TRIBHUVAN UNIVERSITY

INSTITUTE OF ENGINEERING

THAPATHALI CAMPUS

A Project Report

On

An Electronic Watch Dog

Submitted By:

Paras Pujara	(31267)
Prasamsha Dotel	(31269)
Rajat Dulal	(31270)
Suramya Pokharel	(31288)

Submitted To:

Department of Electronics and Computer Engineering

Thapathali Campus

Kathmandu, Nepal

May, 2023

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In partial fulfillment for the award of the Bachelor's Degree in Electronics and Communication Engineering.

Under the Supervision of

Er. Suramya Sharma Dahal

May, 2023

DECLARATION

We thus declare that the report of the project titled "**An Electronic Watch Dog**" that is being submitted to the **Department of Electronics and Computer Engineering, IOE, Thapathali Campus**, for the partial fulfillment of the requirements for the award of the Degree of Bachelors of **Engineering in Electronics and Communication Engineering**, is a bona fide report of the work we have carried out. The materials and contents contained in this report have not been submitted to any Institution or University for the award of any degree or similar accomplishments and we are the only authors of this complete work and no sources other than the ones we've listed here have been used in this work.

Paras Pujara (Class Roll No: THA076BEI017) _____

Prasamsha Dotel (Class Roll No: THA076BEI019) _____

Rajat Dulal (Class Roll No: THA076BEI020) _____

Suramya Pokharel (Class Roll No: THA076BEI039) _____

Date: May, 2023

CERTIFICATE OF APPROVAL

The students who have signed below certify that they have read and recommended to the Department of Electronics and Computer Engineering, IOE, Thapathali Campus, a minor project work titled "**An Electronic Watch Dog**" submitted by **Paras Pujara, Prasamsha Dotel, Rajat Dulal** and **Suramya Pokharel** in partial fulfillment for the award of Bachelor's Degree in **Electronics, Communication and Information Engineering**. The Project was carried out under special supervision of department and within the time frame prescribed by the syllabus.

We found the students to be hardworking, skilled, diligent and willing to undertake any related work to their field of study and hence we recommend awarding of the partial fulfillment of Bachelor's degree of Electronics and Communication Engineering.

Project Supervisor
Er. Suramya Sharma Dahal
Department of Electronics and Computer Engineering, Thapathali Campus

External Examiner
Madan Neupane
CAAN / Babarmahal

Project Coordinator
Er. Umesh Kanta Ghimire
Department of Electronics and Computer Engineering, Thapathali Campus

Kiran Chandra Dahal
Head of the Department,
Department of Electronics and Computer Engineering, Thapathali Campus

May, 2023

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We would like to express our immense gratitude towards the Institute of Engineering (IOE) for the inclusion of Minor Project on the syllabus for the course Bachelor in Electronics, Communication and Information Engineering.

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Paras Pujara [THA076BEI017]

Prasamsha Dotel [THA076BEI019]

Rajat Dulal [THA076BEI020]

Suramya Pokharel [THA076BEI039]

ABSTRACT

The concept we have proposed is that of a dog that guards a house and notifies the owner whenever a known or unknown person enters the premises. Our project 'An Electronic Watch Dog' is simply like a remote-controlled vehicle with a little twist in it. The dog has a camera integrated which performs live video capture and sends it to the PC. We then use Image Processing for the manipulation of these videos/images and thus, derive information out of them to determine whether the object is a human/person or not. Finally, our proposed watch dog project will use the concept of facial recognition and image comparison to determine if the person in the image is the verified individual of the property or not. After verification an alert is sent to the owner.

Keywords: *Electronic, Facial recognition, Image Processing, Live video capture, Object detection*

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List of Abbreviations

AEWD	An Electronic Watch Dog
AI	Artificial Intelligence
AIBO	Artificial Intelligent Robot
CNN	Convolutional Neural Network
DNN	Deep Neural Network
HTTP	Hypertext Transfer Protocol
IDE	Integrated Development Environment
IR	Infra-Red
LED	Light Emitting Diode
LFW	Labeled Faced in the Wild
ML	Machine Learning
MLL	Machine Learning Library
MRTD	Machine Readable Travel Documents
NumPy	Numerical Python
OpenCV	Open-Source Computer Vision
PReLU	Parameterized Rectified Linear activation Unit
ReLU	Rectified Linear activation Unit
SGD	Stochastic Gradient Descent
SMTP	Simple Mail Transfer Protocol
VGG	Visual Geometry Group

1. INTRODUCTION

1.1 Background

Coming to the 21st century, technology has modernized the world to a whole new level. The use of technology is being embraced all over the world in almost every field. So, with the advancement in technology, the interest of the people in ensuring the sophisticated security system using surveillance cameras and sensors for movement has increased a lot as security and safety has become the major concern of the world these days.

As security and safety nowadays are the main thing we think about, a lot of experiments and research are being performed in this field and researchers are getting a positive response too. A lot of inventions have already been made in this domain. Some examples are AIBO watchdog and an electronic watchdog. Technological advancement has grown to a whole new level and is not avoidable soon. So, considering this fact, it is necessary to make a proper system for security that could replace the traditional concept of stationing dogs at the entrance of the home for security using robotics and automation.

Traditionally, people would have pet dogs kept at the entrance of the home for safety purposes. Furthermore, these days also we can see pet dogs placed at the entrance of the house for safety. The purpose of the dog is to alert the owner whenever an unknown person tries to enter the house. This is what made us name our project “An Electronic Watch Dog (AEWD)” as in our project, we have tried to implement a similar concept.

The application domain of the AEWD is huge such as home, office, and so on. The world has already made advancements in ensuring sophisticated security systems. For e.g., a CC TV camera is widely in use all over the world but the problem with this system is that it does not necessarily stop people from breaking in and does not alert the owner about the intrusion and the intruders so, considering all these things, we are proposing a system that not only captures the images and videos but also notify the owner whenever any known or unknown person tries to enter the premises.

1.2 Motivation

It is understandable that as a student of Electronics, Communication, and Information Engineering, we would be interested in working in the technological field. As a technological enthusiast, we have a passion for learning about the latest developments and innovations in the field that is gaining lots of interest all over the world. As security and safety have become the major concern of this world in the present context, we are motivated to contribute something to this field. So, the primary motivation of our project is to reduce theft and robbery using advances in Artificial Intelligence.

1.3 Problem Definition

It is true that violence can have devastating effects not only on individuals and families, but also on communities and economies. The fear of violence has led people to take measures to protect themselves and their belongings, such as installing alarms, surveillance cameras, and security systems and hiring guards. As technology has advanced, many aspects of our daily lives and work environments have become more reliant on computers and automation, the feasibility of using autonomous robots, or robots that are capable of functioning without direct human control, has become an important topic in recent years. The use of computer-based systems to improve everyday life and safety is a topic that is currently being actively researched and developed. This includes the development of new technologies and techniques to make daily tasks easier and more efficient, as well as to improve security and privacy. Violence, theft, and robbery can occur in a variety of settings, including public places that are typically considered to be safe, such as train stations and shopping malls, and in homes. This can be a source of concern for many people, as they worry about their own safety and the safety of their belongings. It is understandable that people may have concerns about the security of their homes when they are away for work and especially if they are going on holiday or will be away from home for an extended period of time. So, keeping all these in mind, we have proposed a system that will ensure a better security system at home notifying the owner every time any unknown person tries to enter the premises of his/her home.

1.4 Project Objectives

The major objectives of our project are as follows:

- To be able to detect a human face from the plethora of the objects.
- To be able to compare the detected face with the ones stored in database and give out the appropriate response.

1.5 Scope and Application

The main application of our project is to ensure a tight security system in a home. Furthermore, the scope and application of our project can be listed as follows:

a) Houses and Offices:

   In houses and offices, our system can be useful to ensure that only the authorized person enters the premises and maintain security.

b) Industries/Factories:

   Security is the major concern in industries and factories as well so our system could also be useful in maintaining security in such places.

c) Border Security:

   It is important for border areas to have adequate surveillance and security measures in place to protect the country from potential threats. An upgraded version of our system could be beneficial in improving the efficiency and effectiveness of these measures.

d) Replacement of Watchman:

   The Watchman does only have a front vision but the electronic dog does have a 360-degree viewing capacity and also human nature is not trustworthy as we have been hearing several news about the watchman himself being involved in a robbery so in such a case, an electronic dog could be a better replacement to the watchman as it will never betray us.

1.6 Report Organization

There are eight chapters in this report. Each chapter focuses on a different aspect of the project. The first chapter provides an overview of our project “An Electronic Watch Dog” which includes background, motivation, problem statement, objective, scope and application. The second chapter includes literature review, which provides background information on similar sort of previously established works and their principles. The third chapter contains information about our project's various hardware and software requirements. Chapter 4 discusses the hardware system methodology and software system methodology, as well as their operating principles and system flowcharts. The project's implementation, including hardware and software implementation, is described in Chapter 5. In Chapter 6, the outputs of the object detection, face recognition, and alerting the owner are simulated. Chapter 7 discusses future improvements that can be made to this project. Finally, Chapter 8 discusses the conclusions reached by the project members as a result of this study.

