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Department of Electrical Power Engineering and  
Mechatronics

**Border Security Electrical Fencing with Face Recognition**

MASTER THESIS

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Tallinn, 2017

**AUTHOR’S DECLARATION**

I declare that I have written this graduation thesis independently.

These Materials have not been Submitted for any academic degree.

All the works of the others used in this thesis have been referenced.

This thesis was completed under Mr. Dmitry Shvarts Supervision  
.....2017

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## **MASTERS THESIS SHEET OF TASK'S**

Student: Naveen Soni, MAHM156360

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### **THESIS TOPIC:**

(In Estonian): Border Security Electrical Fencing with Face Recognition

(In English): Piiriturvalisuse tagamine elektriaia ja näotuvastuse alusel

**Engineering Problem to be solved:** There are many borders' in this world that are not peaceful, it means that two countries residing each side of that border and are involving in fighting. They also have problem trespassing of border illegally, because it's not possible to protect the border by soldier every single meter and each and every moment. These borders do have metal wire fencing but it's very easy to cut it and cross the border to perform illegal activities.

To avoid these problem, I am suggesting a method to pass the high voltage current in fencing so that it can create a current environment around the fencing and human cannot even come closer to this fencing. High voltage will help to create a big magnetic environment around the wire will have current.

But all-time continuously passing the current would be not good for metal life, and also it would not be economic. to overcome this problem, I am also suggesting here face recognition with neural network techniques. Which can help to recognize the favorable soldier and extract from Unknown human. With that current flowing start, automatically in fencing. This will reduce the power consumption also will help to avoid to harm our own soldier.

**Language of the thesis:** English

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## FOREWORD

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My heartfelt thanks to all my friends who worked with me on various projects and gave me motivation towards learning and specially on Handicapped project team where I was first introduced with OpenCV.

I also would like to thanks to twin's brother [Mr. Anton Bolotin](#) and [Mr. Artyom Bolotin](#) who participated in Experiment for Face Recognition on twins.

,

At last but not least, I would like to express my gratitude and love to my family who was always stand with me by giving me moral and emotional support.

## LIST OF ABBREVIATIONS AND ACRONYMS

GDP – Gross Domestic Product.

CRT – Cathode Ray Tube

USA – United States of America

IDF – Isreal Defense Force

WW – Word War

FBT- Flyback Transformer

A.C/ D.C – Alternatic Current / Driect Current

CFL – Compact Flourescent Lamp

DMM – Digital Multimeter

T.V – Television

O.S – Operating System

IDE – Integrated Development Envionment

RAM/ROM – Randome Access Memory / Read Only Memory

VGA – Vide Graphics Array

LAN – Local Area Network

USB – Universal Serial Bus

HDMI – High Definition Media Interface

Mbps- Mega Byte Per second

GB – Gigabytes

LPDDR – Low Power Double Data Rate

PAL/NTSC – Phase Alternating Line / National Television System Committee

Fps – Frame per Second

PCA – Principle Component Analysis

LDA – Liner Discriminant Analysis

SD card – Secure Digital Card

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# 1. INTRODUCTION

## 1.1 Motivation

*“World is more distributed today due to war on terrorism. Refugees are on move everywhere. Securing the borders by a country has become more important to prevent illegal entries of people in the country.” [1]*

According to an Indian News Paper every year around 70 Crore Rupees smuggled into India to encourage illegal activities such as Terrorism and drugs, by trespassing border [2]. After independence only from Bangladesh there are more than 30 million illegal immigrants came in to India and apart from that there are also from Burma (Myanmar), Tibet, and Pakistan [3]. This thing sound very little for such a big country name India, but it influences a lot in terms of Economic Loss and GDP influence and peace and reputation of World 7<sup>th</sup> Largest country, India.

I always wished to serve for my Nation in any terms, especially for defense, but I couldn't get into in army as it's not a mandatory to serve in Army in India.

This Thesis half inspiration comes from the part that I mentioned above, and another half come from an accident.

I have an old CRT Television at home, which has old big Picture-Tube which is connected through an Electrical device name **FLYBACK Transformer**. This device has ability to transform 10000V – 30000V from 220 V AC supply. Somehow internal in CRT T.V. there was a breakage in wire from FBT to Picture Tube. This breakage had a metal wire connected to near a speaker net directly, so the whole current was in same way to this net. As CRT was making noise, so I went near to it to unplug it, so that I can open it and check it why it is making noise. But I got a huge shock from distance (nearly 7-8 inches) from Speaker metal net. Whole T.V frame is made up of wood which is a bad conductor of electricity.

