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Preface

In the era of fourth industrial revolution or Industry 4.0, Computational Intelligence, Data Science and smart Information and Communication technology (ICT) are gaining huge importance in our society. Governments around the world started relying heavily on information and communication technologies to build smart and hyper-connected infrastructures that allow cities to provide better services to people and reduce energy consumption, as the global urban population is growing substantially. These intelligent technologies allow cities to introduce new ways of monitoring the atmosphere, buildings, street lighting, traffic, crowds, crime, etc.

In building a smarter and more intelligent city around the world, Computational intelligence and ICT are the underlying technologies; but if not wisely applied, ICT can be a major environmental problem. At present, about 2 percent of global greenhouse gas (GHG) emissions are accounted for by the global ICT industry. This footprint is expected to increase dramatically to about 14 percent by 2040, according to a recent report. Intelligent use of advances in ICT will assist in minimizing GHG while still achieving its goals. ICT is theoretically able to reduce the carbon footprint in other fields by a factor of 10, based on the Global e-Sustainability Initiative (GeSI) report. ICT technologies such as Green ICT, the Internet of Things (IoT) and Artificial Intelligence (AI) can play important roles, not just in making our environment smarter, but also greener and more sustainable.

To address this need of the hour, International Conference on Computational Intelligence, Data Science and Cloud Computing (IEM-ICDC) 2020, was organized by Department of Information Technology, Institute of Engineering & Management, Kolkata, India, during September 25-27, 2020. The three-day online event was graced by eminent speakers and researchers from academia and industry from all over the world, working in the field of Computational Intelligence, Data science, Cloud Computing, IoT, Blockchain and recent trends in ICT.

8 papers from the tracks “Computational Intelligence” and “ICT” of the conference IEM-ICDC 2020 has been selected for publication in this conference special issue of American Journal of Advanced Computing named as "Computational Intelligence and Smart Information and Communication Technology”.

American Journal of Advanced Computing: International Conference on Computational Intelligence, Data Science and Cloud Computing (IEM-ICDC) 2020 Special Issue on **"Computational Intelligence and Smart Information and Communication Technology"** aims to bring together researchers and practitioners in the fields of Smart Cities, Renewable Information and Communication Technology, Artificial Intelligence, Innovation, and Energy-Aware Systems involved in smart ICT developments and applications. We hope that this will be helpful and be a motivating force for future research in the practical designs of cutting-edge systems in related fields.

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An empirical study on fall-detection using K-means based training data subset selection

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***Abstract*—Falls in elderly people are a significant cause for injury. Effective prevention strategies are therefore helpful in addressing this problem. A number of machine learning approaches have been proposed for identification of near fall situations, thus by preventing fall related injuries. However, many of the existing algorithms are supervised and require long training time, especially on large datasets. This paper investigates training data subset selection using a well-known unsupervised algorithm K-means clustering. The effect of cascading the priori information obtained from K-means is evaluated using three supervised algorithms namely K-nearest neighbor, Decision-Tree and Random forest. Experimental results illustrate that computational time is reduced significantly and the fall recognition rate is preserved on the reduced training dataset.**

Keywords—Fall detection, K-means, Training data subset selection, Activity recognition

I. INTRODUCTION

Human falls are becoming common health issue in elderly people. Falls result in injury and thus impacts one's health and productive life cycle. According to the World Health Organization [1], approximately each year around 37.3 million falls occur and the majority of fall victims are people aged 65 and above. The increase in fall-rate each year postulate effective prevention strategies that emphasize on education, training and safer environments for reducing fall related risks. In this context, fall detecting devices are commonly utilized by healthcare professional. These assistive devices alert when a fall event occurs so that necessary assistance can be given immediately [2].

Machine learning algorithms have been widely employed for fall detection [2, 3]. Most of these algorithms regard fall detection as an activity recognition problem which classifies the input features into one of the activities such as walking, standing, sitting, running and falling, etc. Here, the set of activities constitute class labels and the signals received from various sources like accelerator, magnetometer, etc., form feature vectors of the classification problem.

Traditional machine learning algorithms such as K-nearest neighbour [3], Hidden Markov Model [4], Multi-layer perceptron [5] and Support Vector Machine [6, 7] are used for wearable fall-detection. T. Zhang et al. [6] proposed a fall-detection system which extracts temporal and magnitude features from accelerometer signals and then classifies them as normal or abnormal (fall) activity using one-class Support vector machine. Cheng et al. [4] proposed a framework for daily activity monitoring and fall-detection using surface electromyography (SEMG) and accelerometer signals. The framework first segments the activities into static and dynamic types using Decision-Tree algorithm based on SEMG and accelerometer signals. The dynamic activities are further recognized as normal transition or fall activities using Hidden Markov Model (HMM) based on accelerometer amplitude threshold.

Other classification algorithms such as neural networks have also been studied for fall-detection [8]. Neural networks are a kind of machine learning models where a set of neurons connected to each other and perform some task by analysing training examples. Typically the neurons are arranged in sequential layers where output of a layer *i* is connected (feed-forwarded) as input to the subsequent layer *i + 1*. On receiving certain input, each neuron is triggered based on activation function. Multi-layer perceptron (MLP) is a type of feed-forward neural network which uses back-propogation for training the network. MLP finds its uses in various scientific applications including fall-detection. One of the studies on fall-detection reported that MLP has shown good performance as compared to other algorithms namely Naive Bayes, Decision tree, Support Vector Machine, ZeroR and OneR [8].

Most of the fall-detection algorithms are based on supervised-learning and their long training time pose computational limitations for large datasets [4]. S.Zhang et al. [9] have proposed an efficient K-NN algorithm using preliminary partitions obtained using K-means algorithm. Given dataset is divided into a number of clusters using K-means and K-NN algorithm is applied on each of these clusters separately. Experimental analysis on medical image data report that their proposed K-NN algorithm have shown improved accuracy and efficiency.

This paper investigates the effectiveness of employing K-means algorithm for reducing cost of training in three supervised learning algorithms namely K-NN, Decision-Tree and Random forest. For experimental purpose, Kaggle fall-detection dataset is considered. Results indicate that cascading of K-means significantly reduces time taken for training the fall-detection algorithms.

Rest of the paper is organized as follows. Section II briefly explains related algorithms and Section III describes proposed methodology. Section IV presents details of the dataset and the experimental analysis. Finally, results are concluded in Section V.

II. RELATED METHODS

A. K-Nearest Neighbour Classifier

K-nearest Neighbour (K-NN) algorithm classifies a data instance based on the number of closest training instances in a given dataset. Given a data instance x_i, K-NN first computes distance of x_i with every other data instances and choose top-K neighbours and classifies x_i based on majority voting from the K neighbours. Here, the number of neighbours K is user-defined parameter, and choice of K

impacts the classification results [6]. Fig. 1 illustrates how K-NN algorithm classifies a test point based on 3 nearest neighbours.

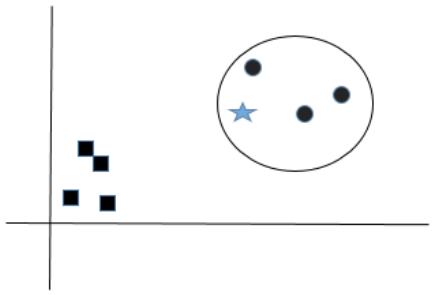


Fig. 1. K-NN Algorithm *K*=3 The test point represented by star symbol will be assigned to the class as that of points represented by circle as it is having 3 nearest neighbors from circle class.

B. Decision-Tree and Random-Forest Algorithms

Decision-tree classifier is another popular classification algorithm which is based on a tree-structure. The internal nodes in the tree represent test on an attribute and branches originating from that node represent each possible value that the attribute may take. Leaf nodes in the tree nodes represent the class label. The path from root to the leaf nodes indicate the classification rules. Given a dataset *D*, the tree is constructed using attributes in *D*. The choice of attributes for branching are depends on their discriminating nature, which is computed using information gain (*IG*). Suppose an attribute A_i of the dataset *D* has m possible values $\{v_1, v_2, \ldots, v_m\}$. Let $H(A_i)$ denote entropy before branching on an attribute A_i and $H'(A_i)$ denote entropy after branching on A_i. Then IG of A_i is computed as follows [10].

$$IG(D, A_i) = H(A_i) - H'(A_i) \quad (1)$$

Here, entropy is a measure of degree of homogeneity of samples in a node in the tree. Entropy is calculated as $-p_j \, logp_j$, where p_j is probability that the attribute A_i will have value v_j . If all the samples in a node are homogeneous, i.e., belong to same class then, entropy is less and vice versa. Generally an attribute that attains more reduction in entropy leads to higher information gain and thus preferred over all other attributes for forming branching condition on the node. Information gain is computed for all the attributes and the attribute having highest *IG* value is chosen as next splitting attribute. The splitting continues once all the attributes have been used for branching or all the samples in a node belong to same class label. Fig. 2 illustrates an example of decision tree for a binary classification problem having three attributes namely A_1, A_2 and A_3. Assuming A_1 attribute has highest information gain, A_1 becomes root node of the tree. Suppose if a test sample has < High, yes, 4 >. Then it will be classified as class-A using the rules depicted in the tree of Fig. 2.

Random forest is a variant of decision-tree algorithm. While decision-tree algorithm builds the tree using the entire set of samples and features in the dataset, random-forest algorithm constructs multiple trees based on random subset of samples and features. Class decision of a test sample is finally based on the output of all the subtrees.

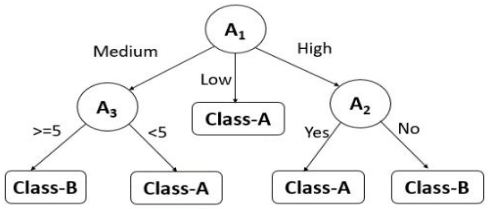
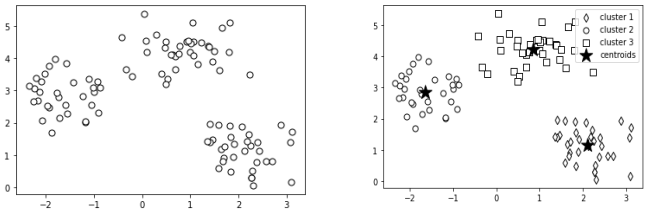


Fig. 2. Decision Tree Algorithm for a binary classification with three attributes A_1, A_2 and A_3.



(a) (b)

Fig. 3: K-means clustering: (a) An example 2-dimensional dataset. (b) Clusters obtained using K-means algorithm.

C. K-means Clustering Algorithm

K-means is one of the popular unsupervised learning algorithms used for cluster analysis. K-means works on the principle of partitioning a given set of points to *k* clusters C_1, C_2 …. C_k such that sum of squared error (*SSE*) is minimized. The *SSE* is computed as follows.

$$SSE = \sum_{i=1}^{k} \sum_{j=1}^{n} \|x_j - \mu_i\| \quad (2)$$

where *n* is the number of points in cluster C_i and μ_i is the center of cluster C_i. Getting local minimum of the objective function *SSE* is NP-hard problem. The complete steps of the algorithm is explained in Algorithm 1 [10].

Algorithm 1: K-means Algorithm

Input: *Dataset D, number of clusters k.*
Output: *k clusters.*

1. Randomly choose k points from D as centers of k clusters $C_1, C_2, \ldots C_k$.
2. Assign each point x_i to its nearest cluster.
3. Recompute the new cluster centers.
4. Repeat steps 2 and 3 until there is no change in reassignment of points.

As K-means clustering chooses initial partitioning based on random centers, resulting clusters may not be stable due to the local optima. To address this issue, several initial seed selection methods have been proposed in the literature. This paper adapts deterministic initialization approach presented

in [11]. Fig. 3 illustrates clustering of a dataset using K-means clustering.

III. PROPOSED METHODOLOGY

Once the given dataset is partitioned into k clusters, top p neighbours of each of these cluster centers are chosen. Let us call these points as core points. The number of core points p is studied empirically and discussed in Section 4.2. If each core point agrees with its corresponding activity class label in the given dataset D, it will be considered for training subset D'. Algorithm 2 explains the proposed algorithm.

Algorithm 2: Proposed Algorithm

Input: *Dataset D.*
Output: *Training subset D′.*

1. Set number of clusters k as the number of classes in the fall-detection dataset. For the current study, number classes is 6.
2. Get a set of clusters C_1 , C_2 . . ., C_6 using K-means algorithm.
3. Initialize the number of core points p to be chosen from each cluster, where n is size of the cluster under consideration.
4. Initialize $D' = \{\phi\}$.
5. For each clusters C_i, choose top p nearest neighbours to its cluster center μ_i; Let us call these points as core points.
6. For each core point $x_j \in C_i$
   6.1 If both x_j and μ_i belong to the same activity class in the given dataset D, then add these points to D'.
   6.2 Else ignore this core point.
7. Return D'.

IV. EXPERIMENTAL ANALYSIS

A. Dataset

For experimental purpose, fall detection dataset from Kaggle repository is chosen [12]. The dataset comprises of 16382 samples and featuring six different activities namely Standing, Walking, Sitting, Falling, Cramps, Running. The data was collected from old-age patients while wearing motion sensor units. Fig. 4 shows the distribution of samples across different activities. The set of features given in the dataset are Time, Sugar level (SL), EEG monitoring rate (EEG), Blood pressure (BP), Heart beat rate (HR) and Blood circulation. Fig. 5. illustrates each of the five features with respect to six possible activities.

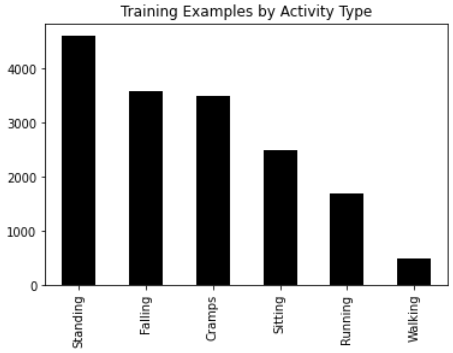


Fig. 4. Activity Class distribution

B. Results and Discussion

K-means clustering partitions the dataset into 6 clusters. Size of each cluster is as follows: {Cluster-0: 4233, Cluster-1 : 779, Cluster-3 : 2488, Cluster-4 : 3493, Cluster-5 : 4007, Cluster-5 : 1382}. As per the procedure described in proposed algorithm, reduced training set D' is obtained by selecting only a subset of core points forms each of these clusters. Size of D' depends on the size of subset p chosen from each cluster and choice of p affects the overall results. If p is set to too small, then fall-detection rate may decrease due to insufficient training samples in D' and if p is large, then we cannot achieve reduction in runtime. So, p value is chosen through empirical analysis and it was observed that $p = 5\ \sqrt{n}$ has shown expected reduction in dataset size while maintaining fall-detection accuracy.

Table I presents the distribution of samples across different classes in the reduced dataset. As K-means is unsupervised, cluster number may not correspond to actual class labels in D. For, e.g. a cluster C_i having cluster number 0 may not correspond to activity class 0-Standing as given in the dataset D. So, class alignment is carried out based on activity-class label of the cluster centers. Ideally all the core points in a cluster must have the same activity class label as that of its cluster center. However, some points may get mis-grouped due their position in the feature space. It is observed that almost all the samples from sitting activity class was grouped into the same cluster. It has been also observed that there is a huge overlap between standing and walking clusters. One can see from the table that only 10% of the data is used for training the algorithms.

Each of the three algorithms K-NN, Decision-tree and Random-forest are evaluated on both original dataset D as well as reduced dataset D'. For K-NN algorithm, the number of nearest neighbors K is set to 7. We consider precision, recall, F1-score and accuracy as evaluation criteria. These metrics are calculated based on confusion matrix (shown in Table II) as follows.

$$Precision = \frac{True\ Positive}{(True\ Positive + False\ Positive)}$$

$$Recall = \frac{True\ Positive}{(True\ Positive + False\ Negative)}$$

TABLE I. RESULTS OF PROPOSED ALGORITHM ON TRAINING DATASET SIZE REDUCTION.

Activity-class	$\|\| D \|\|$	$\|\| Cluster_i \|\|$	$\|\| D' \|\|$
Standing	4608	4233	301
Walking	502	779	114
Sitting	2502	2488	245
Falling	3588	3493	266
Cramps	3494	4007	301
Running	1688	1382	181
Total	16382	16382	1408

TABLE II. CONFUSION MATRIX

		Actual		
		Positive	Negative	Total
Predicted	Positive	*TP*	*FP*	*a+b*
	Negative	*FN*	*TN*	*c+d*
	Total	*a+c*	*b+d*	*N*

TABLE III. FALL-DETECTION RESULTS OF K-NN ALGORITHM

	Training on D				Training on D'			
	Precision	Recall	F1-score	Support	Precision	Recall	F1-score	Support
Standing	0.85	0.70	0.77	1511	0.71	0.64	0.69	90
Walking	0.71	0.81	0.76	152	0.69	0.76	0.68	39
Sitting	0.59	0.77	0.67	782	0.56	0.66	0.58	90
Falling	0.57	0.63	0.60	1225	0.51	0.53	0.44	79
Cramps	0.57	0.54	0.55	1199	0.52	0.47	0.49	108
Running	0.55	0.49	0.52	538	0.51	0.36	0.44	59
Accuracy			0.64	5407			0.60	465

TABLE IV. FALL-DETECTION RESULTS OF DECISION-TREE ALGORITHM

	Training on D				Training on D'			
	Precision	Recall	F1-score	Support	Precision	Recall	F1-score	Support
Standing	0.93	0.86	0.89	1511	0.79	0.68	0.71	90
Walking	0.67	0.75	0.71	152	0.69	0.62	0.65	39
Sitting	0.64	0.67	0.66	782	0.56	0.69	0.61	90
Falling	0.62	0.60	0.61	1225	0.57	0.60	0.43	79
Cramps	0.59	0.61	0.60	1199	0.54	0.52	0.49	108
Running	0.53	0.59	0.56	538	0.65	0.54	0.59	59
Accuracy			0.69	5407			0.63	465

TABLE V. FALL-DETECTION RESULTS OF RANDOM-FOREST ALGORITHM

	Training on D				Training on D'			
	Precision	Recall	F1-score	Support	Precision	Recall	F1-score	Support
Standing	0.96	0.95	0.96	1511	0.83	0.80	0.81	90
Walking	0.77	0.80	0.78	152	0.69	0.71	0.65	39
Sitting	0.71	0.76	0.74	782	0.57	0.69	0.68	90
Falling	0.67	0.69	0.68	1225	0.61	0.59	0.56	79
Cramps	0.66	0.65	0.66	1199	0.59	0.55	0.60	108
Running	0.67	0.59	0.63	538	0.61	0.54	0.59	59
Accuracy			0.77	5407			0.70	465

Results of K-NN algorithm are shown in Table 3. Similarly, Table IV and Table V present the results of Decision-Tree and Random-Forest algorithms. It is observed that all the three algorithms show almost similar performance on both original dataset D and Reduced dataset D'. Among the three classifiers, Random-forest algorithm has shown better performance in overall activity recognition. It is able to detect falls with 67% precision and 69% recall, although it has attained higher values for standing activity. Also, it has shown similar results on reduced training set D'. One common behavior with all the algorithms was their performance on reduced dataset D' is not deviated very much in fall-detection.

The proposed subset selection approach is also compared against random sampling. From each of the activity class, samples are chosen randomly such that per-class sample size is same as that of D' obtained from proposed approach. Experiments are carried out for 10 runs with each run using a different set of randomly chosen samples. Results reported in Fig.6 indicate that all the three algorithms K-NN, decision Tree and Random forest perform better using proposed training data subset selection as compared to random sampling.

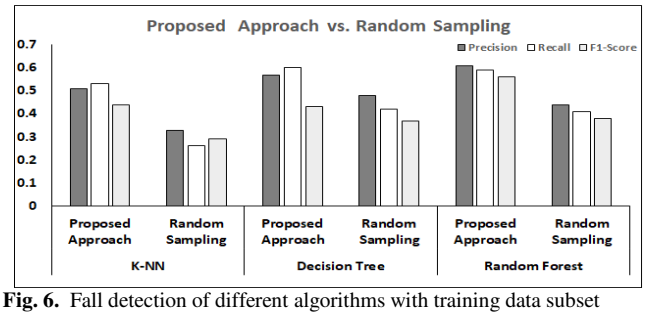


Fig. 6. Fall detection of different algorithms with training data subset chosen using proposed approach and random sampling.

V. CONCLUSION

This paper presented an empirical study of fall-detection using three classification algorithms namely K-NN, Decision-Tree and Random-forest. An efficient training data subset selection using K-means clustering is also proposed. Experimental results on Kaggle fall-detection dataset have indicated that Random-Forest classifier has shown better performance than K-NN and Decision-Tree algorithms. It has also been observed that proposed approach has shown significant reduction in dataset size thus by reducing the overall runtime of the algorithms. Moreover, the proposed approach has shown improvement over random sampling in terms of fall detection rate. As a future work, a mathematical model for bound on the subset size needed for training will be studied and the proposed algorithm will be tested with other classifiers.

