Smart Cane for Visually Impaired People

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CERTIFICATE OF CORRECTNESS AND APPROVAL

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

"Smart Cane for visually impaired people"

is carried out by

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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 Engineering from National University of Sciences and Technology (NUST), Islamabad.

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ABSTRACT

Smart Cane for visually impaired people

Currently, visually impaired people use a traditional device as a tool for directing them when they move from one place to another. Although, the traditional device is the most widespread means that is used today by the visually impaired people, it could not help them to detect obstacles and distinguish different objects. In this context, we propose a new intelligent system for guiding individuals who are visually impaired or partially sighted. The system is used to enable visually impaired people to move with the same ease and confidence as a sighted people. Moreover, it provides the direction information as well as information to avoid obstacles based on digital image processing. The whole system is designed to be small, light and is used in conjunction with the device. The results have shown that the blinds that used this system could move independently and safely.

DECLARATION OF ORIGINALITY

We hereby declare that the work contained in this report and the intellectual content of this report are the product of the sole effort of our group, comprising of Muhammad WaleedZaman, Nayyab Rashid, and SalaarArshad. No portion of the work presented in this dissertation has been submitted in support of another award or qualification either at this institution or elsewhere, nor does it include any verbatim of the published resources which could be treated as a violation of the international copyright decree. We also affirm that we do recognize the terms ‘plagiarism’ and ‘copyright’ and that in case of any copyright infringement or plagiarism established in this thesis, we will be held fully accountable of the consequences of any such violation.

Dedicated to all those

who lead us on the journey

from ignorance to knowledge.

ACKNOWLEDGEMENTS

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Chapter 1: Introduction

1.1 Background

It is necessary that we should take a look at some important aspects of the concerned areas of study before we talk about their application in the project.

1.1.1 Digital Image Processing

Digital image processing (DIP) is a technique where an image is attained from a source and that image is then processed, passed through different techniques that are meant to enhance the quality of that image and make it more readable for further processing. Afterwards different image detection schemes are used to detect the content of the image. This information can be helpful for a number of causes and can have a variety of real world applications.

It is a sub category of the digital signal processing and it makes use of computer algorithms to help derive useful information from the input image.

1.1.2 Artificial Intelligence

Artificial Intelligence (AI) is intelligence shown by machines that is similar to the natural intelligence displayed by humans and other animals. This term refers to machines that show a certain likeness to human character or show characteristics that are usually associated with human beings like cognitive skills, learning and problem solving. This new concept has become more and more popular in the recent years and artificially intelligent machines have been performing tasks usually meant for humans with more and more efficiency.

Therefore,AI is the ability of a computer program or a machine to think and learn. It is also a field of study which tries to make computers smart. As machines become increasingly capable, mental abilities once thought to require intelligence are removed from the definition. Artificial inelegance has many types.

1.1.3 Machine Learning

The idea of machine learning is to program the computer to collect data and learn from it along the way. So using statistical techniques computers can be given the ability to learn and thus perform tasks that they were not explicitly programmed to do, and progressively improve performance to a certain level.

Machine learning also has a lot of applications in the field of data processing. Within the field of data analytics, machine learning is a method used to inventintricate models and algorithms that lend themselves to understand, analyze and predict information [1]. Over the years powerful tools have been developed to aid developers to incorporate machine learning and image processing in modern technologies to make work easier and to assist human beings.

1.2 Future of Image Processing and Artificial Intelligence

Bothe artificial intelligence and digital image processing are growing fields and developers are interested in exploring the different fields in which these processes can be used to enhance the performances of certain machines. Although we don’t know the exact future, it is quite evident that interacting with AI will soon become an everyday activity.

- **Automated transportation** is a concept that has been in development for a long time and many big name companies have been associated with this concept. The success of these

vehicles and their increasing use speaks volumes of the success that artificial intelligence has achieved.

- Robots are already performing some of the most dangerous jobs available, including bomb defusing. In the future it is expected that we will be able to do more to avoid unfortunate loss of life or damage to health by developing machines that can efficiently replace humans in life threatening jobs.
- It is believed that Artificial Intelligence can be the decisive tool in tackling **climate change.**

Figure 1: Automated transportation

- At present almost all robots are pretty much emotionless but that could change very quickly in the future. Researchers are working to produce robots that through some exceptionally advanced machine learning algorithms could be taught to feel emotions like a real human being. This will be the first step towards creating robots that could act like friends.
- For many senior citizens, everyday life is a struggle, and many have to hire outside help to manage their care. AI is at a stage where replacing this need isn't too far off.
- Robots could help older people with everyday tasks and allow them to stay independent and in their homes for as long as possible, which improves their overall well-being.
- Human body has its limits that can be pushed using these artificially intelligent robots called **cyborgs.**

Figure 2: The demonstration of a cyborg

- The future of image processing in equally promising and has applications in almost all formats.
- In satellite based image processing ranges from exploring the milky wayto surveillance applications.

1.3 Problem Statement

There are many types of disabilities. Advanced technology has been used in helping people overcome such impairments. However, developing such an advanced technology is expensive, making their selling price high.

So, in order to help the visually impaired people and provide them with more independent environment and using technology and other senses to make their life easier we need to come up with a new product that will allow them to get information about their surroundings without relying on other people for help.

One of the main problems of the visually-impaired is that most of these people have lost their physical integrity because they have to rely on their peers for even the most basic everyday tasks. Also, they do not have confidence in themselves.

1.4 Solution

We have come up with a solution that involves the use of a smart device to help the blind people to get to know more about their surroundings. Smart Device is one invention which was originally created to help the blind people but it comes with a raspberry pi camera kit. This invention looks like a Guide.

This invention has been created with the aim at helping the blind in navigating and finding things. The camera will take photos at 5fps and tensor flow algorithm or DIP algorithms will identify the object.