The moment I got a huge shock I fell down and I was thinking that why I felt shock when I didn't even touch anything. But later I had an idea to implement this thing on border fencing. What if invaders felt the same current. But it will take lot of power. Which Is not economical, for which I was thinking even during my master.

To Finding the solution of this power wastage I was keep looking for solution and I found a way **Face Recognition**, in 3<sup>rd</sup> semester I came to knew about Image Recognition techniques from all the way, through MATLAB, C++, Python, C#, Java, through all this way we can make, not just image recognition but, live streaming Face Recognition.

## 1.2 Overview of the Topic, Task and Previous Research

The globe has changed so many time with respect to time. Some countries working under rule of another country, and then later they got independence. After independence from colonialism their map has changed because of division of that country. The land they used to have not same anymore. In some case the country had divided in to parts or some another country had taken some part of their land. e.g. **India –Pakistan – Bangladesh** was used to be part of India before 15 August 1947 under British Rule with just one name “India” but after freedom it is divided in to two country India – Pakistan. Pakistan further divided in to two parts again from East Pakistan – West Pakistan to Pakistan and Bangladesh.

All these three countries still have issues about land acquisition. The biggest one is in Jammu and Kashmir, which is situated in northern frontal, which is claimed by three countries **India – Pakistan – China**. And another is on Eastern front of India border with Bangladesh.

Another good example of border conflicts is **Israel – Palestine** Conflicts which is also about land war and invaders in country.

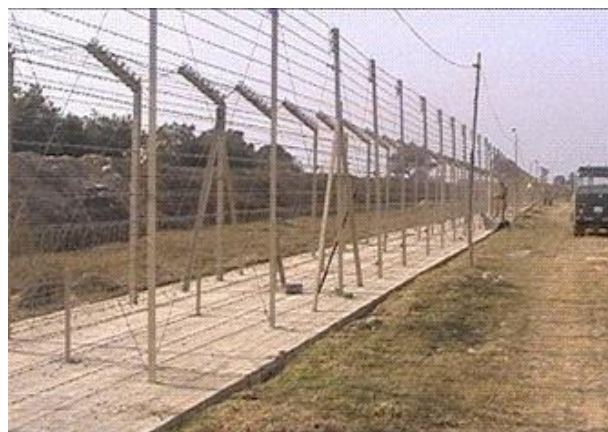
Although all these conflicts are about the misconception about the territory, Greed to acquire the land, illegal immigration. Some time they all claiming on the basis of History and Ethnicity of population living there.

With India and Pakistan border are both type Without fencing and fenced. Without fence, they have just small pillars as shown in fig.1, this pillar show last line of Indian border and after that there is Zero line which is also known as No Man Land, after no man land, Pakistan territory starts.

On another side, some part of India Pak border is fence, it hard to tell where exactly it is fence or not throughout all border, because its Confidential things, only military knows. But you can look on fig.2, its shows that a vehicle is patrolling on border which is already fence to make sure that, if the fence is not cut down from anywhere.



*Figure 1 Border Pole 609 between India and Pakistan*



*Figure 2 Indo – Pak Border with fence*

In most case the purpose of trespassing the border illegally is, to migrate into that country or suppling illegal activities, such as ammunition, duplicate currency, fake/copy of branded products, Drugs, Human Trafficking. Due such countries, who trespassed by another country has to suffered in different manners.

The First ever border barrier was built in China in 220 – 206 BC to protect China’s border from Mongolians. Its 21,196 Km long also visualize from space as well.

In history, the first ever record of arrangement of wires connected to electrical machines to protect a display known as Dorfeuille’s Hell” in Western museum of natural history in

Cincinnati. In 1905, Russian Army used in Russo – Japanese War at Port Arthur. In world War 1, used an electric wire fence between Belgium and Netherlands and named it “Wire of Death”. In America, there was an attempt to make an electric fencing in 1936 – 1937 by New Zealand Inventor Bill Gallagher for controlling of Livestock. He made this with the help of car ignition trembler set, in 1969 another New Zealand Inventor, Dough Phillips, invented the non-sortable electric fencing based on capacitor discharge. [4]

## 2. LITERATURE REVIEW

### 2.1 Border Protection

From very long time in history there was no era when human didn't fight for land, on the name of Language, Ethnicity, Race, Color. Every time there was a reason. In India, there is very famous Quote that all the reason of fight is Jar, Joru & Jameen which means Money, Woman, and Land. From Pharaoh Era to World War 2 you can see the whole world had gone through war and invasion.