2. LITERATURE REVIEW

2.1 Why Face as a Biometric?

Biometric-based techniques, in recent years, have emerged as the best option for verifying individuals since, rather than authenticating people through physical and virtual domains such as passwords, keys, PINs, cards, and so on, these methods examine an individual's behavioral and physiological characteristics in order to confirm the person's identity. Face recognition was the most compatible with Machine Readable Travel Documents (MRTD) [2] of the six different biometric characteristics evaluated by Hietmeyer [1]. Face recognition has several other advantages. While other biometric recognition requires the individual to take voluntary action, such as placing their finger on the scanner or for iris identification, standing still in front of a camera, face recognition can passively be done without the individual's participation.

Other biometric recognition techniques, on the other hand, are fraught with issues: techniques that rely on hands and fingers can be rendered useless in cases of bruises or injuries to the hands or fingers. Iris and retina identification necessitate costly equipment and are extremely sensitive to any body motion. Background noise can interfere with voice recognition. Signatures can be altered or forged. However, facial images are easily obtained using a couple of low-cost fixed cameras. Face recognition algorithms and image preprocessing can compensate for noise and minor variations and differences in illumination, orientation, and scale. [3]

2.2 Current Trends in Face Detection

Viola and Jones' typical cascade classifier has been an immensely successful technique for face detection [4-5]. The cascade classifier which is a tree-based technology, required Viola and Jones to use Haar-like features [6] for human face detection. The Haar-like features are divided into edge, line and center-surround features. Viola-Jones' Detector involves the usage of a rejection cascade, which can be understood as a series of nodes, where every individual node is a definite multi-tree classifier. In cases of faces almost all (99.9%) of faces were found, but many non-faces (about 50%) were false positives. This is feasible, because a sufficiently large number of nodes (say 20) yielded a false positive rate of 0.00001% and face detection rate of 98% [7].

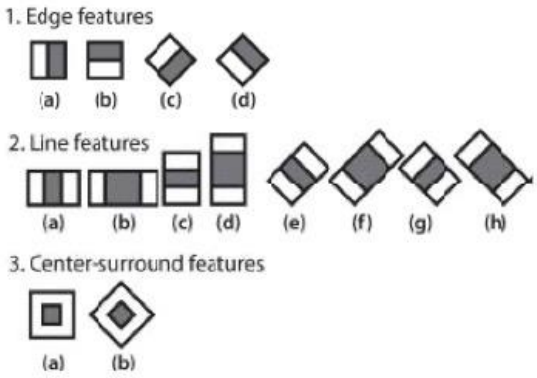


Figure 1: Haar-like features from OpenCV source distribution [6]

Choi [8] in his paper, found that the improvement in processing speed was of 32.05% and reduction in the number of false positives was 25.46% when Haar Cascades were used as compared to histogram equalization methods using a public test dataset with 2845 images and while using a private dataset, 53.85% reduction in false positives occurred.

Another emerging trend in face detection is the HSV color model [9]. It is based on color descriptions that are natural and intuitive to human image observers. The HSV model separates intensity (V) from color dimensions (H) and saturation (S) (S). Hue is a color attribute that tells the observer what color is perceived after the RGB-HSV transformation (pure yellow, green, or red). Based on the principle of color constancy, the face skin color of people of a specific race, assume the yellow race, follows a specific distribution that changes not much under different lighting conditions. As a result, the hue is a relatively strong feature that conveys skin tone information [7]. Although it is impossible to expect varieties of people to have identical skin tones, skin tones do have a relatively fixed distribution. In both human skin segmentation and face detection, [10] the skin tone model has been employed. Zhang [11] discovered marvelous capability for face detection and robustness to lighting changes in his paper using a hierarchical classifier that combined support vector machine [12] and histogram matching.

2.3 Current Trends in Face Recognition

Gabor-LeNet [13], which is an improvement on already existing LeNet-5 [14] convolutional neural network is a trendy model in face recognition sector. Alike LeNet-

5, Gabor-LeNet also contains seven layers. But unlike LeNet-5 which uses hyperbolic tan as the activation function, Gabor-LeNet uses Parameterized Rectified Linear activation Unit (PReLU).

When fed with ORL face dataset with 400 grayscale images, divided into forty labels, Gabor-LeNet model provided a 99.5% accuracy. Likewise, when fed with GT face dataset and AR face dataset with images containing sunglasses and scarf occlusions, the recognition rate was only found to be 98.56% for AR and 91.25% for GT.

Siamese convolutional network [15] is a state-of-the-art model for face recognition. It basically contains two-flow networks. Taking in two inputs, it has also been used in other various tasks such as visual tracking or object detection. It takes in input sampled image of size 256x256x3 and another candidate image of size 256x256x27. Siamese CNN contains seven layers with five convolutional and two pooling layers. The networks are trained using Stochastic Gradient Descent (SGD).

Wu [15] in his paper, performed 100 epochs for the training of networks each of which is designed up of 20,2000 sampled pairs. A negative pair comprised of sampled and candidate faces from different people and he assumed if the maximum value of mark was under 0.75 there was no similar face in the dataset. The accuracy so obtained was 98.21%. When tests were conducted on LFW (Labeled Faces in the Wild) dataset, the results showed the performance to be state-of-the-art.

MicroFace [16] is an improved algorithm based on VGG-16 [17] for face recognition. MicroFace is built by removing 2 fully connected layers, increasing convolution kernels in certain layers and modifying the pooling layer of VGG-16 which consists of 3 fully connected layers and 13 convolution network layers. The end of structure also contains a SoftMax layer and the network is trained suing SGD.

Zhiqi [16] in his MicroFace model used CASIA WebFace as the training and the testing sample set. 80,000 pictures were used for training amd 40,000 for testing with 2000 total categories. The recognition accuracy of MicroFace was found to be 96.26%.

DeepFace [18] is another deep learning face recognition model created by Facebook. It employs a nine-layer deep neural network for face recognition. This neural network has its parameters number upper than 120 million and uses many locally connected layers with no weight sharing, instead of the frequently used standard convolutional layers.

The model was trained on largest facial dataset to-date containing four million facial images belonging to 4000 identities. This method achieved an accuracy value of 97.35% on the LFW (Labeled Faces in the Wild) dataset, which reduced the error of then present state of the art by more than 27%.

FaceNet [25] is another state of the art deep neural network that posesses the capability to extract features from the face of a person. It is twenty-two layers deep and has around 140 million parameters involved. It was introduced by Google researchers who trained the CNN using SGD.

Schroff, Kalenichenko and Philbin [25] trained the model on 2.6 million images. They thus found a classification accuracy of 98.87% on LFW dataset. On YouTube Faces DB dataset the classification accuracy so obtained was 95.12%.

2.4 AIBO Watchdog

AIBO [19] is a self-contained robot dog that can move around freely. This AIBO robot has a built-in camera and other modalities, making this robot dog a viable alternative to static cameras. The AIBO watchdog project was created to protect the home environment. Evidences can be saved using its camera and microphone, and transferred to the appropriate person or instances immediately using its wireless connection. It was created by the Delft University of Technology's faculty of electrical engineering, mathematics, and computer science.

The developed AIBO watchdog is intelligent enough to notice related events and navigate in its home environment while patrolling. Furthermore, AIBO can protect itself from damage while patrolling and respond appropriately in most situations. To improve its intelligence, the AIBO watchdog was given the ability to prioritize events and use tools that it had previously encountered. The intelligence has been encapsulated in the AIBO watchdog's reasoning system.

The concept of AIBO was first introduced by Silvia Oana Tanase [20] in her paper, where the author only demonstrated the overall operation of the AIBO watchdog without providing a solid foundation upon which to build the entire product. The developed AIBO watchdog was tested in a test environment made up of small objects and paper boxes that represented various objects in the simulation. The test results confirmed that AIBO watchdog was capable of caring for a home environment despite these simplifications.

2.5 AIBO Companion Dog

Another concept proposed for AIBO is a companion dog [19]. Calvo, Datcu, and Rothkrantz [21] propose predicting future moods, needs, and actions based on current moods, needs, and other environmental variables. They propose developing a complex personality model for robotic companion dogs that provides realistic needs-oriented behavior. The personality model would be an extension of the nPME model, implying that needs are the most important factor influencing the AIBO robot's behavior in every situation. Personality, mood, and emotions are three layers that, when combined with needs, would cause AIBO to exhibit true doglike behavior.

The companion dog would be extremely aware of its environment and hence could not only walk around an increasingly wider area but also respond to a variety of situations. It would feature a dynamic range of movements, gestures in hundreds of patterns and eager responsiveness. The robot dog would also be intelligent enough to develop its own unique personality as it grows closer to its owners by being capable of learning its environment itself by collecting data from interactions with its owners.