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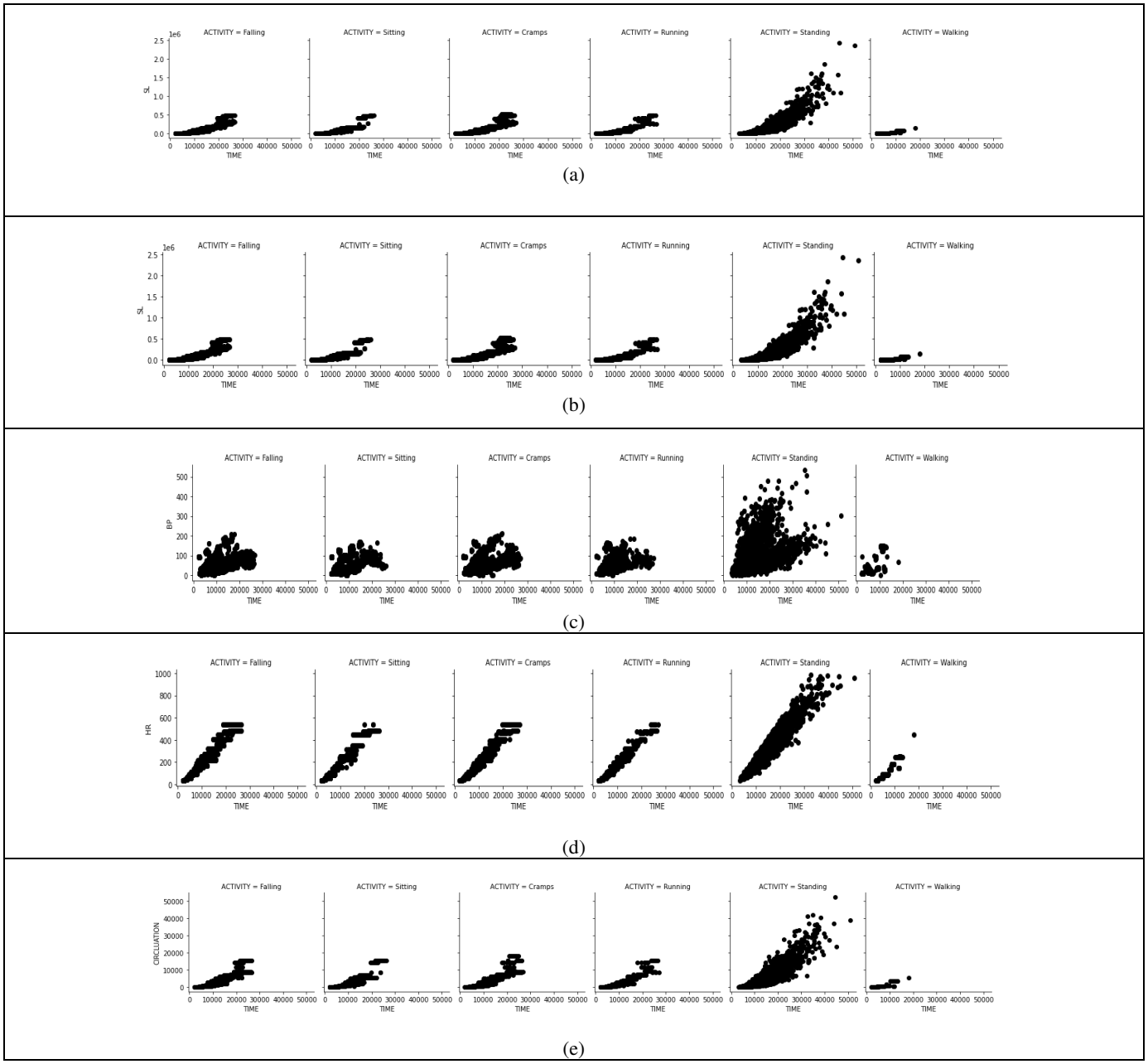

Fig.5. Distribution of features across various activities. (a) Sugar level (SL), (b) EEG monitoring rate (c) (EEG), Blood pressure (BP), (d) Heart beat rate (HR) and (e) Blood circulation

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Study of Security and Privacy Challenges and their solutions in IoT data

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***Abstract*—Internet of Things is the focus of attention these days. It is an interconnection of devices ranging from computers to sensors to mechanical machines and practically any object. Various IoT applications are developed to automate tasks in the field of engineering, environment, agriculture, health sector and other sections of society. This empowerment also presents many challenges that are to be handled in order to use technology advancements. Since communication between devices using different platforms happen at all levels, it becomes very important to secure this data. Huge amount of data is generated when devices communicate, so this data needs to be secured. Security and privacy of data has been very important since the invention of networks and IoT also has many risks associated with respect to security and privacy of data. This paper is intended to provide the reader an understanding of IoT, its use cases, working architecture and its security threats. The paper gives details about basic security techniques as well as the latest block chain technology to secure data.**

Keywords—IoT, Security, Privacy, Cryptography, Block chain

I. INTRODUCTION

Internet of Things (IoT) is an interconnection of devices ranging from digital devices, mechanical machines, things, objects and individuals. Each device has its unique identification assigned to it and they can transmit data over the network [1]. This communication need not require any collaboration between human beings and machines. The term "Internet of Things" was first introduced in 1982 by Kevin Ashton. Fig.1 below shows the evolution of IoT over the years. We can easily observe in our day-to-day life, concept of smart home seemed to be fictional. But it has become a reality now. Smartphones have changed life of all of us. Now, smartphones are AI enabled and have great processing speeds. We see many devices today which perform tasks in synchronized manner with other devices and can be monitored and controlled by us. There seem to be endless possibilities that the evolution of IoT is providing us.

A thing in Internet of things (IoT) can be any device which has capability of computing, has some way to be uniquely identified and can transmit data over the network. These devices have sensors built in them using which they sense the environment, collect data and transfer it over the network. Internet of things gained popularity around the years 2007-2008 and a brief overview of IoT is shown in fig 1. As number of devices are connected over the network, several network characteristics such as how much memory is to be used, how much power could be consumed, how many devices can be handled and robustness of the network are to be taken care of.

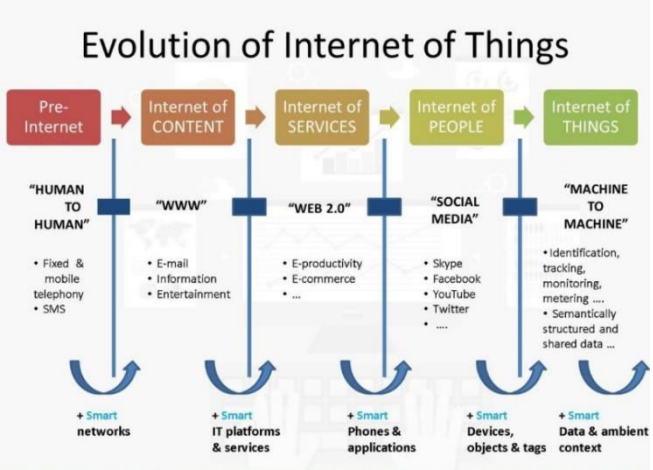

Fig. 1 Evolution of Internet of Things [23]

Architecture of IoT:

Initially three-layer architecture of IoT was proposed which was the most basic architecture. With continuous development in the field, this architecture could not fulfill all the requirements of IoT. So, ITU-T (Telecommunication Standardization Sector) proposed a model comprising of four layers [11] as shown in fig. 1. The layers have following responsibilities:

- Application layer: This layer is the interface between the end IoT devices and the network. It defines various applications which are using IoT mechanism. For example, we are dealing with any health monitoring or smart home kind of system then job of this layer is to provide services to customers. It also determines set of protocols to be used for passing messages at the application level.
- Application support layer: This layer was introduced in the architecture to overcome the security flaws encountered in three-layer architecture. It is responsible for both application specific support and generic support. There are certain requirements which are specific to an application and certain others which impact most of the tasks over the network such as processing capacity, storage related requirements and maintenance [3].
- Network layer: This layer is also called as transmission layer. Transmission can be either wired or non-wired. This layer performs the job of controlling network connectivity by performing certain functions which include authentication,

accounting, mobility management into the IoT system.

- Device layer: Since number of devices can interact in an IoT setup. There are certain device features which include how the devices will interact with the network, how will they collect and further send information etc. Device layer is responsible for deciding all the functions related to different devices, controlling their access, their interface support, communication between themselves etc. Devices have sensors embedded within them to collect information. Depending upon the requirements of the application, the sensors are chosen.

The main reason for switching from three layered architecture to four layered architecture was to strengthen security. Apart from these, these four layered models also include management features and security features [3]. Generic management features in IoT are related to management of different devices involved, their activation and deactivation, any upgradations required, network topology management, congestion control and handling other diagnostics. Generic security features are aimed at device authentication, proper authorization, maintaining data integrity, ensuring protection and privacy of data. An architecture having 4 layered system is shown in fig 2.

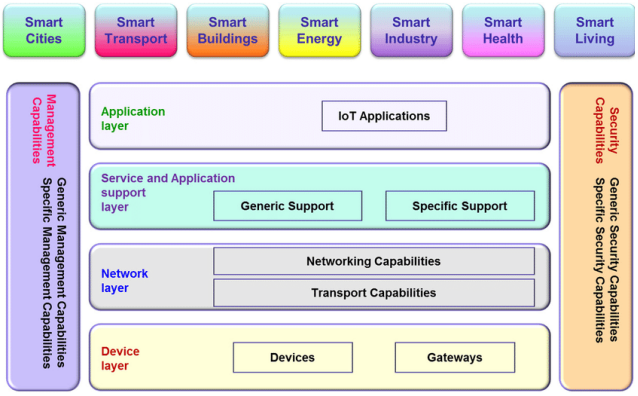

Fig. 2: Four layered architecture proposed by ITU-T

In the times of Internet of Things, number of heterogeneous equipment such as TVs, laptops, fridges, ovens, electrical appliances, cars, and smartphones are connected over the internet. In this new scenario, projections indicate that the Internet will have over 50 billion devices connected until 2020 [1]. And this number is going to increase only.

II. Issues and Challenges in IoT

With all this vast spectrum of IoT applications comes the issue of security and privacy [4]. Along with the security issues faced generally by the Internet, cellular networks, and WSNs, IoT also has its special security challenges such as privacy issues, authentication issues, management issues, information storage and so on [4]. All these issues make the IoT applications very vulnerable for different kinds of cyber threats. Various cyber-attacks on the IoT based applications related to security and privacy have been reported worldwide. Since devices have less computing capability and are less secure, they become soft targets for attackers. The domain of IoT is expanding beyond mere things or objects. Cyber Physical Systems (CPS) is another area benefitting from the growth of IoT. In CPS physical objects in the environment are monitored, and actions are taken based on the physical changes [4]. Security lapses in such systems can result in serious consequences if attacked by attackers.

Inter-operability, lack of standard's, legal challenge's, regulation related issues, issues related to rights, internet of things economy issues and other development related issues are also some minor issues related to IoT. A brief description of internet of things related issues and challenges by The Internet Society(ISOC) are described and various issues and how they were raised [8]. Following are the factors which demands security standards to be accurate and in place:

Confidentiality. Data that is travelling across the network is prone to be attacked and secret information can become public. Communication in IoT based system can happen between Machine to Machine, Machine to Human, Human to Human, or Human to Machine. Data must securely reach from source to destination. Different encryption/decryption algorithms can be used for keeping information confidential.

Data Integrity. Data should remain intact while travelling from source to destination in the network. Data might be attacked during transmission mechanism should be deployed which ensures that data is not exposed even if it has been attacked. Attacker should not be able to see, change or modify data even if they achieve it.

Authentication. Information is to be sent from sender to receiver. Sender and receiver should be able to authenticate each other.

Human IoT Trust Relationship. Trust is not defined for human beings only; it should also be defined for Device or System. Trust is defined as human to human, human to device, device to device and device to human [2].

A. *Security Issues in IoT*

IoT devices like Wearable's, Thermo-stat Systems, Air Conditioner and refrigeration systems that uses wireless communication (Wi- Fi) for remote monitoring. Apart from all the use cases, IoT still has various other issues that need to be sorted before actually implementing it in day-to-day use. There are issues also related to different technologies on which the foundation of IoT should be established, so that hackers can't get access of system. System may get compromised due to these bugs and privacy of the consumer is lost or it may be used wrongfully by hacker. So, implementation of IoT should be done keeping in mind the security of the system.

Very soon, IoT will have an impact in the expansion of areas of cyber attacks in homes and offices by transforming the objects with online capability in the devices that have offline functionality. Security systems are not enough to overcoming the problems however Blockchain is possible solution used for creating IoT system save and secure in upcoming time.

The major classes of threats according to [9] are:

- Accessibility Threat: The motivation is to prevent the illegitimate user from getting access to other's data or services.
- Anonymity Threat: The aim here is to analyze the anonymous transactions done by the user and other related publically available information in order to find out the real-world identity of the user.
- Authentication/ Access control Threat: The aims is gaining authentication as a valid user so as to gain access of data.

a) Attacks that threaten accessibility of IoT devices:

- Denial of Service(DOS) Attacks: In this type of attack, the target system is directed with lot of transactions by the attacker so that the system can be indulged with various requests to work upon and therefore break its availability.
- Modification Attack: In this type of attack, the adversary tries to change or erase stored data for some particular user or for all the users. In this attack adversary tries to compromise the cloud storage security of the user. However, target system might be able to detect the changes in the storage system by comparing/matching the hash value of data in the cloud with stored hash in its local system.
- Dropping Attack: All the received transactions and blocks are dropped once the adversary has established control over a CH(s). This type of attack can get detected because nodes that belong to the constituent clusters would not receive any transactions/services from overlay.
- Appending Attack: Multiple Ch(s) that work cooperatively must be controlled by the adversary to launch this attack. For increasing the indirect evidence rating, the malicious CHs sign the multisig transaction along with the fake block to claim that they have verified the block.

b) For breaking anonymity, an adversary may attempt to link together different transactions having different IDs to any other real identity in the network system.

c) Attacking authentication and access control, where the adversary aims to hack into existing devices in the home. There can be other possibility of the adversary trying to add a new device to the smart home in order to get all the details at some later point of time.

The major factors impacting the security of the IoT model is the rapid growing prevalence of intelligence embedded system in virtually all the types of consumer devices and some very crucial applications such as remote monitoring, e- health and the need for reliable security [15] There are many challenges associated with securing the IoT devices in a reliable manner. The factors that affect it are:

IoT/ CPS technology and systems are comparatively new and less used than the traditional IT systems.

- IoT/CPS systems are geographically distributed over a wide area, generally in open environment.
- IoT/CPS systems are currently deployed singularly across vendor-specific vertical applications, creating fragmented technology and administrative silos.
- End to end comprehensive standard of networking or security are not developed, stabilized, adopted, or even implemented; standardization would enable simpler integrated systems (including security).
- The addressing models and formats are used in a way which get complex across different applications.
- The diverse operating systems of number of devices in an IoT based system have feature sets which affect the functional capabilities of the overall system.
- For reducing upgradation and overall cost, generally there are inexpensive and limited functionality machines deployed in IoT based systems. This further limit the use of heavy-duty firewalls.

B. Privacy Issues with IoT

Most of the applications of IoT includes working with confidential/ private data, Let's say when device is associated to person, in electronic health scenario, problem of data privacy and anonymity are very much needed to be cared off. The important issue here is that the transactions are publicly logged and are available for all to see them. If anyhow the transactions can be linked to their owners or the identity of the owners is disclosed, then the adopted anonymity scheme has failed. In an ideal scenario, it is expected that the publicly available information cannot be used to identify the authenticated users of transactions or address in the network.

Righteousness in unethical use and data storage due to lack of rigorous rule for data collection by the IoT devices is likely to cause promote inappropriate use of data. Due to lack of conservation for the data accumulated by the IoT devices as information, it is likely to be. There are few multi- party models that enables transparency, expression and enforcement. Further, lack of privacy protection model and inability to recognize the expectation of users, there are limited number of resources to develop IoT devices integrated with privacy principles.

III. INCORPORATING BLOCK CHAIN: RECENT TREND

As discussed above, IoT is collection of things and thing can be any object. It need not be necessarily a computer system. From security point of view, decentralization is going to overcome many problems that arise when number of devices rely on a centralized approach.

In recent times, Blockchain technology has been gaining attention in providing IoT solutions. Though, it has been used substantially in the financial domain where the ultimate goal is to secure the money related transactions. But it has shown promising solutions in other domains also. Researchers have been using it in diverse technological areas. It has enabled Internet of Things model to be viewed in different aspects so as to highlight the advantageous

decentralized environment, facilitating interactions, allow coordination between devices in the network and enabling new transaction models [3].

There have been many initiatives by leading companies are leading initiatives to integrate block chain into their production management and supply chains. For example, IBM is using its large cloud infrastructure to provide block chain services to track its products as they move from one stage to another across the supply chain [3].

Several other startups are also promoting blockchain and creating new business model for centralized servers so as to ensure transparency. Several technical and financial companies have formed a consensus to set new standards using which IoT applications will be secured by Blockchain. This group aims at establishing a blockchain protocol to build IoT devices, applications, and networks [5].

IV. ARCHITECTURE OF BLOCKCHAIN

Blockchain: Nakamoto [15] (original Bitcoin developers nickname) introduced Blockchain as a mechanism to ensure auditability, immutability, and non-repudiation to provide security to electronic transactions, serving as a giant distributed ledger. This mechanism is the main innovation introduced by Bitcoin. It represents a way to reach consensus among unreliable participants.[3].

Blockchain technology has 4 underlying pillars, first of them being Consensus, which aims to provide the Proof of Work(PoW) and verifies actions in the network, second is known as a ledger that provides entire details of the transaction within the network, third is Cryptography whose job is to ensure that data in the ledger is encrypted which can be decrypted by authorised users only. Fourth pillar known as smart contract is used for checking the authenticity of the users in the network. Each transaction in the public ledger is verified if majority of consensus from a majority of participant in the blockchain environment, interconnection of ledger. In the blockchain system information can never be erased once verified. The blockchain environment contain verifiable records of each and every transaction ever made in the system.

Blockchain mainly has following 4 components which form its complete infrastructure:

- Network of Nodes: All the nodes present in the network are connected with each other and records are kept for each transaction made on the the blockchain network in collaboration. Using different protocols, the authenticity of the transaction can be checked to further eliminate the intricacy of other 3rd party for validating. After completion of transaction, all its history is concatenated in the ledger of previous transactions and the process is called 'mining'. All the other nodes that are present in the system helps in verifying the proof of work as shown in fig 3.
- Distributed database system: It is consisting of block of data that had a copy of information in rest of node in the blockchain environment. Every block in the system contain: a timestamp and History of the transactions which is used to tie-up previous blocks in the network as shown in fig [3].
- Shared ledger: It is a record of transactions which gets updates after every single transaction. The shared ledger is accessible to everyone which increases transparency of the system.
- Cryptography: which predicaments the record of information with a mechanism that can't be tracked or tempered by unauthorized user.

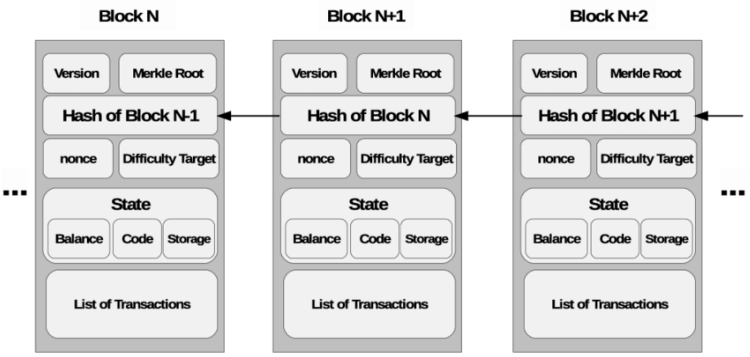

Fig. 3: Blockchain design structure [22]

Deployment of blockchain is based on 3 types of access:

A. Public: In this type of access, all nodes can send or read transaction and can participate in the consensus process. No special permissions are required in this case. Cryptocurrencies like Etherium as well as Bitcoin fall under this category.

B. Consortium: It comes under partial permission the consensus process allows only the defined nodes to take part into it. The permission for reading or sending might be access-able with some restrictions to a pre-determined number of nodes or may be publicly available.

