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IOT: Real-time Face Detection and Recognition internet Based Robot Car Using Raspberry Pi and OpenCV

Research

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by

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إقرار المشرف

أقر أن البحث الموسوم

(أنترنيت الأشياء : سيارة آلية تقوم بالتعرف على الوجوه من خلال الكاميرا بإستخدام

Raspberry pi والمكتبة العالمية Open cv)

قد تم تحت اشرافي في قسم الحاسوب /كلية العلوم /جامعة ديالى وهو جزء من متطلبات نيل شهادة البكالوريوس.

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أهدي جهد السنين السابقة ، ايام الطفولة ، الصبا و المراهقة ، الى أثنين هما أول من نطق لساني إسمهما "أمي" ، "أبي"

لتسير بي عجلة الحياة ، وها أنا ذا أختم مسيرة السنين

بعد طول إنتظار

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إهداء

الى من ربّتني منذ الصغر حين غاب عني الجميع (عمتي)

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شكر وتقدير

نود أن نعرب عن شكرنا لمشرفنا . أ . د . جمال مصطفى التويجري الذي كان مفيدا للغاية وقدم دعما لا يقدر بثمن بإخلاصه وإيمانه بنا

بسم الله الرحمن الرحيم

(وَقُلِ اعْمَلُوا فَسَيَرَى اللَّهُ عَمَلَكُمْ وَرَسُولُهُ وَالْمُؤْمِنُونَ وَسَتُرَدُّونَ إِلَى عَالِمِ الْغَيْبِ وَالشَّهَادَةِ فَيُنَبِّئُكُمْ بِمَا كُنْتُمْ تَعْمَلُونَ)

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ABSTRACT

The robots in general and robot cars in special are one of the popular application in current years. It is using in many application such as economic, military, agriculture and security. Face recognition, on the other hand, works as a major tool for many application and recently it is an important feature in security filed. In this work, this project proposed a robot car that able to detect and recognize faces. The robot car using raspberry pi 3 B+ and can be accessed from any computer in the word by using TeamViewer application. The motion of the robot depending on the moving arrows in the keyboard while the face detection works automatically by using Haar Cascade algorithm.

The results of the robot car showed that the robot able to recognize any face that had been saved before in the dataset. We used 8 images of our friends from the university (we saved their faces) and trained the algorithm. After that, the robot car was able to distinguish between them without any error.

In conclusion; a face detection and recognition robot car were designed. The Tasks of the robot examined. It can be concluded that the robot car is ready to capture video from every environment. Also, it is able to detect and recognize faces and can be controlled from any place in the world with Wi-Fi internet.

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LIST OF ABBREVIATIONS

ASM	Active Shape Model
PCA	Principal Component Analysis
R\C	Remote control
SURF	Scale Invariant Feature
4WD	Four wheel drive
OpenCV	Open Source Computer Vision Library
FLANN	Fast Library for Approximate Nearest Neighbors
DC	Direct Current
TTL	Transistor-transistor logic
JPEG	Joint Photographic Experts Group
USB	Universal Serial Bus
ISP	In-System Programming
CSI	Camera Serial Interface
LBPH	Local Binary Patterns Histogram
GNU	Gnu's Not Unix
OS	Operating System
IC	Integrated Circuit
TXD	Transmit Exchange Data
RXD	Receive Exchange Data
HD	High Definition
mAh	Milli Ampere per Hour
GND	Ground
PCB	Printed Circuit Board
SDA	Serial Data
SCL	Clock Line
MOSI	Master Out Slave In
MISO	Master In Slave Out
GB	Gigabit

Chapter 1

1. INTRODUCTION

1.1 GENERAL OVERVIEW

In general, robots are material devices designed and employed to perform one or more responsibilities frequently, with speed and accuracy. The popular application of robots in our regular life managed to produce several various kinds of robots as there are tasks to accomplish. A robot is an automatic or virtual simulated operator, normally an electro-mechanical device that is controlled by a computer application or electronic systems. Robots can be independent or dependent. Robots have taken human places in performing repeated and critical responsibilities which people favor not to take, or are unable to do because of size constraints, or which take place in extreme circumstances such as outer space or the depths of the sea. Robot cars are one of the classes that appeared with the appearance of the robot and has become very widely used. Robot cars are robots able to move into the environment with or without personal interruption or direction. Robot cars are frequently employed in economic, manufacturing, army and recently also house settings and are widely studied globally [1].

The principle of facial recognition built by following the ability of human eyes to recognize faces. After applying it by technology and given its importance in everyday life, face detection and recognition become an independent department. Face detection work by creating the machine a 70 point to each face which knows as face bunch. These bunch converting to features and then to templates which can be used for comparing to detect and recognize faces [2].

Raspberry Pi is a computer has many advantages such as small size Such as size of credit card and the ability to use mouse and keyboard. It works as a desktop computer with the capability of doing many things. The raspberry pi capable of browsing the internet and playing a game. Also, it is able to processing text. The different from the other microcontrollers is the raspberry pi able to run many high-level programming languages such as Python [3]. The raspberry pi gives the ability to building several projects with different sized and an acceptable efficient can be used to solve many problems especially the raspberry pi is inexpensive and available with a huge amount of reference and free code examples [4].

Many applications can be built by implementing the face reorganization algorithms by using the capacity of raspberry pi. Also, the ability to provide the raspberry pi with a camera to capturing stream video from the environment helped to implement many image and video processing applications.

1.2 MOTIVATION

The Robot car presented in this project was specifically developed for implementing movable face detection and recognition system. The user will be able to control the robot car from any place in the world by using TeamViewer application which requires only the internet. The robot will send video stream from the environment at the same time it has the ability to detect faces and recognize them if they are already in the database.

1.3 PROBLEM DESCRIPTION

The requests what will be?? The first and main issue to be considered before building the robot car. The request here is a robot car that able to move and capture video from the environment. The video will be an input to a face recognition system in order to process it and providing results. That's mean the robot car must contain all the suitable hardware for implementing these aims. To do that, the components for the robot car must be determined. Our robot car most important features for its components are:

- Robot car frame: the frame of our robot must be suitable for achieving our aims. The frame size must be small to enable the robot car to move fast. But also it must be large enough to put all the components.

- Camera: the camera is very important to get the required data. Otherwise, there is no data will help us to build a face recognition system.

- Control board: we need a control board that able to handle all the required process such as receiving video from the camera, implement machine learning algorithm, ability to connect to the internet for transmitting data.

1.4 OBJECTIVES

The objectives of this project is to design a movable robot, so that involves the mechanics, localization, dynamics, and travel. There are two main objectives to implement our research:

1. Built a robot car that can be moving in any environment by receiving control signals from any place in the world.
2. The ability to capture video from the environment by using the camera and detect and recognize the faces from this video stream.

1.5 AIM of PROJECT

The main aim of this project is to design a mobile robot car that capable of moving in any environment and capture video to detect and recognize faces. The movable robot involves the mechanics, localization, dynamics, and travel.

1.6 PROJECT OUTLINE

This project contains six chapters. The second chapter is a general overview of the related works with ours. The third chapter is about hardware components that been used in our work and how assembled all the components. In the fourth chapter, we explained how we built our application program to control the robot car and detect and recognize faces. And the fifth chapter is the result while the sixth chapter is the conclusion and future works of the project.

Chapter 2

2.LITERATURE REVIEW

2.1 INTRODUCTION

In this chapter, we will talk about some previous works related to our topic. We will take a lock about works which built robot cars using a raspberry pi. Also, we will take a lock about some works of face detection and recognition.

In the second part of this chapter, we will discuss the haar cascade by showing the main advantages, steps, etc. of this method.

2.2 LITERATURE REVIEW

In [5], the robot car controlled using a raspberry pi. The robot provided with a USB camera to get live video from the environment. The controlling application built using the android system. There were four different activities in order to control the car which is forward, backward, right, and left. The connection between the android phone and the raspberry pi established using Wi-Fi. The signal moving from the phone toward the robot and the robot compile and run the signal using python language.

In [4], they built a robot car using a raspberry pi and Arduino UNO. The raspberry pi is the master and the Arduino is the slave. The user is able to control the car by voices and the ability to get data as feedback. The commands which are a voice signal stored in cloud service. Also, the incoming data saved in the cloud. A GPS system and ultrasonic sensor helped the user to drive the car by tracking the path using the GPS and avoiding the obstacles using the sensor.

In [6] they worked to build a self-control car that able to move from source to destination points. They offered many tracks such as straight, curved and straight than curved track. They provided the car with a camera in order to take images to the way and sending this image to a convolutional neural network algorithm. The job of the algorithm is to make a decision about the next move such as right or left. The used raspberry pi in the car and Arduino in the controller center. The results showed that the car able to move without human interaction.

In [7], they aimed to implement face detection using a boosted cascade algorithm and implemented local binary pattern to recognize the detected faces. They used raspberry pi with a

camera as the main components. They used a network of computers each one connected to raspberry pi in order to build the network of detection. This application can be used in any company such as airports or universities. The result showed that the system able to recognize human faces.

In [2], they used a vehicle to implement a security system inside it to detection thefts. The security system based on face recognition. They used raspberry pi in order to build their system. The system contains a sensor in the keyhole. This sensor gives an instruction when the car engine starting. When the sensor gives the instruction, a camera capture the photo of the driver. The camera connected with the raspberry pi by cable. Histogram equalization used to preprocess the incoming image. They used the Viola-Jones algorithm to detect face and Local Binary Patterns Histograms algorithm to recognize faces. The system sending the driver image and car location through MMS message to the owner of the car. Also, the system able to send an email to the owner. They used python and OpenCV.

In [8], they worked to implement a self-driving car that able to detect obstacle and traffic sign. The system worked base on Feature matching in Image processing using a number of algorithms such as SURF detector, Brute force matcher and RANSAC. They prefer these algorithms because is not affect by changing light conditions and is able to detect with rotations. They tested the algorithm and the found it gives good result even at high speeds. Also, they used a distance estimation algorithm to estimate the distance between the car and the obstacles. They used the raspberry pi to implement their system.

In [3], they implement a Wi-Fi controlled car that contains a camera to build a dynamic monitoring system. The user could control the car from any place in the world by using the Internet. The camera helps the user to the controller of the car. They used the web application to control the car and displaying the video stream which coming from the camera. The web application contains the video stream with five buttons forward, reverse, left, right and stop. The main components of this research are the raspberry pi and USB camera.