Previously, this creation had the same weaknesses as the Guide device where there will be a problem to save space or to place the smart device but this will be a normal foldable device with a raspberry pi chip mounted on it. Besides that, it will be not as expensive as the previous smart devices. If the cost is too high, users are not able to afford for it because the average income of the visually-impaired people is relatively small.

1.5 Devices Used

Now let us briefly explore the different devices, instruments and software utilized in the project. Also we will discuss why specifically these instruments were used.

1.5.1 Raspberry Pi

The main work possible is because of the raspberry pi as it is a processing device with much more power than aurdino the machine learning algorithms ,digital image processing and computer vision is being use don it these are the main pillars and the main code is written on python the operating system that is being used is raspbian

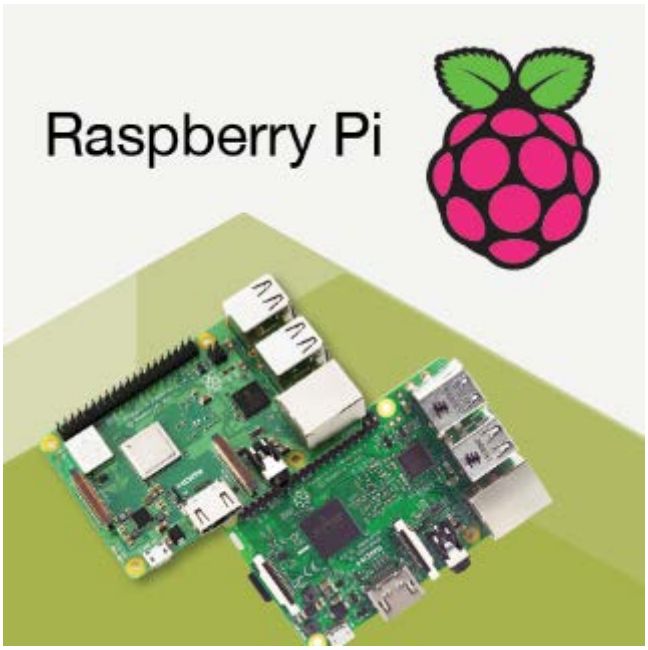

Figure 3: Raspberry Pi

- The pi 3 work as a mini computer that has processing power up to 1 GB
- It uses external memory source so external memory card can be used for storage of data
- It has a audio output, VGA port and USB ports
- It uses up to 2A of current to operate without any problem.

1.5.2 Python

- Python is Single threaded which means that the tons of libraries it has are for free which can be used for different purposes

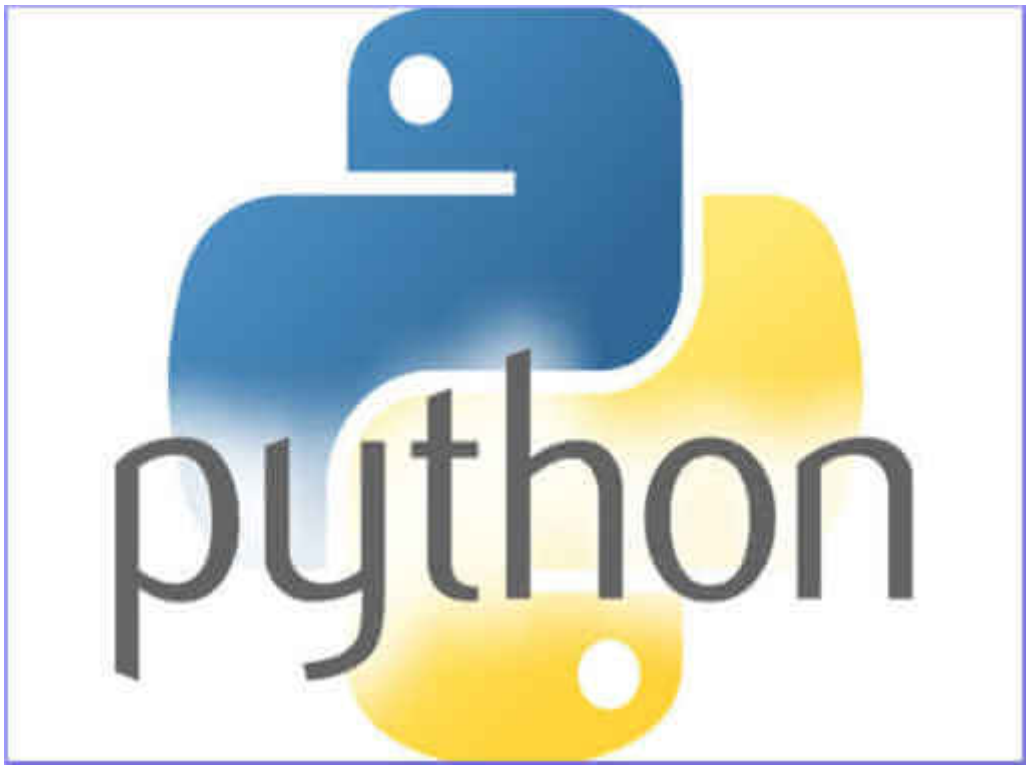

Figure 4: Python programming language

- In python we have to find out how different libraries can be compiled together so it can be helpful for us.
- Best for algorithm involving mathematics
- A lot of mathematical calculations are required in digital image processing and machine learning and that chaos of calculation can be avoided by simple libraries of python.
- Python is our best friend when it comes to dealing with image processing as most of the algorithms can be found in the libraries
- Python is the most user friendly language for working and can run on any platform (Windows, Linux, OSX)
- Python got a very clean syntax and help user to easily connect with raspberry pi with the real world.

1.5.3 R Pi Camera

- With the added accessories of raspberry pi we can also use a camera with it which is easy to handle and use.
- Raspberry pi camera and produce images up to 1080p, 720p depending upon the quality of the camera.