C. Private: In this type of system, transactions can be written only by the organization to whom the network of blockchain belongs to. Depending upon the requirements, reading permission of the transaction might be restricted or publicly available. This type of system is generally deployed in industrial fields.

Main fundamental functions of blockchain network are:

a) Peer- to- peer messaging

b) Distributed data sharing

c) Autonomous coordination with the device.

An example of blockchain technology can be illustrated using yap payment system [13] where a buyer broadcasts to a network that the seller's Bitcoin address is the new owner of specific Bitcoin unit. Thus, information is distributed over the network until all nodes are informed about the ownership transfer, detailed architecture of blockchain is shown in fig 3 and brief architecture is shown in fig 4.

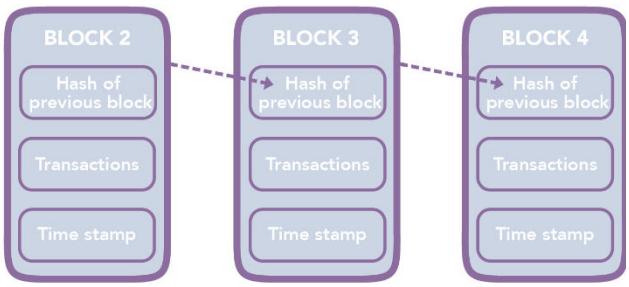

Fig 4: Blockchain Ledger System.

The advantages of blockchain for improving conventional IoT systems are described as follows:

- Decentralization: Blockchain decentralization denotes the following:

(i) There are no centralized nodes controlling over the system

(ii) Blockchain nodes can freely join in or leave the blockchain network.

(iii) Nodes can interact with each other implicitly without involvement of some 3rd party.

For IoT based on blockchain it is easier to merge external nodes in the network to increase the performance of the system. And the system, can abide attacks like Denial of service(DOS).

- Collective verification and tamper resistance: Collective verification states that all the information is needed to be verified with the help of history of transaction stored in the ledger before concatinating the data in the ledger. And to increase the credibility of the system, all the transaction in the system cannot be altered throught-out the system.
- Privacy: Some blockchain platform provides security and privacy ensurity for the users (e.g. Zerocash [6] and Monero [14]). Thus, blockchain may be considered as the system that can secure privacy of the users.

V. Strengths of Blockchain towards IoT

Blockchain is very much a perfect solution which addresses identity management of IoT, however as in case of Bitcoin ecosystem, there may be application where inconspicuousness needs to be managed. In case of wearables with the functionality of not to disclose identity of the user while sending transmitting data to ensure the privacy of users.

IoT is optimizing and automating processes to become a key component of digitization. By using volumes of data that can be used to get more meaningful insights in the behaviour of consumers. This knowledge helps in improving the quality of life of citizens through the digitization of services in the cities. IoT can get high benefits from the functionalities provided by blockchain. Various advances in blockchain will helps in developing current IoT environment and this research topic is still in a preliminary stage.

The problem of data privacy in transparent and public blockchain has already been discussed in the previous section. The problem of data privacy in IoT device starts at data accumulating and extends to the communication and application levels. Securing the device and the associated database should be taken care-off so that data is stored securely and without permission no one can access it is a challenging task since it requires the integration of security cryptographic software/algorithms into the device. Many technologies are used to facilitate the secure communications using encryption (IPsec, SSL / TLS, DTLS) as shown in Table1. IoT device limitations often makes it necessary to use less constrained devices like gateway to assimilate security protocols. With the usage of cryptographic methodology, hardware can accelerate cryptographic operations and the associated functions will avoid the overhead of other complex secure software protocols thus concentrating more its useful features.

VI. Securing IoT using Blockchain

Secure communication: In the network, different IoT devices communicate amongst for the purpose of exchanging data which is required to process a transaction. It is then saved in the ledger [19]. Encryption keys are also saved in the Shared ledgers so that exchange and transaction processing is done in a confidential way. Using the public key of target device, IoT devices sends encrypted message to store it in the blockchain network, a detailed description is shown in Table 1 for various issues that occur in IoT and their proposed solutions. The node is then asked by sender to fetch public key of receiver which is there with the ledger. After that, the message is encrypted using public key of the receiver in a way such that the message can be decrypted by receiver by using its private key [20].

A. Authentication of users:

Message if digitally signed by the sender before sending it to all other devices. Receiving devices fetch the public key from the ledger system and uses it to check the digital-signature of received message. Digital-signature methodology works as:

- Firstly, the sender calculates hash of a message that is then encrypted with its private key.
- The digital-signature along with the message is transmitted.
- This digital-signature is then decrypted by the receiver by using the public key of the sender which is stored in the ledger. It will be further used by the sender to obtain the hash value.
- In order to consider the message valid, the protected hash value should be equal to the calculated hash.

The trust factor of retrievable messages improves the digital-signature of each message if already had a place in the ledger.

VII. Conclusion

Privacy and confidentiality are still considered as a problem with IoT. With integration, IoT is going to get strengthened by the features provided by block chain technology in the areas of security and privacy. Basic security techniques like

steganography and cryptography have also been discussed so as to give the reader overall understanding of data securing techniques. This article emphasizes on the use of block chain technology with IoT to ensure safe and secure transmission of data amongst devices connected in a network. Overview of blockchain technology and security issues faced by IoT environment is discussed as well as the use of block chain-based system as a solution for overcoming various issues.

TABLE I. MAJOR ISSUES AND THEIR SOLUTIONS IN IOT.

Issues	Proposed Solutions
High latency, high band width and security and privacy issues [16].	1) A Hybrid distributed architecture for sustainable smart city network. 2) A proof- of- wok scheme to ensure security and privacy.
Software and network, missing connection with the real world and Lack of digitization [17].	1) RFID chip based solution with built in asymmetric encryption algorithm. 2) Uses advantages of both decentralized blockchain and Waltonchain implementations.
Decision framework for using blockchain in IoT [18].	Questions Answered: 1) Do user actually need to use blockchain. 2) if yes, which platform is most suitable for user for comparing existing systems.
Blockchain is costly and needs high bandwidth [10].	Proposes new secure, private and light- weight architecture for IoT to eliminate overhead of BC retaining benefits of the blockchain technology.
Access control nature of blockchain by third party users [11].	Proposes FairAccess as a new decentralized pseudonymous and privacy preserving, authorization management framework. And Leverages the consistency offered by blockchain based cryptocurrencies to provide stronger and transparent access control.
Access control functionality [21].	Model exploits the immutability feature of Blockchain to store the whitelist of devices. The account number in Blockchain solves the problem of no unique identifier in IoT. So, no one can alter its contents providing better authentication and access control.
Security issues of centralized servers [12].	1) In BeeKeeper system, servers can process a user's data by performing homomorphic computations on the encrypted data without learning anything from them. 2) Malicious nodes can be scrutinized to secure computation. 3) No need of large memory and high computational resources.

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Computer Vision based Pre-processing System For Autonomous Vehicles

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***Abstract*—Autonomous vehicles are considered to be the future of automobile industry. With improvement in autonomous vehicle's efficiency, they can be made much safe for people to use them. Our aim is to contribute a robust and realistic approach to improve the data interpretation and decision making capability of the vehicle. It consists of three major parts. First part includes pre-processing of raw data captured by camera for better interpretation and understanding of surrounding in which the car is being driven. Second part discusses about path and object detection from the pre-processed image for making decisions. Third part is extension of second part which discusses about implementation of an algorithm simultaneously being applied to calculate the distance between the objects and cars in real time.**

Keywords—Digital Image Processing, Computer Vision, Deep Learning, Reinforcement Learning, Autonomous vehicles

I. INTRODUCTION

Autonomous vehicles can be defined as a vehicle capable of sensing its environment and moving safely without or little input from human. They combine several sensors to understand their surroundings and act accordingly. They may reduce car ownership with low-cost shared-vehicle services moving from one transport job to the next. For those that choose to still own vehicles, they may make transportation faster, safer and more reliable. Current commercially available vehicles offer some automation, such as self-parking and even limited driving in some circumstances.

Concept of autonomous vehicles can be traced from development in automobiles in early 1920's. But major development started during 1980's after development of modern sensors and growth of wireless technology. After 1 century, even today efficiency of decision making capability of vehicle is a major issue. As of 2020, we have 1.2 billion vehicles running on road, and have annual death count of 1.35 million people due to road accidents. According to Navigant Research report we would have 2 billion vehicles on road by 2035 which can lead to annual death count to reach 1.8 million by 2035. Driving in such conditions would be beyond human capabilities, thus we need to enhance the decision making capability and build a system for future.

Our aim is to propose a system through this paper that helps vehicles in better understanding of their surrounding by a continuous process that includes better pre-processing of raw data that is used for feature extraction by path and object detection by digital image processing and computer vision. Distance approximation algorithm is also implied parallel to feature extraction on preprocessed images. This would help in providing better understanding of surrounding of vehicle and can enhance decision making capability of system.

The paper is organized as follows: Section II discusses about the research work in related field; methodology is explained in Section III; followed by working in Section IV and results in Section V; Section VII depicts conclusion and discussions.

II. RELATED WORK

Path and object detection along with distance approximation algorithm are the main objective of this paper. Few of the available research work and literature study were referred to understand the already implemented and proposed systems in autonomous vehicle's domain.

Burleigh N[1] proposed a system similar to Audi Autonomous Driving Cup and Carolo Cup using deep learning for independently handling lane keeping and traffic sign recognition.

Zanchin[2] through their research discusses about improvement of comfort, safety and performance of autonomous vehicle for potentially reducing traffic and congested traffics. Through their paper they also discuss about sensor fusion for autonomous vehicles

Rajat Kumar Sinha[3] discussed about different deep learning algorithms that are used in solving conventional artificial intelligence problems. It also discusses about various approaches followed by applications like image classification, object detection, image extraction and segmentation in presence of noise.

Locktev [5] proposed an algorithm to estimate distance between objects based on geometric and kinematic parameters. It also discusses the use of methods and procedures of statistical analysis and probabilistic approach.

Xia. W and Li. H [6] proposed a system for autonomous vehicles which works on principles of reinforcement learning, where system learns from experience of professional driver and a Q-learning algorithm with filtered experienced and trained and implemented in the central system.

K. Tanwani [8] through their research explains usage of reinforcement techniques in real world complex situations and how can machine learn and implement how human solve such complex situations.

V. Mnih and K. Kavukcuoglu [9] in their research work discussed about psychological and neuroscientific perspective of behavior of models, which helps in optimizing their control in real world situations that may be difficult to depict on simulators.

All models and research works were considered and analyzed while building our system.

III. PROPOSED METHODOLOGY

The autonomous vehicle would have a system with attached sensors mainly camera towards front, side and top of the car. In order to increase the efficiency of vehicle, a separate system is needed that preprocesses the raw input captured through the camera. We focus on getting raw data from the camera, this data is then pre-processed using dilation and erosion techniques for better analysis of raw data which can be helpful in better interpretation of surrounding.

The pre-processed images are then used by object and path detection algorithm for locating path and finding objects on the roads. Simultaneously along with multiple object detection, distance between those objects and vehicle is recorded to analyze approaching and deviating objects from the vehicle. Distance is calculated by distance approximation algorithm that works on approximating the centroid of detected objects and tracing between centroids of those objects. All these collected information will be forwarded to centralized system for taking required decisions.

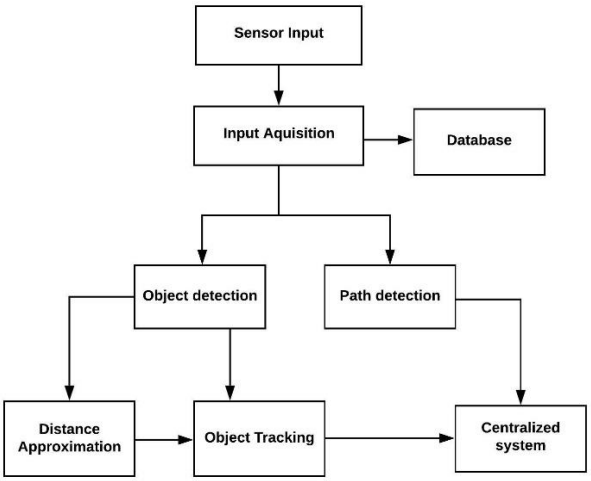


Fig 1. Block Diagram of Work Cycle

IV. WORKING

Following techniques are used for implementing the proposed system:

A. *Preprocessing*

Images of surrounding are captured from camera sensors and sent to processors for pre-processing. Many a times the vehicles are been driven in conditions like sunny, cloudy days or other conditions that would result in colour contraction among images. This may result in ignorance of vital information for vehicles. Therefore pre-processing of images from camera sensor is done before image processing for better interpretation of information.

Morphological operations like erosions and dilations are performed depending on requirement. Dilation is done for increasing the pixel values and erosion is done to decrease the pixel values from the targeted region of the image. These techniques are mainly applied on sign boards and objects in images. Above discussed morphological operations are performed using computer vision and applying kernel on the targeted portion. Kernel of odd matrix runs through the image and depending on timely requirement the changes are made (the 0,1 pixel of image would be considered as 1 ,if all values under kernel is 1 in case of erosion and would be considered as 0,if all values under is 0 in case of dilation).

(a)

(b)

Fig 2. (a) Image of a signboard prior to Image dilation, (b) Image of a signboard after to Image dilation

In situations when images are captured from different views, it becomes difficult to interpret, we apply perspective transformation for targeted areas of images. In is achieved by computer vision techniques by which the object traced in targeted area by detecting and marking of object corners. Object's distortion is then changed multiple times and shape with better understanding than others is selected and then forwarded for analysis and detection.

(a)

(b)

Fig 3. (a) Image of the signboard before image transformation, (b) Image of the signboard after the image transformation

B. Path and Object Detection

While driving the autonomous car on the road, the vehicle may come across situations where an unwanted or unknown object is on its path. If such situations are not resolved quickly, it may result in accidents. To tackle such situations, an Object detection mechanism is designed such that it detects unwanted objects on the roads in between the lanes and acts accordingly.

This can be done using the Binocular Vision model which is based on a 2-CNN model. This imitates the human eye structure by using the left and the right cameras as a pair of human eyes collecting images from two different viewpoints. It simulates the achiasma case, in which the right and the left images are used to train two different CNNs without any crossing of the signal between the two of them. This helps to determine the position distance and the speed of the object

The mechanism of the autonomous car allows it to take snapshots of its surroundings through cameras mounted on the left, right and center of it. If any image with an anomaly such as presence of a vehicle or person on the road is captured during a particular instant of time, which is different from that on which the Behavioral Cloning CNN has been trained, it is quickly identified. The cameras capture the same object from two different viewpoints.

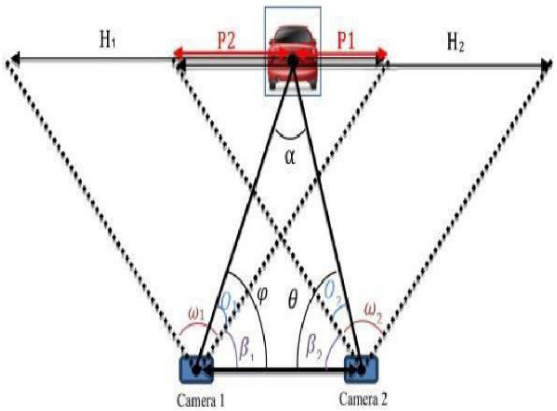


Fig 4. Illustration of the angles used to calculate the value of 'h'

The images are pre-processed and cleaned to enhance the image for easy processing. The pictures are then fed as input into the model. The feature outputs from the two Convolutional Neural Networks are then given as inputs to the Flattening layer and flattened out.

Following this, the distance between the autonomous car and the object on the road is calculated using the Triangulation formula using the separation between the x coordinates of centroid of object from both the images.

$$h = \frac{Asin\left(P2 \cdot \frac{\omega_2}{H_2} + \beta_2\right) \; sin\left(P1 \cdot \frac{\omega_1}{H_1} + \beta_1\right)}{sin\left(180 - \left(P2 \cdot \frac{\omega_2}{H_2} + \beta_2 + P1 \cdot \frac{\omega_1}{H_1} + \beta_1\right)\right)} \quad \text{…….. (1)}$$

The distance of the object from the vehicle is closely monitored. If the object falls in between the lanes on both sides and distance between them seems to be decreasing then an alarm or notification is raised to tackle the same

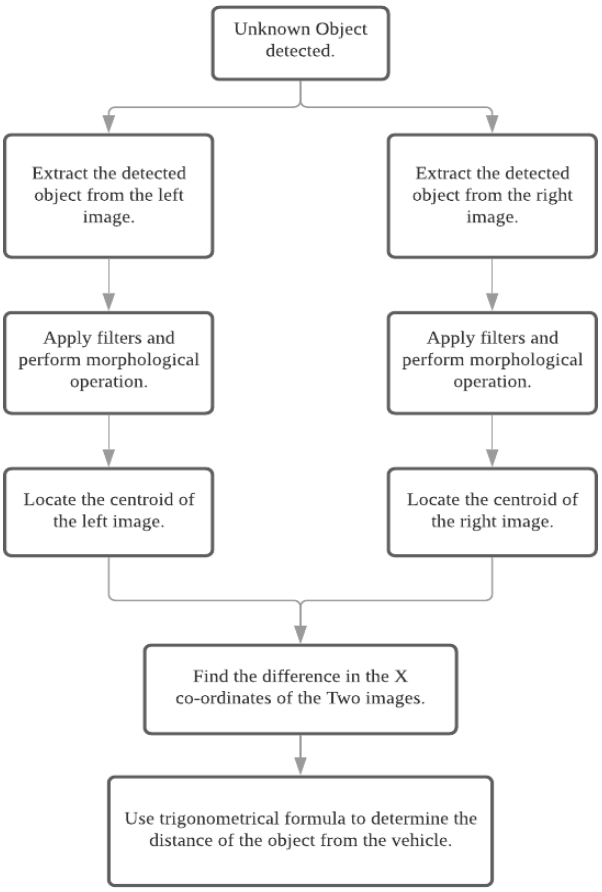


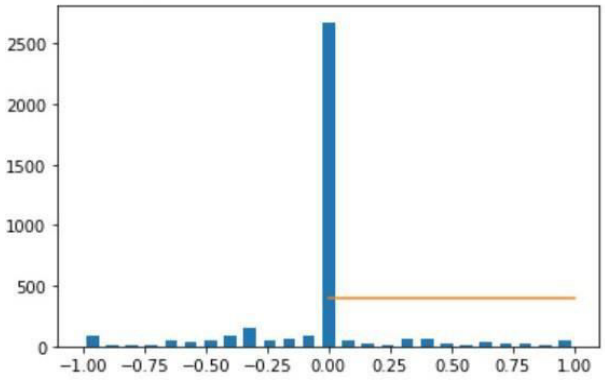
Fig 5. Flowchart depicting the above methodology

C. Distance Approximation Algorithm

Behavioral cloning is a method, by which a Deep learning model can capture the sub cognitive skills of humans, through the training data provided and replicate the same. The training data consists of the recorded data while the human subjects performs required action corresponding to the situation. The dataset used by the Autonomous car model consists of steering angle, throttle, reverse, speed as well as the front, left and right

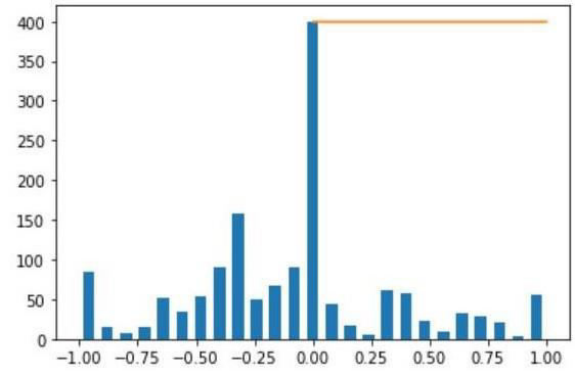
views' snapshots taken while manually driving the car in the simulation.

The Steering angle is the behavior that the model needs to learn and predict with the help of the other data from the driving log. It is represented by a normalized value in the range of -1 to 1. Initially, on plotting the histograms for the values of Steering angle against the numbers after adding the pairs of consequent values, we notice a segregation of 0 angle data



(a)

```
total data 3754
removed 2278
remaining 1476
[<matplotlib.lines.Line2D at 0x7f5bbbcdb438>,
 <matplotlib.lines.Line2D at 0x7f5bbbd7df60>]
```



(b)

Fig 6. (a)The dataset before removal of unnecessary steering angle data, (b) Dataset after cleaning.