Using an AIBO robot, the prototype was tested in various scenarios. An extensive user study involving several students and workers was conducted to test the realism, emotional responses, and event coherency in robot behavior. When comparing the behavior of the AIBO robot dog to that of a real companion dog, the studies yielded very positive results.

2.6 Electronic Watch Dog

Electronic watch dog [23] is another project of a similar kind but one not so versatile due to lack of use of AI. It was made by Shirisha Vantepaka of Kakatiya Institute of Technology and Science, Warangal.

At the entrance to the premises that needs to be secured, an IR sensor transmitter and receiver were installed. When a person or intruder enters the door who is unaware of the security device installed at the entrance, the IR rays are cut. This cutting of IR rays sets off a chain of events in the circuit, culminating in the sounding of a burglar alarm. The owner of the premises may learn that someone has entered through the door after hearing the alarm. The alarm went off for 30 seconds.

3. REQUIREMENT ANALYSIS

3.1 Hardware Requirements

3.1.1 Arduino UNO

The Arduino UNO is a microcontroller board who's value lies in its inexpensiveness, versatility, simplistic usage techniques and open-source nature. This microcontroller board has the ability to be integrated into a large domain of electronic projects. This board as its output can not only control LEDs or relays but also motors and servos. It can also be interfaced with other Arduino boards and shields and even with Raspberry Pi boards. It has an Atmega328 AVR microcontroller, 6 analog input pins and 14 digital I/O pins, 6 of which are used as PWM outputs.

Figure 2: Arduino Uno

There are two types of Arduino elements:

• Hardware includes a microcontroller, an outside supply of power, a USB plug, an insider programmer, a button for reset, analog and digital I/O pins, as well as power and ground pins.

• Software includes a text editor, a message zone, and a text and console toolbar.

3.1.2 L293D Motor Driver IC

The L293D motor Driver IC can be thought of as an integrated circuit that has the ability to drive two different or same motors at the same time and is also typically used in order to control those motors in a self-contained system. This IC allows us to conduct a DC motor in both forward and backward direction and also control its speed. Inside it contains two H-bridges. The H-bridge circuit is the most basic circuit to control a low-current-rated motor. A single H-bridge can drive one bidirectional DC motor. L293D

is in essence, a current enhancing integrated circuit which also has the functionality of a switch.

The L293D is an IC having 16 pins where 8 pins on each individual side are dedicated to motor control. Each motor has 2 input, 2 output and 1 enable pin. This L293D IC has been constructed in such a way so that it can to supply up to 600mA of bidirectional drive current from 4.5V to 36V. It has the ability to drive inductive loads like solenoids, relays, DC stepper motors and bipolar and other similar high voltage loads in positive supply applications.

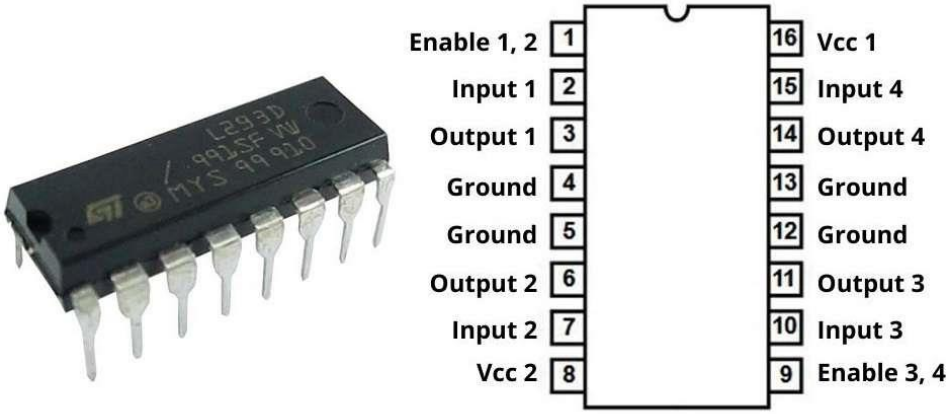


Figure 3: Pin Configuration of L293D IC

3.1.3 VS1838B IR Receiver

An infrared receiver, also known as a photodiode, in simple terms is a simple electronic circuit which collects IR rays transmitted from a source which may be a TV remote or an LED that has the ability to emit IR rays and converts them into a signal that is electrical in nature which then can be used for controlling any other devices like lighting fixtures or appliances for home and so on.

Figure 4: IR Receiver

Features of VS1838B IR Receiver are as follows:

- Voltage Requirement: 2.7V to 5.5V
- Reception Distance: 23M
- Angle of Reception: ± 35 Degree
- Low/High Voltage Levels: 0.4V/4.5V
- Made up of: Plastic and/or Alloy
- Color: Black and Silver Tone
- Carrier frequency: 38KHz

3.1.4 IR Remote

It is a 38K universal infrared remote controller/transmitter that is extremely thin. It can be used in conjunction with an infrared receiver for infrared communication. The transmitter resembles a typical LED, except that the light it emits is in the infrared spectrum rather than the visible spectrum. The infrared wavelength of launch tube is 940Nm. It also contains a crystal having a 455 kHz oscillation frequency.

Features:

- Remote control range: greater than 8 meters
- Carrier frequency of IR: 38KHz
- Encoding: NEC encoding format, upd6122 encoding scheme
- Power supply: CR2025/160mAH
- Button: free height has a value lower than 3mm, force 200-350g

Figure 5: IR Remote

3.1.5 TT DC gear motor

TT DC gear motors are simple, low-cost motors with no built-in encoders, speed control, or positional feedback. Simply put, voltage enters and rotation comes out! It is used for the movement of the watch dog. It is strong magnetically and has anti-interference feature. Its rated voltage is around 3V/6V and the value of current thus passed is generally lower or equal to 180mA/250mA. Its speed ranges from 45±10% r/min to 90±10% r/min and torque ranges from 0.45±10% kgf.cm 0.85±10% kgf.cm

Figure 6: TT gear motor

3.2 Software Requirements

3.2.1 Arduino IDE

The Arduino IDE is an open-source software where code to the Arduino development board can be written and uploaded. IDE applications are available for different operating systems such as Windows or Mac or even Linux. It supports C and C++ languages for programming. Here IDE is an abbreviation for Integrated Development Environment.

3.2.2 Python Programming Language

Guido van Rossum created Python, a computer programming language that was released in 1991. It‘s frequent usage is seen in creation of websites and software, automation of tasks, and data analysis performation. It is essentially a general-purpose language for programming, which signifies that it’s usage can be highlighted in creation of a large range of programs and is not specialized just for solving any particular problem. This versatility, along with its easiness in usage for starters, has it be regarded as one of the

most used programming languages in recent times. Similarly, it has a simple syntax that is not complicated, and it places a greater emphasis on natural language.

3.2.3 NumPy

NumPy is a fundamental package for scientific computation in Python. Itself being a Python library, it provides not only a multidimensional array object but also many derived objects (like hidden matrices and arrays), and various methods for performing quick operations on arrays, including logical, shape, mathematical, sort, select, discrete Fourier transform, basic linear algebra, I/O, basic statistical operations, stochastic simulation, etc. At the heart of the package of Numpy lies the ndarray object. It encapsulates in itself n-dimensional arrays of homogeneous data types. Plenty operations are performed in the code that has been compiled to improve performance.

3.2.4 OpenCV

OpenCV is an open-source computer vision library which runs on plenty of operating systems like Linux or Windows or Mac. The primary motivation for developing OpenCV was for increasing efficiency of computations, with a strong prioritizing on real-time applications. It has the ability to take full benefits of multicore processors as it's writing and optimization was done in C. A primary goal of OpenCV is to provide a simple and easy to use computer vision infrastructure that allows people to quickly construct nicely cultured vision applications. The library contains more than 500 functions that encapsulate a large range of vision applications, like medical imaging, factory product inspection, robotics and security. Since machine learning frequently goes hand in hand with computer vision, OpenCV contains a general-purpose, full Machine Learning Library (MLL).

3.2.5 Matplotlib

Matplotlib is another library of Python that allows one to create visualizations which may be animated, static or interactive . It was first written by John D. Hunter. Matplotlib in simple terms is just a plotting library for the programming language of Python, and NumPy is its numerical extension. It provides an API which is object-oriented, for integrating into applications, plots, that use general-purpose GUI toolkits such as GTK,

Tkinter, Qt, wxPython. Matplotlib is also used by SciPy. We have used Matplotlib for the same (i.e., plotting the image).

3.2.6 Deepface

Deepface is a facial recognition and feature analysis framework in python created by Facebook's Artificial Intelligence Research Group in 2015. Keras and Tensorflow inspired the core components of this library. It is a hybrid framework for face recognition that uses modern models like Google Facenet, VGG-Face, Facebook Deepface, etc. for analysis, all integrated into a single framework. With a facial recognition accuracy rate of up to 97%, Deepface has proven to be more effective in detecting faces than general facial recognition frameworks. This framework allows users to detect face, verify images, find similar images on database, emotion analysis, etc. with ease compared to any other framework available on market.