In another case, there is also very big another issue, to trespassing the borders or illegal immigration. Because of which there is currently going on many issues in the world. In India, these trespassing of border and illegal immigration is not always for to become a national of India, but sometime it for Smuggling of ammunition, Drugs, Human Trafficking, using fake currency or Spy in country.

Border is not always a plain land that we can live there and protect it. Sometimes it's a River, a forest or high altitude mountain, India has very different version of borders. such as India and Pakistan are fighting over highest battlefield in the world, it's 5753 m above the sea level and the temperature goes down as low as -58 °C. Temperature is always negative there and full of snow. With this kind of border, it's hard for soldier to guard the border, but still there are soldier continually guarding the border, with special training.

Since April 1984, as many as 869 soldier have been killed because of Avalanche, blister cold and other trouble related to snow mountain and almost similar on another side of border.

The Jammu and Kashmir border is almost mountaineer, and apart from that there are other three provinces, attached with Indo – Pak Border in Indian side, Punjab, Rajasthan, and Gujrat. All the three borders are different and difficult. In Punjab, the border has gateway to cross the border legally, in city Amritsar, but the whole border with Punjab is land and full of grass and field, people even producing crops on both side. After all this, there is still Border with fencing and most of the Drugs and Fake Currency comes from this border.

In last few years, according to a newspaper there is 811.6584 Million \$ drugs were seized from Punjab region only in 6 years. During this kind of raid, BSF even encountered Pakistani and Indian Smuggler “as this is operated from both side people”. [5]

*Table 1 statics: Net Worth of Drugs seized During 2008 – 2013 [5]*

<b>Year</b>	<b>Kg</b>	<b>million \$</b>
2013	322	258.0000
2012	288	230.7578
2011	68	54.48447
2010	115	92.14286
2009	120	96.14907
2008	100	80.12422
		811.6584

Border from Rajasthan province is full of desert where the temperature is go max to 52 °C in summer days and in winter’s night it can go as low as 0 °C. other than this, there is problem with desert storm, dry air. Another province Gujrat, 93 km of the border not even fence there, cause this area is full of marshes and saltwater lakes and ponds. Which makes it harder to put the fencing over there. That is the reason that it is also a gate of Human trafficking and drugs supply prone area. [6]

From Bangladesh Border, this border is very long and mostly with jungle and river delta. This is also largest single block tidal halophytic mangrove in the world. Humidity and Rain and because of rain, flood is the biggest problem of army.

With China, this border is mostly with mountain and also have issue for land, and same kind of issues with them, but mostly the land acquisition.



## 2.2 Fenced Border

India has more than 15000 kilometers of border with all its neighbor country, and individually is as you can see in table.2

Table 2 Total border with individual Statics (in Km) [7]

<b>Name of the Country</b>	<b>Length of the border (In Km)</b>
Bangladesh	4096.7
China	3488
Pakistan	3323
Nepal	1751
Burma	1643
Bhutan	699
<b>Total</b>	<b>15000.7</b>

Out of this list, Nepal and Bhutan doesn't need any barrier, as there is no big harm from them, but from rest of border countries we need to make barrier. We do have barrier with it, but it still somewhere under construction, and need to upgrade as well. It would a surprising news that, India has largest border barrier in the worlds, still under construction.

Out of the all mentioned above in table 2. There are two major big fencing project are running on which are describing in below:

### **Indo – Bangladesh Border (IBB) –**

Indo – Bangladesh border is marked as high sensitivity border in term of illegal immigration and Smuggling, Human trafficking and Other anti – national activities. This is why Govt. of India has sanctioned to construct border roads and fence in two ways. [8]

Here is table that shows that Indo – Bangladesh border fences and Roads

Table 3 Status of fencing and Border on Indo - Bangladesh Border [8]

State	Fence Approve(Km)	Complete	Road Approve (Km)	Complete
W. Bengal	1528	1193.29	1170	1616.57
Assam	230.03	219.38	325.03	251.06
Meghalaya	470.23	378.25	539.16	412.14
Tripura	855.97	708.67	1109.49	762.71
Mizoram	352.33	154.85	582.56	314.09
<b>Total</b>	<b>3436.56</b>	<b>2654.44</b>	<b>3726.24</b>	<b>3356.57</b>
		<b>77.24 %</b>		<b>90.07%</b>

### Indo – Pak Border

This border is 3323 km including **Line of Control (LOC)** this border includes 4 Indian Province Jammu & Kashmir, Punjab, Rajasthan & Gujrat. All these 4 borders have different variance situation such as Mountain, River, Forest, Desert, Field, Mashas & Bog. [8]

Table 4 Fencing of border on Indo-Pak Border. [8]

(Length in Km)