A lot of same values in the dataset may lead to the model being biased to that as well as reduce the efficiency of the model. To tackle this, we remove the excess of 0 angle data. All the steering angle values are flipped as well to make sure that the model is not biased towards any specific condition

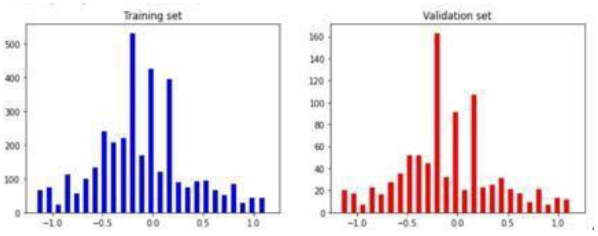


Fig 7. (a)The Training set and the Validation set

In any machine learning model, it is very important to pre-process the data by data augmentation and cleaning. For this, we use various pre-defined classes from the Cv2 library. The data is randomly selected and is resized. Followed by which Color space conversion from RGB to YUV is applied allowing reduced bandwidth and thereby providing a more efficient coding for image processing. Next, the Gaussian blur function which is a low pass filter function, is applied on the images to reduce the noise and detail in the images.

After the images have been corrected, we augment the dataset to increase the diversity of the data by creating variations of the images in the data. Generating more samples from already existing ones can be helpful if we don't have large enough datasets and also prevents over-fitting. The data hence becomes more diverse. Data augmentation for this model was applied to 50 percent of the data through random selection. This is done using the Affline class from the imgaug library in python. The following changes are made: Changing the scale of the images, panning the images to keep the main subject in focus, Adjusting the brightness and Flipping the images. These are applied to a randomly selected set of images from the provided Training and validation set.

Layer (type)	Output Shape	Param
conv2d_1 (Conv2D)	(None, 31, 98, 24)	1824
conv2d_2 (Conv2D)	(None, 14, 47, 36)	21636
conv2d_3 (Conv2D)	(None, 5, 22, 48)	43248
conv2d_4 (Conv2D)	(None, 3, 20, 64)	27712
conv2d_5 (Conv2D)	(None, 1, 18, 64)	36928
dropout_1 (Dropout)	(None, 1, 18, 64)	0
flatten_1 (Flatten)	(None, 1152)	0
dense_1 (Dense)	(None, 100)	11530
dropout_2 (Dropout)	(None, 100)	0
dense_2 (Dense)	(None, 50)	5050
dropout_3 (Dropout)	(None, 50)	0
dense_3 (Dense)	(None, 10)	510
dropout_4 (Dropout)	(None, 10)	0
dense_4 (Dense)	(None, 1)	11

Total params: 252,219
Trainable params: 252,219

Fig 8. Detailed summary of The Nvidia Model

The deep learning model used is the Nvidia model which is proven to be one of the best models for behavioral cloning for Autonomous cars. The input is a 3 channel image of size 200 by 66. The model is initialized by defining an object from the Sequential subclass from the 'models' class of the keras library which is a deep learning API, while using a Tensorflow backend. It has 5 convolution layers with 24, 36, 48, 64 and 64 filters respectively. The filter sizes in the first three convolutional layers are of 5 by 5 size while the remaining two are of 3 by 3 size. The stride length of the kernel is set to be 2 for both vertical and horizontal traversal for the first three layers only. All of the layers have

the activation function as 'elu' which is a modified version of 'relu'.

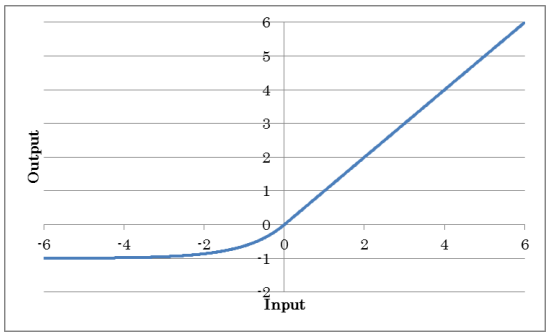


Fig. 9. The 'elu' activation function graph

The image pixels are flattened out after dropping 50 percent of the neurons to prevent overfitting. Followed by which 4 fully connected layers are added having 100, 50, 10 and 1(Output layer) neurons respectively. After every dense layer 50 percent of neurons are dropped out. Finally, the model is compiled by using the loss function as 'mse' (Mean Squared Error) and the 'Adam' optimizer with a learning rate of 0.3. A detailed summary of the Nvidia model is above.

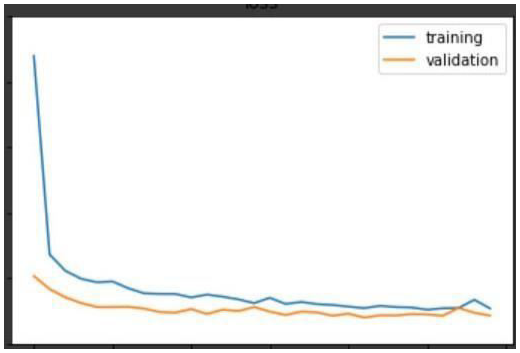


Fig. 10. Evaluation of model performance

The models goes through 30 Epochs with a batch size of 100 and verbose value of 1. The results of the trained model performance on the test set is evaluated using the graph plot.

V. RESULTS

The proposed system was trained and deployed on simulator. The results of new system was better than older systems available for simulator. The system was able to predict sign boards and lanes with better accuracy after learning from driver's behavior while driving.

VI. CONCLUSION

We have demonstrated a detail and step-by-step approach for the analysis system. The proposed method use pre-trained reinforcement learning based system, object detection algorithm, and a centralised system to pre-process input for better understanding of data. Based on the observations, the proposed methods can take decisions without human input

This paper can help in reducing road accidents and provide better experience of driving for driver. There are certain limitations with the system. Future prospects of our study include verifying the simulation results and further tuning them using Robocar (fully functional driving car, 1/10th the size of standard commercial car. The verification results are expected to demonstrate that learning autonomous driving in a simulated environment is a step towards driving on real streets.

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Rapid Measurement of Physical Quality of Dry Chili – A Machine Vision Approach

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***Abstract*— This paper presents a conveyorized machine vision system for the rapid quality estimation of dry chili based on visual appearance like size, shape, color, etc. Dry chili is extensively used as raw material to make Curry powder, Masala, seasonings, and pizza toppings. It has got certain standard characteristics parameters to meet the export quality like color, length, broken percentage, loose seeds, pods without stalks, damage and discolored pods, aroma, pungency, etc. Currently, these features are inspected manually by individuals by their expert vision. The human inspection methodology is subjective, non-repeatable, time-consuming, and error-prone. In this paper, a novel attempt has been taken to address the above problem by using a conveyorized system with machine vision technology, backed up by advanced software algorithms, and an effort has been made to correlate the results with human perception. The software has been developed to take color images using a digital camera in real-time and extraction of the dimensional and color features have been done through various image processing techniques and based on the export quality standards, chili quality has been estimated. Experiments have been conducted with different varieties of chili like LCA334, TEJA, Bidigi, etc. The accuracy of the system has been calculated as 96% as validated by human experts. Moreover, it has been found that manual inspection takes 15-20 minutes to analyze 1 Kg of chili samples whereas inspection using the developed system takes less than five minutes.**

Keywords—Chili; Conveyor; Color; machine vision; Image processing; Quality standard

I. INTRODUCTION

Chili is an annual sub herb belonging to the family Solanaceae. It is also called as hot pepper, red pepper, cayenne pepper, capsicum, etc. Most of the cultivated varieties in India belong to the species Capsicum annum [1]. Dry chili is extensively used as an ingredient in Curry powder, Seasonings, and pizza toppings. Chili imparts pungency and color to the dishes. It is an important ingredient in day-to-day curries, pickles, and chutneys. It is also a rich source of Vitamin A, C, and E [2] and assists digestion. It also prevents heart diseases by dilating blood vessels. Today, India has emerged as a major producer, consumer, and exporter of this spicy commodity. India is the largest and biggest exporter of chili in the world with production capacity about 8 lakh tones of dry chili from an area of over 9 lakh hectares [1]. Some varieties of chili samples are famous for red color because of the pigment capsanthin, others are known for biting pungency attributed by capsaicin. The export industry needs to evaluate certain physical quality parameters of chili like color, length, aroma, pungency, etc. Appearance-based quality parameters of chili are the length of the chili pod (greater than 5 cm, 3 to 5 cm), broken chili, pod without a stalk, discolored chili, foreign matter, loose seed, etc. According to the Indian Export Quality Standard, chili has got certain standard characteristics parameters to meet the export quality. The export quality specification of chili is described in Table-1.

Quality Parameter	**Specification**	**Specification/ Allowable range (based on Indian Export Standard**
Color	Bright Red	-
Pod Length	More than 5 cm	less than 5 cms, allowed up to 5% by weight
Broken	Less than 3 cm	Allowed up to 7% by weight
Pods without stalks	Pod only	Allowed up to 8% by weight
Foreign matter Discolored and damage Loose seed	Other than chili, loose stalk Yellow pod, pale red Seeds (White color)	Allowed up to 2% by weight Allowed up to 6% by weight Allowed up to 2% by weight

TABLE I. EXPORT QUALITY SPECIFICATION OF DRY CHILI [9]

Presently, the above said quality parameters are inspected manually by human experts. About 5 Kg chili sample is taken from 50 bags (each bag contains 50 Kg) for quality inspection using standard sampling mechanism. From 5 Kg of chili sample, only 1 Kg is used for appearance-based quality inspection. Each chili sample is inspected manually

by the naked eye and classified accordingly. The involvement of humans in the quality inspection process makes the quality assessment process subjective, non-repeatable, and cumbersome due to the pungency property of chili which creates burning to our eyes. Error due to subjectivity is influenced by individual experience, sex, fatigue, biasness to a particular brand, etc. Again visual inspection of tons of chilies is time-consuming and tedious also. Husin et al [3] describe a novel method to detect the chili plant leaf disease using image processing technology. Dimension based chili sorting using machine vision has been described in [4]. A machine vision system based on Hyperspectral imaging and machine learning has been proposed in [5] to estimate the Aflatoxin detection in chili pepper. [6] Has proposed a method to classify chili based on color (either green or red) and dimension (broken or whole) using image processing and machine learning methodologies. But none of the above research papers indicate any non-invasive methodology for chili quality estimation for the export industry based on digital image analysis. Also, there does not exist any instrument which can efficiently assess the quality of chili in a fast and reliable manner. In this paper, a novel attempt has been taken to address the above problem, by using a conveyorized system with machine vision technology, backed up by advanced image processing algorithms, which leads to a quality measurement procedure free from human intervention thereby improving the productivity and accuracy. This paper describes the experimental hardware setup with a schematic diagram and image analysis techniques implemented to assess the appearance-based chili quality parameters. A brief testing and analysis results have also been described here with a scope of future improvements.

II. Materials and Methods

A. Experimental set-up

The schematic diagram of the system is shown in Fig. 1 and the developed system is shown in Fig. 2. The system comprises of three main parts, a conveyor, a sample feeding cum spreading unit, and a machine vision module connected with a PC or laptop through USB (universal serial bus). The attached computer contains the machine vision software developed in the Visual C++ programming language.

The conveyor comprises a specially designed non-reflecting, textureless, uniform sky blue colored moving belt, electro-mechanical set-up for smooth movement of the belt, and a user-friendly control panel for controlling the speed of the belt movement.

The sample feeding cum spreading unit comprises a hopper where the chili sample is fed, a discharge chute where samples are dropped from the hopper, a vibrator which is mounted below the chute. The vibratory discharge chute is used to separate the chili sample such that it appears as non-connecting and non-overlapping when it passes on the conveyor belt. The separation is done by using several specially designed 'S' shaped, 'V' shaped, and 'U' shaped metal separators mounted on the discharge chute. As the chili sample passes through the separator, the lump of chili samples separate from each other and drop on the conveyor belt separately. A vibrator is used to vibrate the chute from its bottom to help this separation process. Hopper, chute, and other parts of the system which come to direct contact with the sample are made of food-grade steel. A machine vision module is placed on the conveyor belt such that the chili sample passes below it when moving on the conveyor belt. This module comprises of an enclosed cabinet, a digital camera, and a uniform illumination arrangement. The camera with illumination arrangement is placed inside the closed cabinet to avoid the external disturbance due to the change of ambient lighting condition. The camera is connected with a computer through a USB interface. When the chili sample is passed below the module, the camera captures the images of chili, and the image is analyzed by the machine vision software and the result is shown to the user.

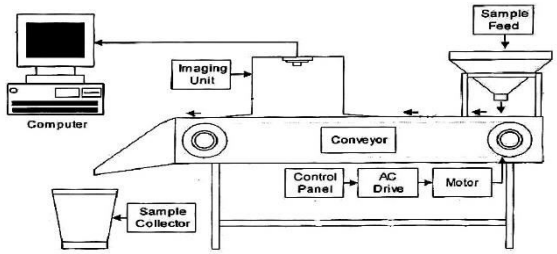

Fig. 1. Schematic block diagram of the developed system

B. Image Analysis

Digital Image Processing is one of the emerging areas in advanced research to extract various important information and features from the acquired images through some complex algorithms and techniques. So, digital image processing can be successfully applied here for quality estimation of dry chili. The conveyor belt starts rotating by pressing the start button on the control panel. About 1 Kg of chili sample is poured into the hopper. The slider at the bottom of the hopper is adjusted to control the flow of the chili sample to the vibratory dispensing chute. The digital camera acquires the image frame continuously with a speed of 5 frames/ second. As the speed of the conveyor is slow as compared to the image acquisition speed of the camera, the camera may take the image of the same object multiple times and produce an erroneous result during image analysis due to multiple counting of the same object. To address the above problem, a methodology has been provided to take the image of a single object once by partitioning the conveyor belt in several frames with white-colored strips. The camera attached to the system continuously feeds the live video stream of the chili sample (object) passing on the moving conveyor belt to a computer. The developed machine vision software analyzes the video streams and searches those image frames which have two white strips in predefined positions at the left and right side of the image. Only those images are sent for further analysis to extract

various dimensional and color features for quality assessment of chili. The result of chili quality analysis is stored in the database. The current frame analysis result and the accumulated result are presented simultaneously to the user.

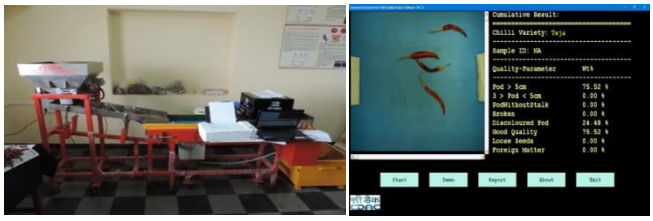

Fig. 2. Developed chili quality analysis system and software

Image Capture is done continuously from the live camera stream when the conveyor belt is moving and raw image data is extracted by this module. It checks whether the raw image data has two white stripes in the predefined position of the left and right side. If the condition is satisfied then the image data is sent to the next image analysis modules, else the next image is captured and again raw image data is extracted and checked. If it is found that the left and right white strip position of the next few images is the same then those images are discarded.

Cropping or masking operation removes the undesired parts of the image. The cropped image is then fed to the further processing steps.

The cropped image contains pixel data of the chili sample as well as the blue-colored conveyor belt. The contrast between the chili object and the belt color has been enhanced in this step for better background segmentation. The function is applied to all the pixels of the image. Here the input image is a color image, so the function has been applied on R (Red), G (Green), and B (Blue) channel separately. R, G, or B value of each pixel of the output image is the original value-added to the function output as described in (1).

Algorithm : Non - linear Image Enhancement
Input : Color image I
Output : Color image I′
for each pixel $p_{(R,G,B)}$ *of the image I*
begin

$$p_{(R,G,B)} \leftarrow p_{(R,G,B)} + \left(p_{(R,G,B)} \times c \times \left(\frac{1}{1+e^{-p_{(R,G,B)}}} \right) \right)$$

if $p_{(R,G,B)} > 255$ *then*
$p_{(R,G,B)} \leftarrow 255$
end if
end for ...(1)
Where, c is a factor depends on how much enhancement is needed

The value of 'c' describes how much contrast enhancement is needed. Pixel value p (R, G, and B value) of the image lies between 0 and 255. So, if the final output value of p(R, G, B) crosses the highest range of pixel value (i.e. 255) then the output value must be set to the highest pixel value as described in (1).

Before the segmentation operation, the original image data has been copied into a separate array to store the RGB color information of each pixel for further image analysis steps. Hue [7] is responsible for changes in color. The range of hue angle is 0° to 360° where 0° implies basic red, 120° implies basic green and 240° implies basic blue and again 360° implies basic red. A small variation in color under the same illumination or lightness and the same saturation can be measured by calculating the change in the hue angle. Realizing the fact that the color of the chili pod, chili stalk, and background has entirely different color the hue angle has been selected to segment the objects from the background. “Chili_Pod_Stalk_Threshold” has been used to segment the pod with a stalk from the background and “Chili_Pod_Threshold” has been used to segment the chili pod and chili stalk. The enhanced image is in the RGB plane. So to perform background segmentation in Hue requires the image transformed into HSI (Hue, Saturation, and Intensity) plane. As there is no need for Saturation and Intensity components of the HSI plane, only the hue component of each pixel has been extracted using (2).

Algorithm : RGB to Hue calculation
Input : Color image I
Output : Color image I′ with Hue values of each pixel
for each pixel $p_{(R,G,B)}$ *of the image I*
begin

$$p_{Hue} \leftarrow \frac{0.5 \times [(p_R - p_G) + (p_R - p_B)]}{\sqrt{(p_R - p_G) \times (p_R - p_G) + (p_R - p_G) \times (p_G - p_B)}}$$

end ...(2)

The hue value is then checked with the threshold condition to decide whether the pixel is foreground or background by (3).

Algorithm : Background Segmentation
Input : Color image I with Hue values of each pixels
Output : Binary image I′
for each pixel p_{Hue} *of the image I*
begin
if ($p_{Hue} >= hue\_low$ *AND* $p_{Hue} <= hue\_high$) *then*
$p_{(R,G,B)} \leftarrow 255$ *(Make pixel foreground)*
else
$p_{(R,G,B)} \leftarrow 0$ *(Make pixel background)*
end if – else
end
Where, hue_low = *Lower threshold limit*
hue_high = *Higher threshold limit* ...(3)

A fixed threshold has been used here because the images are captured in controlled conditions. The output image in this is a binary image containing a pixel value either 0 or 255.