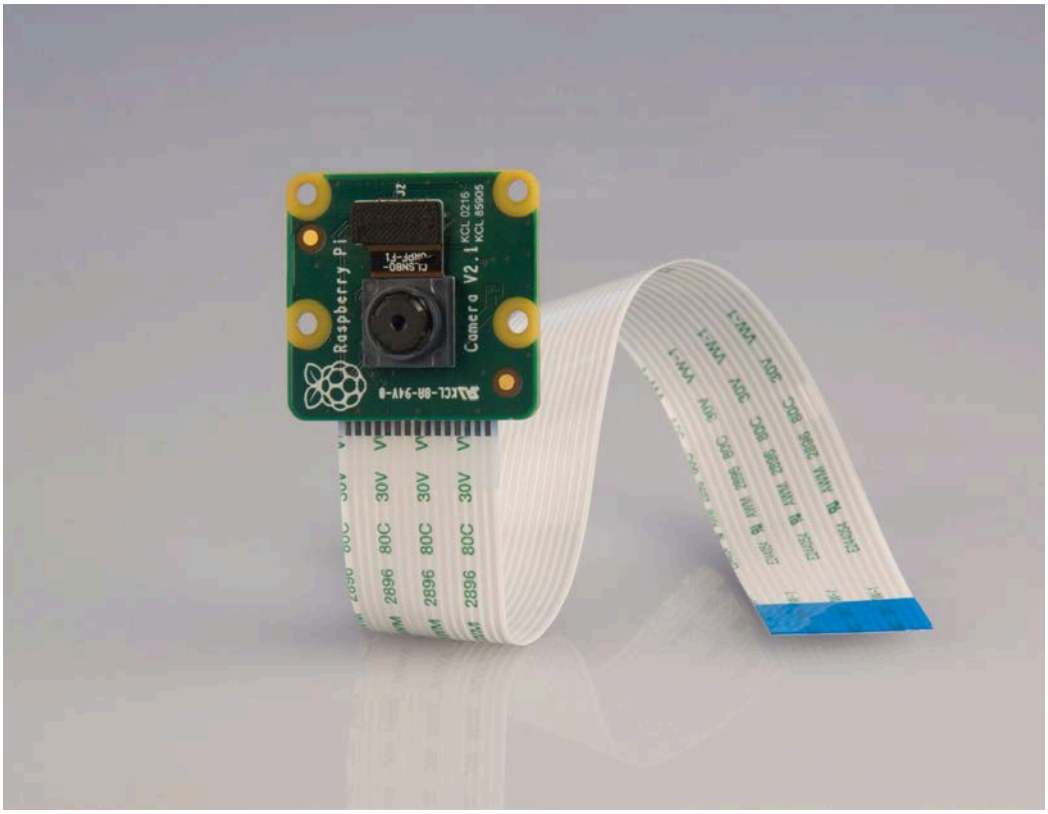

Figure 5: Raspberry Pi camera

- It connects the modem of raspberry pi using a 15cm strip that connects camera with it and with some basic commands we install the camera software in the raspberry pi.
- It can capture the image and can also make a stream of it

- 25 x 23 x9mm are the physical dimensions of the camera
- It can capture images in low light, in a time lapse ,fast moving objects, still images,can zoom in and zoom out as well can recode a video and pictures in the memory
- To connect this we need raspbian OS in out processor so we can operate it easily.
- It is ultra small and light weight it will give very less noisy images and low cross talk.

1.5.4 Computer vision

- In order to learn something we have to visualize it first. Same approach is used via computer vision.
- It is a technique for high level understanding of the digital images by the computer
- To extract out the data from the image is done by computer vision and the data can be multidimensional

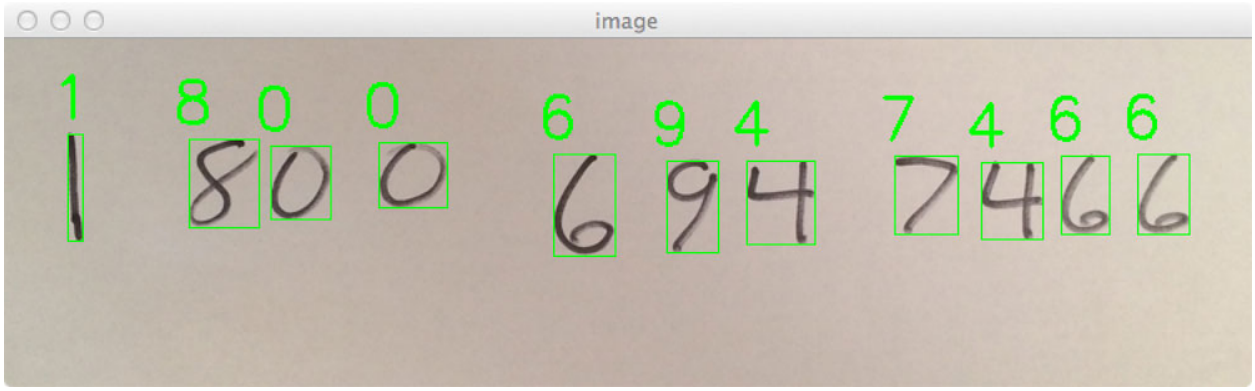

Figure 6: Visual representation of computer vision

- In a computer vision there are various things like detection of the object ,separation of objects ,brightness and contrast ,the depth of the image and edge detection of the image all give various data that ultimately forms an image.
- Computer vision is the basic pillar that lays the foundation of artificial intelligence.
- Photogrammetry also falls in the field of CV.

1.5.5 Text to speech:

- Text to speech is very easy to get in raspberry using python
- Speech output needs a few software updates and a library that perfectly fits without code.
- The audio output can be taken by a speaker or by a headphone.

