

Patrolling Robot with Facial Detection

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Abstract—Security of any facility and the people inside it is a huge responsibility of the management of that facility. This, even though it can be achieved using humans, it leaves them at risk and introduces a factor of human error. Thus, The proposed system aims to improve the surveillance and security of a compound, without putting any human lives at risk and naturally removing the human error factor from the process. The paper discusses the implementation of such a system and all the work related to it. The proposed system is a fully functional robot which can follow the direction of a sound. It also has an on board camera which sends live footage of everything to a server. This feed is then processed for detection of a face and it is displayed to the user.

Index Terms—security, IoT, facial detection, patrolling, arduino,

I. INTRODUCTION

For billions of years mankind has faced threats which were potentially life threatening and has found ingenious ways to overcome them. Even so, one of the most pressing concerns in society today still remains the safety of its citizens. The threats in today's modern day world are not as simple as a lion attacking a human like the good old days, but have developed as the civilization has evolved. Sadly the measures to counteract these threats are not improving at the same speed. As it is rightly said by John Maxwell "Change is inevitable, but growth is optional". According to a research conducted in [1] the acid attacks on women in south Asian countries are still prevailing and cause a great deal of damage to the women. It was not until 2019 that Bangladesh could reduce the frequency of these attacks by a mere 20-30%. Another survey says that 38.7% of youths which were interviewed showed signs of committing at least one hate crime [2].

All the above is evidence that even in the 21st century the crimes are at an all time high and don't seem to be going down. Even though we have various measures to prevent or stop such threats all of them involve human lives being put in danger. This system has been put as a last resort and not as a foolproof solution. The bypass to this system has become so common that even in crime thrillers it is a common practice to introduce at least one scene in which the convict can slip through the "secure" facility when the guards are changing shifts.

Thus, in order to reduce the risk of any further human being and remove the possibility of any human error the idea of the proposed system was put forth by the team. As this is a well

researched field the team found lots of research papers which helped improve the overall concept and make the world a little safer.

II. LITERATURE REVIEW

One of the most important needs of modern times is security. The rise in population is directly proportional to the need for proper security. A night patrolling visionary robot would help achieve certainty, especially during the night. All the research papers have directed to the fact that the basic must-haves for the night patrolling systems are the logic for sound sensing, moving towards the area of target and back to the original location, image capturing and processing.

The night vision patrolling robot has the primary objective to ensure the safety of the people without putting any human life at risk. There are certain essential features needed in the robot, such as a night vision, obstacle detection, and motor driver circuits for controlling them [3]. All of these are controlled using a microcontroller board such as an Arduino UNO or raspberry pi. In addition, a wireless IR transceiver would be helpful in the navigation of the robot [4]. According to [3] the proposed system has the best advantage over disadvantage ratio if it uses an IR Camera with a wireless controller and some form of an obstacle detection system. Furthermore, optional features such as a GPS Module, GSM radios [4], sound sensor [3] will greatly help increase the productivity of the project. Journals have shown that a sound sensor and a smart camera are primary necessities for the system. Along with this according to the paper by N.Hemavathi the robot is built with a DC motor and transistors. The movement of the robot is handled by multiple logics operated on the transistors. These transistors allow the motion of the DC motor in the desired direction [5]. Bluetooth technology has also been used in the process for serial communication with the robot [6]. In another paper, the authors have mentioned the use of a special GPS for location tracking. Object detection algorithms have been designed for the robot to understand the route [7]. Technology is advancing at a rapid pace nowadays. These shifts are also visible in the robotics industry. As a result, the system suggested in the given papers reflects the current state of the field. The main objective of this is to offer ladies safety at night. Using a credit-card-sized Raspberry Pi and an open CV, the author of this paper, created a night patrolling robot (computer

vision). [8] To detect the face, the suggested system employs a Raspberry Pi camera. Anomaly detection is done using deep learning technologies [9]. As a result, the image is recorded using the pi camera and sent to the raspberry pi for face and human detection using OpenCV. The accuracy of this approach is around 83 percent [8]. The sensors used are IR sensors and sound sensors. According to this project, the entire territory monitoring is completed using a night vision camera and a programmed framework. When a sound is detected, the robot will follow a certain path to that space, capture the region, and send the picture to the user via IoT. Behind this project is a pre-programmed dazzling path for night vision viewing. [10] The proposed system focuses on the security of the place where it is implemented. It is specially designed to carry out the security assessment function at the night time when it will be dark all over the place. It is equipped with a night vision camera which will be used to capture the pictures of the spot if any suspicious activity takes place. It moves on a predestined path, and it moves in the direction of sound. It is also equipped with human face recognition technology. This system uses the LAN protocol of IOT, and it sends the recorded images to the responsible authority so that they can take any actions if necessary. It system uses a microcontroller, night vision cameras, sound sensors, Infrared sensor and Motor drivers. [11] This system is built to ensure women safety in remote regions and public places. IOT gecko is used for receiving transmitted snapshots and displaying them to people with alert sounds. This system consists of a combination of 2 HD cameras to monitor the environment sharply and closely. The hardware used in this system are HD infrared camera with night vision, Sound sensor, DC motor, IR Sensor, Ultrasonic sensor, LCD display, and a motor driver. [12]

