EYE CONTROLLED AUTOMATIC WHEELCHAIR (ECAW)

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In the name of ALLAH, the Most benevolent, the Most Courteous

CERTIFICATE OF CORRECTNESS AND APPROVAL

This is to officially state that the thesis work contained in this report

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under my supervision and that in my judgement, it is fully ample, in scope and excellence, for the degree of Bachelor of Electrical (Telecom.) Engineering in Military College of Signals, National University of Sciences and Technology (NUST), Islamabad.

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DECLARATION OF ORIGINALITY

We hereby declare that no portion of work presented in this thesis has been submitted in support of another award or qualification in either this institute or anywhere else.

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The group members, who through all adversities worked steadfastly.

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ABSTRACT

About 15% of the world's population lives with some shape of disability, of whom 2-4% trip great difficulties in functioning. The international incapacity incidence is greater than preceding WHO estimates which date from 1970 and cautioned a figure of round 10%. This international estimate for incapacity is on the upward due to populace getting old and the fast unfold of persistent diseases, as properly as upgrades in the methodologies used to measure disability. Approximately about 132 million of the world population from which there are 34 developed and 156 developing countries, who has the requirement of the state of the art wheel chair. It round about constitutes 1.86% population with respect to the complete world. Moreover, motor disabilities is common among the people with varying condition, which causes incapacity to produce a willing movement in any of the limbs or even rotation/movement of head. Our venture is a concept to make lives of individuals experiencing this peculiarity, simple and easier and by being more straightforward in our approach, we mean being confident, and normal while living a life with such diseases. The idea is to make an Eye Monitored System which endorses and causes movement of the wheelchair depending on the direction of movement of retina. We comprehend that any person battling quadriplegia can somewhat have control over his eyes and slant his head, therefore creating a system that recognize such moves. The thesis is aimed at providing a solution to disabled people as a contribution towards the betterment of the society. Quadriplegia is paralysis whereby all the four limbs of a person are paralyzed which results in partly or completely losing control of limbs and torso. We desire to build a machine, where a patient sitting on a wheel chair is gazing into the camera, and be able to move in the desired direction just by movement of retina. The camera signals are monitored by a PYTHON script, a control signal is generated which causes the motion our wheelchair after necessary processing through Arduino ATMega1284P. This work

not only a big step towards the welfare of immobile wheelchair user, yet additionally gives a state of the art device to those associations who needs to support/give wheelchair to clients who can't bear the cost of it.

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Chapter 1: Introduction

The natural eye is seen to be an instinctive approach to translating human verbal communication and connection that can be taken as a way of information . Due to a number of illnesses like locked-in syndrome, paralysis, Parkinson's disease and spinal cord injury, multiple sclerosis, , muscular dystrophy, arthritis, the individual's physiological capacities are seriously ceased from creating movement in any of the muscles or even the head, almost around 132 million debilitated people who need a wheelchair, and exclusively 22% of them actually have it. Hence, it is vital to search for a novel eye based discovery and checking methods that can improve human-PC connection, and upgrade the living incapacitated individuals.

Research of eye monitoring system has been applied in many applications. There are many requirements like reliable execution as soon as the control signal is received, inordinate exactness, accessibility of parts, and having a convenient smart machine. A few related works have proposed eye-controlled wheelchair frameworks; in any case, these, scarcely at any point tackle the limitations of the framework's program execution, encompassing difficulties past the framework, exactness of calculations, and last but not the least client's solace.

In this project, we suggest an economical and robust eye-controlled wheelchair model involving retina identification in various encompassing circumstances. The proposed machine has savvy sign handling and navigation wheelchair control system as represented in Figure 1. As soon as patient sit on wheelchair along with its eye gadget; it starts the detection of eye movement. As we move our eye left, wheel chair will move left, when we move our eye right, wheel chair will move right. When we see forward, wheel chair will stop. Closing left Eye for 1 second will move the wheel chair fwd. Delay of 1 second is to avoid mixing of normal eye blinking with the stopping command.