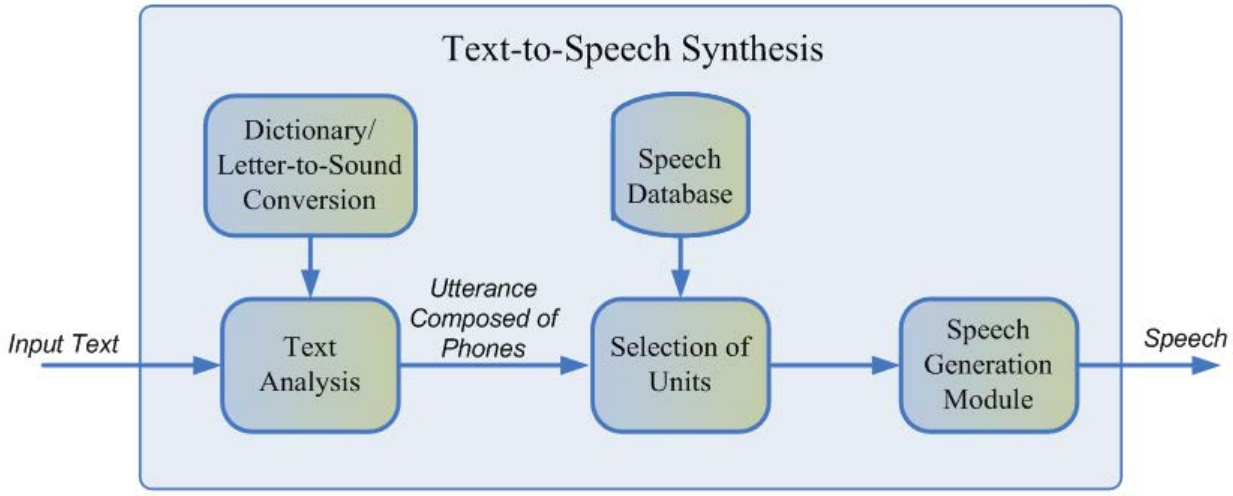

Figure 7: Text to speech process

- The raspberry uses 2A battery so we should avoid connecting large speakers with it as they may draw more power from it
- For installing the text to speech we type following commands in our python.

sudo apt-get install alsa-utils

- We can also install libraries that do not require internet connection like Cepstral.
- By this it will also give results when it is offline.

1.5.6 Computer learning:

- Computer learns by the help of computer vision and artificial intelligence
- Computer learning or machine learning basically works by pattern learning
- It learns how a process takes place over time by learning its pattern and predicts what outcome may come in future by it.
- The field of machine learning is very vast it can also work on data mining, mathematical optimization, neural networks, deep learning
- To get our desired results we need to train our model several time with this traing it learns the pattern of a situation can predicts better results
- So, once it has learnt something it can give new examples and work on that thing by concept of generalization.

Chapter 2: Background

2.1 Background Study:

we studied a couple of research papers and documents on obstacle detection and object recognition and each document focused on a special aspect of this project and the most suitable algorithms were selected for this project. Following are the things that were studied and played a key role in our project.

2.1.1 Ultrasonic:

- The main part of ultrasonic sensors in previous projects was to detect the object
- The person only knew there was something in front of him.
- The ultrasonic sonic send waves of certain frequency and those waves return with a change in them through this any object can be detected.
- The ultrasonic module is interfaced to the microcontroller of 8051 family
- Ultrasonic has its limitations as it produced a vibrating sound when it detects something and people need training for that.
- It can cause awkwardness when the buzzer make a sound when it detects something.

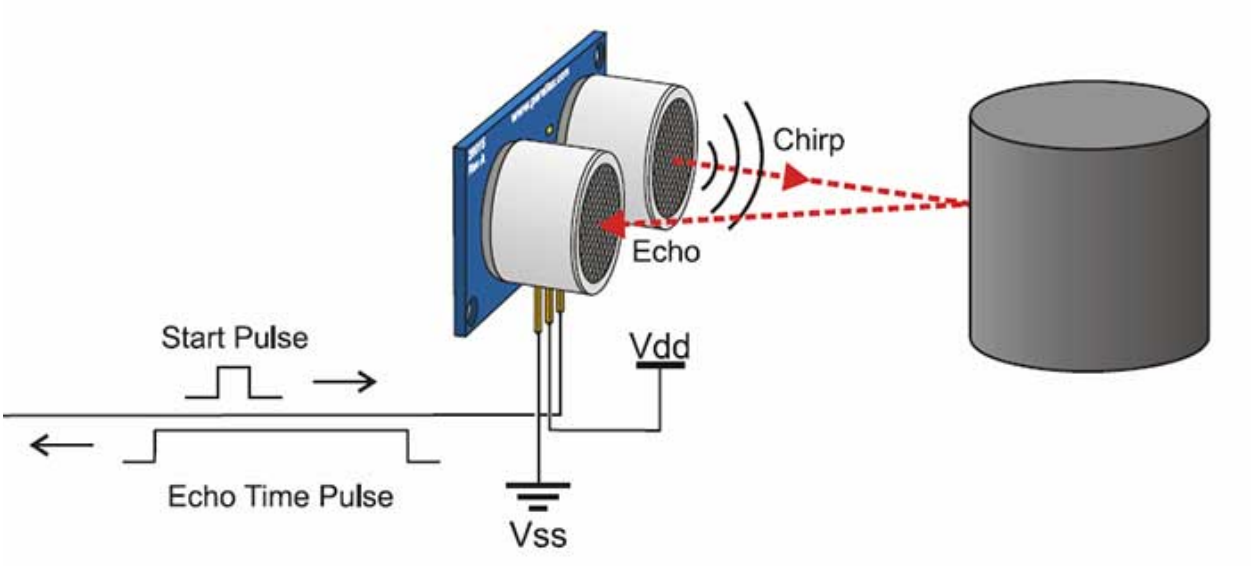

Figure 7: ultrasonic sensors

2.1.2 Laser system:

- Improvements were made in previous projects by adding some improvements
- A laser was used in some for aiding visually impaired people that gave them distance of the object or anything coming near them
- The drawback for that system was that laser was not that much reliable
- Because of the reflection, refraction of the waves of laser or objects that absorb laser
- Distance was one of the main problem as it can only measure up to a certain range

