A Real-time Emotion Detection Application by Human Facial Expression

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***Abstract*—Human face is the mirror of human mind. Man can’t hide expressions from face. Human emotion detection from human facial expression is a complex process. Therefore, an intelligent system is required to detect emotions. In this paper, an improved real-time human emotion recognition by detecting frontal-face expression has been proposed. The performance depends on classiﬁcation algorithms. This process requires high level of knowledge about computer vision, convolutional neural network and working process of the algorithm. An android application and a web application are developed to detect human real-time emotions using device camera. The proposed model was trained in the TensorFlow library with deep neural network would detect different seven types of emotions: happiness, anger, disgust, fear, neutral, sad and surprise with great accuracy. Thus, creating ways for many applications in the future for industrial purpose and many more real time applications like humanoid robot, video gaming, medical diagnosis etc.**

Keywords— Land Record, Land Record Management System, Blockchain, Asymmetric Cryptosystem, Data Encryption

# Introduction

According to the American Psychological Association (APA), emotion is defined as “a complex reaction pattern, involving experiential, behavioral and physiological elements.” **People expresses emotions in many ways such as facial expression, speech, gesture and verbal expression using text etc. [3-j]. Emotions are fundamental features of human [2-j] and they play an important role in human communications.** Emotions play an important role in human interactions as they let people articulate themselves without words. It includes cognitive appraisal, bodily language, action tendencies, expressions, and feelings [2]. People would not be able to get along with each other without emotions. However facial expressions are produced by the contraction and relaxation of some facial muscles. [4]

**Emotion detection** is the task of recognizing a person’s emotional state — for example, anger, confusion or deceit across both voice and nonvoice channels. Emotion recognition involves considerable information including facial expressions, body language, pitch and tone of voice, and semantics. Facial expressions are crucial because they convey considerable information that can be widely used in various applications in different fields. Furthermore, facial expression can convey the same information across different cultures and countries.

Now-a-days uses of smartphones are increasing very significantly in the progressive countries like Bangladesh. In Bangladesh, real-time emotion detection (RED) with any application is almost new and this real-time application can detect human emotion with a decent accuracy. Other works on emotion detection on the improvement in number of classes, accuracy rate but in this paper, we present some steps towards the development of a prototype: a real-time android application that automatically finds faces in the visual video stream, detect the emotion and label the emotions of that particular frame. It can find multiple frames as well as can detect all of the face’s emotions.

The RED can solve many problems.

1. It can reduce suicide rate by monitoring emotional imbalanced people specially the teenagers.
2. The proposed system can be deployed in humanoid robots to increase human-robot interaction.
3. It remains challenging for computers and robots to classify facial expressions under different lighting conditions, poses, and backgrounds and across people of different ages, genders, and ethnicities. This problem can be solved by this method.
4. It can be used in several video games.

The rest portions of the paper are organized as follows. Section II analyses the related works. Section III explains the required building blocks. Section IV explains the proposed C2I table, and section V demonstrates the proposed LRMS. Section VI describes the experimental results, and section VII concludes the paper.

# Related Works

In the last decade, there are several works related to emotion recognition, facial expression recognition, deep neural network and transfer learning. And we can discuss them below.

T.H.S. Li and T.N. Tsai [4] developed an emotion detection robot which can detect human emotions using CNN. They analyzed static images for facial expression recognition. They consider six different emotions using static photo for facial emotion detection, but it is not feasible way, because human facial expression can fluctuate rapidly. Build a model which can take photos of a human continuously and detect emotions with the best frame can give the accurate data.

J.M. Garcia-Garcia et al. [5] developed emotion detection technology for the corporate sector. They developed a survey gathering emotional information from the user of a system on their voice. They focus on that When a person starts talking, they generate information in two different channels: primary and secondary [6]. The primary channel is linked to the syntactic-semantic part of the talking (what the person is literally saying), while the secondary channel is linked to paralinguistic information of the speaker (tone, emotional state, and gestures). E.g., someone says “That’s so funny” (primary channel) with a serious tone (second channel). By looking at the information of the primary channel the message that the speaker thinks that something is funny, and by looking at the information received by the second channel, we get to know that the real meaning.