Closing right Eye for 1 second will move the wheel chair backward. The proposed machine can control through a jam-packed region swiftly and with less errors. Appropriately, the proposed machine can help the vast majority of the debilitated individuals with spinal cord injuries and likelihood diseases that affects motor performance of human. Moreover, as the proposed gadget is focused to utilize reasonable equipment and open source programming, it might be used to mobilize non-mechanized wheelchairs to deliver a mechanized wheelchair in minimal expenses.

The scope of our project is Eye controlled automated wheel chair which is a concept , widely being researched in number of universities in world today. Several Technique such as IR detection to monitor eye movement, Image processing and Psychokinesis techniques are being employed for this purpose. This project based on Image processing of eye retina to control the movement of Wheel chair

1.1 Overview

Today's era is the era of digitization. Growing tech field and exponential development in every field of life solicits that same effects of technological revolution may benefit those people who are otherwise suffering with such diseases that causes immobility or partial mobility. While there have been many researches in the field of medical engineering that has benefitted a lot of people. A lot of research is being done to benefit those that are suffering with paralysis. As the population of the world is increasing manifolds with succeeding year to come, more and more patients are yet emerging which are suffering from disease that hampers or otherwise destroys mobility. Various techniques that are being employed for the mobility is exoskeleton, psychokinesis limbs and various sensor based wheel chair. In this project, we have tried to achieve the mobility of a wheel chair using retina of the eye. The processes involve capturing images from camera and processes same to detect direction of the retina and decide movement. We have also integrated a simple to use joystick for the patients that are partially immobilized yet they can use their limbs amply enough to move the whe

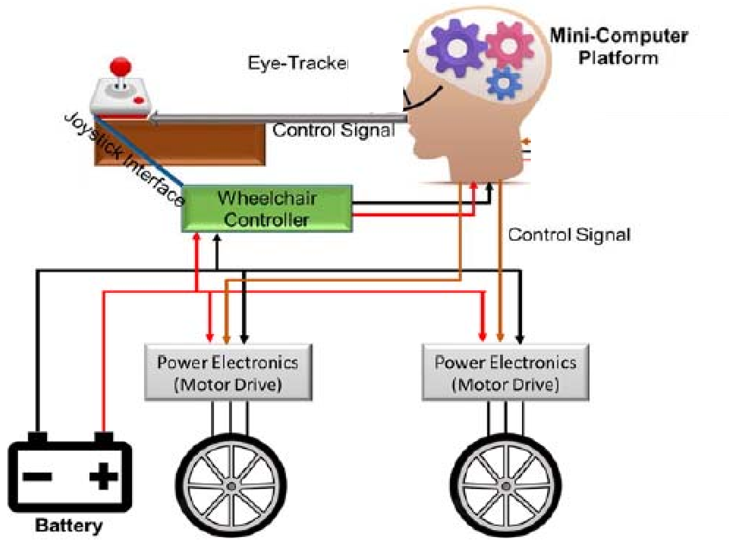

Figure 1: Block diagram for the Eye Controlled Wheel Chair

1.2 Problem Statement

There exist almost 132 million debilitated individuals who need a wheelchair, and just 22% of them have approach to one. They couldn't get their hands onto a technologically advanced wheelchair. Hence we find it necessary to delve into novel techniques that can revolutionize the mobility of paralyzed or disabled people. So we are designing an eye control wheel chair to address the following:

1. Mobility issue for people who are suffering various type of partial or complete paralysis (quadriplegia).
2. Mobilizing the patients who are suffering with diseases such as Parkinson disease, or multiple schlerosis whose symptoms are similar to that of paralysis.
3. Various novel techniques being researched for locomotion of wheel chair lacks accuracy.

1.3 Proposed Solution

The major goal of our proposed solution is to provide mobility to the people who are suffering with temporary, partial or complete paralysis in a way that they can mobilize independently. Moreover, there are various novel techniques thare currently being researched or employed for the purpose of mobility of the suffering people, however most of them are still under research or lack accuracy. So one of the goal of our Wheel chair is to attain maximum possible accuracy.