Facial recognition is an important aspect in terms of the proposed system. This serves a greater importance in order to assess the threat and act accordingly. [13] Facial recognition is a subset of the highly expanding computer vision field. This field has been overly dominated by the areas of Machine Learning and Deep Learning from the very beginning [14]. Taking into consideration the scope of lighting in a night patrolling robot it is safe to assume that the best approach would be to perform IR recognition [13]. Thus according to [13] the best possible way of training the TIR based facial recognition is to use a Deep CNN Classifier with substantial training data. The losses given by equation 1

$$\sum_i^N [\| \int (x_i^a) - \int (x_i^p) \|_2^2 - \| \int (x_i^a) - \int (x_i^n) \|_2^2 + \alpha] \quad (1)$$

Are the minimum and give the best possible output with a method called triple loss learning. [13] There are three main steps for facial recognition and tracking in real time [15]. The First Step is Detection of Faces to track them, the next being recognition of facial features, which is determined using equation 2

$$\Omega_{[w,h]}^m = \left(\left\lceil \frac{m}{w} \right\rceil + \left\lceil \frac{m-1}{w} \right\rceil + \dots + \left\lceil \frac{w+1}{w} \right\rceil + 1 \right) \cdot \left(\left\lceil \frac{m}{h} \right\rceil + \left\lceil \frac{m-1}{h} \right\rceil + \dots + \left\lceil \frac{h+1}{h} \right\rceil + 1 \right) \quad (2)$$

The last step is to begin tracking the face in real time.

Object detection bases the image processing. The image is seen in a digital form of the same. Process of Image processing, object detection majorly involves object recognition, object localisation, image classification. According to a survey for different processes for image processing, multiple techniques have been identified which present different accuracies for the same. The survey paper implies that numerous techniques have separate sets of specifications. For example, Deep CNN shows 85% sensitivity especially for medical cases, face recognition vendor test (FRVT) makes identifying a male easier than female. According to this paper, Deep neural networks and CNN which are AI based techniques are recommended for object detection [16]. Furthermore, another paper by Sandeep Kumar, has emphasized on the kind of image processed. It mentions the use of Convolved neural networks, for static images with static background. After preprocessing, and feature extraction, single neural networks are integrated for image recognition and processing [17].

The author of this work presents several innovative models for all stages of a face recognition system. To perform the process of face detection efficiently, the authors suggest a hybrid model integrating AdaBoost and Artificial Neural Network (ABANN). The labeled faces detected by ABANN will then be aligned using the Active Shape Model and Multi-Layer Perception in the next stage. The author proposes a novel 2D local texture model based on Multi-Layer Perceptron in this alignment step. The model's classifier enhances the accuracy and robustness of local searching on faces with ambiguous outlines and expression variation. The authors of the research offer a way for boosting efficiency in the feature extraction step by combining two methods: geometric feature-based method and Independent Component Analysis method. [18]

III. RELATED WORK

A. Haar Cascade Classifier

One of the most popular study topics is the facial detection system. This section discusses the work defined by prior scholars on facial detection. Face detection algorithms and approaches have been the subject of numerous investigations.

For the algorithm, Harleen Kaur and Arisha Mirza used OpenCV and NumPy, and they divided facial recognition into two parts. The first step in this technique is the classification task, which takes any random image or media as input and outputs a binary value of yes or no, indicating whether or not there are any faces in the image. The second phase is a face localization job, which takes an image as input and outputs the location of any face within that picture in a bounding box with width and height parameters. [19]

Di Lu and Limin Yan describe that In the field of face detection, the OpenCV approach is widely used. It begins by extracting the face from a big sample set and then extracting the feature photos. The face detector is Haar characteristics in the image, followed by the AdaBoost algorithm. The algorithm detects faces. can easily adapt to challenging conditions, such as insufficient illumination and backdrop blur, resulting in a significant improvement in performance. [20]

The author of the last paper describes various algorithms which are available for face detection. The author of this paper says that their paper is for anyone interested in learning about the various types of face detection algorithms. The following is how the rest of the paper is structured: first, they go over the feature-based techniques in more detail. After that the image-based techniques are discussed. Also., the face detection techniques are compared in a thorough manner. [21]

The Haar Cascade technique is an Object Detection Algorithm that may be used to recognize faces in images or real-time videos. Viola and Jones proposed edge or line detection features in their research paper. [22] Features are one of the most significant aspects of the haar cascade approach. This trait is depicted in Fig. 1. These elements on the image make it simple to locate the image's boundaries or lines, as well as locations where the brightness of the pixels abruptly shift.