Y. Liu et al. [7] developed a system on human emotion detection concentrating on recognition of “inner” emotions from electroencephalogram (EEG) signals. They propose real-time fractal dimension -based algorithm of quantify-cation of basic emotions using Arousal-Valence emotion model. Two emotion induction experiments with music stimuli and sound stimuli from International Affective Digitized Sounds (IADS) database were proposed and implemented. Finally, the real-time algorithm was proposed, implemented and tested to recognize six emotions such as fear, frustrated, sad, happy, pleasant and satisfied. Real-time applications were proposed and implemented in 3D virtual environments. The user emotions are recognized and visualized in real time on his/her avatar adding one more so-called “emotion dimension” to human computer interfaces. An EEG-enabled music therapy site was proposed and implemented. The music played to the patients helps them deal with problems such as pain and depression. An EEG-based web-enable music player which can display the music according to the user’s current emotion states was designed and implemented.

E. Maria et al. [8] worked on research and their aim was to give an overview of methods to recognize emotions and to compare their applicability based on existing studies. They work on smart wearables which provide contact with the skin and physiological parameters such as electrodermal activity and heart related signals can be recorded unobtrusively also during dynamical tasks. Looking forward, heart-related parameters might be an option to measure emotions accurately and unobtrusive with the help of smart wearables. They achieved of 88.86% accurate data based on the real emotions.

R. Horlings [9] worked on Human emotion detection based on brain activity, measured by EEG signals. They classified the received EEG signals into 5 classed on two emotional dimensions, valence and arousal. That system designed using prior knowledge EEG signals in practice. For that purpose, they gathered a dataset with EEG signals from people that were emotionally stimulated by pictures. That method enabled us to teach our system the relationship bet-ween the characteristics of the brain activity and the emotion. They found that the EEG signals contained enough information to separate five different classes on both the valence and arousal dimension. However, using a 3-fold cross validation method for training and testing, we reached classification rates of 32% for recognizing the valence dimension on from EEG signals and 37% for the arousal dimension when. Much better classification rates were achieved when using only the extreme values on both dimensions, the rates were 71% and 81%.

Table I.

Analyzing all the state-of-the-art works, there exists some research gaps which must be incorporated in a realistic LRMS. Firstly, almost all the works stored plain LR in the blockchain which could breach the data privacy. To the best of our knowledge, no system embeds any trading platform and that may lead the manual process again. And some of the systems take huge time in processing transactions and creating a new block which leads LRMS impractical. However, the proposed LRMS in this paper addresses the limitations.

# Required Building Blocks

## CNN

Deep Learning has proved to be a very powerful tool because of its ability to handle large amounts of data [10]. The interest to use hidden layers has surpassed traditional techniques, especially in pattern recognition. One of the most popular deep neural networks is Convolutional Neural Networks in deep learning. Since the 1950s, the early days of AI, researchers have struggled to make a system that can understand visual data. The [convolutional layer](https://www.sciencedirect.com/topics/computer-science/convolutional-layer) encompasses a set of kernels for determining a tensor of feature maps. [11] These kernels convolve an entire input using “stride(s)” so that the dimensions of an output volume become integers. The dimensions of an input volume decrease after the convolutional layer is used to execute the striding process. Therefore, zero padding is required to pad an input volume with zeros and maintain the dimensions of an input volume with low-level features.

 where I refer to the input matrix, K denotes a 2D filter of size m × n, and F represents the output of a 2D feature map. The operation of the convolutional layer is denoted by I\*K. To increase [nonlinearity](https://www.sciencedirect.com/topics/computer-science/nonlinearities) in feature maps, the rectified linear unit (ReLU) layer is used . ReLU computes activation by keeping the threshold input at zero. It is mathematically expressed as follows:

f(x)*=*max (0, x) (2)

The pooling layer performs a down sampling of a given input dimension to reduce the number of parameters. Max pooling is the most common method, which produces the maximum value in an input region. The FC layer is used as a that makes a decision on the basis of features obtained from the convolutional and pooling layers.