Figure 7: Laser distance meter

2.1.3 NumPy:

- NumPy is a platform that defines a multi-dimensional array object and associated fast math functions that operate on it
- It is a library of python use for arithmetic and mathematical purposes
- Python is not for mathematical purposes but keeping in view how mathematical calculations were used and needed numPy was introduced
- There are some limitations for this library
- It can work on multidimensional arrays
- Usually operated in OpenCV

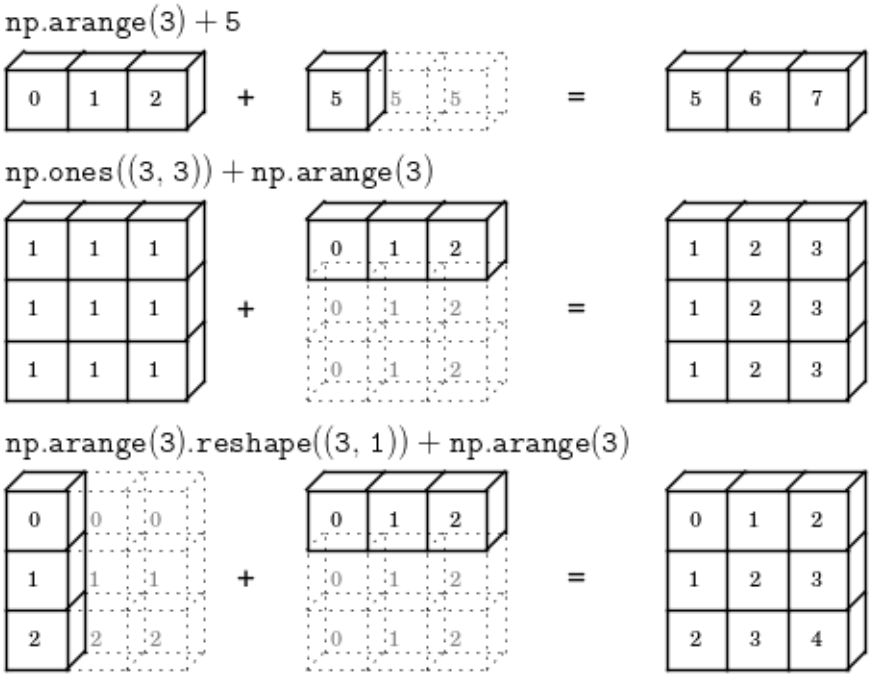

Figure 8: Visual representation of numPy functions

```
>>>importnumpyasnp
>>>importcv2
>>> r =np.reshape(np.arange(256*256)%256,(256,256))  # 256x256 pixel array with a horizontal gradient from 0 to 255 for the red color channel
>>> g =np.zeros_like(r)  # array of same size and type as r but filled with 0s for the green color channel
>>> b =r.T# transposed r will give a vertical gradient for the blue color channel
>>> cv2.imwrite('gradients.png', np.dstack([b,g,r]))  # OpenCV images are interpreted as BGR, the depth-stacked array will be written to an 8bit RGB PNG-file called 'gradients.png'
```

2.1.4 Espeak:

- One of the main feature of our smart device is that the output should produce that would guide the person
- Espeak command is used for that it is a library that is present in python and OpenCV.
- Espeak uses a “format synthesis” method, this allows many languages to be provided in a small size.
- The speech is clear but that much natural can be used at high speeds but it not as smooth as a natural human voice.
- Google has integrated Espeak that is an open source software speech synthesizer for English and other languages.

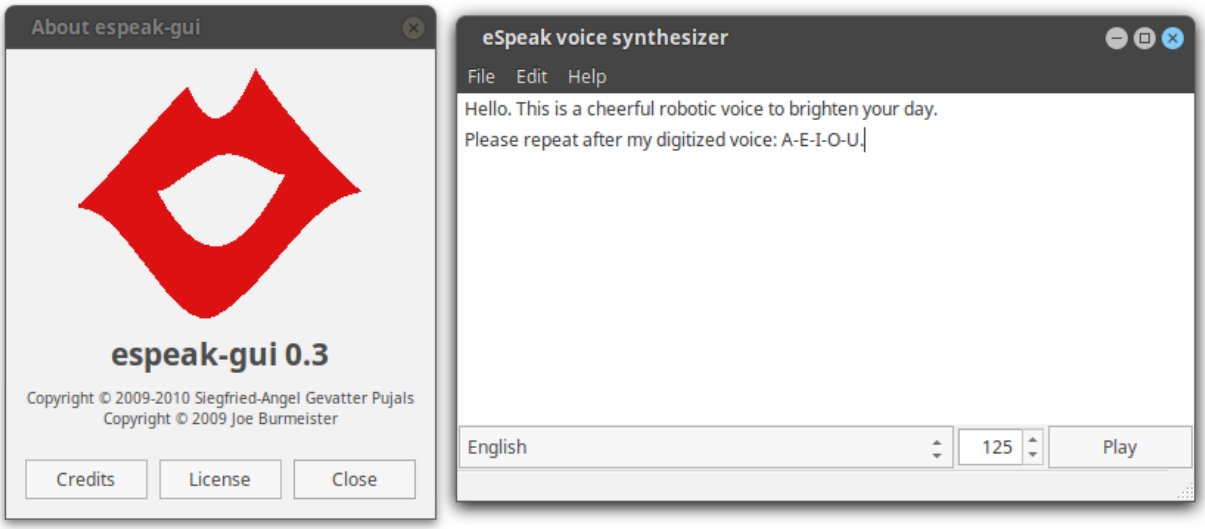

Figure 9: Espeak voice synthesizer

2.1.5 Edge Detection:

- It is an image processing technique for finding the boundaries of objects within the images.
- It works by detecting discontinuities in brightness.
- Edge detection is used image segmentation and data extraction
- Subjecting our static image to the raw image gives a substantial boost in accuracy for template matching.
- For this purpose, images are first converted to black and white y defining a threshold value which makes edge detection easier and more efficient.