State	Total length of border	Total length of border to be fenced	Length of border fenced so far	Remaining length of the border proposed to be fenced
Punjab	553	461	462.45*	--
Rajasthan	1037	1056.63	1048.27*	--
J & K	210	186	185	1
Gujrat	508	340	219	121
<b>Total</b>	<b>2308</b>	<b>2043.63</b>	<b>1914.72</b>	<b>122</b>

Table 5 Floodlighting on Indo - Pak border [8]

State	Total length of border	Total length of border to be floodlit	Length of border floodlit so far	Remaining length of the border proposed to be fenced
Punjab	553	460.72	460.72	---
Rajasthan	1037	1022.80	1022.80	---
J & K	210	195.80	176.04	19.76
Gujrat	508	340	202	138
<b>Total</b>	<b>2308</b>	<b>2019.32</b>	<b>1861.56</b>	<b>157.76</b>

### **3. ELECTRICAL FENCING**

#### **3.1 Fencing Techniques**

Israel is the country that is totally protected its country from invaders through border fenced. Even US and Indian Delegates went there to learn this technique. Both these countries need to protect their border. In USA protection need from Mexico side. It's not like that all the invasion from Mexico is only by Mexican's but this border is also used by another Latin American's and another part of the world.

In case of India the problem is same as like as Israel, need protection of all side from North to West from Pakistan and on another side East 5<sup>th</sup> largest border of the world with variance of border situation and high rate of invasion (Indo – Bangladesh). Also in east, this is not only the border, there are other as well which need to be protect.

IDF having most advanced border protection system in the world, they are moving more towards technology rather than Human protection, because to save human life and remove human error. Their technology includes High Quality Long-Range day cameras as well as Night observation systems, a very advanced Thermal Imagers, Electronic touch and motion sensors on the fence as well as ground sensors to detect any tunneling attempts. An electronic pulse will run through the fence, and give an alarm signal to security guard to locate the exact location of invasion. A sandy tracking path shows the footprints of invader and border guard will be alert from the location. [8]



*Figure 3 labour working on Israel border with Egypt [1]*

There are two major ways to crate the border fence such as US has proposed to create a concrete **Wall** with Mexico which is quite similar with the Great wall of china. This technique is robust and may be useful. But this thing involves a huge cost and still there is no guarantee that you will have protection, cause it a barrier but it's not like that no one can trespass although it's would be high enough. There are cases when in US jails prisoners even cross such kind of walls when there was high security according to **Prison Break Series** on Net Geo Channel.



*Figure 4 Wall border from Israel to Palestine to avoid Sniper attack*

On another place the border can be **Barbed Wire** net up to some height. It was first proposed by Leonce Eugene Grassin-Baledans in France in 1860. Five years later it was improvised with double wire and diamond shaped bard over wire. [9] and this was used for many and many years for different purposes such as to kept animals in farm or boundary or to protect a private property. But majorly was used in WW I and WW II. an example you can see in fig.3

In my thesis proposal, I am proposing to have racket net type of fence (shown in fig.5) with high voltage current with the help of Flyback Transformer. Cause its similar of barbed wire so that it's less costly than other option and it also involve metal so that it can be option to use as current carrying conductor material. The thing here we need to design, the material we need to use and in which shape to get the better result. Better result in form of, to get the desired output which is, to get away invaders from even fencing. They can't even come near to fencing, so that it would be harder for them to cut the fencing and trespass the border.

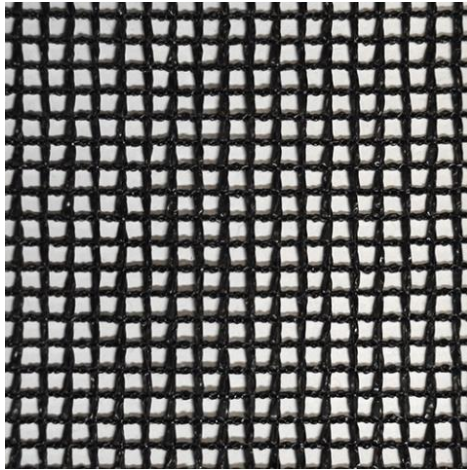


Figure 5 Metal Net suggestion for fence design

### 3.2 Flyback Transformer Design

Flyback transformer is high voltage, mid to high frequency transformer which was used to power CRT monitors and Televisions. This device invented to mean to control the horizontal movement of the electron beam in CRT. It's different from conventional transformer. In other word, it is similar as an inductor with extra winding where energy is stored in inductance of the primary winding during on time of circuit which transferred to output circuit when the circuit is off. [10]

In case of traditional transformer Primary current and Secondary current flow mutually and only small amount of energy stored in the transformer in the form of “magnetizing energy”. On another hand Flyback is more like multiple inductor under a unit system rather than a typical transformer. Generally, transformer doesn't stored energy but it transferred the energy immediate from primary to secondary coil.

