

Deep Learning Approach to Home Security System driven by OpenCV and Face Recognition

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Abstract— In order to assert peace the security to the place where we live is one of the essential objectives to count. Nowadays, people think that installing a Closed-circuit television (CCTV) surveillance system would secure the home. It only records the footage and help us to monitor the sight of the home, but for an effective result we need something which is authenticated reliable system. To solve the problem statement of security, I made an algorithm using face recognition and few complex approaches to make a CCTV a smart camera. The model is based on the deep learning algorithm of face detection named Viola-Jones method. Using this recognition we authenticate the guest and the model will allow the guest on the basis of invitation.

Keywords: Convolution Neural Network, Deep Learning, Facial Recognition, Validation, Big Data, Internet of Things, LSTM, VGGFace

I. INTRODUCTION

A. Home Security

Introduced system provides an effective way to apply privacy and security for the homes and also allow the owner to monitor his/her at real time without acquiring useless data. The approach is very basic for the authentication, it uses a CNN face recognition model of DL viz. VGGFace. The Visual Geometry Group (VGG) is developed by Omkar Parkhi at Oxford and described in the paper “Deep [Grab your reader’s attention with a great quote from the document or use this space to emphasize a key point. To place this text box anywhere on the page, just drag it.]

Face Recognition”[1] the focus of the paper was on how to collect a very huge training dataset to train a deep CNN model for face recognition which gives a state-of-the-art results on the standard dataset []. This research is initiate by Medi-Caps University, and the fellow students are working to penalise the noise in the training dataset.

The main question arises: Why is this problem considerable?

According to the research of Len Doyal, Ian Gough in the paper “A Theory of Human Needs”[2], they discuss that the living place is the essential need among foods and clothes. Keeping this in account, our model gives the security to the casa by providing the high end authentic bio informative algorithm working backend on the Raspberry Pi or Cloud Services. Following the previous researches in the field of pattern and face recognition this paper has been drawn, we authors as a team chose to opt Divide and Conquer approach i.e. we divided the problem statement into sub problems based on the technology we are using. The major parts of the model are: DNN face recognition, IoT based locking system, Cloud for processing and database to store useful footage.

The objective of this research is to create a business model which is reliable and useful for the society. Our World is getting smarter on daily basis and so does the technology.

In this smart generation, a smart security system would play a big role in residences.

Every technology which is used in the research is interconnected with each other. The recognition model sends update to locking system and correspondingly camera records the necessary footage. The practical implication of this project is to people who live in mediocre residential areas. The rate of heist is increasing day by day and this research would be a great remedy to this problem.

According to the book of Frank E. Hagan, “Introduction to Criminology” [3] author says that loss to residence per robbery is \$1,469. In cities like Costa Rica and Argentina the rate of robberies are approximately 1500 per 100,000 people[4]. The economy is badly affected by such heists. The government is also unable to take actions on them because the identify of thief is anonymous. Again the research can lead to identify the image of thief if we get the access to the list of all the wanted thieves and pickpockets. Integrating the system to an alarm would inform the police the second any thief comes in the front of camera when he is not invited. This system has a potential to cover a grand piece of area in 24x7 surveillance of police and legitimate camera owner. The measure of robberies and homicides is increasing by the rate of around 12% - 20% every year. Following is the chart which shows the rate of the year 2012:

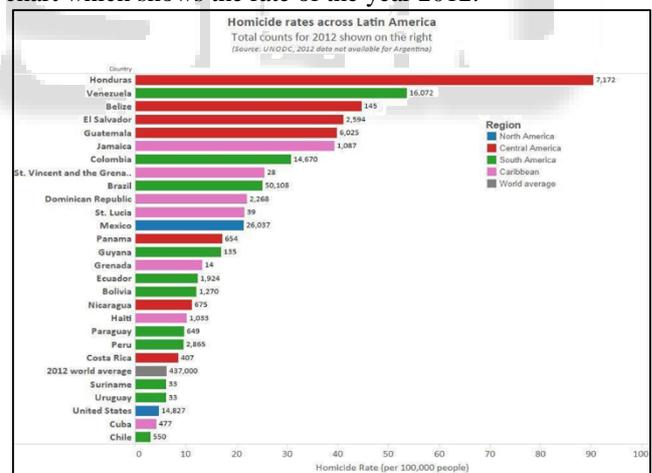


Fig. 1: Unsecured cities of Latin America: Rate of Homicide cases for year 2012 [7]

These counts have been increased with a tremendous amount and to control the damage the countries are taking huge loans. Thus the economy is getting very affected by such small incidents. The smartest way to control these counts by the help of technology and integrated profiles.

B. Effects of Problem on Society

If no actions are taken to this problem, then this problem could lessen the overall economy of the world. The money reservoir prints limited and fixed amount of cash to control the wholesome per capita, when a heist happened the huge amount of money has been drawn out of the rotation of a bank or an individual. People are actually committing suicide

because of such robberies. The undeniable fact is that if these heists are not stopped immediately then it will get even worse by the time goes.