1.4 Working Principle

The project mainly works on the principles of image processing, whereby a camera detects movement of the eye retina and based on that movement of retina moves the wheel in the said direction accordingly. The project is divided into different modules and every module is inter-woven with the next module. The list of modules is as under:

- Training and processing
- Output extraction
- Decision based upon Output
- Integration
- GUI presentation

1.4.2 Training and processing:

The dataset is prepared using images of 2 officers eye retina's various movement. This prepared dataset is used as input to train eye detection models using machine learning.

1.4.2.1 YOLO algorithm:

YOLO stands for 'You Only Look Once'. IT is such algorithm that it can identify and recognize the object and detects the object of interest using image processing techniques.

Our project uses YOLO (you only look once) algorithm to train the dataset, this prepares eye detection model

1.4.2.2 OpenCV:

OpenCV is a library which is a yet a novel code for picture handling and performing PC vision errands. Its an Open source library and can be utilized to perform assignments like face identification, object following, shape recognition and so forth. It comes for various languages including python.

1.4.3 Output Extraction:

The outputs are extracted on the basis of objects (person, head, eyes, face) detected, these objects are counted and stored to keep a record.

1.4.4 Decision based upon Outputs:

Decision is based on the eye ball/ retina movements that are translated into commands to the chair's motor drives. The phenomena is completed by implementing a gaze detection algorithm using python based code onto a minicomputer. The safety of project has been added by introducing joystick control system to give more safety for the user.

1.4.4.1 Gaze Estimation System:

System may be implemented by dividing it into the following steps;

- ✓ Designing and implementing a gaze detection and estimation system.
- ✓ Implementation of the results with hardware.

Proposed framework can distinguish the face and eye of any individual, who is present before the camera. However it is feasible to train the framework to distinguish either single face or multi-face, yet we prepared the framework to identify just single individual as per the requirement. In this manner, as displayed underneath in figure 2 & 3 the appearances and eyes are identified.

Convolutional Neural Networks (CNNs) were proposed as a smart and efficient choice to characterize eye bearings in a quick and exact way. In this image matching-based techniques, an orientation procedure is first done to create a dataset known as essential learning dataset that is required to train the network for the work to be done in future. The said training will be required only for the first time for specific user, and it keeps training itself for the user as the time passes. Ultimately, a small user-specific data, calibrated for the best user experience, is acqiured within 5 minutes at the rate of 30 frames/sec, develops a particular CNN per user. So a shorter training time with better user experience is achieved by real-time eye tracking.