But In case of Flyback all the energy stored into air gap of the core, or in distributed air gap of permalloy power core. It should be designed in this way to *minimize* the **leakage inductance**, **AC winding** and **Core losses**.



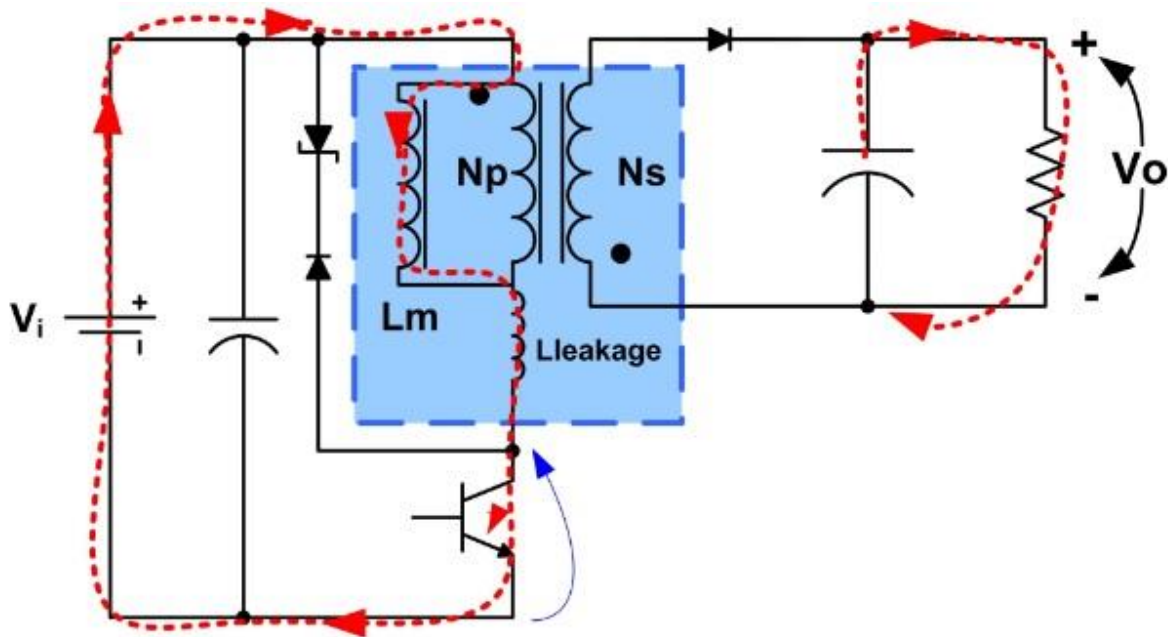


Figure 6. Flyback Power Supply operating in Continuous Conduction Mode

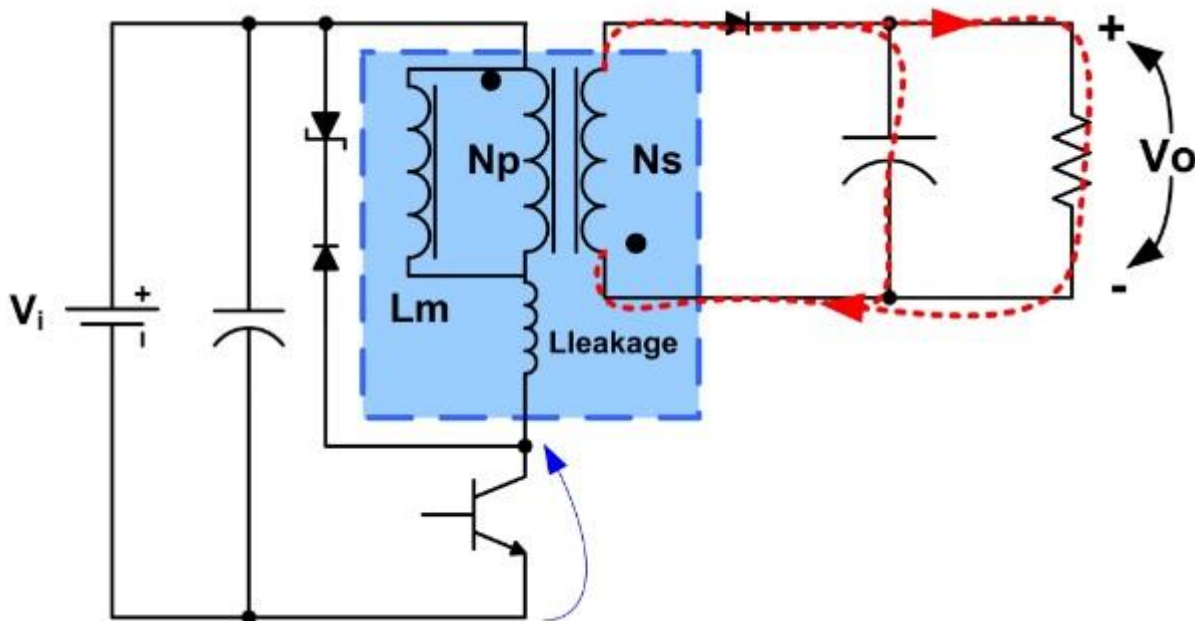


Figure 7. Flyback Power Supply operating in Continuous Conduction Mode

From fig. 6 and fig. 7 you can see the *red* line showing the direction of flow of current in Primary winding with respect of Secondary winding. From fig. 6a you can see the current is flowing in whole primary winding and partially in secondary winding with output, this partial current is saved energy down peak current. In fig. 6b after the Mosfet is turned off the primary

energy is transferred into secondary, and this secondary current is following around in the circuit.

In fig. 6 and fig. 7 you can see a closed loop mentioned with blue line which is actually imaginary line denoting closed loop of primary and secondary winding where the energy transformation occurs, this loop has more chances to leakage the amount of energy. To save the energy transformation we need to design in such a way to save as much as energy.

Here are some steps of designing of Flyback transformer which is not fully applicable on our border fencing requirement but we are assuming to understand a normal Flyback transformer which was initially designed to having an assumption to undemand the Flyback working system.

### **3.2.1 Select the core material and Configuration**

Ferrite is most commonly used material for electrical applications and Molybdenum-Permalloy powder toroidal cores have higher losses, but it is quite often use material at Switching frequency less than 100 KHz when flux swing is small. Permeability of Powdered iron cores is either too low or too loose for practical use in switching power supply applications above 20KHz.