Figure 10: edge detection process

2.1.6Template Matching:

- To identify the matching area, the template image is compared against the source image by sliding it over it and detecting the highest matching area
- .The patch is moved one pixel at a time(left to right, up to down).

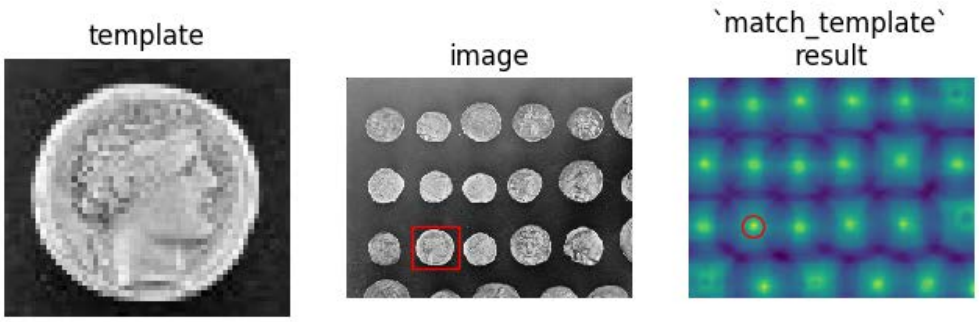

Figure 11: template matching process

- At each location, a metric is calculated so it represents quality of the match at that location.
- For each location the metric is stored in the result matrix (R). Each location (x,y) inR contains the match matrix.
- OpenCV has function cv2.matchtemplate() for this purpose
- .It simply slides the template image over the input image and compares the template and patch of input image under the template image.
- There are five methods for template matching

1. Cv2.TM_CCOEFF
2. Cv2.TM_CCOEFF_NORMED
3. Cv2.TM_CCORR
4. Cv2.TM_CCORR_NORMED

5. Cv2.TM_SQDIFF

2.1.7Neural Networks:

- Neural networks are basically use for recognizing any object for if the given object is "cat" or "not a cat".
- Neural networks, a beautiful biologically-inspired programming paradigm which enables a computer to learn from observational data
- Neural networks and deep learning currently provide the best solutions to many problems in image recognition
- Our device slowly learns because of this neural network these neuron work like a human brain but once a machine a trained it's speed increases for detecting any object.
- Every neural network possesses knowledge which is contained in the values of the connections weights.

2.1.8Artificial intelligence:

- AI can search social media platforms looking for photos and compare them to extensive data sets
- It then decides on relevant image matches at a rate much faster than humans are capable of.
- Image recognition was around before AI. Yet the machine learning factor is revolutionizing methods for identifying an object or person's face

- For example: A self-driving car that can detect objects and people on the road so it doesn’t crash into them doesn’t happen automatically. It needs to recognize the images to make informed decisions.

Chapter 3: Design

3.1 Working points

The project works on the following working points:

- The input is taken in the form of a picture taken from the Raspberry pi camera. This image contains possible obstacles and the successful detection of the various objects placed in the image is the basic purpose of the project.
- The processing of the image, this includes several steps through which the image is passed to produce a result that can help us recognise the objects in the input image data.
- An audio based output that will inform the person using the device of the result of the image processing.

3.2 System level diagram

We can show the process carried out by the device once we use it with a simple diagram.

- The diagram indicates that firstly a python camera library prompts it to take a picture as an input image.
- That image is then carried through an extensive pre-processing phase
- This enhances image then becomes the input for the google cloud library
- The output is finally shown in audio form.