In [9], they implemented face monitoring system by using face detection and face tracking algorithm. They used MATLAB ready algorithm and used Raspberry pi B. the used haar classifier to detect face an array of LEDs follow the face after detecting it. the algorithm capable to follow face area in the range selected using the eigenfeatures of the face, which are identified by eigenvectors of MATLAB and by face tracking, which is been provided by geometrical

transmutation so that movement and appearance of the face can be followed. So they built a new method of facial tracking on real-time streaming by the using of Viola-Jones algorithm and an IR camera.

In [10], they built a system that able to detect the face in the image and recognize the emotion on the detected face. Face detection is done by using three steps. The first step is face detection and for that, they used haar cascade. Then the extracted features by applying the Active Shape Model (ASM) where they extracted 26 facial points. Finally, they used AdaBoost classifier for classification the incoming image into one of the five emotions. The emotion was a surprise, disgust, anger, happiness, and neutral. They used Raspberry Pi II and they get a result with average accuracy equal to 94% in real-time testing.

The [11] research showed a structure to implement face identifying and face sensation detection. Their system built by using characteristics of face and the effects of this characteristic. User and emotions of face details analyzed in order to make predication. Each emotion defined by using differences between the emotions. Many images trained using machine learning method for classification the images. The basic techniques that they used are openCV and how to build classifications and training image using machine learning functions in this library. The result showed that their system able to training and classification images with acceptable accuracy.

The [12], aim to use inexpensive and available board rather than using the expensive workstation in order to build an image processing system by using OpenCV with raspberry pi. So the main two basics of this system were raspberry pi as a processor and openCV as a library for all required functions. One of the functions in the OpenCV library is a principal component analysis known as the PCA algorithm. This algorithm can be used in many fields one of them face detection and recognition. There are many aims that the system not only faces recognition. They worked to make their system working with low power and faster. The machine of the system can be summarized in this way: the system starting work after pressing the bell of the door. A camera takes many images for the person. The face will be compared with the dataset. If unsaved before, the person will be save to the dataset. The system has many methods to inform the homeowner such as with smartphone, speakers and a website for monitoring security.

In [13], the project aimed to implement face detection algorithm without using any existing algorithm. They combined strong popular algorithm known as haar cascade with three algorithms classified as weak algorithms in image processing field. These three algorithms have different jobs. One of them working based on histogram idea. The second work depending on the eye features. And the last one takes the features of the mouth to make some predictions. The pipe of the system contains many steps. First, one using haar cascade without any rejection for any face. Which mean any matching will take as a true. The accuracy was limit. After that, they used the histogram method to increase this accuracy a little bit. The third step included eye detection algorithm to find the images which not contain faces and reject them. The final step, the detection of mouth features running to ensure the remaining images contain a human face. All these methods implemented by using the OpenCV library. All images in training set and test set tested and confirmed that the combining of haar cascade with the three method gives a good and perfect performance.

The [14], built a system for tracking eye. The position of the eye founded by using Haar cascade method. To achieve this the selected rectangular of human eye features. After that, they founded the position on the screen where the user was locking. The screen resolution changed to adapt with the eye range. The difference if a feature from one image to another helped the classifier method to discover the eye position. These features must be adapting to the resolution of the screen in order to find the right position. One of the import things that effected on the eye position was the position of the head. If the head located in the right position the eye tracking gives optimal results. Otherwise, the results were different from one person to another. The results showed that the eye tracking system can perform better with haar cascade and giving acceptable accuracy.

2.3 OBJECT RECOGNITION

Image processing is a widely separate field. It mainly works to process and analyze images in order to achieve some goals. Object recognition is one of these goals. Recognize the object including the face, lettering, and car plates, etc. the application which works with objects recognition is coming from computer vision and learning fields. These two fields have many related subjects such as cascades and decision tree. In the next few paragraphs, we will describe some object recognition approaches including haar cascades which is the approach used in this project [15].

2.3.1 Local Invariant Feature Detectors

One of the popular methods which using any object as a group to recognition is the local feature-based [15]. The idea of this method is trying set of images and building many transformations. In this method they did not use global features. They are using local features to determine the characteristics of local area or region and defining the intensity or texture. The difference in intensity and texture can be found by applying a kernel on the image. After applying kernel the result will be an area of pixels computations to find the amount of gradient change within this area. The detector will specify the feature of the area and this happens after transform the image in different ways.

Harris corner detector as an example. Intuitively a perpendicular corner would be found when the horizontal and vertical gradients (within a sub-window of pixels) sums up to a large value since in that case there is a contrast in both horizontal and vertical directions { but a rotation of the image would hide this feature if the measurement was done perpendicular. The Harris Corner detector compensate for such rotation by applying eigenvalue decomposition to the second moment matrix [15].

When comparing the locally based method with many typical methods we found that the local method contains many types of invariance. Also, it contains partial occlusion. There are many reasons to apply recognition techniques on gradient images such as grayscale images give more robust rather than any other types of images to be different in illumination. The brightness of singular gives matrix and led to more efficient use of memory consumption with high speed of processing compering with the other methods. After finding the local features on two images, the

two set of the feature will be compared in order to produce one set of the features the can be found in both images which mean the common features between the two images. The threshold of the feature number determines for finding matching if it passes the threshold mean matching had found. Otherwise, no matching [16].

2.3.2 Speeded Up Robust Features

The first choice of recognition method was SURF (scale-invariant feature) based technique. It is an approach designed for efficiency that at the same time have a high level of invariance to the transformations and conditions expected in the setting gave [17].

The SURF method work by using a filter with box shape to apply on the integral images to find the approximate value of the Gaussian derivatives with the second order on the matrix [16]. The SURF principles same to the way of finding eigenvalues in the same image as we described before for the method of Harris Corner Detector.

For scale invariance, these filters are applied to different scales over the image. The processing time over different scales over some point is size invariant due to the use of integral images [18]. To get rotation invariance each interest point is given an orientation vector and this vector is the maximum of response (gradient change computed with Haar wavelets) around the point. When the extraction of the descriptor is done some matching technique is applied to find correspondence between the descriptors (feature vectors); when using OpenCV the FLANN library (Fast Library for Approximate Nearest Neighbors) can be used, applying the nearest neighbor search. Figure 2.1 showing the most used filters in this method.

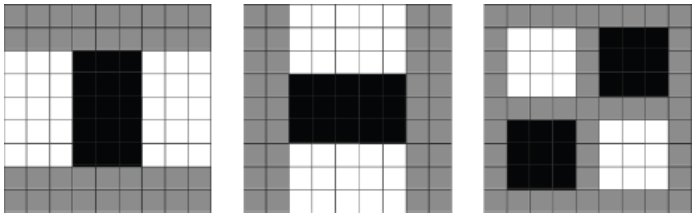


Figure 2.1: Recognition Method Filters.

2.3.3 Haar classification

The machine learning used in many approaches to computation object detection with many advantages. The generic method for features matching detection works better when collecting information localization, shape, and scale. One of the popular methods is Haar classification. It is working by building a tree in the training stage to create the statistical values to determine the boosted rejection cascade. The aim of finding Boosted is building stronger classifier by using many weak classifiers. The weak classifier works correctly and finding the right class but with a ratio equal to fifty percent of the total dataset. This makes up good classification by using weak classifiers which occur by making the penalty higher so the misclassified samples which make the chance of choosing the not selected sample more luckily. Finally, after doing these steps the hypothesis of all classifiers will be combined into general one [19]. Figure 2.2, 2.3, 2.4, and 2.5 showing how it has done.

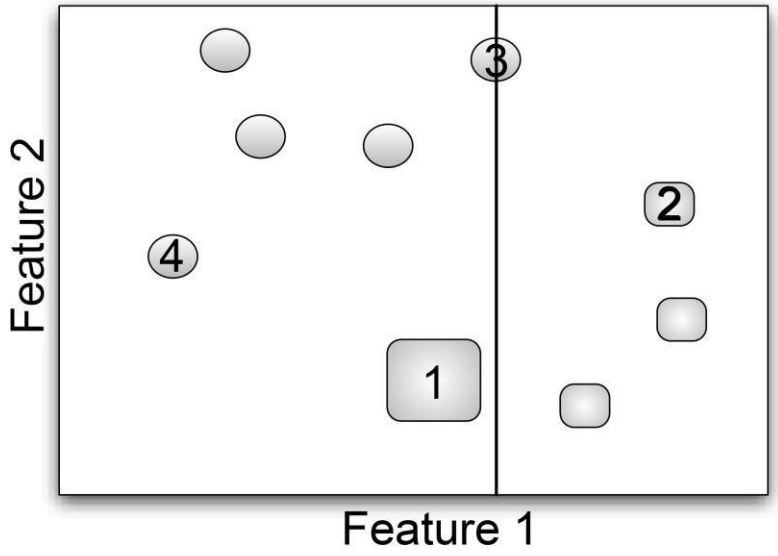


Figure 2.2: A hypothesis (line) is selected.

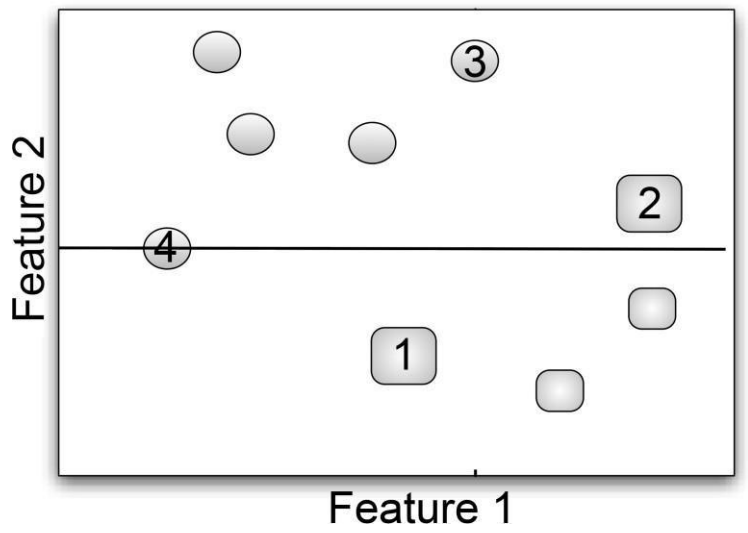


Figure 2.3: The next hypothesis misclassifies object 2.