Connected component labeling is an essential task in digital image processing. After the background segmentation process, the foreground objects must be correctly labeled for feature extraction. Stack-based connected component labeling has been introduced here which has better performance than the general two-phase connected component labeling technique. The algorithm has been described in (4). This algorithm raster scans the whole image and checks every pixel whether it is foreground or not and whether it has been labeled or not. If it is a foreground pixel but not labeled yet, the algorithm labels the pixel and put it onto the stack. Then it checks the stack and pop the pixels from the stack one by one and checks the 8 neighborhood of the popped pixel whether any of its neighborhood is foreground and labeled or not. If not then labels it and push it onto the stack. In this way, at the end of

scanning, every connected object within the image is labeled.

```
Algorithm : Connected Component Labeling
Input : Segmented binary image I
Output : Uniquely labeled groups of connected objects
Initialize variable lab ← 256
Initialize Stack S ← ϕ
for each pixel p in the image I
  begin
      if p = foreground AND p ≠ labeled then
            p ← lab
            PUSH p(x, y) to S
            while S ≠ ϕ
            begin
                  p'(x, y) ← POP S
                  for each 8 neighbor location i(x, y) of p'(x, y)
                  begin
                        if i(x, y) = foreground then
                              i(x, y) ← lab
                              PUSH i(x, y) to S
                        end if
                  end for
            end while
            lab ← lab + 1
      end if
end for                                                    ...(4)
```

Hole filling operation has been done to fill the unwanted holes created in the background segmentation step. Hole filling is necessary for this scenario because the reduction of the actual foreground area of chili due to holes will affect the actual output. Also, another reason to apply hole filling in this image analysis technique is to reduce the probability of unwanted shape recognition at the time of morphology analysis and to preserve the connectivity of foreground objects. Before filling the holes, pre-processing optimization needs to be done to close some open holes created at the perimeter level which are just 1 pixel away of being closed. In this pre-processing step, two opposite neighborhoods of any background pixel have been checked whether both neighborhoods have the same label or not. If the condition is true then the background pixel is updated as the foreground of the same label as described in (5).

```
Algorithm : Hole filling pre - processing
Input : Labeled image I
Output : Labeled image I' with 1 - pixel gap filled
for each background pixel p(i, j) of the image I
begin
      if (p(i, j - 1) >= startlabel AND p(i, j + 1) >= startlabel
                              AND p(i, j - 1) = p(i, j + 1)) then
            p(i, j) ← p(i, j + 1)
      end if
      Repeat the process for every opposite neighbor
end for
Where, startlabel = Initial label                          ...(5)
```

Hole filling has been done differently unlike morphological hole filling. First, all holes have been labeled by the above said connected component labeling algorithm. Then the neighborhoods of the perimeter pixels of the holes have been checked to see which foreground object the hole belongs to. Then the hole is filled with the label of the foreground object it belongs to as described in (6).

```
Algorithm : Hole - Filling
Input : Labeled image I
Output : Hole filled image I'
for each foreground object obj of I
Begin
      for each hole h belongs to obj
      Begin
            p(i, j) = perimeter point of h
            if (p(i, j - 1) = objlabel OR p(i - 1, j - 1) = objlabel
                  OR ... repeat for all neighbors) then
                  if(BoundingRect(h) ∈ BoundingRect(obj)) then
                        fill h with objlabel
      End
End
Where, objlabel = Label of obj                             ...(6)
```

The morphological skeletonization [7-8] technique has been used here for curvature length calculation. The morphological skeletonization has been done using (7). The skeletonization algorithm has been applied here to each foreground object for multiple iterations to extract the one-pixel wide skeleton. First, the labeled image has been copied to an array for the skeleton operation. Then the array has been converted from a labeled image to a binary image. Then the binary image is checked with four conditions in two sub-iterations as described in (7).

```
Algorithm : Morphological Skeleton Detection
Input : Labeled hole filled image I
Output : Labeled skeletons of all foreground objects
Img ← I
for each pixel p(i, j) in Img
Begin
      if p(i, j) is foreground then
            p(i, j) ← 1
      else
            p(i, j) ← 0
End
for each pixel p(i, j) in Img
Begin
      Delete p(i, j) iff Conditon(G1) AND Conditon(G2) AND Conditon(G3)
End
for each pixel p(i, j) in Img
Begin
      Delete p(i, j) iff Conditon(G1) AND Conditon(G2) AND Conditon(G3')
End
Condition G1 :
      X_H[p(i, j)] ← 1
where,
      X_H[p(i, j)] ← Σ_{i=1}^{4} b_m
      if x_{2i-1} = 0 AND (x_{2i} = 1 OR x_{2i+1} = 1) then
            b_m = 1
      else
            b_m = 0
x1,x2...,x8 are the values of the eight neighbors of p,
starting with the east neighbor and numbered in counter - clockwise order
Condition G2 :
      2 ≤ Min{n_1(p), n_2(p)} ≤ 3
where,
      n_1(p) = Σ_{k=1}^{4} x_{2k-1} ∨ x_{2k}
      n_2(p) = Σ_{k=1}^{4} x_{2k} ∨ x_{2k+1}
Condition G3 :
      (x_2 ∨ x_3 ∨ x̄_8) ∧ x_1 = 0
Condition G3' :
      (x_6 ∨ x_7 ∨ x̄_4) ∧ x_5 = 0                          ...(7)
```

Here dimensional features like area, perimeter, curvature length, and color features have been calculated. Details calculation of feature parameters is given below:

Area: The area of the object is the number of pixels within that object. The algorithm for area calculation has been used in (7).

```
Algorithm : Area Calculation
Input : Labeled image I
Output : Area of each labelled object
for each labelled foreground object obj of I
Begin
      obj_area[obj] ← obj_area[obj] + 1
End
Where, obj_area[ ] = array of area of all objects          ...(7)
```

Perimeter: Perimeter of the object is the number of boundary pixels of that object.

The algorithm for perimeter calculation has been used in (8).

```
Algorithm : Perimeter Calculation
Input : Labeled image I
Output : Perimeter of all labelled foreground objects
for each foreground object obj of I
Begin
        p(i, j) = point of obj
        if (p(i, j - 1) = 0 OR p(i - 1, j - 1) = 0
                OR ... repeat for all neighbors) then
                obj _ Perimeter[obj] = obj _ Perimeter[obj] + 1
End
Where, obj _ Perimeter[ ] = array of perimeter of all objects        ...(8)
```

Curvature Length: The length of the chili pod with and without stalk has been calculated by counting the number of pixels along with the skeleton after morphological thinning. The skeleton of chili objects may have multiple branches that have been removed by searching the largest skeleton branch. Only the largest branch length has been taken into consideration.

Average Color: At the very beginning of image analysis, the original RGB array has been copied in a separate array. In this step average R, average G and average B of every object has been calculated by correlating the labeled pixel of each object with the original RGB array. Also, the RGB pixel values have been converted into Hue value using (2) and the average hue has also been calculated for each object. Here only the thresholded pod region has been considered for average color calculation.

Discolored chili pod has been identified by checking the average R and average hue with predefined thresholds. As specified earlier, two separate hue component ("Chili_Pod_Stalk_Threshold" and "Chili_Pod_Threshold") has been applied to segment the chili pod with a stalk from the background and only the chili pod from the background. During feature extraction, the curvature length of each foreground object has been calculated which is used to differentiate "chili pod with stalk" from "chili pod without stalk" as the "chili pod with stalk" is always larger than the "chili pod without stalk". Broken chili has been also calculated by checking the curvature length of each "chili pod with stalk". Loose seeds have been identified by using both color and area feature parameters as the loose seeds are extremely smaller than the chili objects. Finally, the foreign matters like loose chili stalks have been identified by the color and area features as the loose chili stalk color and area is different than the whole chili. Brief details of the image processing steps have been described below and shown in Fig. 3.

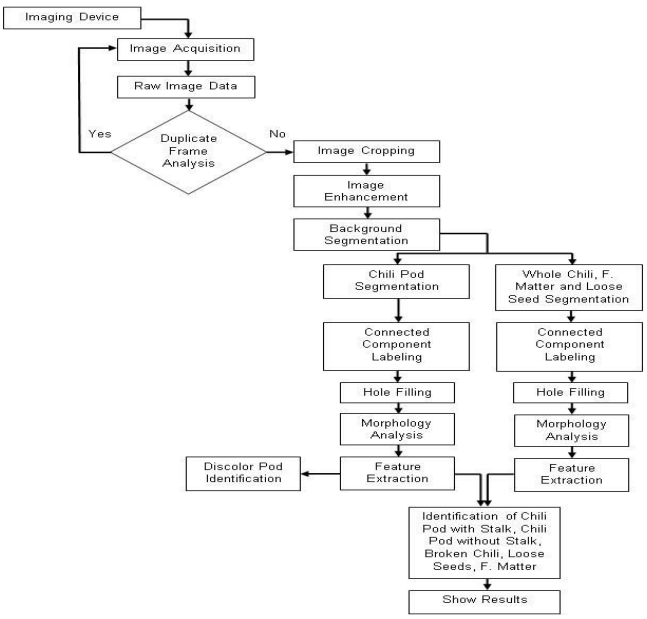

Fig. 3. Schematic diagram of the proposed methodology

III. RESULTS AND DISCUSSION

A. System Calibration

Before the experiment, it was required to calibrate the system with the number of chili samples whose parameters are known. The following plan has been made to calibrate the system.

Optimization of the speed of the conveyor has been done by calculating the accuracy obtained manually by counting the chili sample in each frame comparing the results obtained using image analysis application.

The threshold color values have been checked and corrected for the identification of discolored pods and good chili pods with known chili samples. Experiment with the developed system has been carried out by three different varieties of chili namely – LCA-334, TEJA, and Bydigi. These chili samples have been collected from different places in India and manual quality testing results of the sample have also been obtained.

$$Accuracy\% = \left(1 - \left|\frac{manual - system}{manual}\right|\right) * 100 \qquad ...(9)$$

TABLE II. OVERALL ACCURACY OF CHILI QUALITY ANALYSIS SOFTWARE

Chili Variety	Pod >= 5 cm (%)	3cm <= Pod < 5 cm (%)	Pod w/o stalk (%)	Discolor Pod (%)	Broken & size <3 cm (%)	Good Quality (%)	Loose Seeds (%)	Foreign Matter (%)	Overall Accuracy
LCA -334	95.65	94.15	96.43	84.92	95.88	95.49	87.93	86.90	95.65
Teja	94.77	93.67	97.65	85.70	91.67	94.23	85.77	86.31	94.77
Bydigi	98.64	94.74	93.04	94.46	94.74	96.01	88.46	88.49	98.64

B. *Performance testing*

Performance testing was conducted with controlled chili samples by comparing manual counting and system-generated data. Every single testing has been conducted with 1 Kg. of the chili sample. All quality parameter like [Pod >= 5 cm], [3cm <= Pod < 5 cm], [Pod w/o stalk], [Discolor Pod], [Broken & size <3 cm], [Good Quality], [Loose Seeds] and [Foreign Matter] have been compared with the manual results in each testing. The accuracy% of the system has been calculated by (9) where the deviation between the manual measurement and system measurement has been taken into account and the accuracy has been calculated accordingly and has been shown in Table- 2. The average accuracy has been found in the tune of 96%. The overall throughput of the system has also been calculated during the testing and compared with the current manual quality analysis process. As shown in Table-3, 1 kg (Approx. 2000 nos.) of chili can be analyzed using the developed system in 5 minutes which is quite less than the manual analysis which takes 15-20 minutes.

TABLE I. PERFORMANCE ANALYSIS

Performance parameters	**Values**
Chili sample	1 Kg
Quantity	Approx. 2200 nos.
Manual Inspection time	15 -20 minutes
Machine inspection time	less than 5 minutes

IV. CONCLUSION

The developed instrument will be helpful for the quality estimation of chili. The instrumental analysis will reduce the dependency on human perception & reduce the requirement of expert manpower. It will increase the performance of the grading operation in terms of accuracy & consistency. Again, the overall accuracy of 90% is quite encouraging and establishes that the system can be used successfully in the quality measurement of red chilies. Finally, the system would be more realistic if the variety wise sorting would also be done within the system through some automation. Currently, the developed system has been successfully deployed at the Agricultural produce market committee (APMC), Karnataka, and at a few locations of Agricultural Market Committee (AMC), Andhra Pradesh.

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Mobile Application Development for West Bengal Tourism

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***Abstract*—Mobile applications are extremely popular nowadays as people can access it whenever they want. Smartphone users are increasing worldwide and thus, mobile application is gaining popularity. On the other hand, tourism is one of the most important sectors of any country or state's economy and one of a very few ways of earning foreign currency. However, this new era of technology has made everything very easy including tourism. People can plan and execute their entire vacation using just their smartphones. In this paper, a mobile application for West Bengal Tourism is proposed and is developed for android based mobile phones. This application will be useful for the users who are willing to visit West Bengal and therefore need an application that can guide them for planning and organizing their trip. West Bengal Tourism app will provide the user all the information that they need for planning a trip to West Bengal. The key aspect of this app is that it allows the user to find detailed information for making a trip to West Bengal (*Abstract*)**

Keywords— Mobile Application, Android Studio, Tourism, Destination, User Authentication, West Bengal.

I. INTRODUCTION

Tourism is one of the major sources of income for any state and country and thus they take extra measurements for making the tourism more attractive. People nowadays are considering travel for taking a break from their daily hectic schedule. Apart from that there are a lot of people who loves to explore different places, people and their culture, its origin and more. However, sometimes it becomes very complicated to plan the entire trip as most of the people don't have enough information regarding the place they are visiting as well as the mode of transportation that can be suitable for that trip. In this era of technology, people are very much dependent on their smartphones for every little things of their lives. Therefore, a mobile application dedicated to the tourism of West Bengal can prove to be helpful for people who are deciding to take a vacation there. There are a lot of tourism apps for android phones but this app is particularly dedicated for West Bengal as this state is full of beautiful places for hill station to forests and enriched with various culture and people. It allows the users to create a distinct account for themselves and operate everything from that account. This app also allows the user to find flights, trains and hotels in West Bengal. Admins can handle the database using the same app and are able to make primary changes to both the app and database. Lastly, personal data of both admin and users will be kept in a secure manner in the database.

Rest of the paper is organized as follows. Section 2 contains Related Works which describes other papers on similar mobile applications, already published in various journals. Section 3 contains system architecture along with the proposed solution as well as the detailed design of the application and database structure. Section 4 contains detailed description of implementation and its result, followed by section 5 which contains conclusions and future works.

II. RELATED WORK

Tobing, Roy Deddy Hasiholan [1] designed and developed an Android based tourism mobile application. The application displays information related to the tourism of Samosir Regency. There are three components for developing the tourism application. This application uses the web services in order to connect the front end of the application with the backend application. JSON format is used for wrapping the messages that are used for communications. Visit Samosir is the front-end application as well as the main function of the application. Taxonomy for mobile application for tourism is used as the design base of the front-end part. This mobile application is suitable for three out of seven categories in the taxonomy classifications.

Alrehili et al. [2] mentioned in their paper that they have designed and developed an application, Taibah Visitor, that will be used as a guiding system for the tourists who will be visiting Al Madinah. They have explained that in traditional system people waste a huge amount of money on the experts to guide them during the tour but this application comes with an easy interface that will help them save both money and time. Therefore, this mobile application will help them to find those places without putting any effort. Taibah Visitor application will help the users to find their desired places in an effective way by using filters based on rating, distance between places and unique features like vegetarian food or places available for disabled people.

Artemenko, Olga, Volodymyr Pasichnyk, and Na-talia Kunanec [3] designed a hybrid recommender system based on e-tourism mobile location and context evaluation. This recommender system recommends the users about three types of places which include predictable points for destination. In this category, users get the closest points to their current location and those locations are subjected to their signification class. Another one is prediction of places that are new as well as of interests of the users. Third one includes a set of various localized routes. Authors have mentioned that if the sensory devices are used from the smartphones of the users then that will be more helpful for the recommendation system to provide better and more information about the present state of the current route of the users. This in turn, helps the application in case of improving the quality of the recommendation that it suggests by combining the contextual

tools of analysis and classical techniques of alternative generations.

Calibo, Iris, Caballero, and Virata [4] have used agile methodology in their project as it is more flexible and anticipate changes in a better way. In their paper they have showed the position of M-Commerce model in the tourism industry and their first motive is to create a relationship between the m-commerce model and socio-economic transformation. They have reached to some conclusions in their paper. First one mentions that business community which are developing must address the socio-economic transformation by strategically embracing the innovation. In this paper, the authors have focused on the development of an m-commerce solution of the tourism business problem and they have successfully met the user's expectations.

Dwaaraknath, Ashok, Dinesh Kumar, Sahana [5] designed an application for predicting the budget of a tour with the help of mobile computing using the needs in real time location and complete requirements. Default categories are available in the cloud database whereas the guidance of various tourist spots is provided along with multiple information about each and every tourist spot such as map, SOS emergency, location, direction and much more. This application also provides an opportunity for establishing parameters that helps in interpretation of route planner even before route planning. This application also helps in determining the capacity of the users to plan any journey and their awareness regarding the vehicles.

Kontogianni and Aepis [6] in their paper have reviewed a wide range of pre-existing papers from the field of smart tourism, they mentioned in their paper that in order to build a strong foundation and gain further advancement a proper literature survey is necessary as it helps in finding the area and challenges that need further research. They have identified some useful and popular concepts and approaches in the field of smart tourism along with some major challenges in this field. One of such major challenges that they have pointed out is continuously increasing data size. Therefore, the available information is becoming overwhelming. They have identified recommender system, IoT, context awareness, real time, big data and augmented reality as the contributing factors for the field of smart tourism that need more researches.

Naramski and Herman [7] in their paper mentioned that their main objective is to measure the way mobile applications can be developed based on the tourist spots of Upper Silesia region of Poland. There are two industrial sites in that have been inscribed in the list of World Heritage Site's list by UNESCO. They have focused on 14 mobile application which are capable of finding restaurants, hotels and attractive tourist spots. The entire paper is divided in two sections, where the first one provides a literature review on the usage of digital technology in the field of tourism. Second part is where they have examined the functionality of those existing tourist application for that region and compared the results.

III. Design and System Architecture

A. System Architecture

The application is a two-tier system. The first tier includes user devices i.e., smartphones. Those devices can communicate with the second tier with the help of internet. The second tier includes the database system which stores different data and based on the client requests data are fetched from the database in order to fulfil those recommendation. Firebase, which is a real time database has been used in the development of the proposed tourism app.

B. Proposed App

We have proposed the idea of developing a mobile application that will be helpful for tourism in West Bengal. This application will provide all the information that one will need before making a trip to this state. It will guide them to select the places they want to visit based on the nature and culture of the place. Moreover, this app will provide the user all the information about the transportation that will be useful for them to make this trip happen. As the users will be in West Bengal for a vacation it will be very common for them not to have any idea which mode of transport will be useful for them within the state. Therefore, they can check the buses and trains that are available from the place they are in to the place they want to visit. Based on those information users will be able to make a proper decision.

The key feature of this application that will stand out from other applications include:

- This application will provide the opportunity for secure registration and login to the user, which will keep their information secured in the database.
- Cities and districts are categorized based on the geographical description which will help the user to decide whether they want to visit that place.
- Each and every district of West Bengal is organized along with the information of the tourist spot so that user do not miss out anything.
- It also provides the facility of checking flights from different cities to Kolkata.

C. Detailed Description of West Bengal Tourism App

This West Bengal Tourism App is divided into two modules, one for the users and another for the admin. The users use that application based on their demand whereas the admin will monitor, control and update the databases as well as the entire application based on the requirement. Fig. 1 shows the flowchart of the application that describes the way West Bengal application is working.

1) Admin Module

In this West Bengal Tourism app, we have a separate admin module and users will not have access to it. Admin will get the access of that module by selecting the admin login option where admin can use his login credentials that have been used during the time of registration.

Admin are able to do the following things.

- Register and login to the admin module.
- Add new flight, train and hotel records in the database.
- Delete any records from the database based on the scenario.
- Update any particular information in the database if that is needed.
- Find any record from the database if necessary.

2) User Module

Users will be given the opportunity to register themselves so that they can use this application from their own account and their activities will be separated in their own account from the other users. New users have to register at the beginning so that their login credentials can be stored in the application database. Users who have already registered can use their registered user id that is their email id and password in order to login into their account. After successful login, the user will be able to choose multiple menus form the grid view. They will be able to get the idea of districts that they can visit during that trip and which tourist spots are located in those districts along with the historical and geographical knowledge of that particular district. Moreover, from this application, tourists will get to know about various festivals and culture of West Bengal which are famous worldwide. There are so many tourists who love to visit places and try the local authentic cuisines. Therefore, this app contains a particular activity where name of the authentic Bengali foods will be there along with the images so that tourists will get an idea about the food they should try. They can check flights that are available from different states to Kolkata. They can check trains and their availability from one place to another in West Bengal.

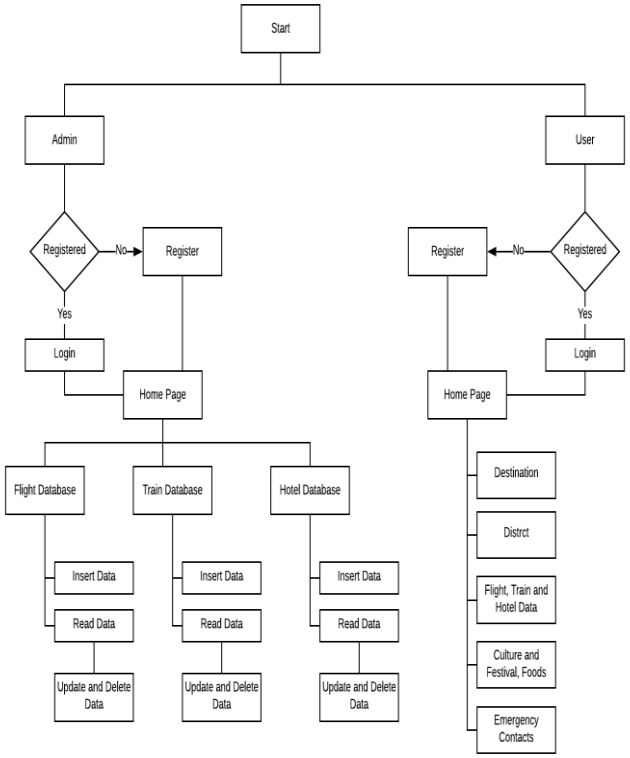


Fig. 1. Flow Chart

D. Database Design

Databases are implemented in Firebase database which is a Realtime database.

- The train database which contains all the train records. It has five field including, atime (arrival time), dtime (Departure time), to, from and price, that is price of the ticket.
- The flight database which contains all the flight records. It has five field including, landtime (landing time), depart-time (Departure time), to, from and price, that is price of the ticket.
- The hotel database contains all the hotel records. It has four fields including, hotel name(name), location, contact and rate per day (ratepd), that is price of a single for one day.
- The user database contains all the user records. It has four fields including, user name(name), email, contact and password. Email and password will be stored in firebase authentication, which will have the same unique id.
- The admin database contains all the admin records. It has four fields including, admin name (name), email, contact and password. This data will be used for admin login.
- Firebase authentication stores the users' email and password under the same unique user id so that users can login to their specific account.
- Firebase storage stores all kinds of image that have been used in the application. User folder stores images of user's profile picture, district folders contain district images, festival folders contain festival images, food folders contain food images.