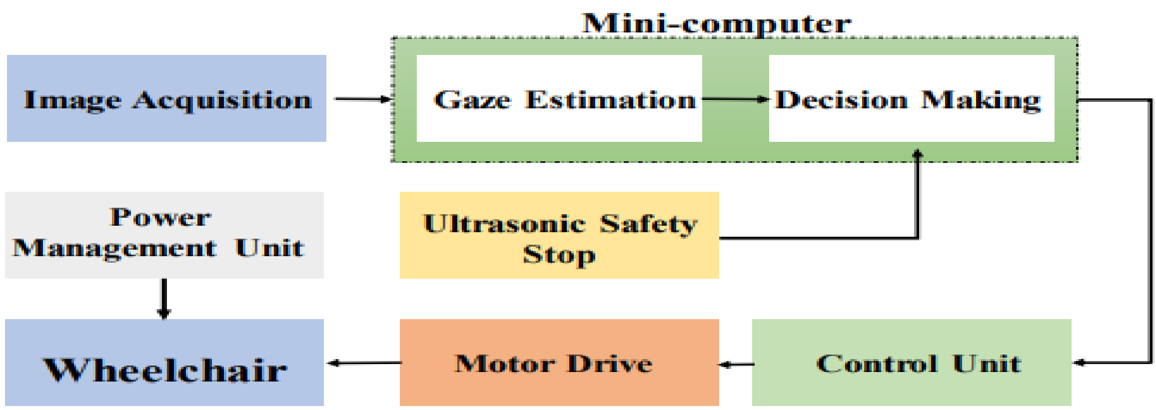

Figure 2: Flow chart for the processes Eye Controlled Wheel Chair

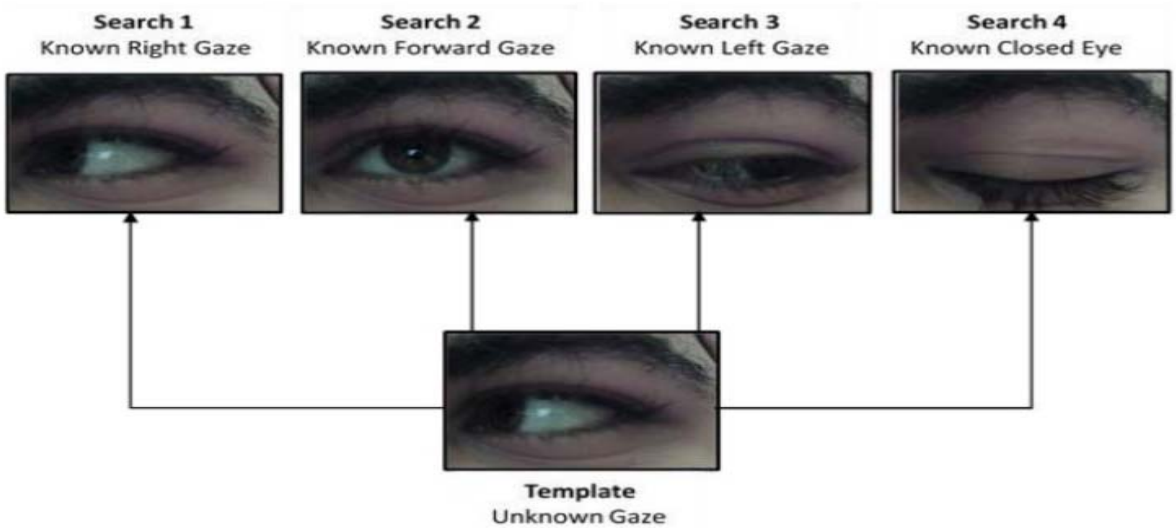

Figure 3: Gaze detection using gaze templates

1.4.4.2 Locomotive System:

After reading the movement of eye through OpenCV, minicomputer will then initiate a control signal, This control signal will then received by Arduino Nano microcontroller. Based on the received signal microcontroller will send in the signals to the wheels via relays. There will be four directions of movement

a. Front (Both wheels moving forward)

b. Back (Both wheels moving backward)

c. Left (Left wheel stopped, only right wheel moving)

d. Right (Right wheel stopped, only left wheel moving)

1.4.5 Integration:

The different modules are integrated in conjunction with each other. This integration provides an entity which is essentially a compact solution.

1.4.6 Minicomputer:

A minicomputer is integrated in this wheel chair. Image is acquired through camera , which is further detected through YOLO algorithm in OpenCV. To ensure faster processing a laptop is integrated which initiates control signal to Arduino nano; which in turns send signal for wheel chair to move accordingly.

1.4.7 Arduino- Nano:

Arduino Nano is a small, complete and breadboard friendly microcontroller based on ATmega328. It is being used as a microcontroller which will receive the control signals from the mini computer and sends output based on the input signals. It is one of the key factor in controlling movement the wheel chair

1.5 Objectives

1.5.1 General Objectives:

"To build an innovative state of the art software integrated hardware prototype powered by Machine Learning (ML) and Image Processing (IP) techniques, providing a smart wheel chair to help mobilize people suffering with partial or complete paralysis"

1.5.2 Academic Objectives:

- Development of a Eye controlled retina based wheel chair
- To implement Machine Learning techniques and simulate the results
- To increase productivity by working in a team
- To design a project that contributes to the welfare of society

1.6 Scope

This project finds its scope within the niche of disabled people. It is an innovating state of the art software integrated hardware prototype powered by machine learning and image processing techniques, providing an automatic wheel chair for the patients that are suffering with partial or complete paralysis or the likewise disease such as multiple sclerosis, Parkinson disease etc. to help them mobilize independently and instead of being considered a burden, they can be active part of the society development at large.