The magnetic material has very high permeability ( $\mu_r = 3000 - 100,000$ ) which is not able to store much energy, it's good for transformer but not for an inductor. The amount of energy stored in FBT is stored in air gap (non-magnetic material  $\mu_r = 1$ ). The energy storage gap in molybdenum- Permalloy and powder iron cores is actually in the non-magnetic binding holding the magnetic particles together. This gap can't be simply measured so equivalent permeability is specified instead.

### **3.2.2 Determine the Peak Flux Density**

In this procedure, inductance and current values are referred to primary, and thus Inductance  $L$ , required the peak short-circuit inductance current,  $I_{pk}$ . It is set by current limiting circuit and define the maximum inductor energy ( $L \cdot I_{pk}^2 / 2$ ), an inductor must be designed in such a way that it can store with acceptable (core + copper) losses.



The inductor must be operated at  $B_{\max}$  (maximum peak flux density) to get the smallest possible gap to be able to store the required energy, it reduces the eddy current losses, winding turns and inductor size and of course this influence cost. In reality  $B_{\max}$  is limited either by core saturation or by core losses. In ferrite core losses are proportional to frequency and 2.4 power of peak to peak flux density  $\Delta B$ , during each swing cycle. The value of core saturation for such a strong ferrite 3C8 material is above 0.3T and  $B_{\max}$  of 0.28 – 0.3T tentatively chosen

### 3.2.3 Determine Core Size

Core must have an ability to store required peak energy in small gap shown in fig.6 without saturating or having core losses. Must contain required number of turns with desired value of winding losses.