3.2.7 TensorFlow

TensorFlow is an open-source framework for machine learning which lets developers to build and deploy machine learning models. TensorFlow has in it a variety of tools and libraries for building and deployment of machine learning models. The core building block of TensorFlow is a tensor, which is a multi-dimensional array. Tensors can represent various types of data, such as images, audio, and text. TensorFlow also provides a wide range of operations for manipulating tensors, such as matrix multiplication, convolution, and activation functions. To build a machine learning model in TensorFlow, developers define the model architecture using high-level APIs such as Keras or TensorFlow's own low-level API.

3.2.8 Keras

Keras is also high-level API used in construction and training of deep learning models in TensorFlow. Keras gives its users a basic and intuitive interface to build and train deep learning models. It allows developers to quickly define the architecture of a neural network by simply stacking layers on top of each other. Keras provides a wide range of pre-built layers, including convolutional layers, recurrent layers, and dense layers, which can be easily combined to create complex models. Keras also provides tools for monitoring the training process, such as callbacks and tensor board integration. Keras

supports a variety of input data formats, including NumPy arrays, Pandas dataframes, and TensorFlow Datasets. It also provides tools for data preprocessing, such as data normalization and data augmentation.

3.3 Feasibility Study

3.3.1 Technical Feasibility

Though the project seemed to be complicated but it is possible and can be built without any difficulties. Likewise, with the less workforce, we can accomplish the project. Heavy equipment and technologies are not necessary.

3.3.2 Financial Feasibility

We are designing our project in such a way that the installation cost is as minimum as possible. Since, heavy equipment and technologies are not used, the project is cost effective. The hardware equipment used are affordable and software required are easily available.

3.3.3 Safety Feasibility

Since none of the components used in our project harms any form of living creature, it is completely safe to say that our system is safe for the human and environment.

3.3.4 Operational Feasibility

Since our final product can reduce operating cost, active human involvement in the home safety (security guard) which ultimately reduces the human labor and risk of human being exposed to risk, it is safe to say that our system is operationally feasible.

4. SYSTEM ARCHITECTURE AND METHODOLOGY

4.1 Hardware System Methodology:

The intention of this project is to create a Watch Dog that has a simple hardware constitution like that of a moving vehicle. The hardware consists primarily of an infrared remote, an infrared receiver, capacitors, a motor driver, TT gear motors, and an Arduino UNO. The watchdog is controlled by an Arduino UNO microcontroller as its core unit. A power supply of around 7.5 Volts is provided though a pair of rechargeable batteries to Arduino UNO and L293D motor driver. This Voltage is regulated to 5 Volts using a voltage regulator which is used by IR receiver (VS1838B). The Watch Dog can be controlled in two modes: manual and automatic. In manual mode, in this mode, the watchdog is controlled using an IR Remote following the concept of IR Signal Modulation. While in automatic mode, the watchdog is trained initially to follow a certain pattern then this pattern is stored in the EEPROM of Arduino which is repeated automatically by the watchdog. In addition, we have connected the Esp32 camera module to the Watch Dog, which will provide 24 hours of video streaming to our system for video/image processing.

4.1.1 Working of IR receiver and remote along with Arduino:

An infrared communication system typically consists of an IR transmitter and its corresponding IR receiver. The IR transmitter resembles a standard LED, other than the fact that the light it emits is in the infrared spectrum rather than the spectrum for visibility. A photodiode and a pre-amplifier in the IR receiver convert infrared light into an electrical signal.

4.1.1.1 IR Signal Modulation

The sources of light such as sun or light bulbs which emits heat also emit infrared light, so we are constantly bombarded with IR light noise. To avoid interference created from this noise with the IR signal, a technique of signal modulation is employed. During this IR signal modulation, a component in the IR remote called encoder changes a binary signal into its modulated electrical counterpart. Thus obtained modulated electrical signal is then sent to the transmitting LED which in turn converts this signal into a modulated IR light signal. Then IR receiver simply demodulates and changes the IR light signal into binary prior to passing it to a module of microcontroller. Thus

modulated IR signal is made up of a series of IR light pulses that are turned on and turned off at different times.

Every time a button is pressed on the remote, a code with unique hexadecimal value is generated. This is the same information which is then modulated and sent to the receiver via IR. For deciphering which key was pressed, the microcontroller must have the prior information as to which code corresponds to which button of the remote. First, we must connect the receiver to the Arduino.

Signal, ground, and Vcc are the three pins on an infrared receiver. These three pins are all linked to their corresponding Arduino pins. After connecting the receiver, Arduino library can be installed and programming may begin. We needed to install the IR remote library and figure out the key codes for our remote control. To accomplish this, we must upload the code to our Arduino UNO and launch the serial monitor. Now the hexadecimal value for the code printed for each button pressed on our remote must be recorded.

4.1.2 Working of Path Memorization

When a certain key on IR remote is pressed, its equivalent hex code is generated, and the counter is initiated. The value of the counter keeps increasing based on time until the next signal is received. As soon as the next signal is received, it will stop the previous counter and initiate the next counter for the next direction, and so on. In such a way, all these patterns are recorded in the EEPROM of the Arduino to store a certain path. Finally, the path can be automatically repeated just by pressing the start button.

4.1.3 System Architecture for Hardware part:

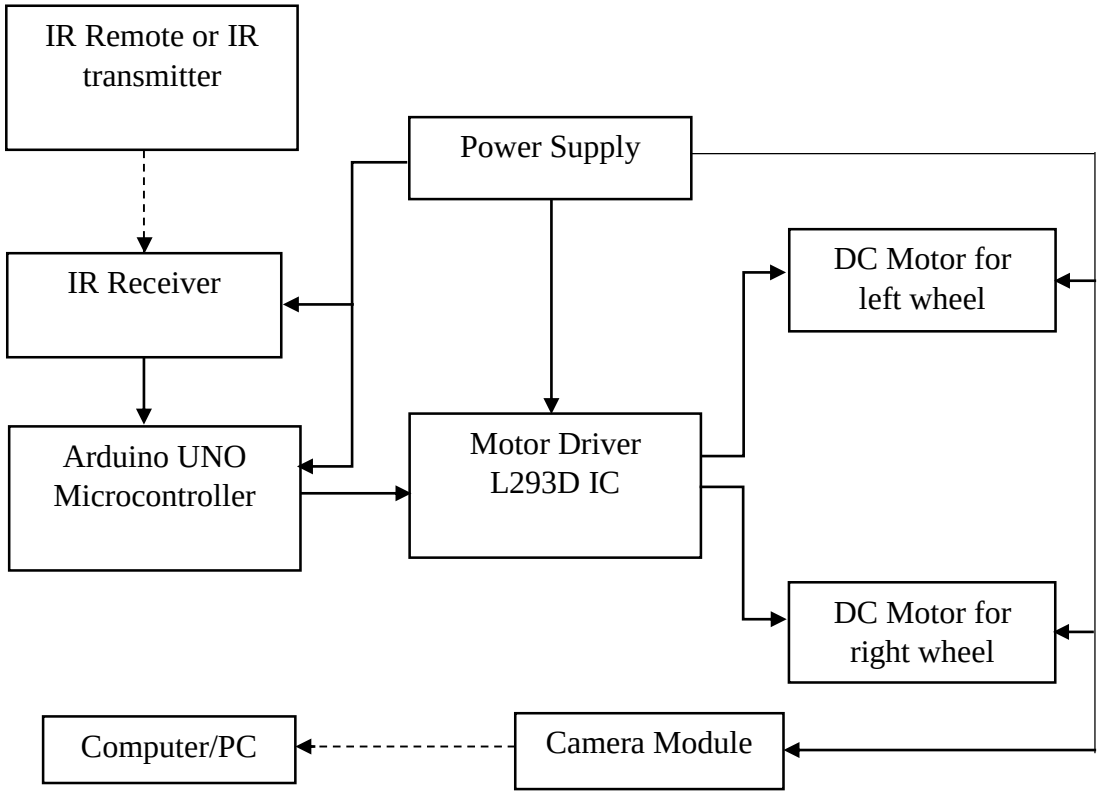


Figure 7: System Architecture for the movement of watch dog

4.2 Software System Methodology:

Our system basically performs two activities in the software system methodology: face detection and face recognition. For example, if we install this system for home security and give the watchdog a path to follow around the house, then as soon as the camera built into the watchdog detects a face, it will take a snapshot of that person's face and save it to the local directory. Following that, our system will proceed to the face recognition phase. Face recognition part and alerting part is left to be implemented as of now.