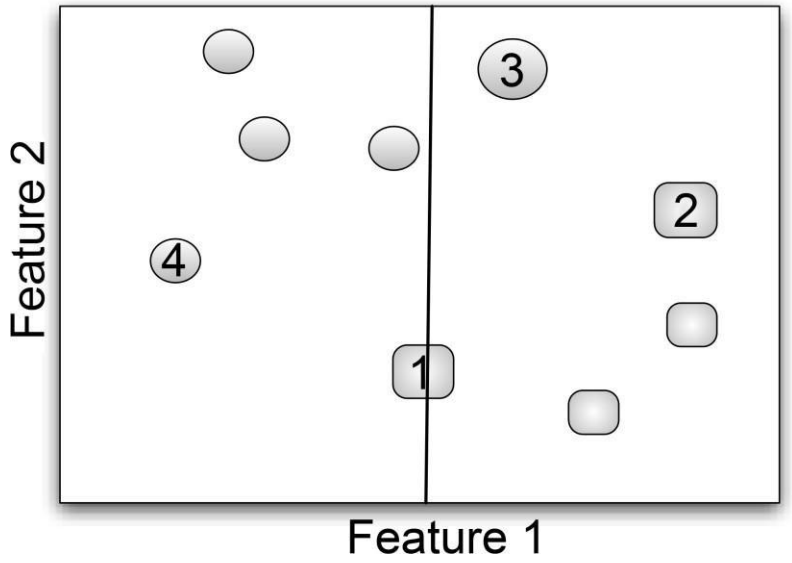


Figure 2.3: The next hypothesis misclassifies object 3.

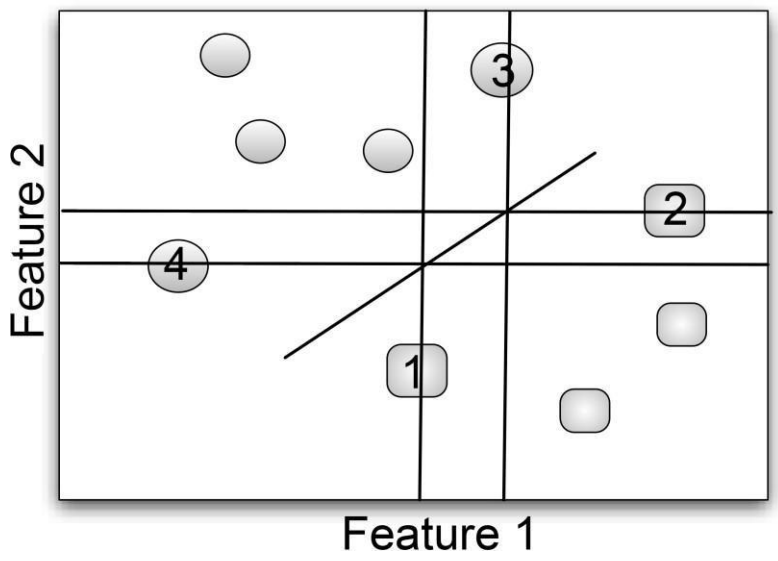
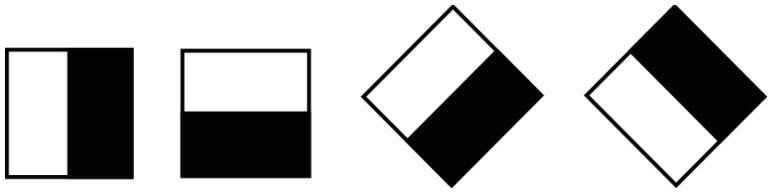
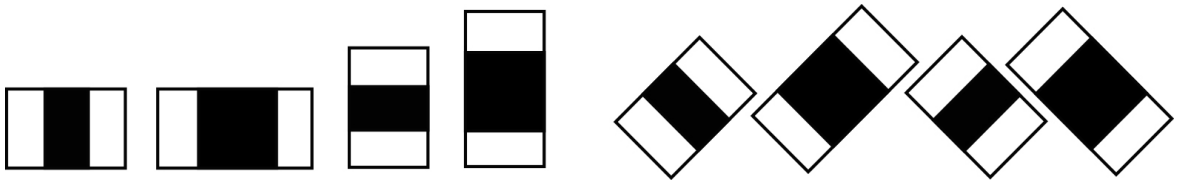


Figure 2.5: After a combination of all hypotheses is computed.

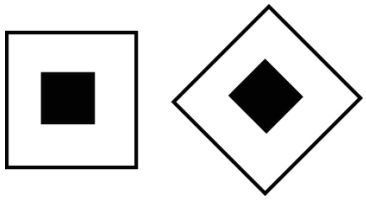
There are four boosting techniques possible for Haar training in OpenCV: Logitboost, Real Adaboost, Discrete Adaboost, and Gentle Adaboost. That Haar classification applies a dismissal cascade suggests that the last classifier consists of a cascade of several easy classifiers, and a section of powers must move all frames of this cascade to pass. The order of the nodes is usually established after complexity, so that several feature competitors are conducted out first, avoiding substantial calculation time [19]. As data to this primary classifier, that makes up the cascade, arrives Haar-like features that are determined according to figure 2.6. When the form is running a mirror of various sizes is cleared over the image, computing amounts of pixel results based on these features, using basic images, and applies the trained rejection cascade.



A: Finding the Features of the Edge.



B: Finding the Features of the Line.



C: Finding the Features of the Central.

Figure 2.6: The Haar Cascade Features.

Chapter 3

3.HARDWARE COMPONENTS AND ASSEMBLING

3.1 INTRODUCTION

This project proposed for designing a Robot car that the user able to control it from any place in the world. The robot car has the ability for detect faces and recognizes these faces according to the trained dataset. The robot car controlled by the laptop using TeamViewer application and supplied with raspberry pi and pi camera get a video stream from the environment. The control signals will be provided from the program on the laptop. The robot car will receive this control signal which is the four directions.

3.2 ROBOT CAR COMPONENTS

In this part, all the components used in a robot car will explain in details. The general features explained and the general structure of each component was explained. So the aim of this chapter is to introduce all used components details and usage. Also, we will talk about the assembling of the components.

3.2.1 Robot car Frame

The aim is to build a robot car in order to be able to use for various assignments in closet indoor and outdoor environment. The selecting of a robot shape very important because it has an impact on robot performance. Also, the number of wheels has a large effect on the robot movement. For this reason, we select a 4-wheels with 15x25 robot chassis. The 4 wheels give the robot flexibility to move in all direction. The size of the chassis gives the robot flexibility to move in narrow areas.

The robot frame showed in figure 3.1. It contains two layers with 4 wheels and a dc motor for each wheel. This type of frame has a lot of advantages to use. One of them a suitable size which can go through many narrow areas. Also, the two-layer gives us the ability to position all the components in appropriate places.

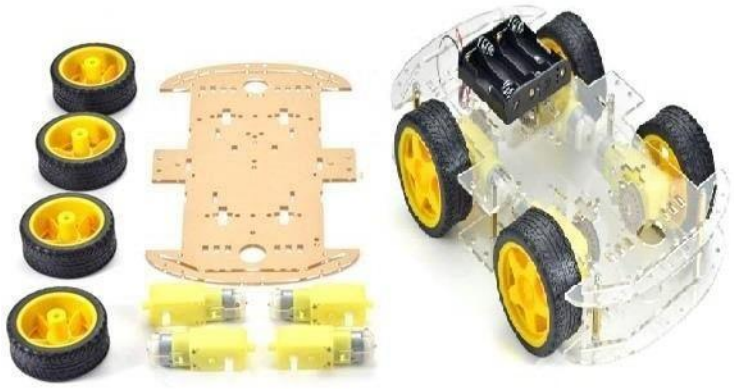


Figure 3.1: The Frame of Our Robot Car.

3.2.2 L298n motor driver

The l298n driver allows the controller to control the speed and direction of two DC motors in each side with ease. It can be used with motors that have a voltage between 5 and 35V DC. The l298n designed to accept standard TTL (Transistor-transistor logic: is a class of integrated circuits which maintain logic states and achieve switching with the help of bipolar transistors) [20]. Figure 3.2showing the l298n.

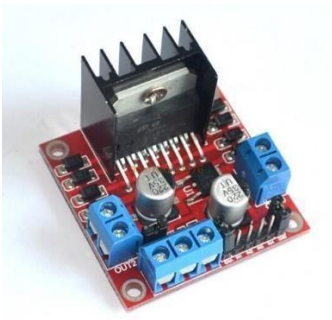


Figure 3.2: the L298n Motor Driver.

3.2.3 Raspberry Pi 3 B+:

The raspberry pi is a computer has many advantages such as small size Such as size of credit card and the ability to use mouse and keyboard. It works as a desktop computer with the capability of doing many things. The raspberry pi capable of browsing the internet and playing a game. Also, it is able to processing text. The different from the other microcontrollers is the raspberry pi able to run many high-level programming languages such as Python [3]. Figure 3.3 showing the raspberry pi with details.

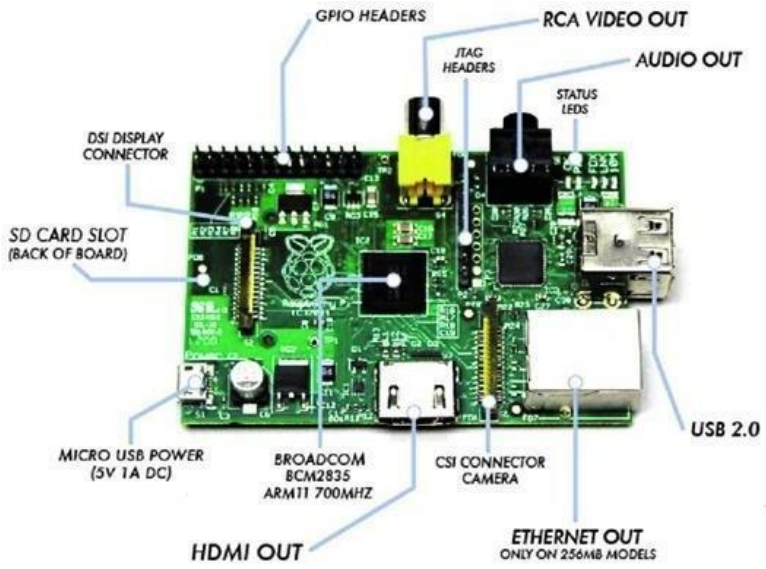


Figure 3.3: Raspberry Pi with important details.

The last version of raspberry pi is raspberry pi 3 B+. This version has many advanced features. The quad-core of this type work with 64 bit and 1.4 GHz. It contains LPDDR2 SRAM and dual-band processor with 2.4 GHz. This type contains wireless connection which is Wi-Fi and wire connection which is LAN port. Also, it contains Bluetooth 4.2 module. The Ethernet speed is high. It is able to transmit data with 300 Mbps speed. It has the ability to power with the Ethernet. The previous module was raspberry pi 3 B. the difference between the previous module and this module can be summarized by table 3.1.