IV. Implementation and Result

The West Bengal Tourism application is developed to work on Android operating system. It is developed using xml and Java programming language. This application is developed in android studio and installed in mobile phone after building apk. The application is running successfully after installing it in multiple mobiles having android 8 as OS.

Fig. 2 shows the registration activity of the user module of the application. Here a user puts their details and select the register button. When the user presses the register button, at first his/her email id and password will be saved to the firebase authentication which will use this two information in future for authenticate the user while the user signs in to the app. When the email id entered by the users stored in the firebase authentication, a verification mail will be sent to that particular email id to check whether the email id is valid or not. If the user is already registered then user can go to the login activity by clicking the sign in link as shown in Fig. 2.

Fig. 3 shows the login activity where users can provide the email id and password that they have entered while registration. If the password and email id match then the user will be redirected to the home activity.

Fig. 4 shows the home activity of the application which displays a grid view with two columns and multiple rows containing various part of the user module. User can select any of the options and visit the activity dedicated to that functionality.

Fig. 5 shows my profile activity for the users. Here, users can see their details that they have entered during registration. These data that are shown are fetched from the user database. The 'Email not verified' part at the top is shown because the user did not verify the email using the link that was sent while registration. Users can click the verify button below and get the verification mail again. Once the user verifies his/her email, these texts and verify button will no longer be visible in my profile activity. Users can click the LOGOUT button

and close their account. They can click the EDIT PROFILE button and go to edit profile activity.

Fig. 6 shows the destination list activity where the users will be redirected after clicking Destinations option from the grid view in the home activity of user module.

Fig. 7 shows the district list activity where the users will be redirected after clicking districts option from the grid view in the home activity of user module. Each of the item in the district list will redirect the users to another activity dedicated to that particular district.

Fig. 8 shows the activity dedicated to the hill station destinations of West Bengal whereas Fig. 9 shows Forest, Fig. 10 Shows Pilgrimage, Fig. 11 shows Historical places and Fig. 12 shows Cultural Hotspot as other destinations.

Fig. 13 shows the Emergency contact options list where users will be redirected when they select emergency contact option from the home activity. When users will select items from the emergency contact list, they will be directed to same activity but the information will change according to the item selected. Fig. 14 shows the activity when item hospital is selected from the emergency contact list. Fig. 15 shows the Culture and Festival activity where users will get information of various festivals that are celebrated in Bengal whereas Fig. 16 will show Food activity where information about various authentic Bengali cuisines are provided.

Fig. 17 shows the activity for Kolkata district. Similar activities are there in the application dedicated to other districts.

Fig. 18 shows the process of entering data. When the record is successfully added to the database, a message of 'Data inserted' will be shown in the application. Fig. 19 shows update and delete record activity. As we can see 6500 was inserted as ticket price but admin has changed it to 6300. If Admin clicks the UPDATE button, the ticket price will be changed to 6300 from 6500 and the message will be shown that 'Flight record updated successfully' as an indication that the job is done. Fig. 20 shows the activity where admin will be redirected after selecting Read Data Button (Fig. 18). Admin will get all the records in the database in this activity

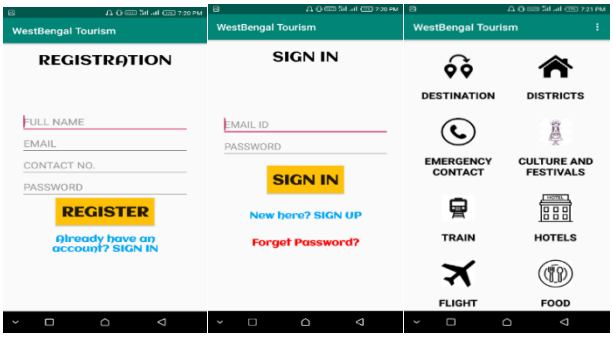


Fig. 2 Fig. 3 Fig. 4

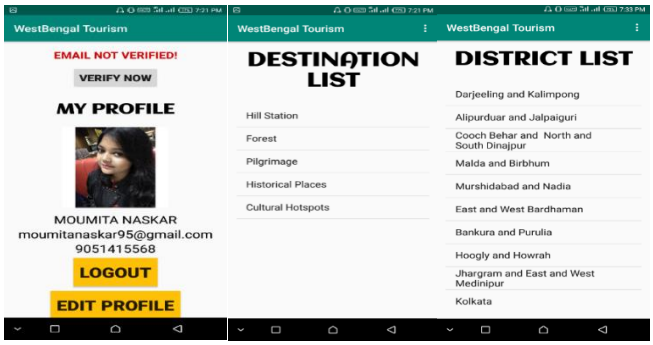
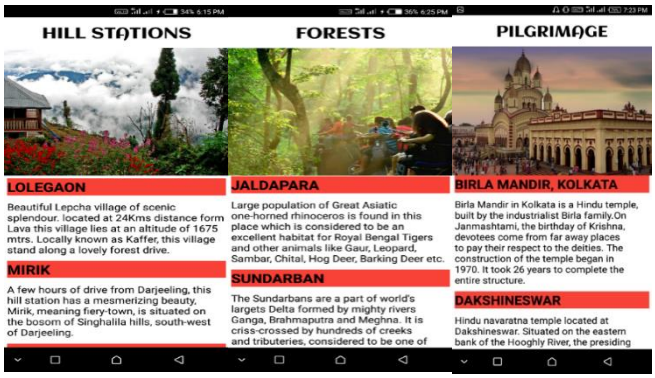


Fig.5 Fig. 6 Fig. 7



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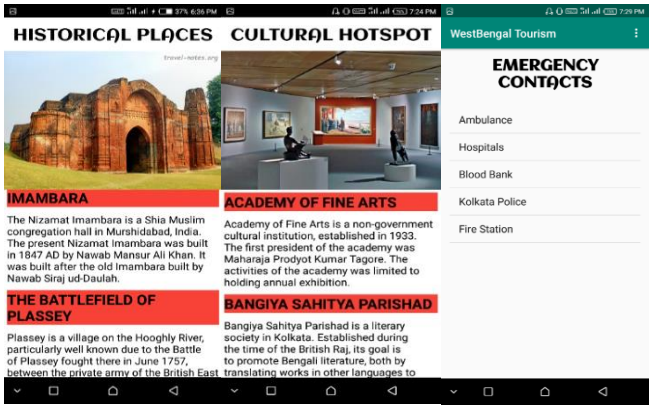

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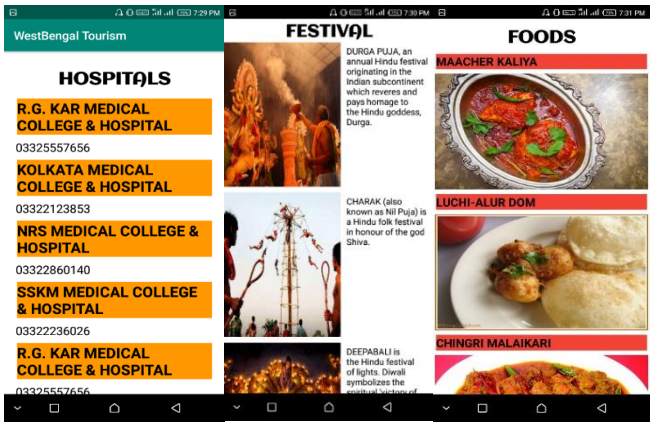

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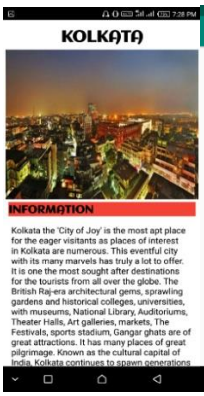

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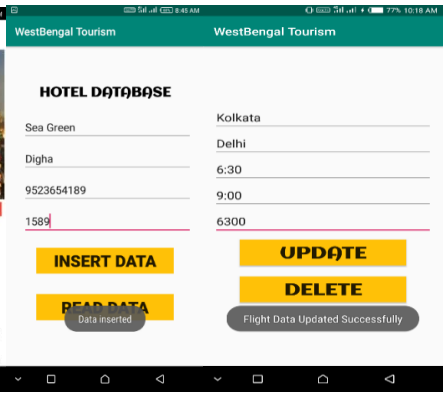

Fig. 18

Fig. 19

Fig. 20

V. Conclusion and Future Work

West Bengal Tourism application is designed and developed for the travel enthusiast who is willing to make a trip to this beautiful state, West Bengal. This app will guide the tourists to plan their trip based on their choice and provide all the information that one may need before visiting this state. This app provides a simple yet interactive interface and thus is very easy to use even for those who do not know much of the technology. This app will guide them to find the proper transportation that they can have within the state so that they don't face any problem during the trip.

There are some features that can be added in this app later as a future work to make it more beneficial for the users and those are included below.

- Adding the booking features to the app so that user can book flight, train and hotels from the app itself, instead of getting redirected to a different website.
- Implementing the use of cloud for storing and retrieving in order to make the database system of the application more efficient.
- Implementing encryption and decryption in order to add an extra layer of security.
- This app is currently working on the android smartphones, but we are planning to make a version for IOS as well.
- Implementing an automatic recommendation system for the users for planning their trip to West Bengal with the help of artificial intelligence.
- Implementing prediction algorithms in the application which will help in providing notifications or pop-ups for the users regarding the nearby tourist spots, hotel, restaurants as well as the vehicles that can be appropriate for reaching that particular location based on the current location of the users.

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A Review on SQL Injection Attack in Internet of Things

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Abstract- The term IoT (Internet of things) is not just a mere technology but has enabled the life of human beings to become easy as it furnishes their needs and makes their life stress-free. Hence, IoT has been widely used in home automations, security, health care and many other aspects of life. Security is a major concern for IoT as they generate huge amount of data. There are multitudes of attacks in IoT networks in order to steal sensitive information. SQL (structured query language) injection attack is one among them. The core purpose of this paper is to highlight various attacks in IoT and focus on different categories of SQL injection attacks and why it is very necessary to prevent it.

Keywords—SQL injection, IoT application, Types of SQLIA

I. INTRODUCTION

The idea of IoT was originated by an associate of the RFID community in 1999 [1]. Considering a world full of objects that sense, these objects are connected via public and private networks. These objects have enormous data which is collected and evaluated. This is called as Internet of things. IoT is formally defined as a network of physical objects. Internet has evolved from being a network of computers to network of devices of every size and type which constitute vehicles, smart phones, cameras and toys [1] . IoT is a technology which helps many devices and objects to connect via internet thereby allowing these objects to communicate with each other. It enables connecting users with devices which offer certain service. The notion here is that the IoT device can communicate with the network. The main concern is that since these devices are connected via internet, developing a security defense is very difficult as they are prone to various unforeseen threats[2].

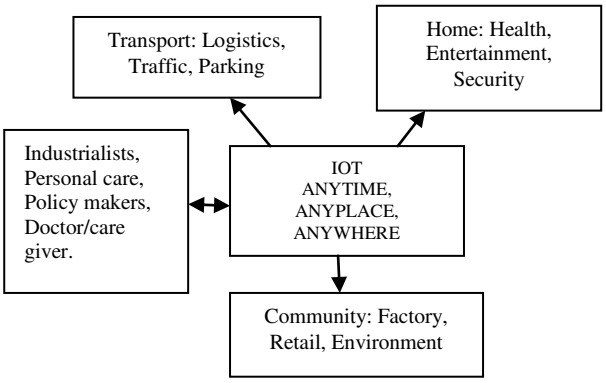

Fig. 1: IoT end users and application area based on data [3]

Use cases of Internet of Things are vast as seen in figure 1, as services provided by IoT are available to the consumer side anywhere, anytime and at anyplace. Its applications range from transport, logistics, traffic, smart parking, health sector, entertainment sector, retail sector etc. Its applications target the policy makers, personal care, and doctor/care givers[3]. Since the applications are vast and many clients' personal data is at risk, any kind of attack will be of concern.

The various kinds of attacks are physical attack, side channel attack, cryptanalysis attack, software attack and network attacks as seen in figure 2.

- Physical attacks tamper hardware and require expensive material to perform the attack and hence this attack is very difficult. For an instance such as layout reconstruction, de-packaging of chips etc.
- Side channel attacks come under those attacks which deals with encrypted data and these are based on the side channel. Attacks such as timing attack, environment attack, fault analysis attack come under this category.
- Cryptanalysis attacks occur when an attacker tries to decode the encryption key and obtain crucial information such as plain text. Attacks under this category are cipher text only attack, known plain text attack, man in the middle attack etc.
- Software attacks are one of the main reasons for vulnerability in all systems. Such attacks exploit buffer overflow and use Trojan horse programs, worms and viruses to insert malicious codes in system. For example such as jamming attacks in which many noise packets will be put in the network.
- Network attacks are the last form of attacks which are the most vulnerable as it effects the wireless systems. The attacks in this are categorized into active and passive attacks.

  Passive attack means the system will be scanned to check for open ports and this will be exploited. Example of passive attack includes eavesdropping, Traffic analysis, camouflage adversaries etc.

  Examples of active attacks include denial of service attacks, node subversion, node malfunction, node capture, node outage, message corruption, false node, and routing attacks because of which the data in the system will be

compromised as the attacker aims to change the data in passive attacks [4].

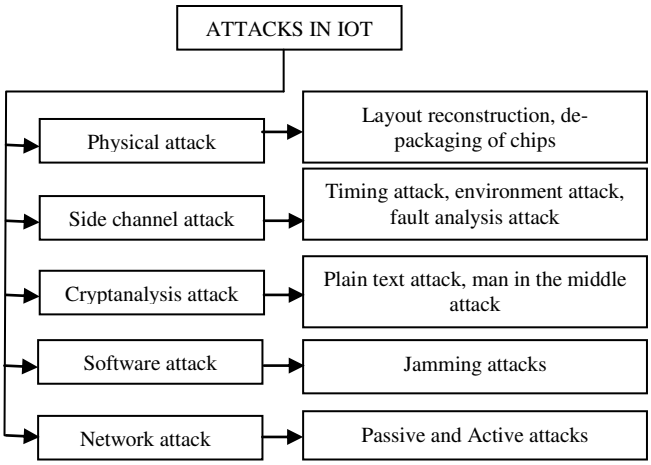

Fig. 2: Attacks in IoT

One of the vulnerabilities in the IoT network is the SQL injection attack which takes place on the database. SQL (structure query language) injection focuses on code injection technique for applications which consists of enormous data generated through these applications. This is a process where intentionally wrong SQL statements are inserted. These kinds of attacks usually takes place in web applications but it can also attack on any software which has huge amount of data. The attacker will access the data via input field from the login of an application. This will allow him to access the data hereby affecting the confidentiality of the system [5]. All of the upcoming trends and software's are totally dependent on security provided by backend storage only such as cloud storage. Thus this becomes attacker's choice to obtain crucial data from that database which will lead to destructive consequences[6].

II. SQL INJECTION ATTACK

SQLIA is SQL injection attack which is an attack carried on a poorly designed application which will provide access to the data of an organization. The target database which is connected with such poorly designed application will have malicious codes injected into its system so as to access database. In an application there will be numerous places where the user may need to input information and such vulnerable spots leads to loss of privacy, reliability and market price of an organization. SQLIA uses crooked inputs so as to find one vulnerable spot to login in an application. These kinds of attacks lead to loss of details and privacy for customers who are a part of such organizations. Many security techniques to prevent such attacks exist on server side but are not helpful when it comes to large organizations because of design complexity. On the client side many security applications are available but it slows down the system there by spoiling user experience. The main reason for such attacks to take place is data extraction from important organizations, or modification of a data so that the attacker can insert, delete or remove a data. The attacker may also have intent of bypassing authentication so as to obtain customer rights. The attacker will use a tool such as a vulnerability scanner to check for vulnerability spots in a web application. Once a spot has been identified he will test the user input fields to check for a vulnerable spot. The attacker uses penetration tester for this purpose. The attacker prevents from the security detection applications using automated detection and prevention techniques. Sometimes the intent of the attacker will be to shut down the system by performing denial of service attack after getting access to the database. A successful penetration will allow the attacker to gain access to the authorization where he can act as an admin and carry on privileged tasks only done by an admin. If improper authentication techniques are used by organization then it is very easy for any attacker to get access to user name and password of the customers. Because of which confidentiality and integrity will be lost [7].

There are many types of attacks in SQLIA but some of them are given in brief below

- Timing Attacks: Information is gathered by attacker using the timing delay.
- Alternate Encodings: This type of technique is used by the attackers to avoid from getting detected by detection devices.
- Union Query: This method helps the invader to connect the query which in injected with the safe query so that the data from the safe query will be obtained. This is used mostly in cases where the attacker needs to pass authentication or need to attract some data.
- Stored Procedures: The foremost aim of this technique is to achieve escalation and perform few privileged procedures.
- Piggy-Backed Queries: The chief aim of this technique is to add some extra data to the original query which is assumed to be piggy backed on to the original query.
- Inference: The foremost aim of such attacks is to modify the actions of the queries. Two techniques which use the concept of inference are blind injection and timing attack.
- Blind Injection: In certain situations the developer tries to hide error details and hence when the attacker tries to attack he notices a page which is generic in nature. This page contains all the information of why the query did not get executed. Now the attacker will ask few questions and get answers to them in the form of true or false. This will eventually help him to steal crucial data.
- Tautologies: This technique is beneficial to the attacker as it assists him to bypass crucial authentication technique. This is achieved by injecting malicious information into conditional statements so that they always get valued as true.
- Logically incorrect query attacks: The chief objective of this technique is to collect backend data from the interface by finding vulnerable parameters from the error messages [8].

III. TYPES OF SQL INJECTION ATTACKS

A. Tautologies

Any attack which comes under this category will inject malicious information's into conditional statements so that they always are evaluated as true. This is done to bypass the most important form of security that is authentication of a user so that the attacker can extract important data of the respective organization. A very authenticate example of tautology is bypassing authentication page and fetching data.

Example: The attacker exploits the WHERE clause. This conditional query is transformed and all the rows are accessed by making the query return the rows. For an instance, select query can be used for this purpose where the attacker will try to obtain the id, this will be 1 or 1=1 and the passcode will be 1234 or 1=1.

B. Logically incorrect query attacks

The main goal of this intrusion is to get the data from the back end. Whenever a query won't be accepted a generic page which contains the error messages will be generated so as to help in further debugging process. This will help the attacker to understand the parameters which are vulnerable and this in turn helps the attacker to access the database. The attacker also writes down garbage input or SQL token so as to create syntax error so that he gets back details about the name of the column and table details so he can organize his attack more adequately.

Example: Once the error message is obtained, the attacker will try to obtain the information of the table name and its respective fields. By such gathered information attacker gets more organized attacks. This attack is the basis of all attacks.

C. Union query

The major objective of this is to masquerade as a user's query so that the attacker obtains information from a table which is not the intended table. By doing this the attacker will be able to join a safe and a malicious query by using the word UNION. This is used for bypassing authentication and to remove some data.

Example: If the attacker wants to obtain the debit card details of a user he will try to join a safe query such as a query to obtain the id of a user but also will maliciously join another query that will give him the debit card details of the user.

D. Stored procedures

The foremost aim of the stored procedure attack is to execute special privileged actions which try to perform SQL queries. Stored procedures are a part of database where extra abstraction layer is set by the help of the programmer. Since this part is programmable, this layer is injectable with attacks. There are many ways of attacks in stored procedure. Here the unsafe query gets piggy backed on to original query and when a safe query is executed subsequently an unsafe query is also executed.

E. Piggy backed queries

This type of attack allows any query to get piggybacked onto the original query so as to help the attacker to modify or execute any type of malicious query. This is called as piggy backing. Therefore this leads to database getting many SQL queries for execution. These kinds of attacks are always dependent on databases.

Example: If the attacker wants to drop users from a particular group he can do so by executing a query with a malicious code and by using a delimiter. After executing the first query the database checks for query delimiters ";" and executes the next query. This would drop the table users and destroy important information.

F. Inference

The core aim of inference attack is to alter the database and application behavior. Under this category there are two attacks which take place and they are blind injection and timing attack.

- Blind injection: This type of attacks happen when the developer purposely hides the important details regarding the error messages. This will further help the invaders to obtain crucial information which leads to compromise of data. The attacker makes use of this page and asks many true or false questions to invade data. If the application is very secure, the queries won't get executed. But in many cases there won't be any input validation and hence when the invader enters the first query he receives an error message, then he submits the next query which is true. If he doesn't get any error while logging in then he discovers that this is susceptible to an attack.
- Timing attacks: In this attack the invader gathers data from the database by understanding and seeing the timing delays in the responses from the databases. The query which consists if-then will make the database to run the SQL engine longer depending on the login which is injected. This is almost same as blind injection and the invader will measure the time to check if the injected statement is true. A term called as "WAITFOR" which will make the database to delay is used.