Statistics show that there are thousands of people committing suicide every day and few with courage and delusion turned into robbers just for the sack of money and living. The robbery in the world is exponentially increasing, according to online articles in year 2012 the robbery, rate per 100,000 population was like:

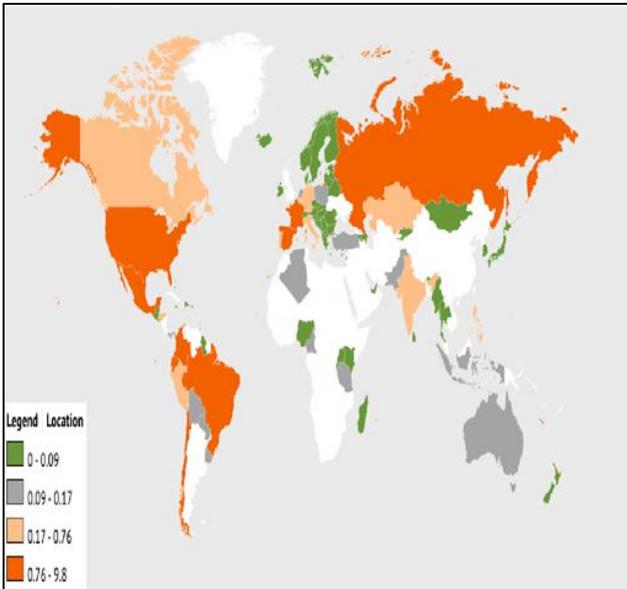


Fig. 2: Robbery, rate per 100,000 population of the Globe for year 2012 [12]

C. State of the Research and Flow of the Model

As the aforementioned processes, the subject model has a quiet regular flow. The idea to use deep learning in home security system is came from the pathetic data management of CCTVs and other surveillance camera. The initiation of the whole research is from input image of a person. The DNN process the matrix of that person and tries to recognise the person, accordingly authenticate him. If the person get the authentication, then using flagging and hardwares the mechanical IoT sensors will open the gate. And if not, then only the CCTV will record the footage.

Using OpenCV and IoT together has been challenging but the results are satisfactory and fast in processing. The challenges we faced in this research is training the model to register any guest, but after improvising the research motive we end this challenge by providing a remote access to the head of the residence.

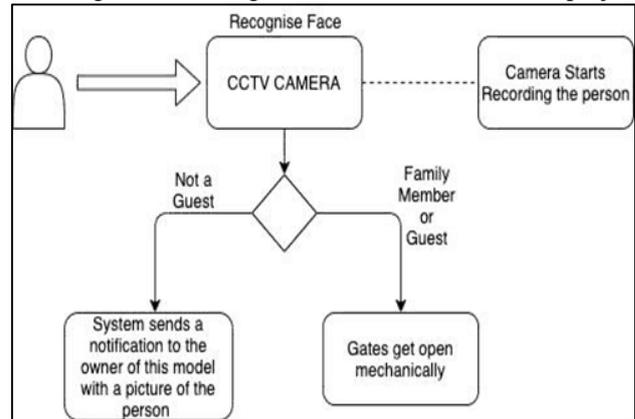
II. METHOD AND ALGORITHM

Algorithm plays a huge role to reach at the goal of this research. Making a camera which works according to the requirements is a big task and to complement these needs the system requires few equipments also. A camera, Raspberry pi module, IoT sensors, and Motors. The use of these equipments is widely described in later sub titles.

The approach to the goal of the research is an interdisciplinary model which includes facial recognition of deep learning, IoT functionalities and programming knowledge to get the task done. To generalise the method we

need to understand the flow of the research. The flow chart of this system has few entities which explains the working and compulsion of the system in the society.

Following is the working chart of the research and the project:



A. Facial Recognition

To identify and verify a person based on a photograph we use a computer vision task called Face recognition. Nowadays deep learning CNN have exceeded the classical A.I. approach and achieving state-of-the-art results on facial recognition. A book of facial recognition titles “Handbook of Facial Recognition” by Stan. Z. Li[5] describes the two major modes of face recognition; Face Verification and Face Identification. In the research, we did Face Identification i.e. a one to many mapping of a given face against a stored database of familiar faces. By using a lite and simpler deep learning model of face recognition VGGFace. It is basically a series of model by Oxford University for demonstrate face recognition.

Currently there are two VGGFace models; VGGFace and VGGFace2, both of these models were initially implemented in Caffe library of python, but in this research we have used the keras implementation of VGGFace and used ResNet50[6]. The library versions we used in this research are:

- Keras v2.2.4
- TensorFlow v1.14.0

Later the model sends a flag which signifies the validation and identification of the actor who came in front of the system’s camera.