4.2.1 Face detection:

For face detection, we have used the pre-trained machine learning model called "haarcascade_frontalface_default.xml.". This xml file is a pre-trained Haar cascade classifier for detecting front-facing human faces. It is part of the OpenCV library and can be used as a basis for developing face detection applications. The classifier has been trained on thousands of positive images (images containing faces) and negative images

(images not containing faces) to detect front-facing faces. The.xml file contains the trained classifier data and can be loaded into an application using OpenCV's "cv2.CascadeClassifier" class. The.xml file contains the parameters and coefficients of the Haar cascade classifier, which is an algorithm that uses Haar-like features to detect faces in images. To detect faces in an image, the classifier is applied using the ".detectMultiScale" method, which returns a list of faces detected in the image as rectangles.

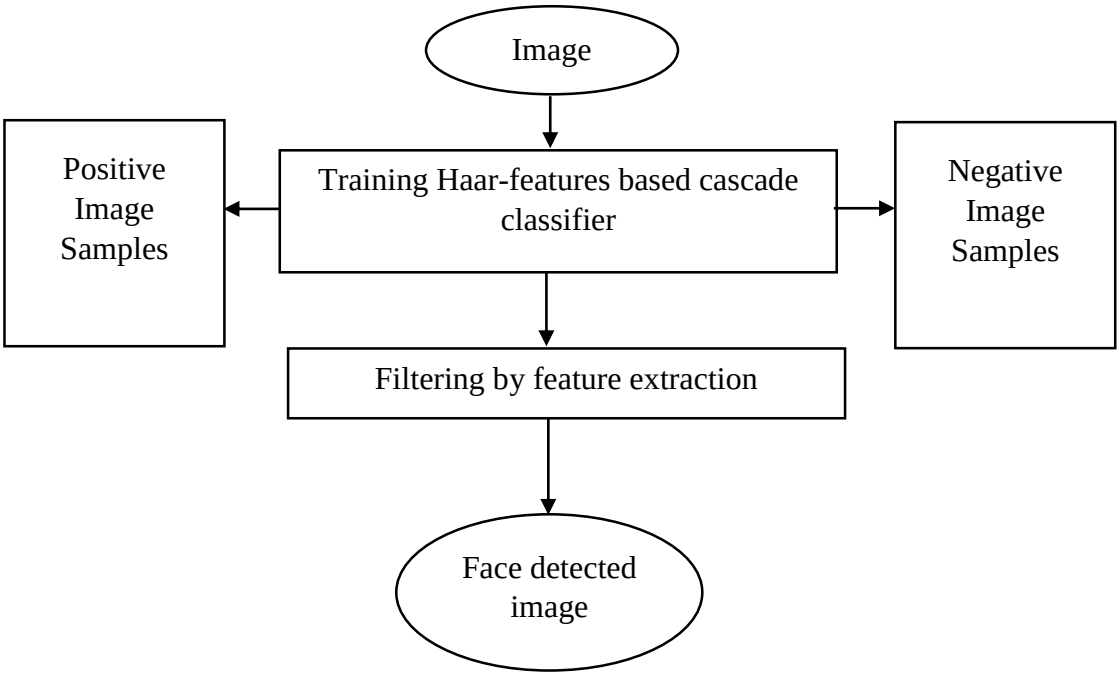


Figure 8: System Architecture for Face detection

4.2.2 Face Recognition

For face recognition, we have employed a state of the art pretrained FaceNet Convolutional Neural Network. It employs one-shot learning for recognizing faces. For this, we have provided our system with the images of faces that are known. Then it evaluates an image containing a single or multiple face and compares the face to the ones stored in database. It first takes in an image and calculates a vector of 128 numbers that point towards the main important characteristics of a face. This process is known as embedding since each important information of this image is embedded in this very vector. Ideally, embeddings of faces that are similar must also be similar.

Now when an unseen image is provided, its embedding is derived and the distance of this derived embedding to that of embedding of the known people is calculated. If this distance is less than the threshold value of the model used, then it is said that the image contains that person. FaceNet basically learns to calculate these embeddings based on anchor, positive and negative samples. So first, an anchor image is taken and also positive (images with the face of the anchor image's person) and negative (images with face but not of the anchor image's person) samples are randomly taken. Then FaceNet learns by adjusting its parameters such that anchor is closer to the positive samples and far from negative samples.

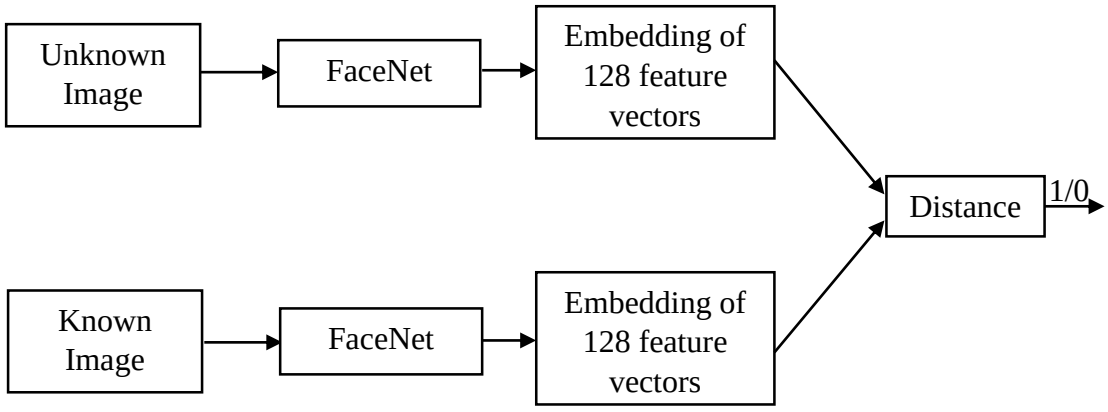
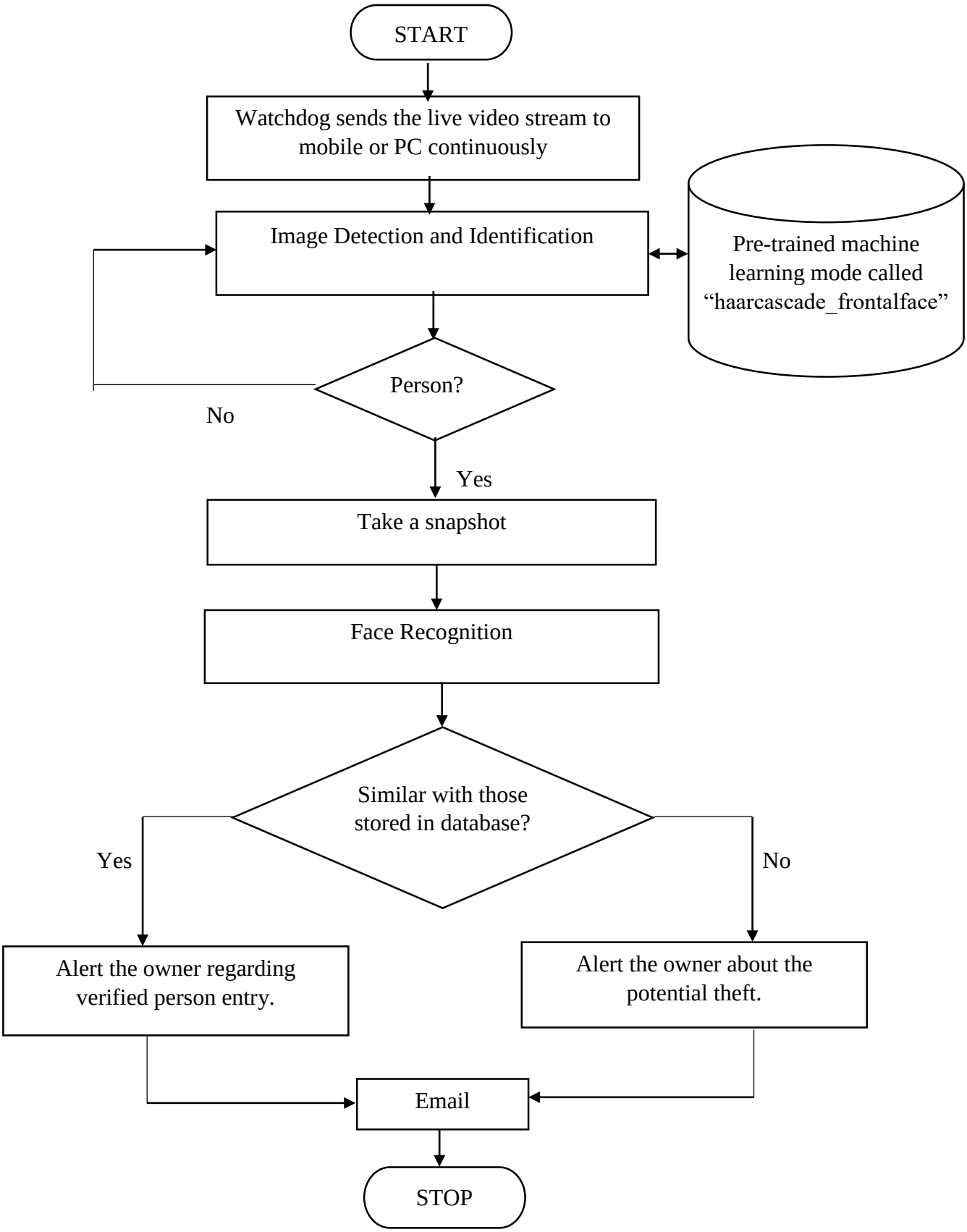


Figure 9: System Architecture for Face Recognition

4.2.3 Email Sending

We have used SMTP (Simple Mail Transfer Protocol) for generating the automatic mail and sending it to the owner. SMTP is a protocol used to send automatic emails. It is a widely used standard for sending and receiving emails over the internet. First of all, we need to import the "smtplib" library into our Python script. Then we need to connect to the SMTP server. Then the next step is to construct the email message, including the recipient's email address subject, and message body. Finally, you can use the "send_message" method to send the email.