Table 3.1: Comparing between Raspberry pi 3 B and Raspberry Pi 3 B+.

Features	Raspberry Pi 3 B	Raspberry Pi 3 B+
RAM size	1GB SRAM	1GB SRAM
Bluetooth	4.1	4.2
CPU type/speed	ARM Cortex-A53 1.2GHz	ARM Cortex-A53 1.4GHz
Ethernet speed	10/100 Mbps	300Mbps
Integrated Wi-Fi	2.4GHz	2.4GHz and 5GHz
Bluetooth	4.1	4.2

Figure 3. Showing the raspberry pi 3 B and the raspberry pi 3 B+.

Figure 3.4: Raspberry P 3 B and Raspberry P 3 B+.

As show in the figure above. The Raspberry P 3 B+, which is on the right side, contains the following ports:

1. Power port which received 5 volts with 2500 mAh.
2. HDMI which gives the raspberry pi the ability to connecting to the HDMI monitors.
3. Ethernet port.
4. 4 USB ports which give the ability to the connecting mouse, keyboard… Etc.
5. Display port.
6. Camera serial port.
7. 4 pole stereo and composite video port.
8. 40 pins each one has a special job (we are going to explain them in the next paragraph).

The 40 pins located side to side and provide many capabilities. Figure 3.5 showing the raspberry pi B+ pins. From the right, the first two pin supply 5 volt power for powering another component such as sensors. This two-pin can be as output and input power. If we not using the power port, we can power the raspberry pi by one of these pins but the power voltage must be between 5.5 and 6 in order to run the board. In the same side, we have 5 pins for ground. Also, this side contains the RX and DX pins which responsible for transmitting data to and from the board.

In the second side, we have two 3.3 power pins for providing us with 3.3 volt. Also, we have 3 pins for ground. There are some pins for wiring interface such as SDA, SCL, MOSI, MISO, and SPI_SCLK. The rest of the pins can be used as control pins for giving signals to other components such as DC motor, fan, light …. Etc.

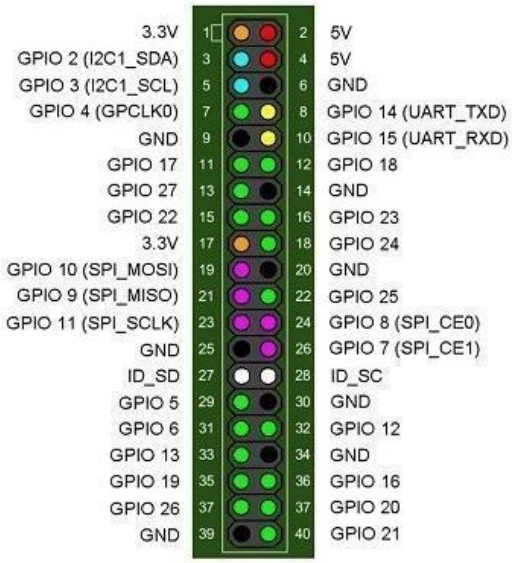


Figure 3.5: Raspberry Pi B+ pins.

The last part in the Raspberry Pi 3 B+ board is the SD card. The card is responsible for holding the operating system, applications, and files. The raspberry pi works with cards with different capacities such as 8 GB, 16 GB, and 32 GB. The 32 is the best size for ensuring the board will not require extra storage in the future. The suitable card for the raspberry pi is a mini card. Figure 3.6 showing the mini SD card [21].

Figure 3.6: 32 GB Mini SD Card.

3.2.4 Raspberry Pi 3 B+ Camera Module

One of the tools that make the raspberry pi an important component in the robot is the pi camera. It can be used in many security and monitor applications. The camera connects to the raspberry pi by a serial cable which supports interface for serial connection. The characteristics of the camera are lens Type 1/4 5 M, focal length: 3.6 mm (Adjustable), Wide image, and 5- megapixel with OV5647 sensor [22]. Figure 3.7 showing pi camera.

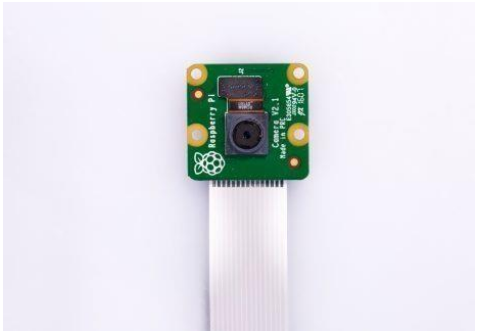


Figure 3.7: Pi Camera.

3.2.5 Battery

The main type of batteries which used now in the robot is the Lithium Polymer batteries which know as (LiPo). Which contain some lithium types such as manganese lithium or any other type of lithium. There are many different types of batteries such as lead acid, NiMH and NiCad but their disadvantages are many when comparing them with the lithium batteries. The main advantages of lithium are low weight and high capacity. Also, it fast to charge rather than the other.

The voltage is the main factor must be considered when choosing the battery for the project. It is an important measurement for the batteries. In general, lithium batteries can be built by combining a number of cells. The number of cells starts from 1 to infinity. Each cell gives 3.7 volts. In this way, the required voltage can be determined first then depending on it the number of cells can be chosen. For example, the two cells battery gives 7.4 voltage while the battery with three cells gives 11.1 voltage. Depending on the voltage and the capacity the charger of the battery can be chosen in a perfect way to ensure fast recharging.

Figure 3.8: Lithium polymer (LiPo) Battery.

3.2.6 Voltage Regulator

The raspberry pi work with 5.5 volt. In order to convert the voltage of the battery from 11.1 to 5.5, we used an LM2596 voltage regulator. Figure 3.9 showing the voltage regulator. We can change the resistor in order to get the required voltage.

Figure 3.9: LM2596 voltage regulator.

3.3 ROBOT CAR ASSEMBLING

The first step in assembling the robot car components is building the body of the car. After doing it we placed the components in a suitable place in order to make the wire connection as easy as possible. The first layer of the robot contains the battery and the DC motor drive. The motor drive receiving 11.1 volt from the battery. It is unable to power the raspberry with this voltage. To do that we used a voltage regulator. The voltage regulator receiving 11.1 volt from the battery and producing 5.5 volt for the raspberry pi board. The DC motor has 6 pins that receiving the signals of movement instructions from the raspberry pi. Figure 3.10 showing all the connections for the DC motor drive.

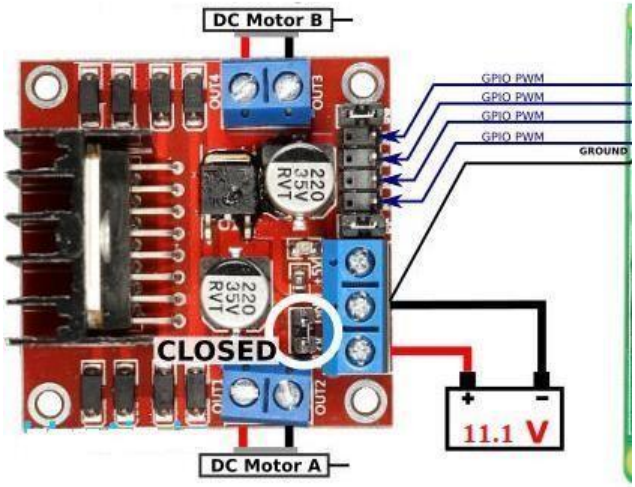


Figure 3.10: DC motor Driver connections.

The GPIO pins connecting to raspberry pi for the GPIO15, GPIO 7, GPIO11, and GPIO13. The raspberry pi receiving power from the voltage regulator to the 5 volt pin and ground pin. The next connection is the raspberry pi with the camera. We used CSI (Camera Serial Interface) port to connect the camera with the raspberry pi. The camera placed in front of the car. We used a servo motor holder to place the camera. This holder can turn with 180 degrees left and right. Also, it can move up and down with 180 degrees. Figure 3.11 showing the camera holder. It fixed and can move only to be the hand.

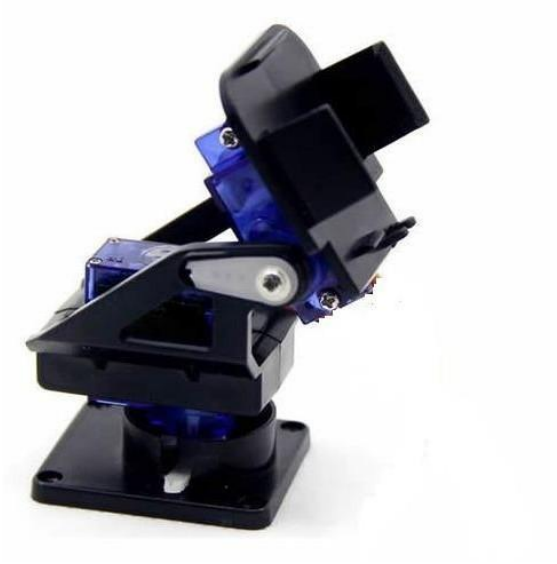


Figure 3.11: Camera Holder.

Figure 3.12 showing the raspberry pi after placing it on the robot car body. The figure showing the motor driver connections with the power connections of the raspberry pi. Also, it showing the connection of the camera.

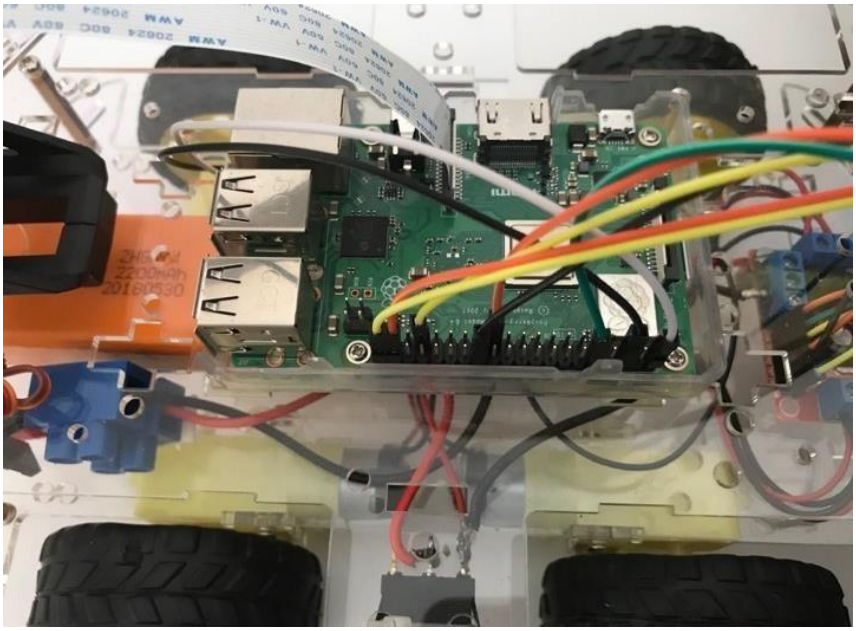


Figure 3.12: Raspberry Pi connections.

