the previous methodologies have admitted that there have been some insecure results which were obtained from their own experiments. This can be clearly observed that all of the systems are declaring that they are error resistant but not error free where our system provides that cushion for those instances. The contributions of the proposed system are as follows:

- There have been many systems proposed in the field of authentication but to the best of our knowledge, no one has ever proposed another tier of security when the instance of False Acceptance or False rejection has taken place in any of that system.
- As there is no system which claims to be having zero percent False Acceptance or Rejection rate so whenever that happens then there isn't any line of defense left afterwards. This much required layer is present in the proposed system.
- In this paper, we point out the abovementioned problems and propose a system which uses Behavioral authentication aided with machine learning and an additional tier of fourth factor of authentication namely "Something You Process".
- This system uses the open pattern lock system which would be visible to all as a sample which the user has to draw. There will be no need of making difficult patterns and remembering them every time.
- The system will be able to eradicate the threats of different attacks like shoulder surfing, guessing or smudge.
- The added layer of fourth factor will enable user to process the result of an arithmetic operation in his mind and then outputting it at the last of the pattern drawn. This will be the added wall of security whenever the scenario of False Acceptance or False rejection occurs.
- We give the probe of paramount classifiers for the proposed system which gives the better rates than other systems.

- Security assessment against different attacks were made including shoulder surfing attack with two different methods referred to as Peak attack and recording attack.
- The operation hiding technique through hand eradicates the shoulder surfing attacks while performing the method of "Something you Process".

8.2 Limitations and Future Work

No matter how much one can strive for perfection there would always be room for improvement and growth. The limitations which need improvement in future are that the experiments should be done even bigger scale with long term results and observations. The behavior features should be added with the added postures scenarios of using two hands and operating in different environment. There should also be a way that the user registration through features and classification should be done in as much less time as possible with minimum number of patterns. In this process the locking of phone can be problematic for which registration category should be introduced which either doesn't lock the phone or separate the data. Arithmetic processing by user can be little tiring for the mind which goes away with time and also can take few more seconds than other modes of authentication. This will be improved in the future study.

9. Conclusion

This system is recommended here Behavioral Authentication using something you Process, a unique addition to the pattern lock setup. We consider that this system with small additional step of fourth factor has given support to the vulnerabilities in the previous existing systems. The attack models which were applied on our system clearly showed the need for another layer of sanctuary in the post pattern security. The attack results clearly showed that usual pattern lock systems stand no chance in front of different attack models. Comparative study also enlightened the point that false acceptance or rejection occurs in machine learning based behavioral authentication. The system has strong approach stacking up three lines of defenses. Machine learning and Behavioral authentication in different postures along with the fourth factor of authentication can back up any smallest loopholes or errors in false acceptance or rejection.

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