1.7 Deliverables

1.7.1 Smart solution

It provides a smart solution for the paralyzed patients by using a combination of image processing and machine learning techniques with the help of camera and a pre-fed data set in real time

1.7.2 Multiple options:

It not only provides eye controlled wheel chair locomotion option but also provides a simple to use joystick for ease of use of those patients who recover from complete paralysis to partial paralysis.

1.8 Relevant Sustainable Development Goals

Relevent Socio-Economic issue that is present in our society is that no products are being offered or they are very very few in numbers that facilitate patients who are suffering from paralysis. As far as the mobility of such patients are concerned only joystick based wheel chair have been introduced so far which is costly as well and it does not address the mobility issue of the patient that are paralyzed neck down.

We have specifically designed our project that are completely paralyzed neck down or are suffering with Quadraplegia. Our project can mobilize patients using eye retina movement /eyelid movement, which will help them to independently move around and carry out their mobility tasks.

1.9 Structure of Thesis

Chapter 2 contains the literature review and the background and analysis study this thesis is based upon.

Chapter 3 contains the design and development of the project.

Chapter 4 Describes the code being used for various finctions

Chapter 5 contains the conclusion of the project.

Chapter 2: Literature Review

An invention in the product is launched by modifying and enhancing the features of previously launched wheel chair. Previously launched wheel chair was joystick based now we have introduced retina based automatic wheel chair which is an important step for development of an idea to a new product. Our research is divided into the following points.

- Industrial Background
- Existing solutions and their drawbacks
- Research Papers

2.1 Industrial background

On factual basis in Pakistani market there is no solution for such patients. So far products being offered to paralyzed patient is joystick based wheel chair and automatic controlled wheel chair, which may not be a top notch option for paralyzed patient.

The concept/ prototype we are offering will revolutionize the helpless life of paralyzed patients. It is basically wheel chair which would move with the help of retina, movement of eye. So it is beneficial product, for both partial and completely paralyzed patient.

2.1.1 Special privileges

A joystick controlled wheel chair is not suffice for such patients who are completely paralyzed and it's also costly and very basic and patients has to control it by his hand with complete brain stability. On the other hand eye controlled wheel chair will simply move with retina movement and patients have not to put in any effort on it and it won't fatigue patient.

2.2 Existing solutions and their drawbacks

Different solutions are previously being provided for the paralyzed patients, but every product has some pros and cons. Following are some solutions which are already being prepared and being implemented.

- Hand gesture based Wheel chairs
- Psychokinetic wheel chair
- Voice recognition based wheel chair.
- Remote Control wheel chair
- Manual Wheel Chair

2.2.1 Manual Wheel Chair

Manual Wheel chairs are available all around the country to facilitate disabled people however it is not a pertinent or exact solution to the people suffering with diplegia or quadriplegia, as for those people whose upper body is functional and only lower body is suffering with paralysis can mobilize but physically get fatigued in case of covering longer distances. And for those patients who are suffering with paralysis of upper body or one of the limbs cannot mobilize the manual wheel chair.

2.2.2 Hand Gesture Based wheel chair

Hand Gesture based wheel chair is still under research and is not completely offered as the product. In Hand gesture based wheel chair, wheel chair is moved based on the direction of hands. Though it is product which does not require a lot of force to mobilize, however there are ambiguities in its operation.

Moreover there are patients that are paralyzed neck down. Such patients are unable to move their hands and cannot create gesture properly so it may not be a complete mobility option for completely paralyzed people.

2.2.3 Psychokinetic wheel chair

Psychokinetic wheel chair offers the solution of mobilizing wheel chair by using the process of human brain. Basically a human brain emits different ranges of EM waves commonly known as brain waves. These waves can be measured through EEG systems and a research is being conducted to relate these frequencies with the thought process of human mind and use them to initiate electric signals outside of Human body.

Psychokinetic wheel chair is based on reading those frequencies that are generated when a human mind thinks of mobilizing wheel chair. But there are glitches in this system right now. One of the main glitch in the system is that , our brain emits various kinds of frequencies for the same kind of thought process. So currently it is not possible to make an accurate system that can work with the brain but work is still being done on it to make a useful product of psychokinesis process.