The block header and the block body are two parts of each block. The block header contains the metadata that typically includes block id, the hash of the previous block, number of transactions, nonce, Merkle root, timestamp, etc. whereas the block body contains each transaction data. The Merkle root is calculated from the binary hash tree called the Merkle tree. Here *Di* represents transaction data and *Hi* denotes the cryptographic hash of transaction *Di*. Secure Hashing Algorithm (SHA)-256 is a very prominent algorithm for hashing used in the blockchain domain.

## Dataset

To train the proposed model a dataset was collected from Kaggle contributed by Manas Sambare. The famous dataset is known as FER-2013. The data consists of 48 × 48 Pixel grayscale images of faces. The faces have been automatically registered so that the face is more or less centered and occupies about the same amount of space in each image. It consists of seven classes: angry, disgust, fear, happy, neutral, sad and surprised. The training set consists of 28,709 examples and the public test set consists of 3,589 examples.

## Haar-casecade frontal face:

The Haar-Cascade Face Detection Algorithm is a sliding-window type of algorithm that detects objects based upon its features like size and location of certain facial features: nose bridge, mouth line and eyes. Eye region being darker than upper-check region, nose bridge region being brighter than eye region.

# Proposed C2I Table

A new character to integer mapping approach named C2I table is presented in this paper. The motivation behind developing the C2I table is the ASCII table requires 3 decimal digits when converting a single character to its corresponding integer value. There are 256 individual characters presented in the ASCII table, most of them remains useless most of the time. The C2I table considers 95 individual characters that are usually useful. As there are only 95 characters in C2I table, it is needed only 2 decimal digits when converting a single character to its integer. It clearly shows that, by employing the C2I table in the conversion of text data to integer data around 33% overhead will be lessen compared to the ASCII table.

# Proposed LRMS

The overall architecture of the proposed blockchain-based LRMS is demonstrated in Fig. 2 and explained below.

## Involved Entities

#### Certification Authority (CA): An entity that acts to verify the identities of entities and bind them to cryptographic keys known as digital certificates is referred to as a CA. Both the seller and the buyer get digital certificates from the CA.

#### Buyer (B): A person who wants to purchase land. B chooses the land and negotiates a deal with the seller.

#### Seller (S): An individual who owns the land and wants to sell it.

#### Advertisement Agency (AA): A platform that is used for trading lands. S posts the land it wants to sell on this platform and B searches for the required land here.

#### Bank (Bn): An organization that acts as an intermediary between B and S for a transaction and offers loans also.

#### Land Registration Department (LRD): A government organization that manages land-related information and stores it on the private blockchain after encryption.

#### Blockchain Storage Server (BSS): The encrypted data is kept on it by LRD.

## Working Principle of the Proposed LRMS

Assuming the *LRD* already created and stored the existing land details after encryption for every landowner. The working procedure of the proposed LRMS as follows.

1. *S* and *B* both get digital certificates from the *CA*. The interaction is shown in the following Fig. 3.
2. *S* login to the *LRD* website to confirm its identity. Then *S* asks its land-related information. `
3. Then the *LRD* retrieves the required information from *BSS* and sends back to the *S*. The communications are shown in the following Fig. 4.
4. *S* posts the land details on *AA* for sale. *B* selects its preferred land from *AA* to buy.
5. *B* login to the *LRD* website to verify its identity.
6. *AA* creates a deed and sends it to both the *B* and *S*. A sample deed is shown in Fig. 5. The interactions are depicted in the following Fig. 6.
7. Both the *B* and *S* sign the deed and send it to the *Bn* for further procedure. The *Bn* signs and returns the deed to both the *B* and *S* after successful transaction. The contacts are illustrated in the following Fig. 7.
8. The deed is sent to the *LRD* for updating the ownership details.
9. The *LRD* creates a new block with the updated information and append it to the blockchain. Here, in Fig. 8 the interactions are demonstrated.