The figures 3.13 and 3.14 showing the final form of the robot car.

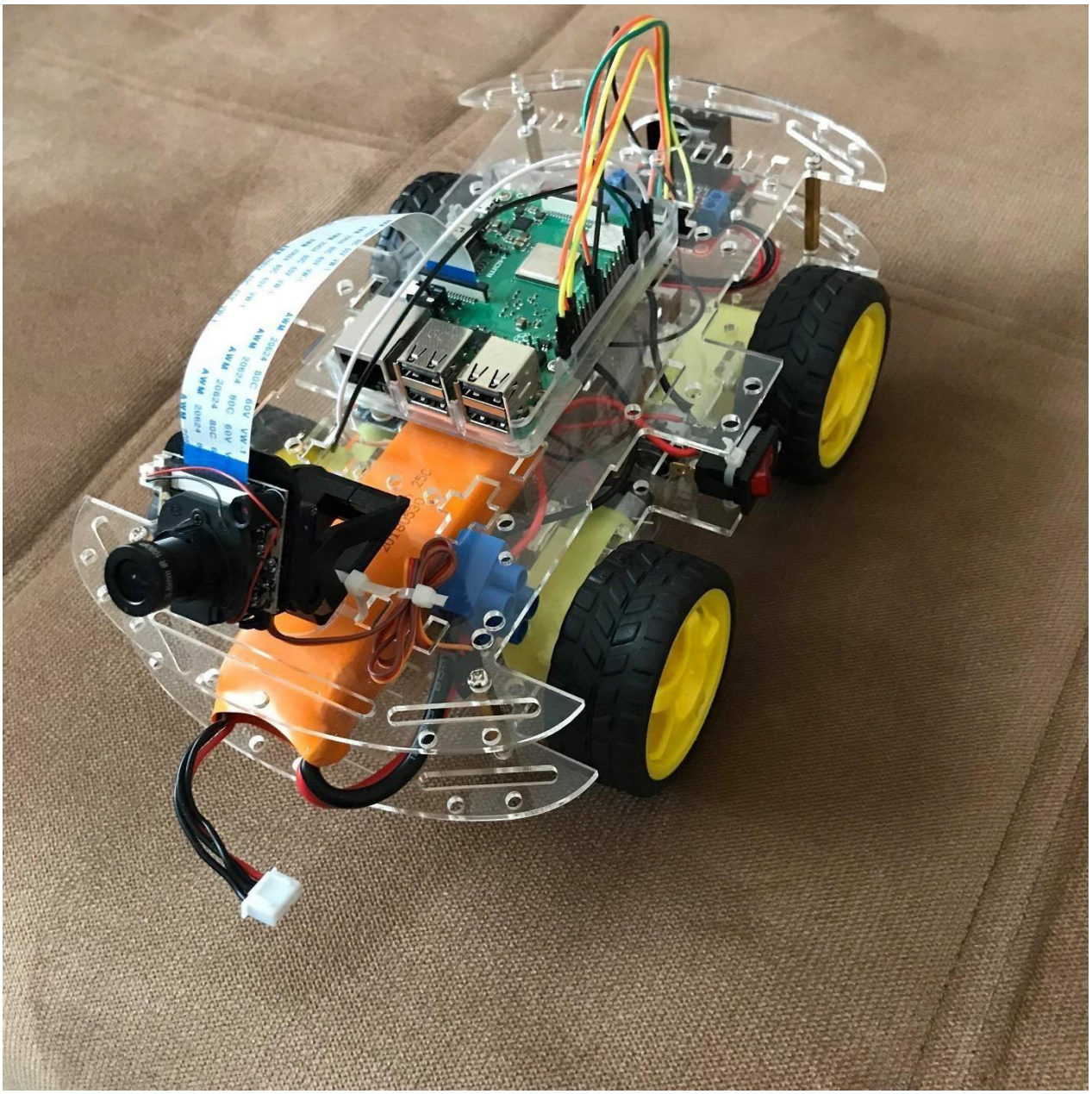


Figure 3.13: Robot Car from the Front.

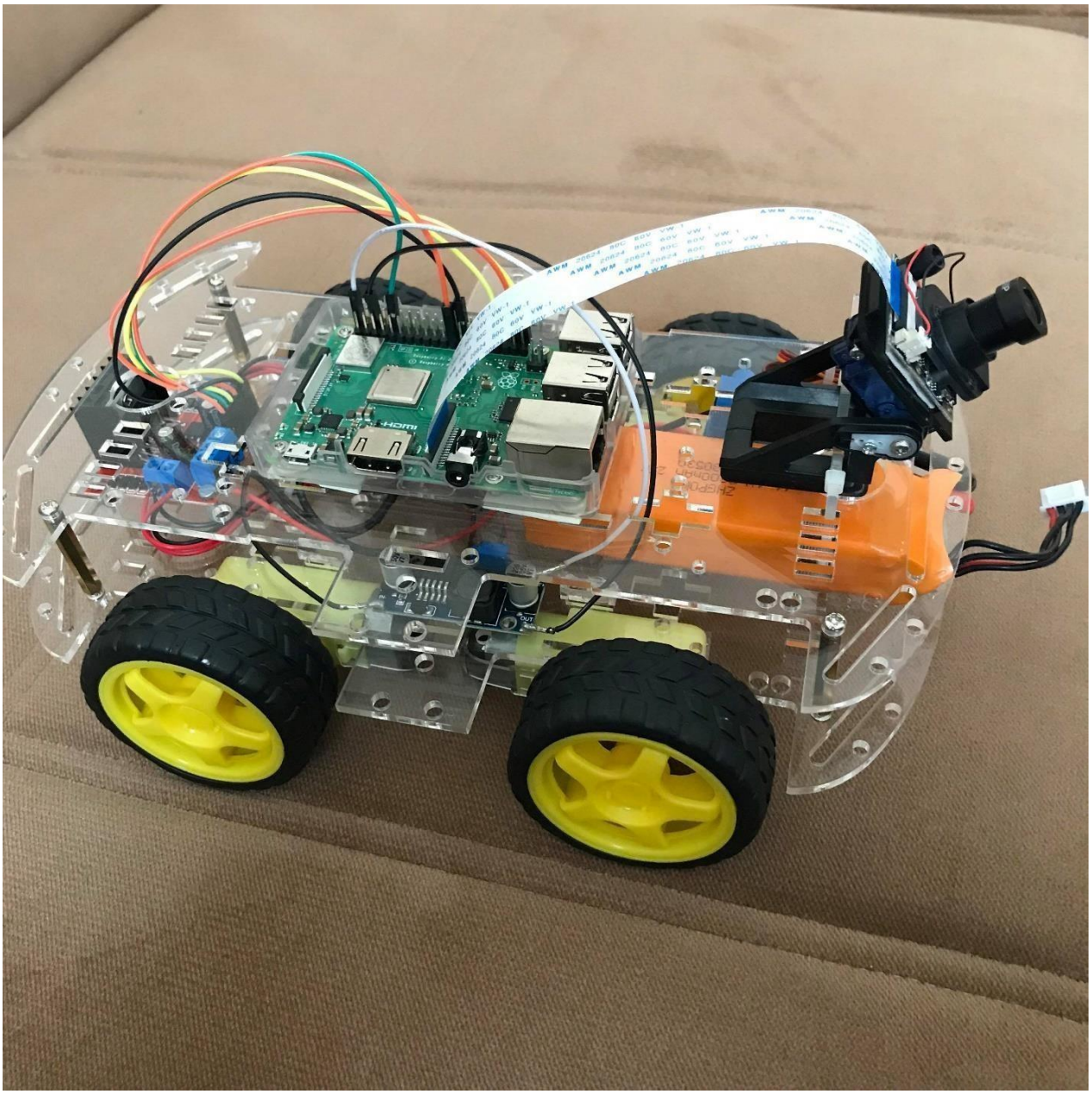


Figure 3.14: Robot Car from the Side.

Chapter 4

4.SOFTWARE

4.1 INTRODUCTION

This chapter showing the implementation of robot car software. It provides all the details about the system preparing by install all the required libraries and the face detection and recognition program. Also, it is showing the control program implementation for control robot car movements.

4.2 SYSTEM PREPARING

The first step is to install the raspberry pi OS on the SD card. The raspberry pi operating system known as Raspbian. This operating system is available on the official site of the raspberry pi [23].

After installing the operating system, the next step is installing the Open Source Computer Vision Library which known as OpenCV library. To install the OpenCV we need first to expand the filesystem to include all space on the SD card. After that install some developer tools, including CMake, which helps to configure the OpenCV build process. Also, install some image I/O packages that allow us to load various image file formats from disk. Examples of such file formats include JPEG, PNG, TIFF, etc. also, we need video I/O packages. These libraries allow us to read various video file formats from the camera. The next step is downloading the OpenCV zip file and then install it in the raspberry pi. In this way, we installed the library and the operating system.

4.3 FACE DETECTION AND RECOGNITION

The face and detection procedure contain three main steps:

4.3.1 Face Detection and Data Gathering.

4.3.2 Train the Recognizer

4.3.3 Face Recognition

Figure 4.1 showing the steps of face detection and recognition in details.