B. IoT and Raspberry Pi

Getting that flag commands the hardwares to unlock the door or not. This system is very reliable because it analysis the person on the basis of the 3D structure of his face so it is quite difficult to hack the system and invade in the home. The module connected to the system has basic snippets of codes. It receives the flag from the VGG model and accordingly lock and unlock the door as the module is programmed. On different gates, the hardware may vary but the raspberry pi module would do the same job at every gates and doors.



Fig. 3: Raspberry Pi Module connected with Camera for testing

C. Procedures

The camera works on the principle of matrix change, whenever the stable image of the scene changes the matrix values then only the CCTV will record the footage. The algorithm works on the idea of Lucas Kanade method of OpenCV, it assumes the displacement of the image contents between two nearby frames is small and approximately constant within a neighbourhood of the point under consideration.

Lucas Kanade Optical Flow is an algorithm which involves finding the motion (u, v) that minimises the sum-squared error of the brightness constancy equations for each pixel in a window. The algorithm will be implemented as a function with the following inputs:

```
def optical_flow(I1, I2, window_size, tau)
#returns (u, v)
```

Here, u and v are the x and y components of the optical flow, $I1$ and $I2$ are two images taken at times $t = 1$ and $t = 2$ respectively, and $window_size$ is a 1×2 vector storing the width and height of the window used during flow computation. [8]

In addition to these inputs, a threshold τ should be added, such that if τ is larger than the smallest eigenvalue of $A^T A$, then the optical flow at that position should not be computed. Recall that the optical flow is only valid in regions where

$$A^T A = (\sum (I_x)^2 \sum (I_x I_y) \sum (I_y I_x) \sum (I_y)^2) \quad (1.1)$$

This algorithm also returns a flag which indicate the camera to record the footage or not. In this way, the research saves data covered by CCTV camera.

III. RESULTS

In order to achieve the goal of this research we took the dataset of robbery stats to analyse the count and get a vivid image. Using this data we were sure to work on this project for social betterment. As the research mentioned above, the expected result of the study is an interdisciplinary hardware product which has turned a regular surveillance camera into a smart high home security system.

This research has been done by the students of Medi-Caps University, the students managed to get the hardware and prepared the prototype of the system. "This could be a good product if we launch it in the less crowded cities" said the research and innovation dean, Medi-Caps University.

A. Team

As a group of students under the professor author's guidance we started the process and in few couple of months we achieved a satisfactory result out of the research.

B. Statistics and Data Analysis

The dataset has been downloaded from kaggle[11] and analysis is done using basic python libraries like Pandas, NumPy and sklearn. The data explains the different crimes of DC city.

Through this data we conclude the idea of this research and thus we got an idea to built this security system.

C. Ancillary Analyses

Few research has been done through previous journals and there are some organisations which are working on the security system for home and industries, but this research has particularly done for the homes and promote the non-security guard culture in the residence.

D. Project Flow

First phase of this project started with face recognition and further the whole project is integrated with one another. The setup of this system has been done by connecting the raspberry module with computer and must be trained on the persons' data.

Afterward the raspberry module performs the computation and send the flag signal to the gate of the house. We must take care of the connection between the camera, raspberry pi and in-house computer.

#(Faces) in dataset	Model	Accuracy (Percentage)	VGG Model Performance (Frames per Second)
8	VGGFace	83.6	7
10	VGGFace2	92.8	12-14

Table 1: Result of the research on different model
Note. Presented table showcases the speed of two different versions of VGGFace, researchers are working on few other models for better performance.

IV. DISCUSSION

Keeping the above presenting results of the work on the mind, there are still few problems we might face after market this as a product. According to the team, this product would be a great security channel for almost every family which doesn't have a security guard. The authors of this research implicated that the research in the form of a product will do very good in market. It is also discussed that later on it will face certain problems but these are unconcerned. The researchers of this paper are working on the project and trying to solve these issues.

Also the motivation of the research came from the high rate of heists and robberies in many developing

countries. This activity is affecting the overall development of the country and pulling the growth backward. These robberies need to be stopped for a good economy[10] in the nation.

The main challenges we have faced in this research are of various kind like (a) Finalising Face recognition model for a fast and accurate result, which is lite in processing and hard to hack. (b) Code the Raspberry pi module according to the requirement of the research, this task took a long time to complete because of the lack of practise with such modules. (c) In some gates the hardware couldn't hold the notch of the door to open it, maybe because of the smooth iron or irregular shape of hinge. (d) It is not threshold for every scenery, thus we built our own algorithm of image processing which can adjust the tau accordingly and this algorithm makes the Lucas Kanade optical flow working on a dynamic tau value.

While discussing the problem faced, nonetheless there are many other problem we might face if we use this product in the street. These issues could be (a) Different locality has variety of roads in opposite the main door, which could change the frame continuously in this manner our algorithm to optimise the storage would be a failure. (b) There are few special types of gates we have seen while researching, it would be very difficult to control such type of unlocking. (c) It could be difficult to append the face of guest in the dataset and customise the access of the faces.

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