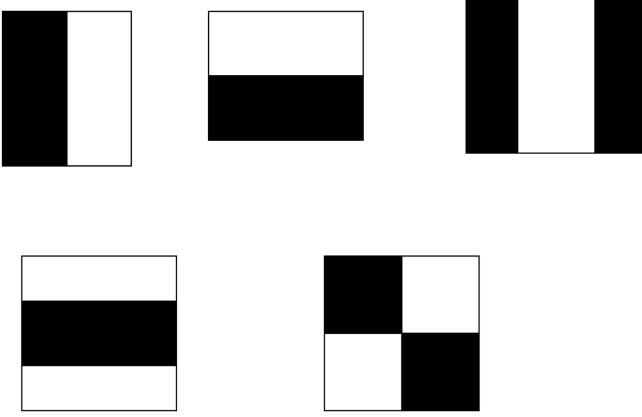


Fig. 1. A sample of Haar feature [22]

Pixels with a value of 1 are darker in the haar feature, while pixels with a value of 0 are lighter. Each of these is in charge of identifying a specific feature in the image. Any structure in the image where there is a quick change of intensities, such as an edge, a line, or any other structure. The goal is to calculate the sum of all image pixels in the darker part of the haar feature, as well as the sum of all image pixels in the lighter portion of the haar feature. Then figure out how they differ. The haar value will be closer to 1 if the image has an edge dividing dark pixels on the right from light pixels on the left. That is, if the haar value is closer to 1, we claim there is an edge detected. There is no edge in the example above because the haar value is distant from 1. The haar feature must traverse the entire image to detect an edge anyplace in it.

B. MediaPipe by Google

Another popular framework for facial detection is MediaPipe developed by Google. It has many features like object detection, facial detection, posture recognition, facial recognition and more. Fig. 2 shows the internal workings of the mediapipe framework [23]

MediaPipe uses a unique architecture which allows the user to incrementally prototype a pipeline. Here each component is

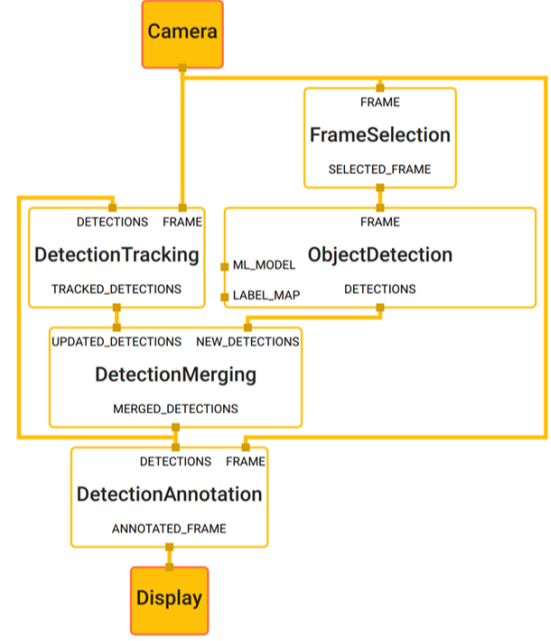


Fig. 2. Media Pipe Internal Workings

a calculator. Graphs are specified in the Graph object using the GraphConfig Protocol. Data streams connect the Graphs and Calculators where each stream is a time-series of data packets [23]

IV. METHODOLOGY

A. Hardware

1) *Arduino UNO*: Arduino UNO is a microcontroller board based on ATmega328p. The board has a set of input and output digital pins as well as analog pins. The board can be interfaced with several other expansion boards. The Arduino board presents a facility for communicating with computers.

2) *DC motors*: DC motors belong to a class of rotatory motors, which convert DC current into Mechanical energy. Using this principle, the DC motors would act as an agency for mobility.

3) *Gyroscope (GY521)*: This is a breakout board which consists of a 3 axis gyroscope, 3 axis accelerometer, and a temperature sensor. Gyroscope helps in calculating the orientation and the angular velocity. The digital motion processor can be used to process complex algorithms on board.