G. Alternate encodings

The core aim of such attacks is to dodge being recognized by the secure defensive coding and automatic prevention system. So this kind of attacks helps the attackers to prevent any detection. This attack combines itself with additional attack methods. The invaders changes the query with alternate encodings such as hexadecimal and ASCII. This will allow them to escape the input filter. This attack then hides multiple attacks within it[8].

IV. PROCEDURE OF SQL INJECTION ATTACKS

The attacker performs the attack usually in three differret procedures as seen in figure 3. An attacker first sends the input to the applicatiton then it checks on the SQL reports and then refers to the backend database. By doing the procedures it is able to attack the database and obtain or delete important data.

The main aim of the attackers is to extract most crucial data from the organization and modify it. The attacker will also have an intention to modify the data.

The main reason for such attacks to take place is data extraction from important organizations, or modification of a data so that the attacker can insert, delete or remove a

data. The attacker may also have intent of bypassing authentication so as to obtain customer rights.
The attacker will use a tool such as a vulnerability scanner to check for vulnerability spots in a web application. Once a spot has been identified he will test the user input fields to check for a vulnerable spot. The attacker uses penetration tester for this purpose. The attacker prevents from the security detection applications using automated detection and prevention techniques. Sometimes the intent of the attacker will be to shut down the system by performing denial of service attack after getting access to the database.
A successful penetration will allow the attacker to gain access to the authorization where he can act as an admin and carry on privileged tasks only done by an admin. If improper authentication techniques are used by organization then it is very easy for any attacker to get access to user name and password of the customers. Because of which confidentiality and integrity will be lost[7].

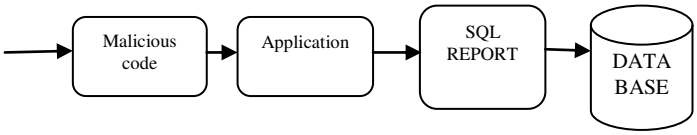

Fig. 3: Process of SQL injection attack

V. INTENT OF THE ATTACKER

Sometimes the intent of the attacker will be different and the goal will be quite different for different purposes. Some of the intents are:

- Identifying injectable parameters: Here the attacker wants to know which application has vulnerable spots in the input.
- Performing database finger printing: Here the intent of the attacker is to find out what version and type of database is used by the application as this can be very unique for different application and hence this acts as fingerprint.
- Determining database schema: In order to obtain crucial database the attacker will need to obtain database information such as column name, table name etc. This information will help the attacker to obtain access.
- Extracting data: This is the most common type of SQLIA with the intent being to get the crucial information of the database.
- Adding or modifying data: The intent of the attacker is to change the contents in the database.
- Performing denial of service: Here intent of the attacker is to shut down the system
- Evading detection: Here the intent of the attacker is to avoid getting noticed by the security systems.
- Bypassing authentication: Here the intent of the attacker is to bypass authentication.
- Executing remote commands: Here the intent of the attacker is to perform some crucial arbitrary commands.
- Performing privilege escalation: Here the attacker bypasses authentication and performs few privileged tasks not meant for him[9].

VI. PREVENTION OF SQL INJECTION ATTACK

The main cause for SQL injection attack is inefficient input validation techniques. So the main aim will be to strengthen defensive coding practices. Some of the best practices are

- Input type checking: Simply checking the inputs with numeric and string can prevent SQLIA.
- Encoding of inputs: Encoding of Meta characters will help in preventing attacks.
- Positive pattern matching: The developers need to match good and bad input so that they can understand the type of attack taking place.
- Identification of all input sources: Checking of all the inputs in the applications needs to be made mandatory.

Although this is the best way to stabilize the input defense, still it is not practical to apply and hence vulnerability spots arise. Therefore future research needs to focus on precision and effectiveness of these approaches along with proper defense mechanisms[9].

A. Current techniques for prevention of SQLIA

In order to develop our research technique it is very important to learn about other methods and they are

- Black Box Testing: This uses a web crawler to identify a vulnerable spot in a web application. Make attacks on these points and use a monitor to check what kind of response in obtained when such attack takes place. Limitation is that it cannot provide guarantee of completeness[8].

- WebSSARI uses static analysis to check taint flows against preconditions for sensitive functions. It needs clean input with predefined filters to work. The limitation of this approach is adequate preconditions for sensitive functions cannot be accurately expressed so some filters may be omitted[8] [10] .

- SecuriFly is tool that is implemented for java. Despite of other tool, chase string instead of character for taint information and try to sanitize query strings that have been generated using tainted input but unfortunately injection in numeric fields cannot stop by this approach. Trouble in recognizing all causes of user input is the main restriction of this approach[8].

- Dynamic Analysis: This approach is also known as post generated approach. Post-generated technique are beneficial for examination of dynamic or runtime SQL query, created with user input statistics by a web application. Detection methods under this post-generated group

implements before stationing a query to the database server[8].

- Code Checkers are based on static analysis of web application that can reduce SQL injection vulnerabilities and detect type errors. For instance, JDBC-Checker is a tool used to code check for statically validating the type rightness of dynamically-generated SQL queries. This is to make the SQL query safe[8][10].

- Combined Static and Dynamic Analysis: AMNESIA is technique that combines dynamic and static for preventing and detecting web application vulnerabilities at the runtime[8] [10][11][12].

- In SQL Guard and SQL Check queries are checked at runtime based on a model which is expressed as a grammar that only accepts legal queries. SQL Guard will check the query after and before the user input. In SQL Check, model is specified by the developer. Both techniques use secret key[8] [10].

- SQL-IDS, a specification based approach to detect malicious intrusions[8][13].

- SQLrand uses a proof of concept proxy server in between the Web server (client) and SQL server; they de-randomized queries received from the client and sent the request to the server. This de-randomization framework has 2 main advantages: portability and security [8][14].

- SQLIA Prevention Using Stored Procedures: Stored procedures are subroutines in the database which the applications can make call to. The prevention in these stored procedures is applied by a mixture of static examination and runtime examination[8][15].

VII. CONCLUSION

There is an exponential increase in interconnection of heterogeneous smart devices in the IoT ecosystem. IoT is envisioned as spectacular phenomena where isolated devices are transformed to communication devices. In this communicative environment, there are a plethora of opportunities for stealing sensitive information. Hence it is very important to prevent the data from leaking as the user information is very crucial and important. There are many attacks which take place over internet but one of the many is SQL injection attack. This paper gives an overview of SQL injection attack and its types. The challenges in SQL injection is briefed along with the countermeasures in prevention of the same.

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Classifying Infected and Uninfected Red Blood Cell Images for Malaria Detection using Convolutional Neural Networks

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***Abstract*—Malaria Diagnosis is tedious and time consuming. The most widely used method is examining thin blood smeared on a glass slide and stained with contrasting agents under a microscope, and visually searching for infected cells. This method takes hours for diagnosis, with the process of staining the blood take approximately an hour. Unnecessary and delayed diagnosis due to false positives and false negatives is one of the foremost causes of deaths. The current work presents an approach for detecting malaria by classifying the red blood cell images as infected or uninfected, done with the help of a deep learning approach that uses a Convolutional Neural Network model. The CNN model uses a simple architecture allowing it to be used on various platforms. It optimizes the use of time and labor. The chances of false positives or false negatives are highly reduced.**

Keywords—Malaria Detection, Convolutional Neural Network, Image Preprocessing

I. INTRODUCTION

Malaria a mosquito borne disease, is caused by protozoan parasites of the genus Plasmodium and is transmitted through the bites of infected female Anopheles mosquitoes, infecting the human erythrocytes. According to the World Health Organization (WHO), 228 million people were affected by malaria worldwide in 2018 with 405,000 deaths [1]. An estimated 3.4 billion people in 92 countries and territories are at risk of being infected with malaria and developing this disease [2].

Although there is no effective vaccine against malaria yet, certain drugs do exist for its cure. However, once infected, the disease spreads extremely rapidly and hence it calls for its timely diagnosis. The key to diagnosing malaria is the detection of the presence of parasites in the infected person's red blood cells. The most widely used method of detection is by smearing the patient's blood cells on a glass slide and staining it with contrasting agents, to help identify infected parasites better, and then put-ting the slide under a microscope to visually search for infected cells [3]. A clinician then must manually count the number of parasitically infected red blood cells- the number sometimes even more than 5,000. The accuracy of this method is highly dependent on human expertise and knowledge, making it inefficient [4]. Alternative techniques such as Polymerase Chain Reaction (PCR) and Rapid Diagnostic Tests (RDTs) are used; however, PCR analysis is limited in its performance [5], and RDTs are more expensive and provide less information than microscopy [6].

Bearing in mind the difficulties being faced by the concerned people all around the world, efforts have been made to develop a new system based on deep learning, making use of the concept of Convolutional Neural Networks (CNN).

CNN is a deep learning architecture suitable for image recognition. It can automatically extract features from images and obtain information from them. A CNN has convolutional layers (using the ReLU activation function), pooling layers, and a fully connected layer. The convolutional and pooling layers may be repeated several times before resulting in the fully connected layer. The idea of using CNN for detection of malaria is that by viewing the images of various red blood cells, it can differentiate infected cells from uninfected ones, through thorough training of the model, making the diagnosis fast and efficiently.

II. LITERATURE REVIEW

Convolutional Neural Network for Malaria Detection classifies the images of red blood cells as infected or uninfected. P. Pundir, S. Aggarwal, and M. Deshmukh [7] proposes a malaria detection algorithm using a deep learning model. Initial layers of the convolutional neural network are used to extract features like irregular shapes and sizes. It makes use of Batch Normalization for improving the performance of the CNN model.

F. B. Tek, A. G. Dempster, and I. Kale [8] used K Nearest Neighbours for implementing parasite/non-parasite classifiers and Bayesian Classification for implementing stained/non-stained classifiers. Color Normalization module Grey World Normalization was used to reduce the effects of different light sources. Feature Extraction to investigate their individual performances of candidate features chosen and then search for a higher combined feature performance was done using 4 different features (color histogram, Hu moments, color auto

correlogram (henceforth correlogram), and a relative shape measurement vector).

H. A. Mohammed and I. A. M. Abdelrahman [9] for achieving better outcomes, uses techniques of pre-processing for enhancing the image. Morphological processing identifies and counts the RBCs in the given blood image. An algorithm is developed for the detection of infected and uninfected RBCs. An additional layer of parasite classification is implemented using the Normalized Cross-Correlation function.

Y. Dong, Z. Jiang, H. Shen, W.D. Pan, L.A. Williams, V.V. Reddy, W.H. Benjamin, and A.W. Bryan [10] identifies malaria-infected cell images using deep learning methods. It achieved higher accuracy than the SVM method in D. K. Das, M. Ghosh, M. Pal, A. K. Maiti, and C. Chakraborty [11]. It uses Convolutional Neural Network which automatically extracts multiple layers of features from the input data. The dataset was created by a group of pathologists from the Medical School of the University of Alabama at Birmingham.

A. Vijayalakshmi [12] identify infected falciparum malaria parasites using a novel deep neural network model. Proposes a transfer learning approach by unifying the Visual Geometry Group (VGG) network and Support Vector Machine (SVM). To analyse the performance of VGG19-SVM malaria digital corpus images were used.

Z. Liang, A. Powell, I. Ersoy, M. Poostchi, K. Silamut, K. Palaniappan, P. Guo, M. A. Hossain, A. Sameer, R.J. Maude, and J. X. Huang [13] proposes a machine learning model based on a convolutional neural network (CNN) for classifying cells in thin blood smears on standard micro-scope slides as either infected or uninfected. The performance of the CNN model is affected by both the architecture and the volume of training data.

J. Hung, and A. Carpenter [14] use Faster Region-based Convolutional Neural Network (Faster R-CNN). The model is pre-trained on ImageNet and finely tuned using the dataset. It uses two stages for classification and detection.

Various Deep Learning approaches have been used for implementing models for malaria diagnosis, which minimize the dependency on skilled technicians for the process. The accuracy achieved by the different CNN models is higher than its SVM counterparts. CNN models can be used to extract multiple features from the input image to make a prediction. Here, a CNN model with a single convolutional layer is used, showing that a simple architecture with low computational power can also be used to achieve better performance. Previous works using CNN models employ a more complex structure and use higher computational power.

III. Methodologies Used

This work aims to detect malaria by classifying the red blood cell images as infected or uninfected. To achieve this, this model uses a Convolutional Neural Network (CNN) as it is capable of studying and analysing images. It is fed with a labelled dataset (images labelled as infected and uninfected) making its learning as supervised. However, the images are initially preprocessed, before feeding them in the model, to enhance certain features facilitating the CNN to analyse the images better.

A. Image Preprocessing

Images in the dataset are refined before using them for the training and testing of models. The cleaning of images (Image preprocessing) includes resizing, generalizing the color space to either RGB (white balancing) or grayscale, labelling the images, and more. It improves the image by reducing unwanted noise leading to the enhancement of essential image features. Image preprocessing [15] helps in achieving better results.

- Resize: Images in a dataset are of varying sizes collected from different sources such as mobile phones, professional cameras, etc. All the images in the dataset are required to be of the same size. Images are resized into a base size, which is set to be used by the model.
- Noise reduction: Noise is an undesired distortion which makes the image appear grainy leading to inaccurate analysis of the image. It can be reduced by blurring of the image which smoothens the image, reducing the effect of noise. Blurring can be done using functions like Gaussian Blur. In this operation, the image is convolved with a Gaussian filter. The Gaussian filter is a low-pass filter that reduces the high-frequency components (noise) of the image [20].
- Segmentation: Identifying regions in an image and labelling them to different classes is called image segmentation [19]. It includes separating different objects in the image with markers, labelling them so that they can be trained accordingly. One way of segmenting an image is to segment it based on its pixel values. This makes use of the fact that there will be a huge difference between the pixel values at the edges of an object and the pixel values of its background pixels. So, in such cases we can set a threshold value, the difference in pixel values falling below the threshold can be segmented accordingly. In case there is one object in front of a single background only one threshold value will work. But in case there are multiple object or overlapping among objects we might need multiple threshold values.
- Morphological operations: Morphology involves image processing operations that process images and makes changes to the shape and structure of the image. In a morphological operation, each pixel in the image is adjusted based on the value of other pixels in its neighborhood. The size and shape of the neighborhood can also be adjusted. There are two types of morphological operations – dilation and erosion. In morphological erosion, the value of the output pixel is the minimum value of all pixels in the neighborhood [21]. Morphological erosion removes grains and small objects so that only substantive objects remain, that is, they help in reducing the noise in the image.

B. Convolutional Neural Network

Convolutional Neural Network (also known as ConvNet or CNN) is most commonly used for the analysing of images and identifying various objects in them. Convolutional Neural Networks can be applied to image processing, natural language pro-cessing, and other kinds of cognitive tasks [16].

Convolutional Neural Networks has an input layer, an output layer, and various hidden layers that are fully

connected. A fully connected Neural Network means that each neuron of one layer is connected to each neuron of the next layer. That is why they are known as regularized versions of a multilayer perceptron.

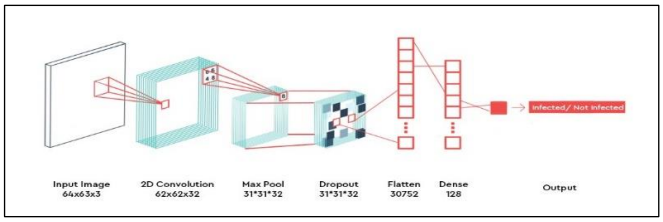

Fig. 1. Block Diagram showing the structure of CNN model.

The architecture of a CNN comprises of the following layers:

- Convolutional Layer: In this layer, a kernel (weighted matrix) is run over the image to extract certain features (mostly edges) of the image. All pixels of the image are covered, and the output obtained is a convolved image. The stride length of the kernel can be modified.
- Pooling Layer: This layer reduces the size of the convolved image obtained. There are different types of pooling like max-pooling and average pooling. Pooling re-turns an image with a reduced size, containing the value selected from each portion of the image covered by the kernel.
- Fully Connected Layer: Here the image is flattened into a column vector that is fed to a feed-forward neural network and back propagation is applied. The images are classified using either a sigmoid or softmax activation function in the output layer, depending upon the number outputs.

IV. Experiments and Results

CNNs have the ability to automatically extract features, which in this case would be the stained parasites present in the blood cells.

The images in Fig. 2 and Fig. 3 are taken from the dataset [17] used. The resulting dataset consists of 27,558 images with 13,779 images for parasitized and uninfected cells each.

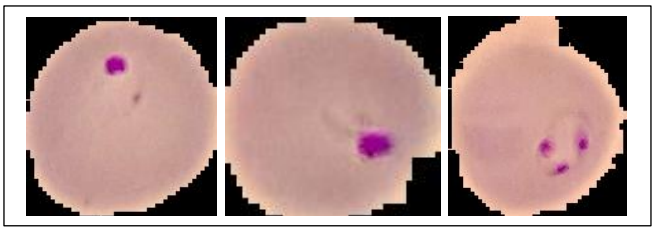

Fig. 2. Infected Cell Images.

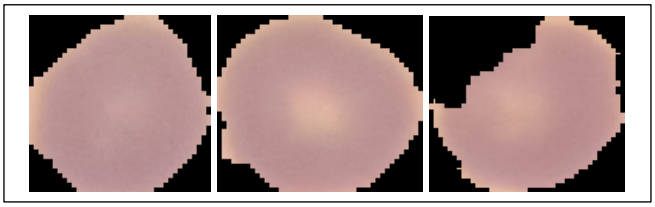

Fig. 3. Uninfected Cell Images.

The dataset used consisted of both infected and uninfected cell images which were not uniform hence resizing of images was done to a dimension of 64*64. Classification of infected and uninfected blood cell images was carried out as a part of label-ling the images.

Once the preprocessing was completed a sequential convolution model was de-signed. The structure of the model has been explained below:

- Convolutional Layer: The aim of this operation is to reduce the size of the images by using feature detectors that keep only the stained portions present within the infected cell images.
- Max Pooling: This layer aims to extract key features and reduce the number of parameters and computation in the network.
- Dropout Layer: To prevent the over fitting of the model random hidden units are removed stochastically.
- Flatten: It is used to combine the feature maps to one vector.
- Dense Layer (Fully Connected Layer): In this layer, every node in the layer is connected to the nodes in the preceding layer. This layer performs classification of the features extracted from the convolution layers and down sampled using the pooling layers. Here, the Fully Connected unit of the model contains a flattened vector and a single hidden layer. The hidden layer uses ReLU to allow only the positive valued vectors.
- Output Layer: The output layer uses sigmoid activation to restrict the output of the vectors within a fixed range. The model has been trained using Adam Optimizer and the loss is calculated in terms of binary cross entropy.

The layer-wise breakdown of the model can be viewed as:

- Input Layer: The input layer receives the images after pre-processing, i.e. images ready to be worked upon.

  Input Image Size: 64*64

  Dimensions of the Input Image: 64*64*3 (due to RGB scaling)

- Convolutional Layer: It receives the input image and applies 32 filters of size 3*3 each across the image.

  Hence,

  Number of parameters for a single filter = (3*3*3) + 1 (for bias) = 28 parameters

  Number of parameters for the entire layer = 28*32 = 896 parameters

  And, output size:

  Output Width/ Height = (n-f+1)/s

  Where,

  n = width/height of input image

  f = filter size

  s = stride

  Output Width/Height = (64 - 3 + 1)/1 = 62

  Hence, Output Dimension: 62*62*32

- Max Pooling Layer: The max pooling layer reduces the size of the image by half using 2*2 filters with stride of 2.

  Hence, Output Dimension: 31*31*32

  Number of parameters= 0 (as all the values in this layer are fixed)

- Dropout Layer: It simply prevents the over fitting of the model by randomly drop-ping certain hidden units.

  Output Dimension: 31*31*32

- Dense Layer (Fully Connected Layer): It takes in the input from the dropout layer and flattens the entire matrix into a single dimension.

  The FC unit in this model has:

  - The flattened vector
  - A layer containing 128 units

  Hence, flattening the input from the dropout layer, we get:

  Number of units (in the flattened vector) = 31*31*32 = 30752

  Hence, Number of parameters for the layer (ReLU) = (30752*128) + 128 (bias for each unit) = 3936384

- Output Layer: The output layer contains a single logistic unit activated by a sigmoid function which classifies the input image of blood cell images as Infected/ Not Infected.