2.2.4 Voice-recognition based wheel chair

Voice recognition based wheel chair is yet an other concept whoch can be used to mobilize wheel chair. The said procedure for mobilizing wheel chair is still under process however it is still not offered as the product and prototypes have been created in this regard.

Voice recognition is one of the good way for mobility of paralyzed people however it may not cover following type of patients:

1. Patients suffering with face paralysis and are unable to speak
2. Patients suffering with partial paralysis and are unable to speak properly.

One of the issue in such model is also that surrounding voices may hamper the performance of voice recognition system, and system may not be able to understand the command completely, specially in the areas of rush or areas of loud voices.

2.2.4 Remote control wheel chair

Remote control wheel chair can also be offered as the product however this concept needs an attendent to run the wheel chair. Or if the patients have to run the wheel chair using remote control themselves than the concept itself falls apart and the same is being offered with the current wheel chairs offered in the market having their own integrated wired Joystick with the circuitry. This is the reason this product was not offered as a complete product in the market

Chapter 3: Interfacing and Detection

3.1 Hardware interfacing and functioning

For our prototype we have integrated a camera with Minicomputer. In computer we have python's library OpenCV for detection and estimation of gaze. As soon as the Retina is detected, camera will start monitoring its movement and the same is being endorsed and processed by the minicomputer. As soon as the retina is moved in any camera will simply monitor and computer will detect its direction of movement. Based on detection of retina movement, computer will generate a control signal and sends to Arduino. Arduino will further be programmed to move the wheel chair in one of the four directions based on control signal received from minicomputer.

3.1.1 Preparing Dataset

This project has rather unique way of preparation of dataset. Unlike other model in which we have to take complete database of various images of different persons to train the machine, here we train the machine based on the needs of the specific user and his/her images and dark / light condition. Ultimately we get a small user-centric data for the system to train on, in less than 5 minutes at 30 frames/sec, which is amply enough to train wheel chair for the specific user for a CNN model. Therefore, we are able to achieve the maximum accuracy within minimum time span and is well suited for a user friendly experience.

Chapter 4: Coding For various Function

Arduino Code for joystick:

```
#define NUM_JOY 2
#define MIN_VAL 0
#define MAX_VAL 1023

//Parameters
const int joyPin [2] = {A0, A1};
const int joyBtn  = 2;
const int joyOffset  = 0;
int analog_J0=0;
int analog_J1=0;
bool button_flag=false;
bool button_pre_flag=false;
bool button_stat=false;
String data_get_f="";

int j1=0;
int j0=0;
int joy_pos=0;
int joyVal [NUM_JOY] = {0, 0};

void setup() {
  //Init Serial USB
  Serial.begin(9600);
  pinMode(3,INPUT);pinMode(4,OUTPUT);
  pinMode(9,OUTPUT);pinMode(10,OUTPUT);pinMode(11,OUTPUT);pinMode(12,OUTPUT);
  /*
  digitalWrite(9,LOW);digitalWrite(10,HIGH);digitalWrite(11,LOW);digitalWrite(12,HIGH);
  delay(2000);
  digitalWrite(9,HIGH);digitalWrite(10,LOW);digitalWrite(11,HIGH);digitalWrite(12,LOW);
  delay(2000);
```

```
  digitalWrite(9,LOW);digitalWrite(10,LOW);digitalWrite(11,LOW);digitalWrite(12,LOW);
  //Init Joystick
  for (int i = 0; i < NUM_JOY; i++) pinMode(joyPin[i], INPUT);
}

void loop() {
  if(Serial.available()>0)
  {
    String data_get=Serial.readString();
    data_get_f=data_decode(data_get);
    Serial.println(data_get_f);
  }

  readJoystick();
  if(button_stat==true)
  {
    digitalWrite(4,HIGH);
  if(joy_pos==0 ){stop_();}
  else if(joy_pos==1){forward();}
   else if(joy_pos==2){backward();}
   else if(joy_pos==3){left();}
   else if(joy_pos==4){right();}
  }
 else if (button_stat==false)
 {
  digitalWrite(4,LOW);
  image_processing();
  }


void forward()
{
  digitalWrite(9,HIGH);digitalWrite(10,LOW);digitalWrite(11,HIGH);digitalWrite(12,LOW);Serial.println("fwd");
  }
void backward()
{
  digitalWrite(9,LOW);digitalWrite(10,HIGH);digitalWrite(11,LOW);digitalWrite(12,HIGH);Serial.println("bckwd");
  }
void left()
{
  digitalWrite(9,LOW);digitalWrite(10,HIGH);digitalWrite(11,HIGH);digitalWrite(12,LOW);Serial.println("left");

  }

void right()
 {
  digitalWrite(9,HIGH);digitalWrite(10,LOW);digitalWrite(11,LOW);digitalWrite(12,HIGH);Serial.println("right");
  }

void  stop_()
  {
    digitalWrite(9,LOW);digitalWrite(10,LOW);digitalWrite(11,LOW);digitalWrite(12,LOW);Serial.println("stop");
    }
```