4) *Ultrasonic sensors*: Ultrasonic sensors are used to measure the distance of any object in the vicinity of the sensor. It has a wide range and uses the emission and detection of ultrasonic waves as the principle. Primarily ultrasound sensors are used for the purpose of object detection in the proposed system.

5) *ArduCam mini*: ArduCam mini is a high definition 2MP SPI camera, which reduces the complexity of camera control interfaces. It integrates 2MP CMOS image sensor OV2640, and provides miniature size, as well as the easy to use hardware interface and open source code library.

B. Software

The software part of the proposed methodology is further subdivided into 2 parts the first being the Flutter application and the second being the facial detection. The Flutter application serves as a Frontend / User Interface for the system, it notifies the user about the status of the robot using the live feed of the onboard camera from the actual robot. The workflow of this application is explained in Fig. 3 Now

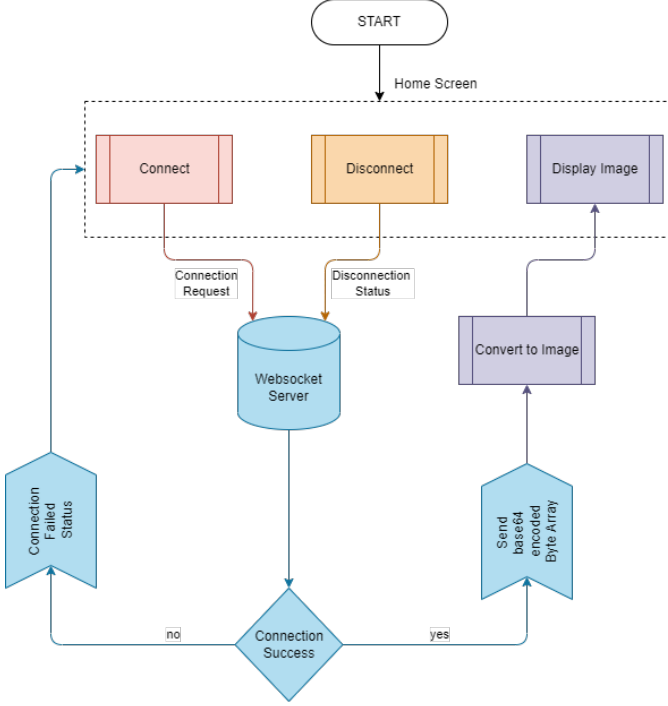


Fig. 3. Application workflow

in Fig. 3 as you can see the Flutter application only makes a connection request to the websocket. This is because as mentioned earlier the websocket protocol can directly dump data on the client without it specifically requesting for any data. The websocket server serves a simple purpose in this application. It first reads the data from the camera (which is the live video feed), frame by frame and then it performs facial detection tasks on that frame. The program then writes the confidence percentage on the image and then reads it as a byte array. This byte array is encoded in a base64 string and packaged and sent from the server to the client side. The Flutter client then reads this string and decodes it which in turn leaves it with a byte array, it then renders that byte array onto the application thus giving the user a face detected live video feed.

As illustrated in Fig. 4, the camera should be started first; if there is a problem with the camera opening, the code will be terminated. Then it will read the frame/image identified by the camera; Haar cascade is a grayscale image-only algorithm, hence the acquired image must first be transformed to grayscale before the algorithm can be applied. The frame is now ready for the haar cascade algorithm to run. The algorithm will scan the facial feature after passing through the haar cascade classifier to determine the face in that frame or image.

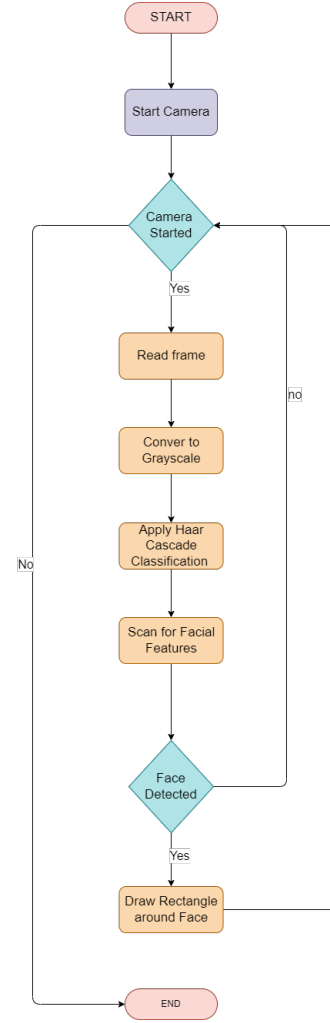


Fig. 4. Flowchart for implemented model

If a face is detected, a rectangle will be drawn around it. Otherwise, the code will be terminated.

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