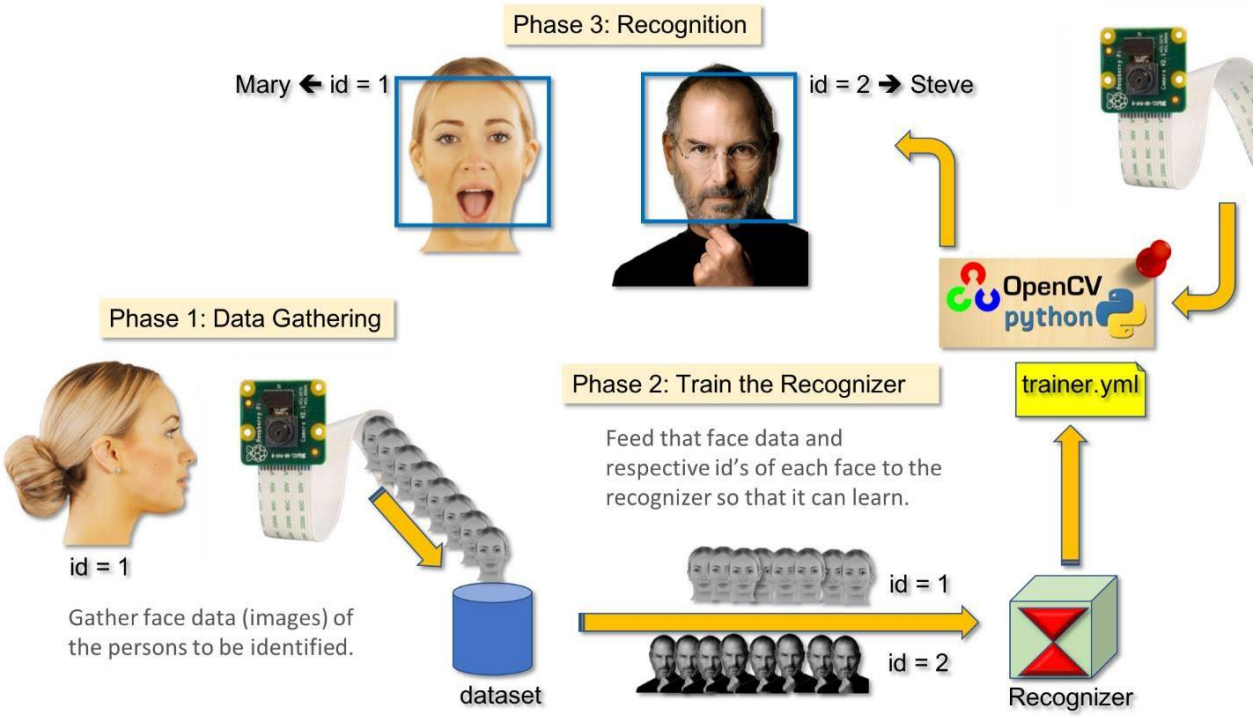


Figure 4.1: Face Detection and Recognition Steps.

4.3.1 Face Detection and Data Gathering

The first step is to face detection and data gathering. The face detection is important and the base of the procedure of face recognition. First, we need to detect the face in order to recognize it. For face detecting, we used haar cascade classifier. It is a popular method with many advances in this field. The OpenCV contain dataset for face detection. The dataset contains many examples with images of the face which is a positive example. And negative examples are images without faces. The OpenCV use this dataset for training the classifier.

By detecting faces, the data gathering working by taking the detected faces and convert the images to grayscale form. In this step, we will give each image an id. This id will represent the person id and if we get matching in the next steps we will use this id for showing the person name. For each person, we will take 30 samples as a dataset. We will assign each simple with the id number and a sequence from 1 to 30. For example user, 1 will have 30 images in the dataset with these names: 1.1, 1.2, 1.3….. 1.30. Figure 4.2 showing the process of data gathering.

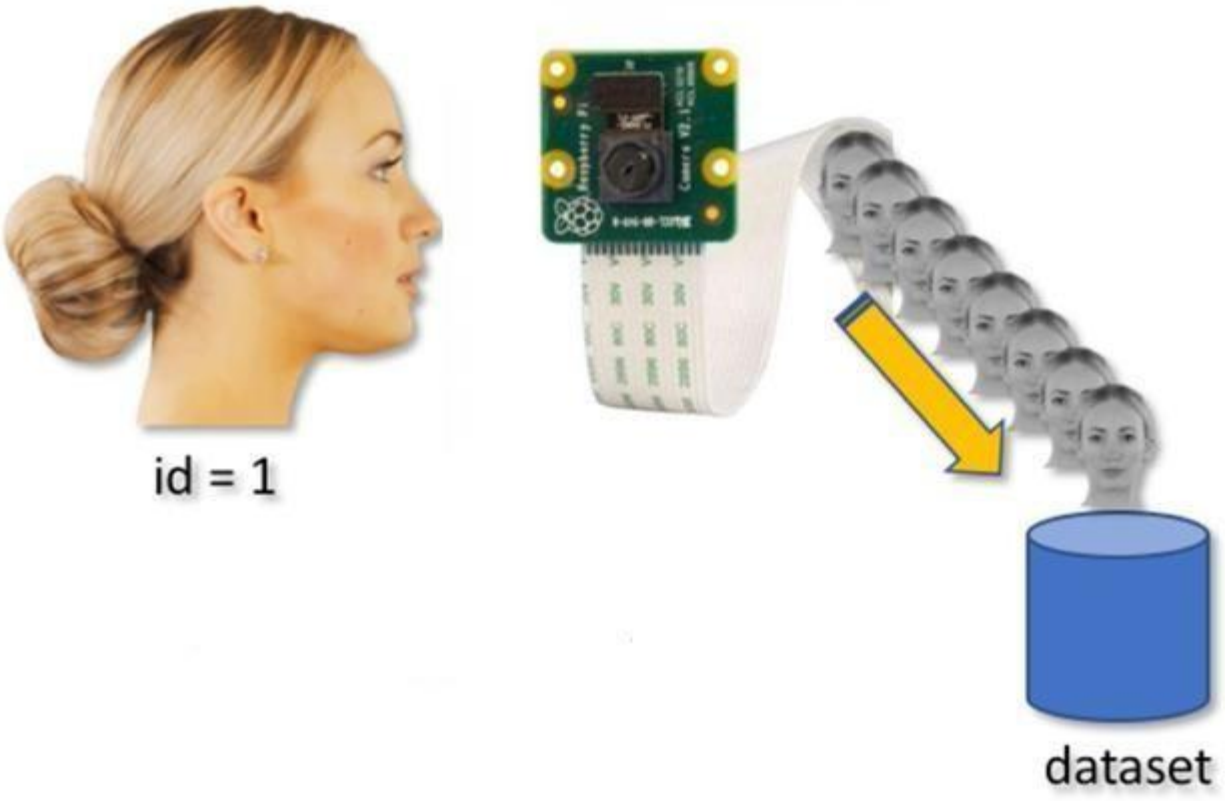


Figure 4.2: Data Gathering.

4.3.2 Train the Recognizer

In this step, we will use all the images in the dataset and training it using the trainer function in the OpenCV library. The trainer is a function to implement the LBPH (local binary patterns histogram) algorithm. The result of this step is a file with (yml) direction. Figure 4.3 showing how this step working.

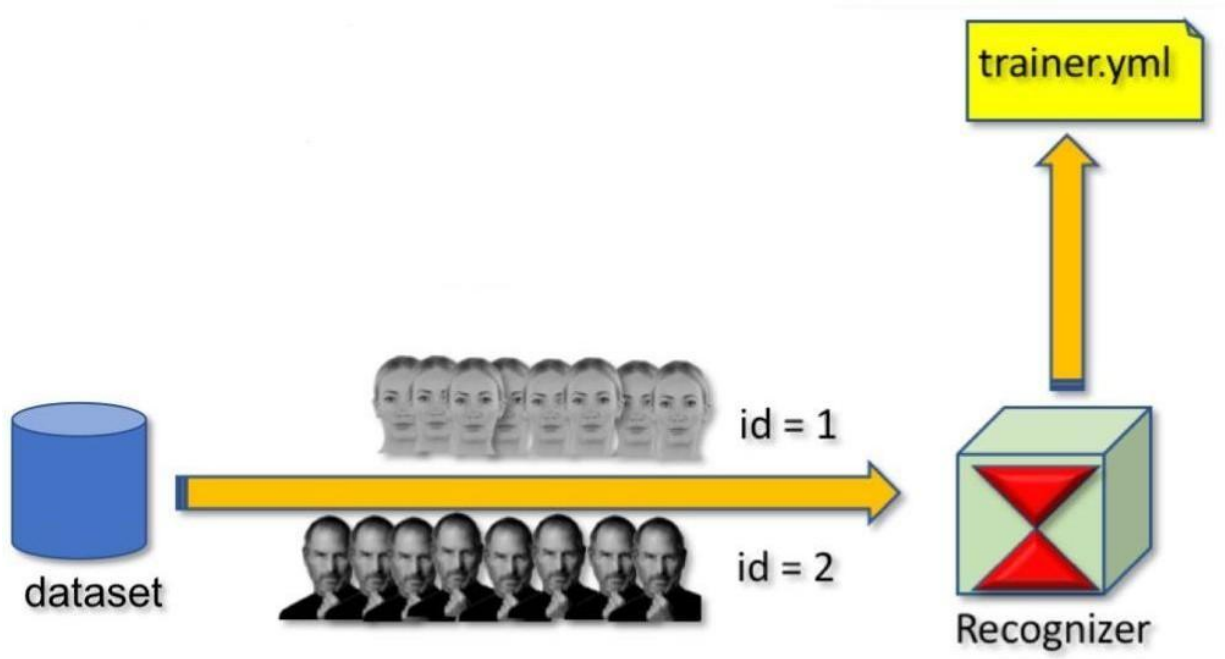


Figure 4.3: Training the dataset.

4.3.3 Face Recognition

The final step of face detection and recognition is faced recognizer. In this step, we will receive a video stream from the robot car. The program will detect the face. If the captured face for a person had captured before and trained, the recognizer will return the id of the user. In this step, we provided the recognizer with an array of names. The first name refers to id 1. The second name refers to id 2 and so. There is a predicted function with name predict in the OpenCV library. This function will match the incoming face with the dataset. The function will return the user id with the matching rate equal to 25%. We tried this ratio with all users and we get the correct prediction for each user. In the screen of the monitor, the camera will detect face and will write the user name if founded with the prediction ratio. Figure 4.4 showing the procedure of this step.