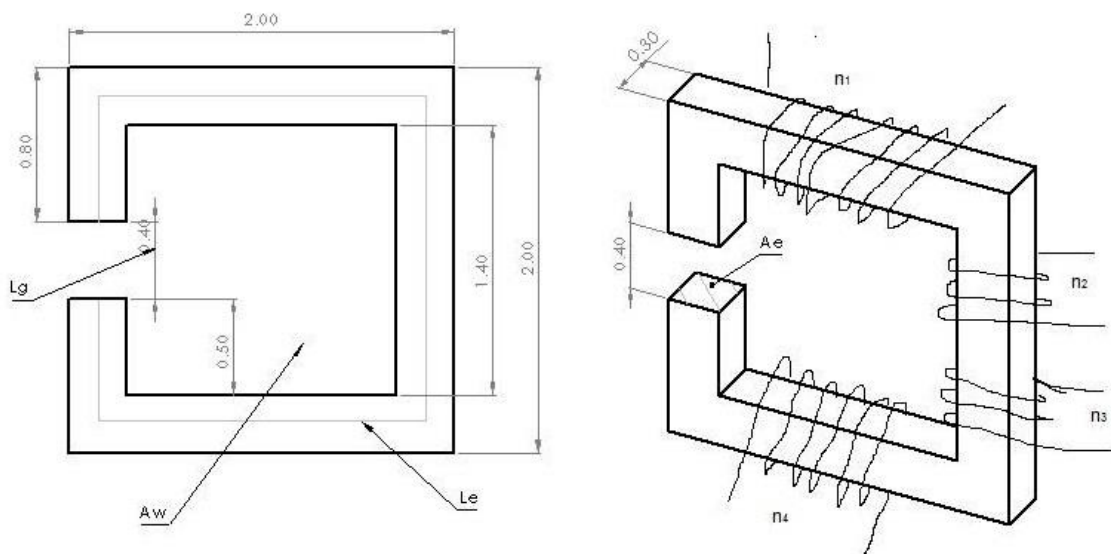


Figure 8 for calculating of Air Gap length

$A_p =$  Cross product of  $A_e$  and  $A_w$ ,  $m^2$

$A_e =$  Cross section area,  $m^2$

$A_w =$  Winding window area,  $m^2$

$L_e =$  Magnetic path length,  $m$

$L_g =$  Air gap length,  $m$

$$A_p = A_e * A_w = \frac{L_1 * I_{pk1} * \sum_i \frac{n_i}{n_1} I_{rms}}{B_{max} * J * K} \dots \dots \dots (1)$$

$$J_{mm} \cong 4.5 \frac{A}{m^2}$$

**K** = Fill factor

**L<sub>1</sub>** = Inductance of Primary winding, H

**I<sub>pk1</sub>** = Peak inductor Current in Primary, A

$\frac{n_i}{n_1}$  = winding turn ratio between Primary and rest of it

**I<sub>rmsi</sub>** = Inductors rms current, A

**J** = Current density of wire, A/m<sup>2</sup>

$\sum_i \frac{n_i}{n_1}$  = ratio of summation of all windings to primary winding.

### 3.2.4 Define N

The minimum number of turn is:

When  $B_{sat}$  limited  $N_{min} = \frac{I_{pk} L}{B_{max} A_e} * 10^4 \dots \dots \dots (2)$

When Core loss limited  $N_{min} = \frac{L \Delta I_m}{B_m A_e} * 10^4 \dots \dots \dots (3)$

Actual number of turns >  $N_{min}$

Here primary turns would be coming in Multiple series such 22, 44, 88 etc.so in that way if  $N_{min}$  is 40 then Smallest value of N would be 44 turns.

$$l_g = \frac{\mu_0 \mu_r N^2 A_e}{L} * 10^{-2} \dots \dots \dots (4)$$

Here  $\mu_0$  = Air Permeability

$\mu_r$  = Relative Permeability

$N$  = Number of turns

$A_e$  = core cross section area

$L$  = Inductance.

In case of Pot cores or Ferrite EE, gap should be in the center port only. But in toroidal cores, gap is placed in between magnetic particles around the entire core. In place of gap length, the

core manufacturer mention equivalent relative permeability as core were made up of homogeneous magnetic material. [11]

$$\text{Max } \mu_r = \frac{Ll_e}{\mu_0 A_e N^2} * 10^{-2} \dots\dots\dots (5)$$

### 3.3 Electrical Setup of Flyback Transformer:

After learning how FBT works and what makes it different from another transformer, it's time to learn how to make a prototype setup so that we can understand its potential of working scenario. Of course, it does not meet with actual requirements, there would be different scenarios but here we just use an assumption of practice, which is easy to perform in lab. As my own experience of shock from FBT was from Television where it was under supply of 220V A.C with 50 Hz frequency. But it's too dangerous and are not permitted to test again under such circumstances.

As we are not performing this practical task cause, as it's dangerous to perform and to for it we need supervision, so I am going to write here a small experimental with FBT to show its intensive power which is still less than FBT working in Television.

In this small experiment, I am going to use a small CFL with FBT because CFL have Electronics Ballast which can control FBT through an A.C supply. Also, it's better if we can find the circuit diagram of CFL system and look for better understanding. So, I am going to write the Step of procedure to do a small experiment.