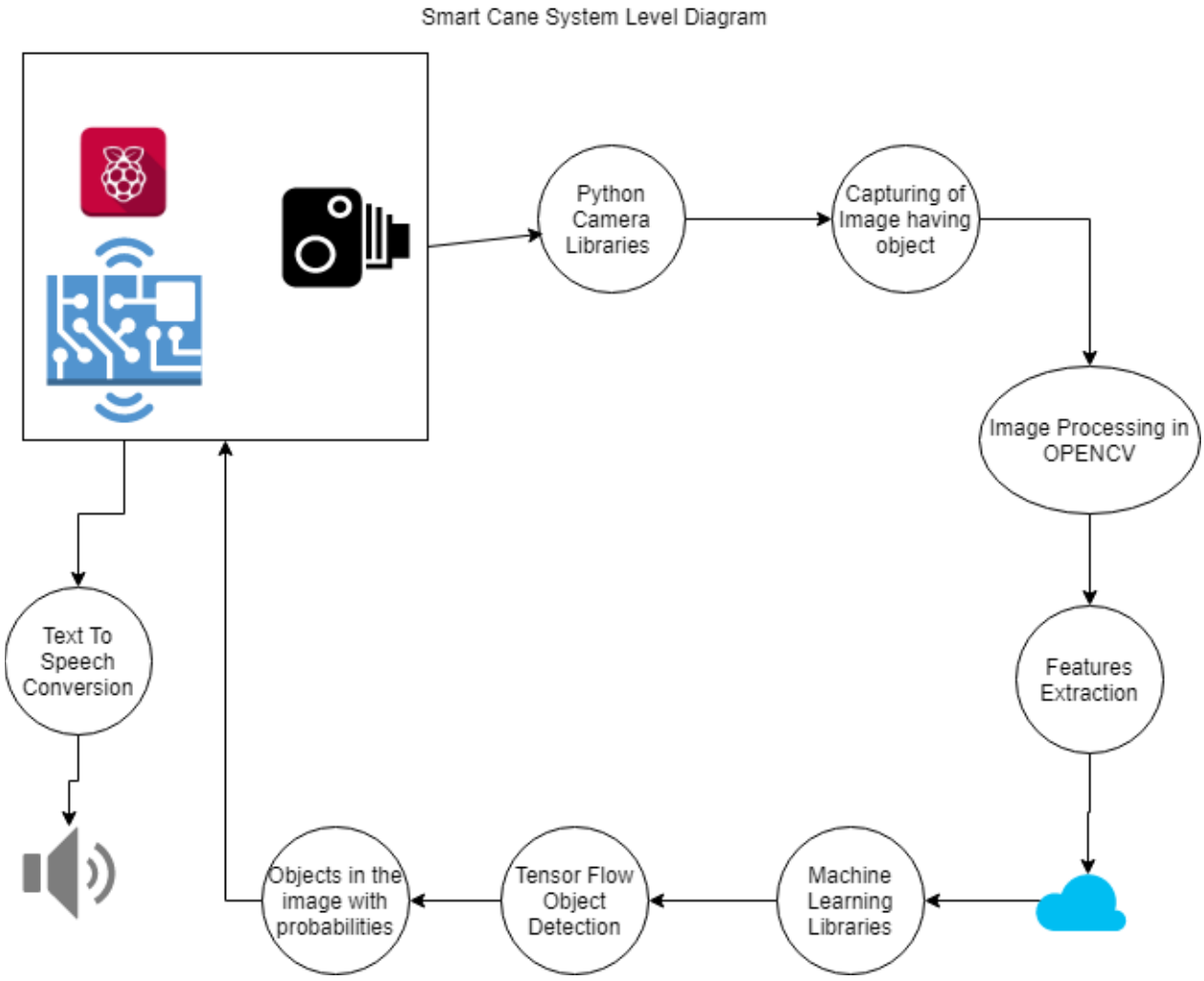

Figure 12: System level diagram

3.3Code

Coding is the most vital part of the project. This part ensures the processing of the image which is vital to obstacle detection.

3.3.1 Code for obstacle detection for an image present in the memory

We start by forming a code that utilizes the libraries already discussed in the previous chapter to process an image that is present in the memory.

```
importio

importos

fromos import system

importespeak

system('espeak "Hello Table"');



os.environ["GOOGLE_APPLICATION_CREDENTIALS"]="/home/pi/Desktop/NayyabFYP/Nayyab.json"

# Imports the Google Cloud client library

fromgoogle.cloud import vision

fromgoogle.cloud.vision import types



# Instantiates a client

client = vision.ImageAnnotatorClient()



# The name of the image file to annotate

file_name = os.path.join(

os.path.dirname(__file__),

    'mcd.jpeg')
```

```
# Loads the image into memory

withio.open(file_name, 'rb') as image_file:

content = image_file.read()



image = types.Image(content=content)



# Performs label detection on the image file

response = client.label_detection(image=image)

print (response)

labels = response.label_annotations



print('Labels:')



while 1:



for label in labels:

    #tospeak= 'Hey Nayyab You have' + label.description + 'infront of you'
```

```
#system('espeak '+tospeak)


system("flite -t 'Hey Nayyab You have " +label.description + " infront of you'")
```

3.3.2 Code for obstacle detection of image taken by raspberry pi camera

We need to write a code that will prompt the camera to take the image as soon as the code is executed and that same image then should be processed to detect the obstacles as we did last time around.

The code for this operation is given bellow:

```
mportio

importos

fromos import system

importespeak

frompicamera import PiCamera

from time import sleep

importRPi.GPIO as GPIO

GPIO.setwarnings(False)
```

```
GPIO.setmode(GPIO.BCM)

GPIO.setup(18,GPIO.IN,pull_up_down=GPIO.PUD_UP)

camera = PiCamera()

while True:

   j=GPIO.input(18)

   if j==1:

      print "Waiting for button press..."

   elif j == 0:

      system('espeak "Hello I am your smart cane and i will try to guide you"');



      os.environ["GOOGLE_APPLICATION_CREDENTIALS"]="/home/pi/Desktop/NayyabFY
P /Nayyab.json"

# Imports the Google Cloud client library

      fromgoogle.cloud import vision

      fromgoogle.cloud.vision import types



# Instantiates a client

      client = vision.ImageAnnotatorClient()
```

```
# The name of the image file to annotate
        camera.start_preview()
        camera.capture('/home/pi/Desktop/image.jpg')
        sleep(2)
        camera.stop_preview()
        file_name = os.path.join(
            os.path.dirname(__file__),
    '/home/pi/Desktop/image.jpg')

# Loads the image into memory
        withio.open(file_name, 'rb') as image_file:
            content = image_file.read()

        image = types.Image(content=content)

# Performs label detection on the image file
```

```
response = client.label_detection(image=image)

print (response)

labels = response.label_annotations



print('Labels:')



for label in labels:

    #tospeak= 'Hey Nayyab You have' + label.description + 'infront of you'

    #system('espeak '+tospeak)

    system("flite -t 'You have " +label.description + " infront of you'")
```

3.3.3 Enabling button operation

The above codes require the use of a screen to run or execute the program which is not a feasible approach. We need a simpler approach that will make operating the instrument and carrying it around easier and more practical.

This problem can be solved by installing a simple button unit. Now a simple button push will execute the code, take a picture with the raspberry pi camera, process the image and output the result in the form of voice output.