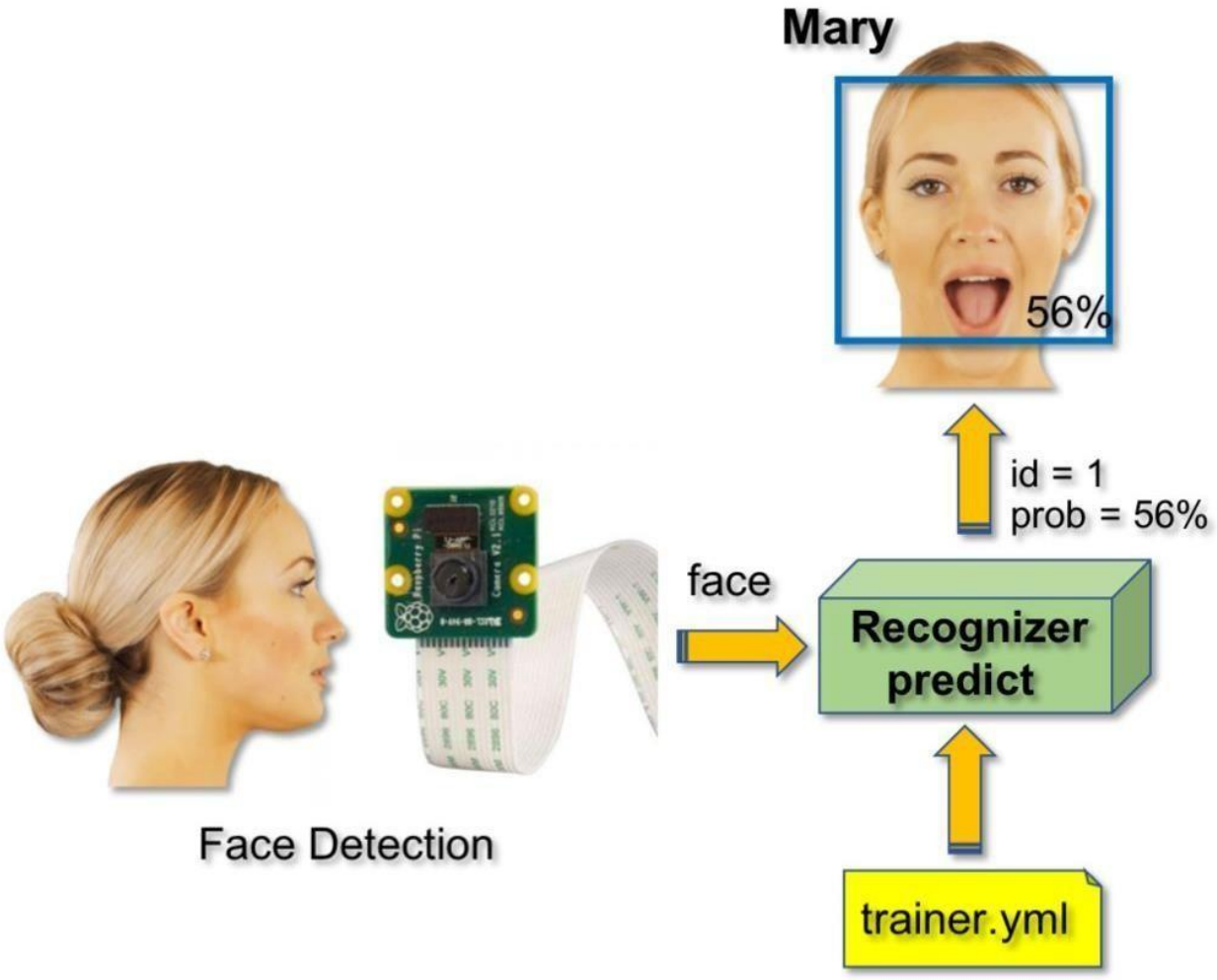


Figure 4.4: Face Recognizing.

4.4 ROBOT CAR CONTROL

In this part of the chapter, we will talk about the program which generates the movement instructions for controlling the movement of the robot car. We built a control program that sending the movement signals to the raspberry pi. This program receiving keyboard signals and convert these signals to output from the raspberry pi pins. There are four movements available to control the car. These movements are forward, backward, left, and right.

The program works separately from the face detection and recognition program. Our screen will contain two windows. First on for showing video stream from the environment and detect and recognize faces in this video. Also, this video work as an eye to the user to driving the car. The second window is the movement window. This widow has nothing only a black screen. When we run the control window the moments will pass from the keyboard to the raspberry. Figure 4.5 showing these screens.

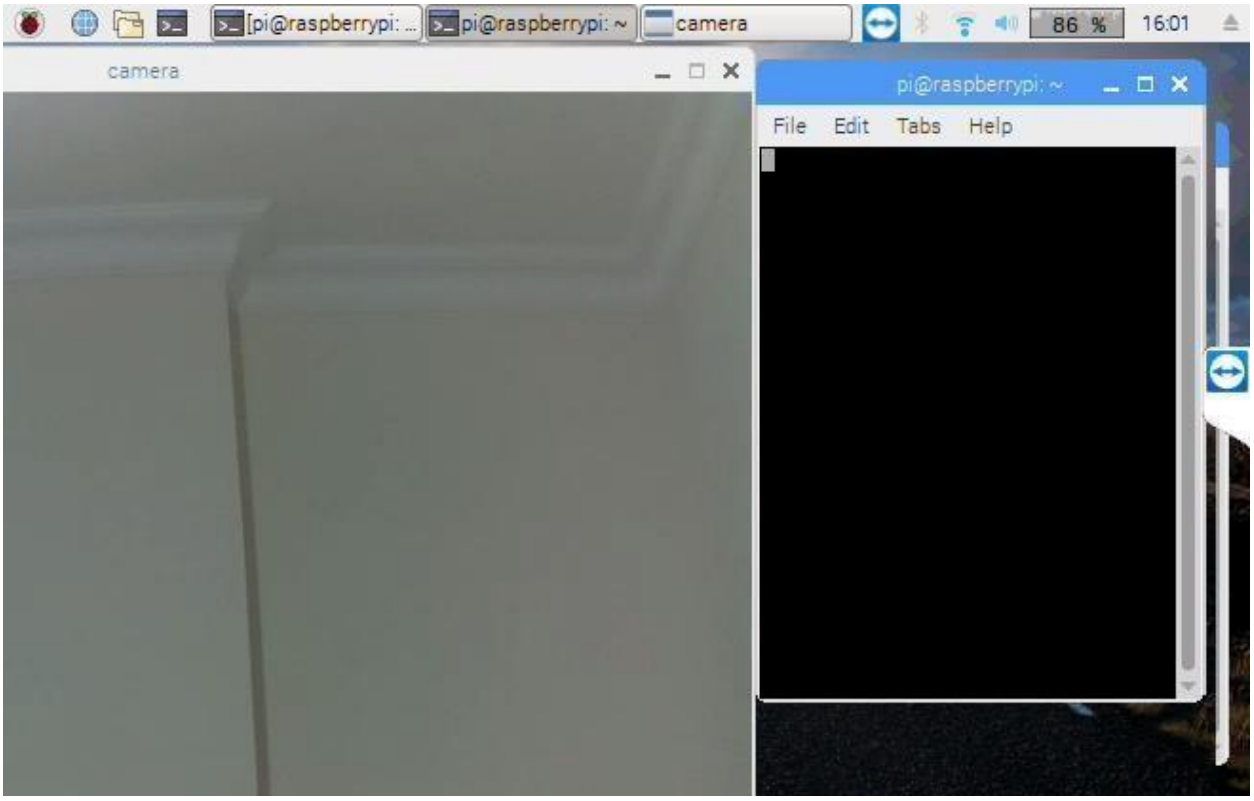


Figure 4.5: Monitoring and control windows Screen.

As we said before there are four movement directions which are the standard directions.

The signals for each direction explained below:

The first instruction is moving forward. When the user press the up arrow in the keyboard the raspberry pi will run this instruction:

Pin 7 ➔ positive signal. Pin 11 ➔ negative signal. Pin 13 ➔ positive signal. Pin 15 ➔ negative signal.

It is mean the pin 7 and 13 will supply 5 volt power while the pin 11 and 15 will be inactive.

The second instruction is moving backward. When the user press the down arrow in the keyboard the raspberry pi will run this instruction:

Pin 11 ➔ positive signal. Pin 7 ➔ negative signal. Pin 15 ➔ positive signal. Pin 13 ➔ negative signal.

It is mean the pin 11 and 15 will supply 5 volt power while the pin 7 and 13 will be inactive.

The third instruction is turning right. When the user press the right arrow in the keyboard the raspberry pi will run this instruction:

Pin 7 ➔ positive signal. Pin 11 ➔ negative signal. Pin 15 ➔ positive signal. Pin 13 ➔ negative signal.

It is mean the pin 7 and 15 will supply 5 volt power while the pin 11 and 13 will be inactive.

The third instruction is turning left. When the user press the left arrow in the keyboard the raspberry pi will run this instruction:

Pin 11 ➔ positive signal. Pin 7 ➔ negative signal. Pin 13 ➔ positive signal. Pin 15 ➔ negative signal.

It is mean the pin 11 and 13 will supply 5 volt power while the pin 7 and 15 will be inactive.

Chapter 5

5.DATASET AND REAULTs

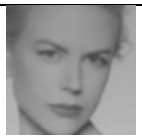
5.1 DATA SET

The first and important step in the face reorganization systems is dataset gathering and training these data. Every face out the data will get matching not more than 10% and will label with unknown. For building our dataset we took 6 images for 6 friends in the university. In the figure below we listed some of them.

Figure 5.1: Images for preparing the dataset.

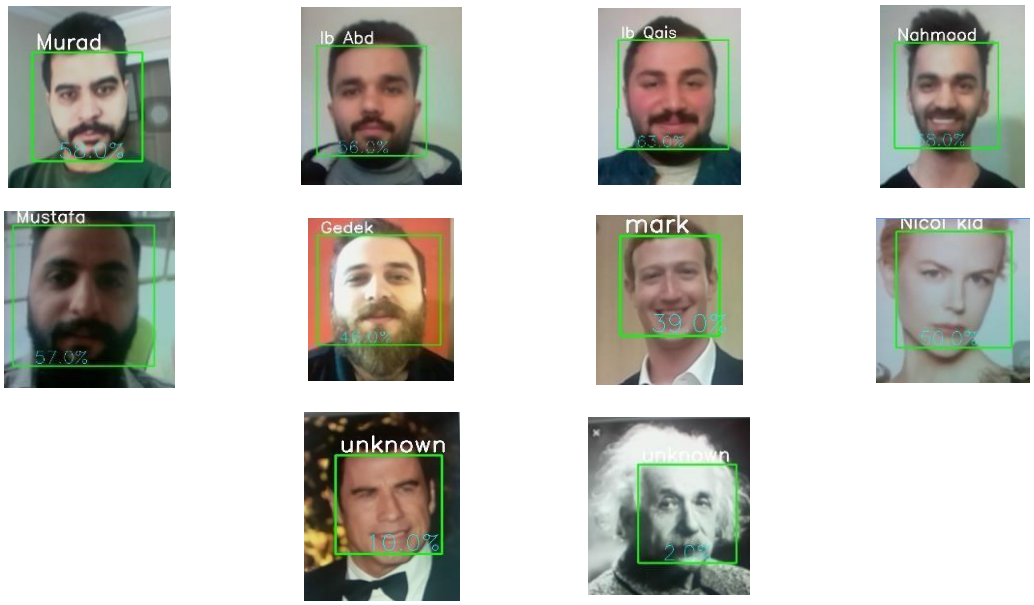
The program will directly detect the faces. Then it will save the features for each face with a corresponding id. We also used famous people such as Mark Zuckerberg and Nicole Kidman. We showed their photos by using a smartphone and the camera detects their faces. The table below showing the images after converting to grayscale and saving them with names and identical id.