4.3 Overall Workflow of the Project



5. IMPLEMENTATION DETAILS

In this section we will be discussing how the hardware and software components has been implemented and integrated for proper functionality of our project.

5.1 Hardware implementation

5.1.1 Arduino Uno for Robot Movement

The Arduino Uno based on ATmega328 is a microcontroller board. It contains in it 14 digital input/output pins (6 of which are outputs for PWM), 6 inputs which are analog in nature, a 16MHz crystal oscillator, a USB connection, an ICSP header, a power jack and a reset button.

Only 5 digital pins of Arduino are used for controlling the robot's movement, four for providing the pulses to the L293D Motor driver and the fifth pin for receiving and decoding the IR signal.

5.1.2 L293D Motor Driver IC

The L293D is an integrated circuit having in it 16 pins with 8 pins on each individual side for motor control. Each individual motor has two INPUT, two OUTPUT, and one ENABLE pin. The IC is made up of two H-bridges. A H-bridge circuit is the most basic circuit to control a low current rated motor.

All these pins are connected accordingly to control the movement of two TTL gear motors.

Movement logic for one H-bridge circuit:

- Pin 2 = Logic 1 and Pin 7 = Logic 0 | Clockwise Direction
- Pin 2 = Logic 0 and Pin 7 = Logic 1 | Anticlockwise Direction
- Pin 2 = Logic 0 and Pin 7 = Logic 0 | Idle [No rotation] [Hi-Impedance state]
- Pin 2 = Logic 1 and Pin 7 = Logic 1 | Idle [No rotation]

Following is the recipe of hardware implementation:

1) Connect digital pin 10 of Arduino to the output of IR receiver.
2) Connect digital pin 2 and 6 of Arduino to the input pins 2 and 7 of L293D IC.

3) Connect digital pin 7 and 5 of Arduino to the input pins 15 and 10 of L293D IC.
4) Capacitor of 470 microfarad is added parallel to the power supply to remove any noise coupling.
5) Connect a TTL gear motor from output pin 3 and 6 of L293D motor driver.
6) Connect another TTL gear motor from output pin 14 and 11 of L293D motor driver.
7) Connect +5V Pin of Arduino, and Enable pins 1 and 9 of L293D to positive terminal of power supply.
8) Connect GND pin of Arduino and Motor Driver (4,5,12,13) to negative terminal of power supply.
9) Attach a caster wheel to balance the robot.

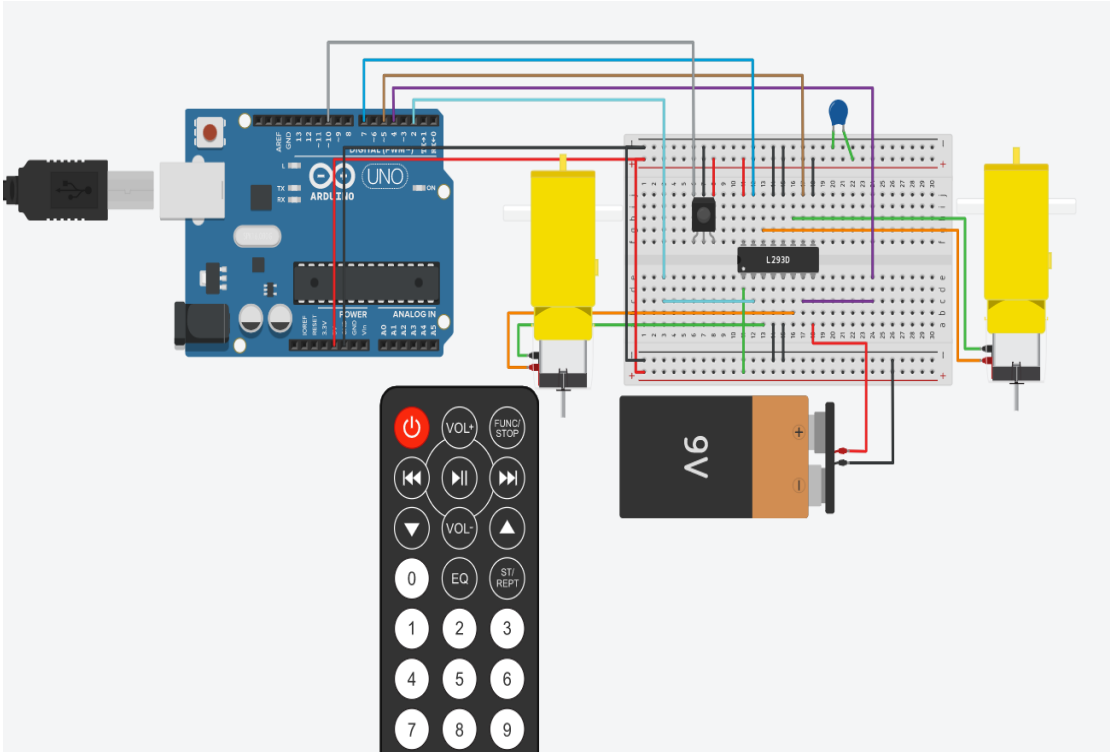


Figure 10: Path Memorization Robot Circuit

5.2 Software Implementation

The code for the robot movement and pattern memorization has been written in Arduino IDE (Integrated Development Environment). For image/video processing OpenCV is used. Haar-cascade, an algorithm for detection of faces is used to detect a human face on the video streamed by the camera module and a snapshot is taken and stored. The pre-trained model that we have used in our system in order to detect faces is Intel's 'haarcascade_frontalface_default.xml'. DeepFace library is used to extract the faces from an image (snapshot) containing single or multiple faces, and to find the image stored in database which is similar to the anchor (unknown/input) image. If a similar image is found in the database, then the person in that image is tagged 'verified' else the person is tagged 'unverified'. After the verification, an automatic email is generated with the image attachment and is sent to the owner as an alert. These algorithms and models have been implemented in Python programming language.

6. RESULTS AND ANALYSIS

Finally, we have completed the designing and testing of our path memorizing robot using Arduino Uno and face recognition system using python programming language. As of now our system is able to navigate a previously learned path while detecting faces in its environment and comparing the faces with the faces in database. The accuracy of robot depends on the accuracy of the face detection algorithm along with reliability of the path memorizing system.

6.1 Path memorizing part

As of now, our robot can navigate a previously learned path which has been stored in the Arduino memory, with a slight deviation from the original path due to a tire calibration issue. Initially, the robot is manually operated by pressing the designated buttons for control on the IR remote. 2 moves the vehicle forward, 4 moves it left, 6 moves it right, 8 moves it backward, and 5 stops it. When the robot is activated for the first time, in its memory a sequence gets stored. For repeating this previously saved sequence, the Repeat button on the IR Remote needs to be pressed. Likewise for storing a new sequence, we must first remove the currently stored sequence by pressing a delete button, and then the current pattern is saved to the Arduino's EEPROM.

6.2 Face Detection Part

As of now our “haarcasade” face detection algorithm is working as it is supposed to. The output can be seen from picture below:

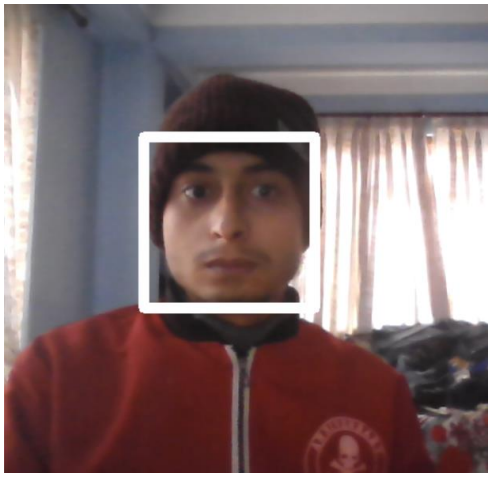


Figure 11: Face Detection

The white rectangular box represents the face detected in the image. After the face is detected, our system takes snapshot of the person and saves it on local directory temporarily.