  Number of parameters for the output layer (Sigmoid) = (128*1) + 1 (bias) = 129

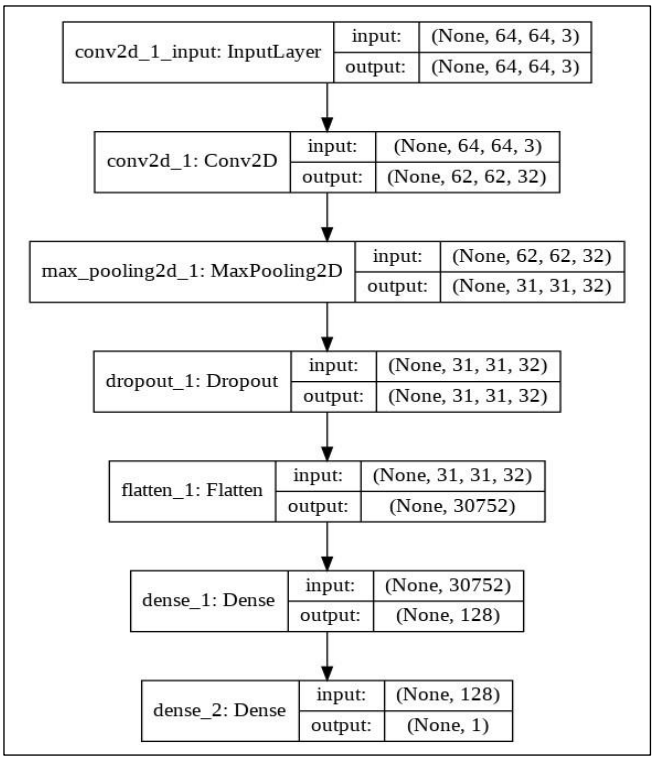

Fig. 4. CNN Model Architecture

The dataset containing 27,558 images was divided into training and testing data with 80 % and 20 % random images respectively. Hence, the training data had 22046 images and the testing data had 5512 images.

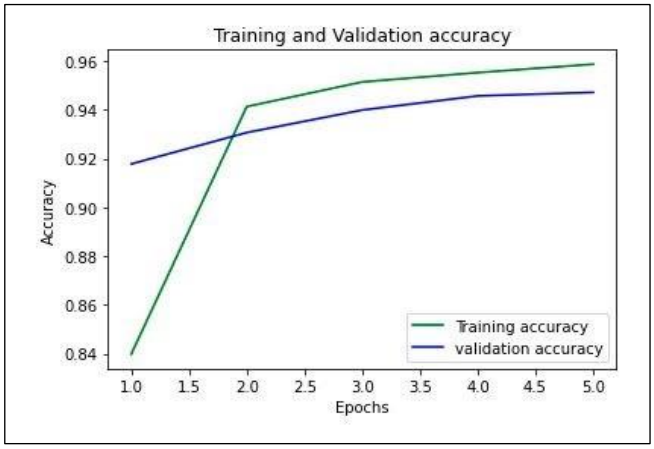

Fig. 5. Training and Validation Accuracy Graph

The model was trained using the training data and validated against the testing data. After the model training was done the classification report was as follows:

- 95.88 % accuracy on training data.
- 94.72 % accuracy on testing data.

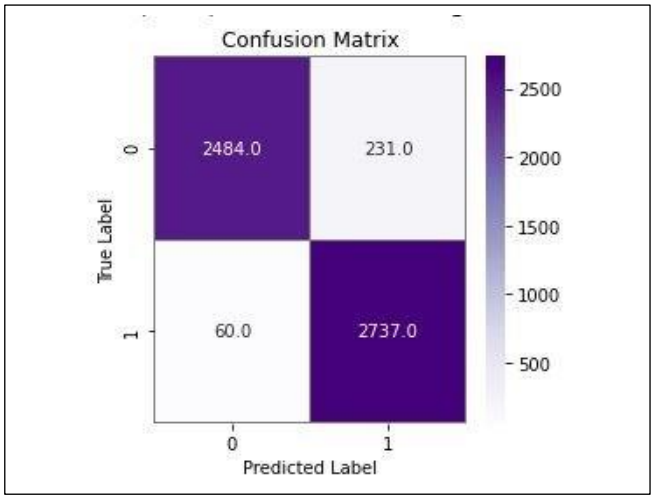

Fig. 6. Confusion Matrix Showing testing data classification.

V. Discussion

While it can be confidently stated that malaria detection is now done better using computer aided services rather than a fully human based system, the choice of the best method is still probing researchers. Even with CNN based approaches, there hap-pens to be a few differently designed systems contending for the top spot. The CNN using batch normalization proposed by P. Pundir, S. Aggarwal, and M. Deshmukh [7] returned 96.02% accuracy, while A. Rahman, H. Zunair, M. S.Rahman, J. Q.Yuki, S. Biswas, M. A. Alam, N. B. Alam, and M. R. C. Mahdy [18] experimented with three different architectures. The highest accuracy was seen by TL-VGG16 at 97.77% with 13 convolution layers. Considering only CNN based models, which have been reported to fare better than other classifiers or ensemble-based models, the proposed technique is clean, simple and easy to implement. It does not include expensive pre-processing and is fast and accurate within the competitive range of the other proposed techniques.

The result from the discussed model is 95.88 percent on training data and 94.72 percent on testing data which is right up in comparison with other much well-designed architectures. Furthermore, by using a larger dataset or using better resolution images along with the introduction of hyperparameters one can always fine tune the model for much better results.

TABLE I. COMPARISON OF ACCURACIES OBTAINED FROM DIFFERENT MODELS.

Accuracy obtained from CNN using batch normalization	*Accuracy obtained from TL-VGG16*	*Accuracy obtained from discussed model*
96.02%	97.77%	95.88% on training data 94.72% on testing data

Fig. 7. Table for Comparison of accuracies obtained from different models.

VI. CONCLUSION

The above use case of classifying infected and uninfected blood cells using CNN is an example of how moderate computing infrastructure can be used to implement models that can reduce the dependency of skilled technicians in the diagnosis of malaria. The model architecture used for classification consists of only a single convolution layer whereas many other models that are used for the same use case use more than one convolution layer. This shows how dynamic the convolution operation is and how by tweaking certain parameters we can achieve near perfect results.

The main objective of this work was to build a lightweight model, which is simple and nimble and generates fairly accurate results. The paper thus far, with the results, proves that the accuracy of results is better than fairly accurate. To that end, the research and experiments have been successful. The accuracy, authors believe can be further improved through training. Tuning hyperparameters in CNN's also have at times resulted in improved performance, which may be considered as future work.

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Prime Generation: Algorithms and Analyses

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***Abstract*—The paper deals with some well known as well as new prime generation methods. The concepts of RSA cryptosystem, primality testing, and the need for prime number generation methods have been discussed briefly in this literature. In this paper the prime generation algorithms are studied and analysed and various methods of speeding up the process of generation of probable primes are suggested. As one traverses from Algo 1 to Algo 3, making the necessary changes in the conditions as mentioned below in the text, a speedup can be achieved leading to a significant reduction in the computational complexity. In the final algorithm, a random k-bit odd number is chosen which undergoes n iterations of the Miller-Rabin test. If the test fails in any of the rounds, the number is incremented, maintaining the conditions as mentioned in the algorithm, and the process is continued. This method leads to a significant decrease in the computational complexity as discussed in the paper.**

Keywords—Cryptosystem, Miller-Rabin test, primes, primality test, prime number generation, probable primes

I INTRODUCTION

Almost all public-key cryptosystems such as RSA, Diffie – Hellman key exchange, and El Gamal signatures make use of large and random prime numbers. Thus fast and efficient generation of prime numbers is a necessity in such cryptosystems. The RSA public-key cryptosystem is one of the first and most popular public-key cryptosystems which was built on the idea of an asymmetric public-private key. The concept of asymmetry arises from the concept of difficulty in the factorization of the product of large prime numbers. The key generation of RSA cryptosystem uses this theory. It chooses two distinct large primes p1 and p2, multiplies them, and then the rest of the algorithm follows. The algorithm has been discussed extensively in [19]. It is often very difficult to retrieve the factors p1 and p2 from the multiplied value, if both p1 and p2 are very large random prime numbers. Thus the generation of large primes becomes a topic of utmost importance. The process of prime number generation using various concepts of primality testing have been discussed extensively in the following sections of the proposed literature.

II PRIMALITY TESTS

Primality testing algorithms help us to determine whether a number is prime or composite. Such algorithms find their applications in cryptography. Primality testing can be both probabilistic as well as deterministic. In this paper, we develop our algorithms based on probabilistic primality testing. Some of the most common probabilistic primality tests include the Fermat primality test, the Solovay-Strassen primality test, and the Miller-Rabin primality test. The Fermat primality test is the simplest amongst the three with Solovay-Strassen and Miller-Rabin being the more sophisticated alternatives. Amongst these, the Miller-Rabin test is the most commonly used one since it can detect strong pseudo-primes, which the Fermat's test is unable to do, as well as it can determine a prime number more accurately than Solovay-Strassen. The Miller-Rabin algorithm is briefly described below.

Miller-Rabin(n):

1. Choose an odd number n such that $n \geq 3$. Take an integer variable m and assign n to m.
2. Express n as $n = (2^x) * y + 1$ where $x \geq 1$ and gcd(2, y) = 1.
3. Choose a random integer b such that $b \in [2, n-2]$.
4. $t \leftarrow b^y (mod n)$
5. If $t \equiv 1 (mod n)$
   return ("Maybe Prime")
   Go to Step 7.
6. for (i ← 0 to x − 1)
   {
   if $t \equiv -1 (mod n)$
   return ("Maybe Prime").
   $t \leftarrow t^2 (mod n)$
   return ("Surely Composite").
7. End

In the above algorithm, we input a number n. If the number is detected to be prime the algorithm displays "Maybe Prime" as output, else it displays "Surely Composite" as output. For a more extensive discussion on this material, one can refer to [15] and [17].

III PROBABILISTIC PRIME GENERATION

In the following sections, we will look at some of the probabilistic prime generation methods which will use the Miller-Rabin test for primality. The Miller-Rabin test produces one of the outputs, either "Maybe Prime" or "Surely Composite".

For any odd composite number, the probability that Miller-Rabin test declares the integer as prime is less than ¼.

Using the Miller-Rabin algorithm, we formulate and discuss various algorithms as discussed in the subsequent text.

IV NAIVE PRIME GENERATOR

Say we have set O_k which denotes the set of all odd numbers in the interval $[2^{k-1}, 2^k)$ where k denotes the bit length of the prime number which is to be generated.

To generate a probable prime number we need to choose an element m_o such that $m_o \in O_k$. In the algorithm described below, the element undergoes only one iteration of the Miller-Rabin primality testing algorithm. The Miller-Rabin test displays "Is-composite" as output if the number is detected to be composite, otherwise, it displays "Maybe Prime." (The Miller-Rabin test is illustrated in Section II).

Algo-1:

1. Select a random odd number m_o of k bits. (where $m \in O_k$).

2. If (Miller-Rabin(m_o) = Is Composite)
Go to Step 1.
Else
Output ->m_o

In this algorithm, the number m_o has been subjected to a single iteration of the Miller-Rabin primality test. The process is repeated until a number m_o is found which is detected as prime by the Miller-Rabin primality testing algorithm.

IV.A Computational Complexity

In this section, we calculate the computational complexity of the algorithm. The computational complexity is determined for the number of modular exponentiations performed. For one Miller-Rabin test, one modular exponentiation is carried out.

The Miller-Rabin test is executed only once, irrespective of whether the number is prime or composite. If the number is a prime, then Step 2 of Algo-1 will be carried out only once.

The method illustrated below calculates the average number of times the Miller-Rabin test is executed for a composite number.

Let $P(i)$ denote the probability of executing i[th] test.
Irrespective of whether m_o is prime or composite, Step 2 is always carried out.

Therefore, $P(1) = 1$.
When m is chosen randomly, the probability that m is a prime is $\frac{1}{(lnm)}$. Here (lnm) denotes the natural logarithm of m.

Since m is always odd, the total number of numbers being judged as composite with the final one being judged as a prime are $\frac{lnm}{2}$.

But the final number is a prime number.
Hence, for $\frac{lnm}{2} - 1$ composite numbers the Miller-Rabin test is being executed.
Say, the average number of modular exponentiations executed to find a prime number is ƛ..

Therefore,

$$ƛ = \left(\left(\frac{lnm}{2}\right) - 1\right) * P(1) + 1$$

Putting $P(1) = 1$, in the above equation we get,

$$ƛ = \frac{(lnm)}{2}$$

Thus,
To generate a 256-bit number, on an average (approximately) 88.72 trials are required.

To generate a 512-bit number, on an average (approximately) 177.45 trials are required.

V NAIVE INCREMENTAL PRIME GENERATOR WITH N ITERATIONS

Algo-2:

1. Select a random odd number m_o of k bits. (where $m_o \in O_k$). Take an integer variable m and assign $m_o$to m (i.e. int $m = m_o$).

2. If for all n iterations, m passes the Miller-Rabin test, then output m and terminate the algorithm.

3. Else if it fails any of the iterations, do$m$<- $m + 2$. Check whether$(m \geq m_o + 2u)$,where u is the maximum number of candidates tested. If yes then output "failed" and terminate the algorithm, else return to Step 2.

V.A Computational Complexity

In this section, we calculate the computational complexity of the algorithm. The computational complexity is determined for the number of modular exponentiations executed.

The Miller-Rabin test is carried out n times. Therefore, when a number is prime, the number of times the Miller-Rabin test is performed is n.

The method illustrated below calculates the average number of times the Miller-Rabin test is executed for a composite number.

Let $P(i)$denote the probability of executing i[th] test.
$P(i+1)$denotes the probability of executing (i+1)[th] test.

Then,

$$P(i+1) \leqslant 1/4 * P(i)$$

Irrespective of whether m is prime or composite, the first iteration of Step 3 is always carried out.

Therefore, $P(1) = 1$

Therefore,

$$P(i) \leqslant (1/4)^{(i-1)}$$

For one Miller-Rabin test, one modular exponentiation is executed. In the algorithm described in this section, the Miller-Rabin test is executed for at most n times. Therefore, the average number of modular exponentiations required to be performed for one composite number is as follows:

$$\sum_{i=1}^{n} P\,(i) \leqslant \sum_{i=1}^{n} (1/4)^{(i-1)}$$

When m is chosen randomly, the probability that m is a prime is (1/ln m). Here (ln m) is a natural logarithm of m.

Since m is always odd, the total number of numbers which are being judged as being composite with the final one judged as a prime is $\frac{lnm}{2}$.

But the final number is a prime number.

Hence, the number of composite numbers for which the Miller-Rabin test is executed is $\frac{lnm}{2} - 1$.

Say, the average number of modular exponentiations executed to find a prime number is λ..

Therefore,

$$\lambda \leqslant \left(\left(\frac{lnm}{2}\right) - 1\right) * \left(\sum_{i=1}^{n} (1/4)^{(i-1)}\right) + n$$

To generate a 256-bit number, if the algorithm undergoes 20 iterations, a maximum of (approximately) 58.48 trials are required.

To generate a 512-bit number, if the algorithm undergoes 20 iterations, a maximum of (approximately) 117.63 trials are required.

V.B Error Probability

In this section, we will calculate the error probability of Algo-2.

Let B -> Event when Algo-2 displays a composite number as output.
Let $p_{(k,n,u)}$= Probability (B).
Let C_i -> Set of composite numbers amongst the set of odd numbers O_k whose probability of passing the Miller-Rabin test is greater than $1/2^i$.
Let c be some constant.
Let s = c log (2^k).

Then,

$$p_{(k,n,u)} \leq \left(2^{(-n*I)} * 0.7 + \sum_{i=3}^{I} P\,(C_i) 2^{(-n(i-1))} * 0.5ck\right) * (ck)$$

where $I \geq 3$and P(C_i) is the probability of a number being randomly chosen from the set C_i.

Also, expressing $p_{(k,n,u)}$ as a function of k, satisfies the following condition:

$p_{(k,n,u)} \leq \wp k^3 2^{-\sqrt{k}}$ where $\wp$ is a constant.

The proofs of the above results are illustrated in details in [2]

VI An improvement over "Naive Incremental Prime Generator with n iterations"

Algo-3:

1. Define π as $\pi = 2 * 3 * 5 * 7 * 11 * 13$.

2. Select a random odd number m_o of k bits. (where $m_o \in O_k$) such that gcd(π, m_o) = 1. Take an integer variable m and assign $m_o$it to m (i.e. int m = m_o).

3. If for all n iterations, m passes the Miller-Rabin test, then output m and terminate the algorithm.

4. Else if it fails any of the iterations, do m<- $m + \pi$. Check whether($m \geq m_o + \pi u$), where u is the maximum number of candidates tested. If yes then output "failed" and terminate the algorithm, else return to Step 2.

In Step1 and Step2 we define $\pi$and try to find a number m which is relatively prime to π, implying that it is not divisible by any of the factors of π. As a result, the number of times the primality test is being performed is reduced.

VI.A Computational Complexity

In this section, we calculate the computational complexity of the algorithm.

The Miller-Rabin test is executed n times. Therefore, when a number is prime, the number of times the Miller-Rabin test is executed is n.

The method illustrated below calculates the average number of times the Miller-Rabin test is carried out for a composite number.

Let P (i) denote the probability of executing i^{th} test.
P (i+1) denotes the probability of executing $(i+1)^{th}$ test.

Then,

$$P(i+1) \leqslant 1/4 * P(i)$$

Irrespective of whether N is prime or composite, the first iteration of Step 3 is always carried out.

Therefore, P (1) = 1

Therefore,

$$P(i) \leqslant (1/4)^{(i-1)}$$

For one Miller-Rabin test, one modular exponentiation is executed. In Algo-3, the Miller-Rabin test is executed at most n times. As a result, the average number of modular exponentiations executed for one composite number is as follows:

$$\sum_{i=1}^{n} P\,(i) \leqslant \sum_{i=1}^{n} (1/4)^{(i-1)}$$

When m is chosen randomly, probability that m is a prime is (1/ln m). Here (ln m) is a natural logarithm of m.

Since m is always coprime to π, there is a reduction of average number of primality tests performed by a factor of Φ(2*3*5*7*11*13) / 2*3*5*7*11*13 = 192 / 1001.

Therefore,
The total number of numbers being judged as composite with the final one being determined as a prime is $\frac{192}{1001} * lnm$.

But the final number is a prime number.
Hence, the number of composite numbers for which the Miller-Rabin test is executed is $\left(\frac{192}{1001} * lnm\right) - 1$.
Say, average number of modular exponentiations executed to find a prime number is λ..
Therefore,

$$\lambda \leqslant \left(\left(\frac{192}{1001} * lnm\right) - 1\right) * \left(\sum_{i=1}^{n} (1/4)^{(i-1)}\right) + n$$

To generate a 256-bit number, if the algorithm undergoes 20 iterations, a maximum of (approximately) 22.02 trials are required.

To generate a 512-bit number, if the algorithm undergoes 20 iterations, a maximum of (approximately) 44.71 trials are required.

VII A TABULAR REPRESENTATION OF NUMERICAL FINDINGS IN BRIEF

In the preceeding sections of the paper, computational complexities are calculated for Algo-1, Algo-2 and Algo-3. For Algo-3, there is a notable decrease in the computational complexity over the other algorithms. This is tabulated below for 256-bit and 512-bit numbers.

TABLE I

	Number of Computations (approximately)		
No. of bits	***Algo-1***	***Algo-2***	***Algo-3***
256	88.72	58.48	22.02
512	177.45	117.63	44.71

1 Table 1. Number of computations performed by the algorithms

VIII DISCUSSIONS

The present work, discusses various prime generation algorithms and proposes how some significant changes in the algorithms can lead to a noteworthy change in the computational complexity. The above algorithms clearly illustrate this phenomenon as we implement the naive prime generators in the initial algorithms and execute the concept of incremental search with repeated iterations in addition to the naive prime generators in the later algorithms. Furthermore, Algo-3 leads to a significant reduction of computational complexity over Algo-2. This is also illustrated in TABLE I of Section VII for 256-bit and 512-bit numbers. Thus the value of the final algorithm is established over the previous two.

IX CONCLUSION

In this paper, it is shown that, Algo-3 outperforms all the previous algorithms discussed. There is a significant reduction in the computational complexity of the algorithms as we gradually move from naive prime generator algorithms to later algorithms which execute the basic concept of naive prime generators along with incremental search, where the increment occurs by a certain factor, maintaining the constraints as mentioned in the algorithms, whenever required, for repeated iterations. Thus it is established that to go for the final algorithm as described in Section VI is more lucrative over the simpler alternatives, as our final algorithm has been demonstrated to fare as the most effective strategy for our illustrated numerical situation than the previous ones. Hence the value of the final algorithm is vindicated.

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