Table 5.1: Images in the Dataset.

Person name	Database image	Person id
Murad		User.1
Ib Abd		User.2
Ib Qais		User.3
Mahmood		User.4
Mustafa		User.5
Gedek		User.6
Mark		User.7
Nicol Kid		User.8

5.2 RESULTS

In this part, we will discuss the results that we received when applied our system. After training the dataset the system became ready for face detection and reorganization. The result showed in the figure below:



5.2: face recognition results.

Figure 5.2 contains the 8 persons which we saved their images before in the dataset. Also, it is showing the result for two people we get them from the internet and they not saved before in the dataset. For the unsaved persons, the matching ratio didn't pass 10%. The saved person's ratio passed 25% without any conflict with another person. We received only the name for the owner of the image.

The matching ratio of the saved persons different from one to another. The camera resolution and the light conditions were the mean reasons for this difference.

Table 5.2 showing the matching ratio for each person in the dataset.

Table 5.2: Matching Ratios.

Person name	Matching Ratio
Murad	58%
Ib Abd	56%
Ib Qais	63%
Mahmood	68%
Mustafa	57%
Gedek	46%
Mark	39%
Nicol Kid	50%

Chapter 6

6.CONCLUSION AND FUTURE WORKS

6.1 CONCLUSION

This project described a robot car that able to capture video stream from the environment and detecting faces in the video stream. Also, it is able to recognize faces depending on the dataset. The robot car built by using raspberry pi 3 B+ for controller the robot car and implementing face detection and recognition system. The robot car provided with a pi camera that transmits video. The camera gives online video stream for the environment. The advantage of our work is that it easy to control the robot car from any place in world. The robot car only need Wi-Fi internet. The Wi-Fi internet give us the ability to access to the raspberry pi through the TeamViewer application. The recognition system give us good result without any error. It is able to distinguish between all persons in the dataset. Finally, the robot car can be move in 4 direction which make it easy to drive.

As a result, our robot can work directly and detect faces and recognizing them from any place in the world by capturing real-time video from the environment.

6.2 FUTURE WORKS

For development an improvement the robot car some changes should be done. Also, some function can be an addition. The main changes and functions can be summarized as follow:

1. Chassis and the main body of the robot can be manufactured using Aluminum material. With the Aluminum material, the robot can be more reliable and dependable especially in outside such as streets.
2. The camera can be change to more accuracy camera with high resolution to get high resolution images and increase the matching ratio.
3. Some of sensors can be added such as ultrasonic sensor for monitoring the distance between the robot car and any object in the side and behind the robot

REFERENCE

[1] S. R. Madkar, Vipul Mehta, Nitin Bhuwania, Maitri Parida, "Robot Controlled Car Using Wi-Fi Module", International Journal of Advanced Research in Computer Science and Software Engineering, Volume 6, Issue 5, May 2016.

[2] Shejina V and Asil Aö, "Automotive Theft Detection Using Face Recognition", IJRET: International Journal of Research in Engineering and Technology, 2016.

[3] Nazirah Ahmad Zaini, Norliza Zaini, Mohd Fuad Abdul Latip, and Nabilah Hamzah, "Remote Monitoring System based on a Wi-Fi Controlled Car Using Raspberry Pi", IEEE Conference on Systems, Process and Control (ICSPC), 2016.

[4] Maliha Rahman Mishi, Rabeya Bibi, and Tanveer Ahsan, "Multiple Motion Control System of Robotic Car Based on IoT to Produce Cloud Service", IEEE, International Conference on Electrical, Computer and Communication Engineering (ECCE), 2017.

[5] Mehmetcan Güle and Murat Orhaniö "Androıd Based WI-FI Controlled Robot using Raspberry Pi", IEEE, 2017.

[6] Aditya Kumar Jain, "Working model of Self-driving car using Convolutional Neural Network, Raspberry Pi and Arduino", Proceedings of the 2nd International conference on Electronics, Communication and Aerospace Technology (ICECA), 2018.

[7] Ayman A. Wazwaz, Amir O. Herbawi, Mohammad J. Teeti, and Sajed Y. Hmeed, "Raspberry Pi and Computers-Based Face Detection and Recognition System", 4th International Conference on Computer and Technology Applications, 2018.

[8] Renjith.R, Reshma R, and Arun K V, "Design and Implementation of Traffic Sign and Obstacle Detection in a Self-Driving Car using SURF Detector and Brute Force Matcher", IEEE International Conference on Power, Control, Signals and Instrumentation Engineering (ICPCS), 2017.

[9] Ali Akbar Shah, Zulfiqar Ali Zaidi, Bhawani Shankar, and Jawaid Daudpoto, "Real time Face Detection/Monitor using Raspberry pi and MATLAB", IEEE 10th International Conference on Application of Information and Communication Technologies (AICT), 2016.

[10] Suchitra, Suja P., and Shikha Tripathi, "Real-Time Emotion Recognition from Facial Images using Raspberry Pi II", IEEE, 3rd International Conference on Signal Processing and Integrated Networks (SPIN), 2016.

[11] Rajesh K M and Naveenkumar M, "A Robust Method for Face Recognition and Face Emotion Detection System using Support Vector Machines", IEEE, International Conference on Electrical, Electronics, Communication, Computer and Optimization Techniques (ICEECCOT), 2016.

[12] Ayman Ben Thabet and Nidhal Ben Amor, “Enhanced Smart Doorbell System Based On Face Recognition”, IEEE, international conference on Sciences and Techniques of Automatic control & computer engineering, 2015.

[13] Li Cuimei, Qi Zhiliang, Jia Nan, and Wu Jianhua, “Human face detection algorithm via Haar cascade classifier combined with three additional classifiers”, IEEE, 2017.

[14] Yunyang Li, Xin Xu, Nan Mu, and Li Chen, “Eye-Gaze Tracking System By Haar Cascade Classifier”, IEEE, 2016.

[15] Staffan Reinius, “Object recognition using the OpenCV Haar cascade-classifier on the iOS platform”, Faculty of Science and Technology UTH unit, Uppsala University, 2013.

[16] I. Tuytelaars, T. Mikolajczyk, and K. Local, “Invariant Feature Detectors: A Survey”, Foundations and Trends in Computer Graphics and Vision, 2007.

[17] Herbert Bay, Tinne Tuytelaars, and Luc Van Gool, “SURF: Speeded Up Robust Features”, Computer Vision and Image Understanding (CVIU), 2008.

[18] Christopher Evans, “Notes on the OpenSURF Library”, CSTR-09-001, University of Bristol, January 2009.

[19] Bradski G. and Kaehler A., “Learning OpenCV: Computer Vision with the OpenCV Library”, O'Reilly Media, 2008.

[20] Arnab Kumar Saha, Subhronil Roy, and Aranya Pratanu Dasgupta, “A Low Cost Remote Controlled Underwater Rover Using Raspberry Pi”, IEEE, 2018.

[21] Ishita Gupta, Varsha Patil, Chaitali Kadam, and Shreya Dumbre, “Face Detection and Recognition using Raspberry Pi”, IEEE International WIE Conference on Electrical and Computer Engineering (WIECON-ECE), 2016.

[22] Xianghua Fan, Fuyou Zhang, Haixia Wang, and Xiao Lu, “The System of Face Detection Based on OpenCV”, IEEE, 2012.

[23] https://www.raspberrypi.org/

الخلاصة

الروبوتات بشكل عام والسيارات الآلية بشكل خاص هي أحد التطبيقات الشائعة في السنوات الحالية . يتم استخدامه في العديد من التطبيقات مثل الاقتصادية والعسكرية والزراعة والأمن .

من ناحية أخرى ، يعمل التعرف على الوجوه كأداة رئيسية للعديد من التطبيقات ، وهي في الآونة الأخيرة ميزة مهمة في مجال الأمان . في هذا العمل ، اقترح هذا المشروع سيارة روبوت قادرة على اكتشاف الوجوه والتعرف عليها . سيارة روبوت تستخدم راسبيري باي 3 بي + ويمكن الوصول إليها من أي جهاز كمبيوتر في الكلمة باستخدام تطبيق TeamViewer. تعتمد حركة الروبوت على الأسهم المتحركة في لوحة المفاتيح بينما يعمل اكتشاف الوجه تلقائيًا باستخدام خوارزمية Haar Cascade.

أظهرت نتائج سيارة الروبوت أن الروبوت قادر على التعرف على أي وجه تم حفظه من قبل في مجموعة البيانات .

استخدمنا 8 صور لأصدقائنا من الجامعة (حفظنا وجوههم) ودربنا الخوارزمية . بعد ذلك ، تمكنت سيارة الروبوت من التمييز بينهما دون أي خطأ .

في الختام؛ تم تصميم سيارة روبوت لكشف الوجه والتعرف عليها . فحص مهام الروبوت . يمكن استنتاج أن سيارة الروبوت جاهزة لالتقاط الفيديو من كل بيئة . كما أنه قادر على اكتشاف الوجوه والتعرف عليها ويمكن التحكم فيه من أي مكان في العالم باستخدام شبكة Wi-F

وزارة التعليم العالي و البحث العلمي
جامعة ديالى
كلية العلوم
قسم علوم الحاسوب

أنترنيت الأشياء : سيارة آلية تقوم بالتعرف على الوجوه من خلال الكاميرا بإستخدام

Raspberry pi و المكتبة العالمية Open cv

مشروع تخرج

مقدم الى جامعة ديالى / كلية العلوم / قسم علوم الحاسوب

كجزء من متطلبات نيل شهادة البكالوريوس في تخصص علوم الحاسوب

من قبل

مها عبد الوهاب عبد
نور فاضل سعدي

بأشراف الدكتور

ا.م.د. جمال مصطفى التويجري

1441هـ **2020م**