6.3 Face recognition part

The FaceNet model we used was relatively accurate in recognizing faces. The processing time required to calculate and compare the embeddings was relatively short as well. Likewise one-shot learning eliminated all the time and effort that would've had to be put in to capture and annotate hundreds of images of a single person to obtain good results. Also, we were able to extract each individual face from a group image.

The output can be seen below:

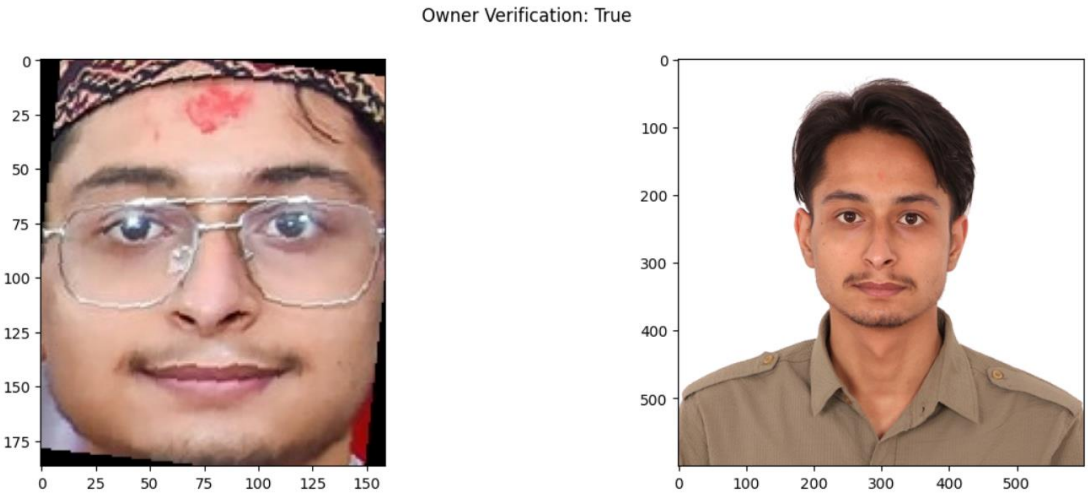


Figure 12: Face recognition/verification

6.4 Emailing Part

Our system generates an automatic mail with image attachment of the previously saved snapshot after the face has been detected and sends it to the owner to alert the owner about who is entering the house.

The output/email can be seen below:

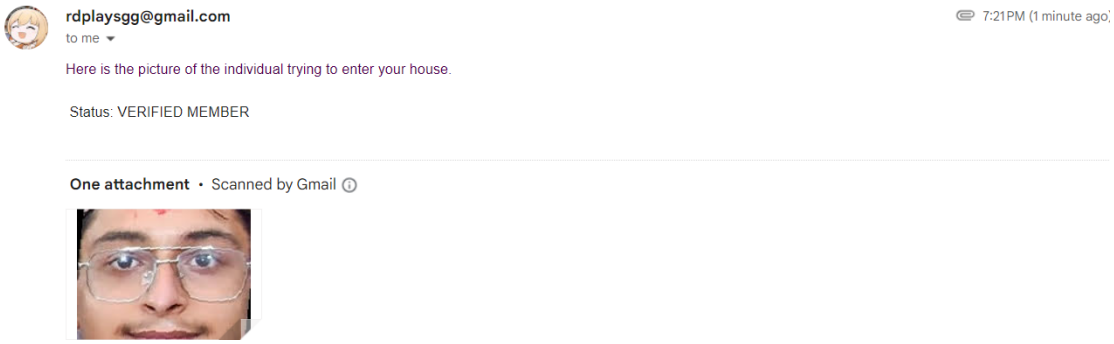


Figure 13: Automatic Email to Owner

7. FUTURE ENHANCEMENT

As technology continues to evolve, there is a need for enhanced capabilities for electronic watch dog to keep up with the increasingly complex and sophisticated electronic systems they are monitoring.

One potential, area for enhancement is in improving fault detection. With the increasing complexity of electronic systems, it is essential to detect faults in both hardware system and software system as quickly and accurately as possible. To achieve this, more advanced sensors, algorithms, or machine learning techniques could be used to detect more subtle or complex faults.

With the increasing popularity of IOT devices, an electronic watch dog can be integrated with other IOT devices. It can be enhanced to work with these devices to monitor and correct faults in real time. This would require the watchdog to be able to communicate with IOT devices and receive real time data to detect and correct faults. Furthermore, it can be customized as per user's need and requirement.

8. CONCLUSION

This report explored the ins and outs of An Electronic Watch Dog. It was equipped with face detection and face recognition abilities. Arduino Microcontroller and L293d motor driver were used to control the movement of the Watch Dog. A camera module was used which continuously sent video live stream to the server where face detection and recognition models did their appropriate tasks properly. Deep insights into each of its components and their implementation has also been thoroughly explained in the paper. An Electronic Watch Dog can be essential component for different kind of systems, and its importance will only continue to grow as technology advances. We have here provided an insight into the design, functionality, and potential for customization of An Electronic Watch Dog.

8. APPENDICES

Appendix A: Project Schedule

No. of days	5	10	20	30	40	45	60
Gather information							
Documentation							
Literature review							
Design and Prototype							
Compilation and Execution							
Testing							

Fig: Gantt Chart

Appendix B: Circuit Diagram

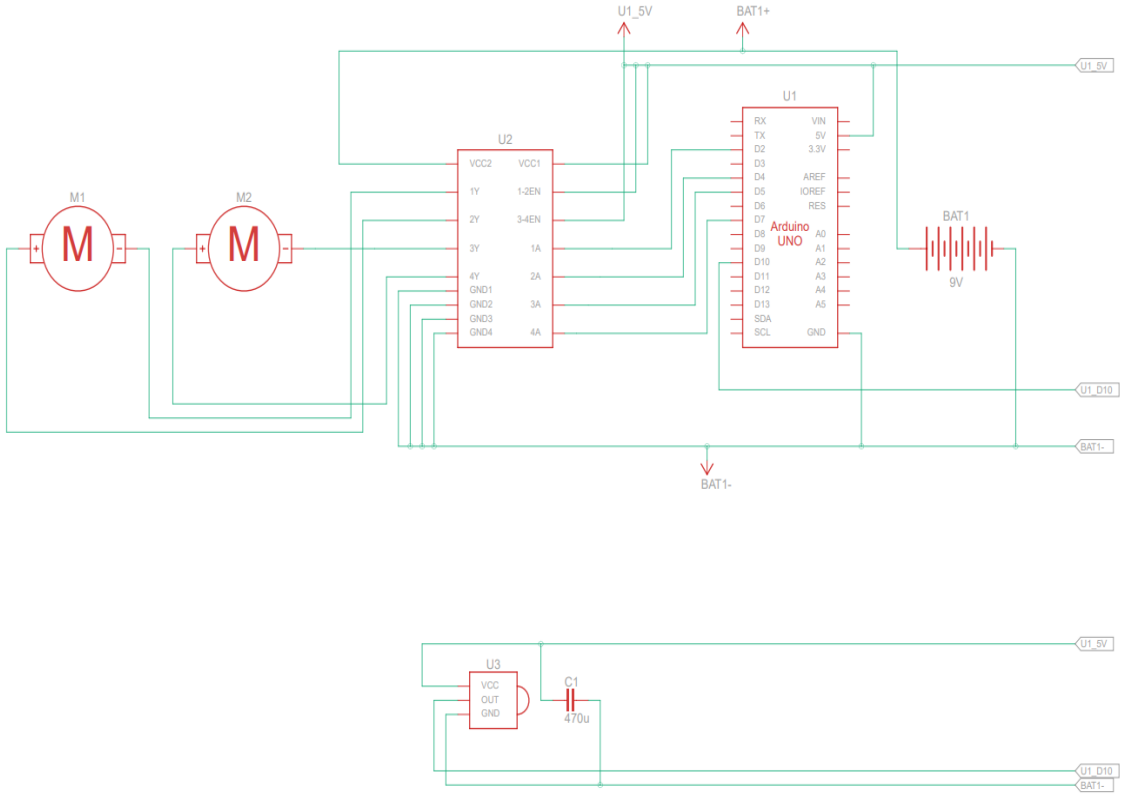


Figure 14: Path memorizing circuit

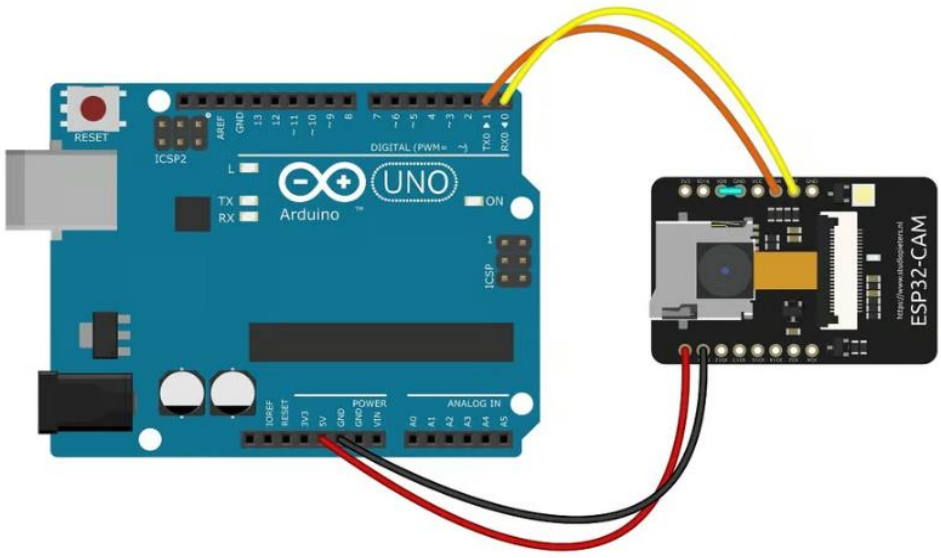


Figure 15: Interfacing ESP32 Cam with Arduino

Appendix C: IR Module Specification

Features of IR Transmitter:

Table 8.1: Features of IR Transmitter

Performance	Value
Transmitter frequency range	38 Khz
Transmitter output power	Few milliwatts
Transmitter supply voltage	1.2V~3.4V

Features of IR Receiver:

Table 8.2: Features of IR Receiver

Performance	Value
Receiver frequency	38 Khz
Receiver current supply	20mA
Receiver operating voltage	1.2V~3.4V

Appendix D: Used Linux Commands

1. Cd for change directory
2. Python <filename>.py for running python file
3. Pip install <packagename> for installing packages
4. Pip show <packagename> for viewing package information
5. ls for viewing directories in a folder

Appendix E: Project Budget

Table 8.3: Budget Analysis

S.N.	ITEMS	No. of unit	Price
1	Arduino UNO	1	1500
2	ESP32 Cam Module	1	1100
3	Breadboard	1	200
4	Connection Wires		200
5	Matrix Board	2	200
6	TT Gear Motors	4	500
7	L293D Motor Driver	1	250
8	Chassis		500
9	Battery and Charger	2	1000
10	Wheels	2	400
11	IR Receiver and remote	1	200
12	Caster wheel	1	200
	TOTAL		6250

Appendix F: Datasheets

1) L293D Motor Driver

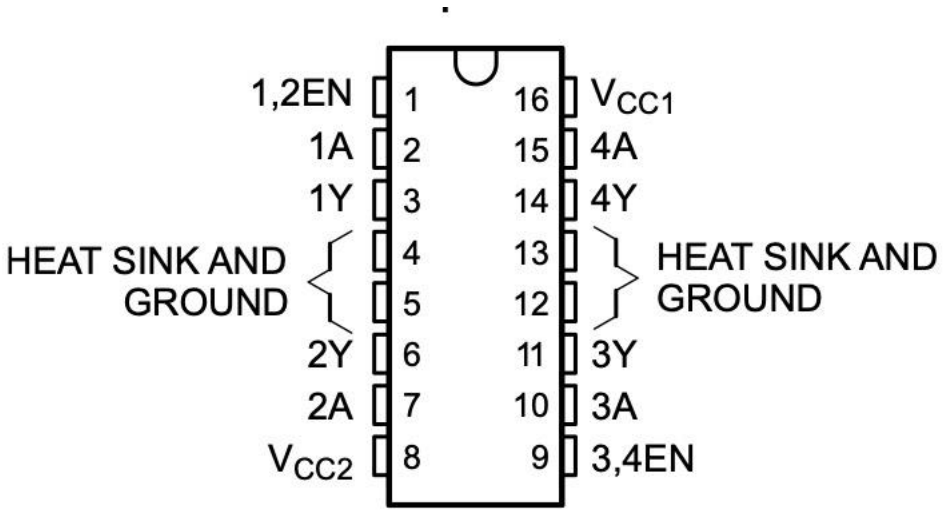


Figure 16: Pin Configuration of L293D [24]

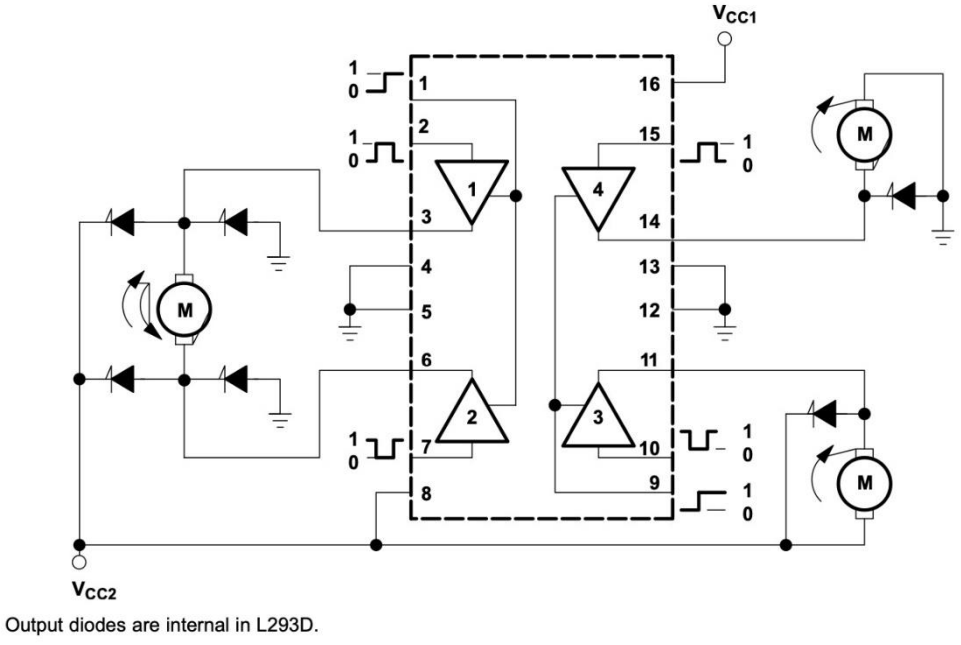


Figure 17: Functional Block Diagram of L293D [24]

2) Arduino

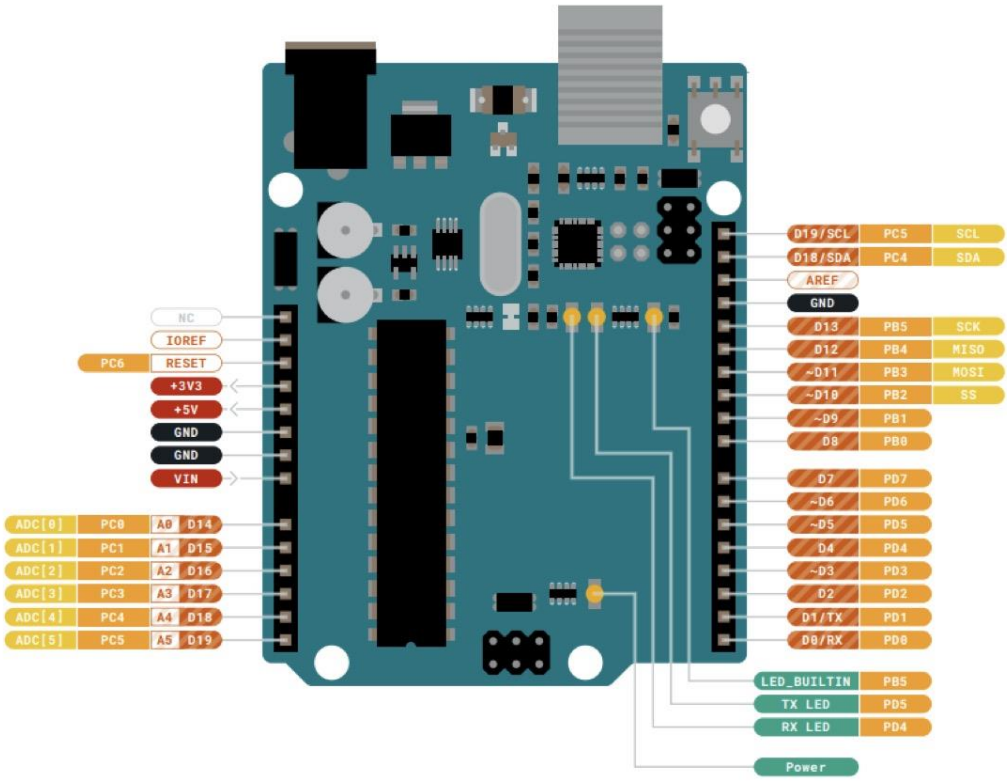


Figure 18: Arduino Pin Configuration [21]

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