## Encryption Phase

The *LRD* encrypts the land records by using the public key of its owner *Pubowner* through the following steps. The operation flow of the encryption process is depicted in the following Fig. 9.

Step 1: First, read the *LR* which usually contains text data.

Step 2: Convert the text data into the corresponding integer value based on C2I table.

Step 3: Encrypt the integer data by using an asymmetric cryptosystem.

Step 4: Convert the encrypted data into binary bits.

Step 5: Transform bits into corresponding DNA bases (11 = A, 10 = T, 01 = C, 00 = G) and store encrypted data in the *BSS*.

Fig. 9. Encryption process.

## Blockchain Storage Phase

#### After encryption of LR, the LRD creates a new block on the BSS. The BSS returns the corresponding block id Idblock to the LRD for further usage. Then the LRD stores the Idblock along with the identity of its corresponding owner.

## Retrieval Phase

## If a landowner wants to retrieve its LR, it requests to the LRD. Then the LRD requests the specific block of landowner to BSS by providing a Idblock and it returns the corresponding block to the LRD. Then the LRD sends back the LR to its owner. Upon receiving the encrypted LR from LRD, it decrypts the encrypted LR using the private key Priowner. The decryption steps are mentioned in the followings. The operation flow of the retrieval process is depicted in Fig. 10.

Step 1: Read encrypted data from the *BSS*.

Step 2: Decode the DNA encoded data to retrieve binary bits.

Step 3: Convert the binary bits into corresponding integer data.

Step 4: Decrypt the individual integer data using the private key.

Step 5: Retrieve the land record (text data) from the integer data using the C2I table.

# Experimental Studies

## Experimental Setup

The prototype of the proposed technique is developed under the environment on Intel(R) Core™ i5-7300HQ CPU @2.50 GHz 64-bit processor with 8GB of RAM running on Windows 10 OS. It was developed in VS code 2019. The ElGamal cryptosystem is adopted as an asymmetric cryptosystem and used a 1024-bit length key for operations.

## Output of the Encryption Phase

Considering the plain LR ‘Seller: Mr. X, Buyer: Mr. Y, Land information: Dag number: 8000, Khatiayan number: 3000, Area:2000 Shotangsho, Transaction ID: BNXY2345’ and using the steps of the section IV(C), Table III depicts the output of the encryption phase.

## Output of the Decryption Phase

Using the steps of the section IV(E) and the LR of section V(B), Table IV presents the output of the decryption phase.

## Comparison with other LRMS

Table V demonstrates the suitability of the proposed LRMS for data privacy and authenticity over the state-of-the-art works. In summary, the proposed LRMS ensures LR privacy and provides users’ authenticity where most of the systems fails to do. By incorporating private blockchain, the system offers very low cost (in fact free if government want). The proposed LRMS facilitates a platform for trading land through an advertising agency. Additionally, the system enables quick processing times for usage by using C2I table.

## Security and Performance Analysis

This section assesses the security aspects, *i*.*e*., data privacy, data integrity, etc., encompassed by the proposed system.

*Data Privacy:* The proposed scheme offers privacy via ElGamal encryption. Because of the robustness and probabilistic encryption over other asymmetric cryptosystems, ElGamal is chosen.

*Data Integrity:* As the blockchain is an immutable ledger, data integrity is ensured by storing in a distinct block of the blockchain.

*Time:* By employing the C2I table, around 33% conversion time will be lessened compared to other scheme.

# Discussion and Conclusion

This paper proposes a blockchain-based land record management system to secure land record management system maintains adequate data privacy, data integrity, availability, etc., about the land record. Herein, an asymmetric cryptosystem is exploited to enrich data privacy. The storage of the land record over the blockchain assures integrity. The trading platform alleviates the burden of searching the proper land. The proposed C2I table reduces on average 33% overhead of text to integer conversion compared to ASCII table. The preliminary assessment refers the effectiveness of the proposed scheme. A forthcoming plan is to improve the encryption and decryption process, and implement the prototype of the proposed land record management system in a more realistic environment.

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