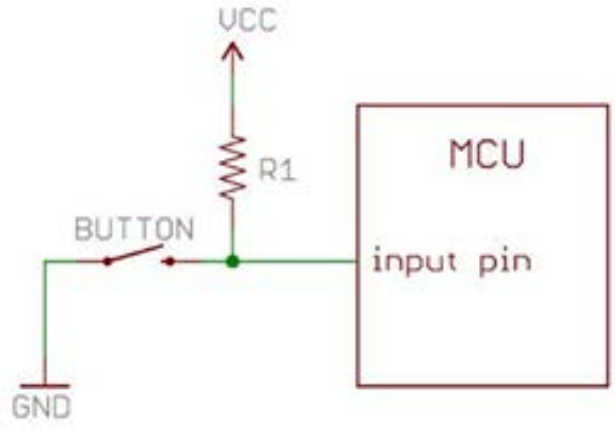

Figure 13: Simple button unit

The complete code for this operation is as follows:

```
importRPi.GPIO as GPIO

GPIO.setwarnings(False)



GPIO.setmode(GPIO.BCM)

GPIO.setup(18,GPIO.IN,pull_up_down=GPIO.PUD_UP)

while True:

    j=GPIO.input(18)

    if j is not True:
```

3.4 Academic Objectives

During the course of this project we have developed sound knowledge and technical skills in the fields of:

- Python programming
- Basics of data processing
- Concept of machine learning
- Different libraries and their applications

3.5 Special Skills Required

The following specialized skills are required to work on this project:

- Raspberry pi
- Python Programming

Chapter 4: Applications

4.1 Applications

This device has a wide variety of applications and can e employed in a number of different fields.

4.1.1 Health Sector

- This product has huge applications in the health sector. Currently there is no efficient product present in the market that can assist the blind people and can help them perform everyday tasks.
- It is sad to know that even in this day and age we have not done enough to solve the problems that are faced by the blind people.
- The introduction of this product in the health sector can help compensate the visually impaired people. This will boost their confidence and enable them to move around without the assistance of a helper.

4.1.2 Helping the War Veterans

- As a nation it is our responsibility to help and support the brave people who put their life on the line to serve us and protect our freedom.
- Many brave soldiers have lost their sight in the operational areas and this product can play a huge role in rehabilitating these people and enabling them to function in a normal manner.

4.1.3 Security Systems

- Such an object detection device can be used to monitor the feed of security cameras and detect possible red flags.
- Such a device will be more efficient and effective then a human being in detecting potential danger.
- Also, a large number of cameras can be covered at the same time.
- This will save valuable manpower.
- The man power can thus be utilized for other useful tasks

4.2 Future Applications

There are still new features that can be added to make these smart device more useful in the future.

4.2.1 Navigation

- In the future we can work on adding a navigation feature in the smart product that will make it more attractive for the customers and more useful in attaining self sufficiency for these blind people.
- This feature can be used by the blind people to gain awareness about their location and other useful information.

Figure 14: Navigation system

- The guardians of these blind people can use this feature to constantly monitor their movement and location.
- Through this feature the blind people will be able to safely reach their destination guided by the navigation system installed in this product.
- This feature will first be installed in controlled environments, in homes and offices and then we can work on widening its reach.

4.2.2 Distance Measurement

- Another possible feature that will help increase the usability of this smart product is the distance calculator.
- The idea is that in addition to telling us about the object in front of us and recognizing the obstacle placed in front of a blind person it should also be able to help identify the approximate distance of the camera to that of the obstacle.
- This information will let the person using this device know how far away an object is placed and the person will be able to take the appropriate decision as to what he wants to do about it.

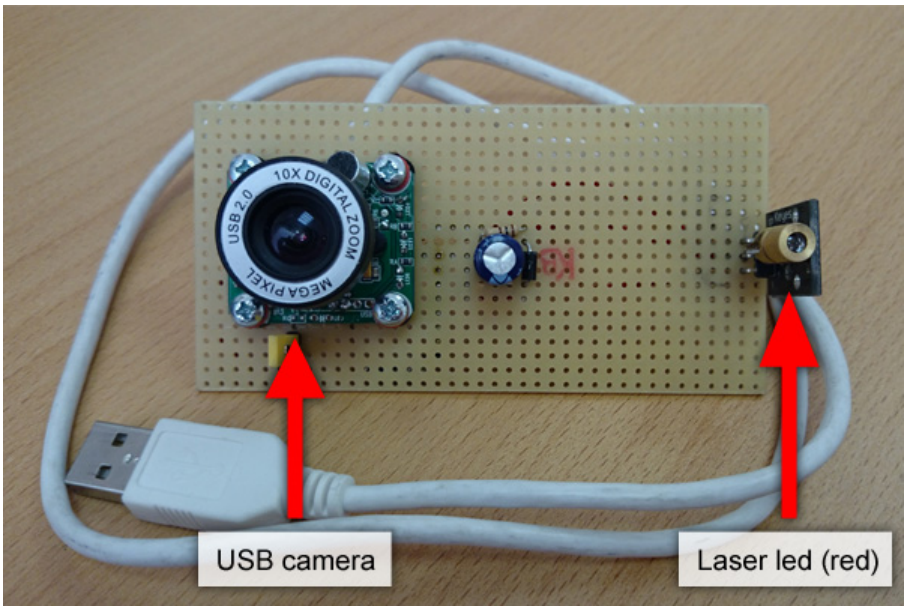

Figure 15: distance measurement through laser

- There are a couple of solutions to this distance problem and how to solve it.
- The use of laser based measurement system has been discussed and may be developed in the future to provide an accurate account of how far away a certain object is.
- The figure shows a simple laser based distance measuring device implemented through a simple C# program.
- A similar device could be used in the already developed smart product to add an additional feature that will greatly increase the usability and the applications of this device.

Chapter 5: Resources Required

Ser. No	Item Required	Quantity	Estimate Cost (Rs)
1	Raspberry pi kit	1	5,000
2	Raspberry pi camera	1	2,500
3	Power Bank	1	5,000
4	SD Card	1	1,500
5	Cables	2	1000
6	Casing	-	2000
		Total	15,000

Chapter 6: References

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