PYTHON Code for Eye Image processing and generation of control signal:

```
if(pre_stat!=pr_stat):
    print("inside_send")
    print(T_count_left)
    print(T_count_right)
    print(T_count_center)
    print("...............")

    if(serial_en==True and pr_stat=="Looking forward"):
        print("Looking forward")
        port_g.write(b"#5#\n")
        pre_stat=pr_stat
    elif(serial_en==True and pr_stat=="Looking backward"):
        print("Looking backward")
        port_g.write(b"#4#\n")
        pre_stat=pr_stat
    if(serial_en==True and pr_stat=="Looking left" and T_count_left==3):
        print("Looking-Left_send")
        port_g.write(b"#1#\n")
        pre_stat=pr_stat
    elif(serial_en==True and pr_stat=="Looking right"  and T_count_right==3)
        print("Looking-right_send")
        port_g.write(b"#3#\n")
        pre_stat=pr_stat
    elif(serial_en==True and pr_stat=="Looking center" and T_count_center==3
        print("Looking-cneter_send")
        port_g.write(b"#2#\n")
        pre_stat=pr_stat
```

Code for Sonar

```
bool sonar_dis_m()
 {
   long duration, inches, cm;
   bool sonar_flag;
  pinMode(pingPin, OUTPUT);
  digitalWrite(pingPin, LOW);
  delayMicroseconds(2);
  digitalWrite(pingPin, HIGH);
  delayMicroseconds(10);
  digitalWrite(pingPin, LOW);
  pinMode(echoPin, INPUT);
  duration = pulseIn(echoPin, HIGH);
  inches = microsecondsToInches(duration);
 // cm = microsecondsToCentimeters(duration);
 if(inches<=30){sonar_flag=true;}
 else if(inches>30){sonar_flag=false;}
```

Code for Reception and processing of control signal

```
void image_processing()
{

  if(data_get_f=="1")
  {
    Serial.println("cond_1");
    left();
    }
  else if(data_get_f=="2")
  {
    Serial.println("cond_2");
    stop_();
    }

  else if(data_get_f=="3")
  {
    Serial.println("cond_3");
    right();
    }
   else if(data_get_f=="4" )
  {
    Serial.println("cond_4");
    forward();
    }
  {
    Serial.println("cond_5");
    backward();
    }
     else if(data_get_f=="5" && dis_m==true)
  {
    Serial.println("cond_4");
    stop_();
    }
}
```

Chapter 5: Conclusion

In this thesis, we have discussed a locomotive system that can handle mobility issues of partially and completely paralyzed people smartly and more efficiently than the typically solutions offered in the market currently. Our proposed system has an advantage over other traditional systems due to the latest algorithms i.e Convolutional neural network (CNN) used for the detection of retina. Techniques used in our proposed system; Image Processing techniques to process the video, frame by frame, and Machine Learning included algorithms such as YOLO , which were used to detect the eyes; are also briefly explained including their working and importance. The purpose of increasing productivity and overcoming problems in existing solutions is being achieved by using the modern techniques. Additionally, the objectives for creating such sophisticated system is to facilitate the paralyzed patients to the maximum degree possible, however , the prototype can further be polished for better user experience.

Simulated results are shown using OpenCV, which is open-source software, easy to install, and can be used in real-time.

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