### 3.3.1 CFL Circuit Details:

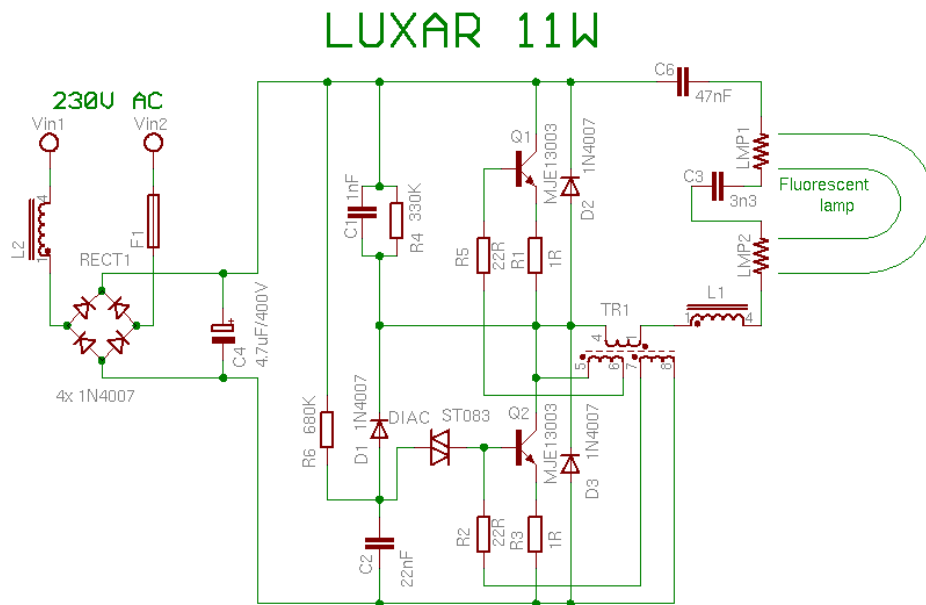


Figure 9 CFL Circuit Diagram

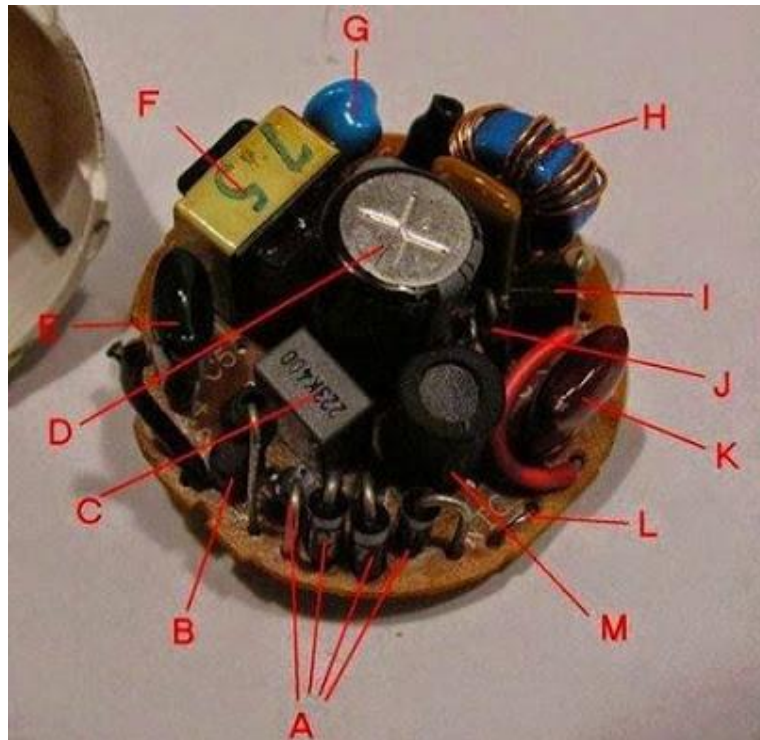


Figure 10 CFL Electronic Ballast (Component List) (a) Rectifier Bridge, (b) Fuse, (c) Serial Capacitor, (d) Capacitor, (e) Capacitors, (f) Choke, (g) PTC thermistor, (h) Feedback Transformer, (i) Transistor, (j) Diode, (k) Capacitor, (l) NTC - Thermistor, (m) Choke.

CFL comes in different size and shapes but their circuit topology is mostly similar. The bigger the CFL wattage power we will choose, the bigger we will get output voltage. If you will open CFL you will found most of them have 4 wires coming out in pair and each pair connects to a filament inside the CFL.

We only need to find the two wires which was connected through fluorescent lamp because there wires we need to be connected through FBT.

### 3.3.2 Flyback Transformer

You can either buy a new one or you can remove from and old CRT which need a little take care before to remove as shown in fig. 9. We already discussed about FBT, but we are going to talk about related to experimental task.

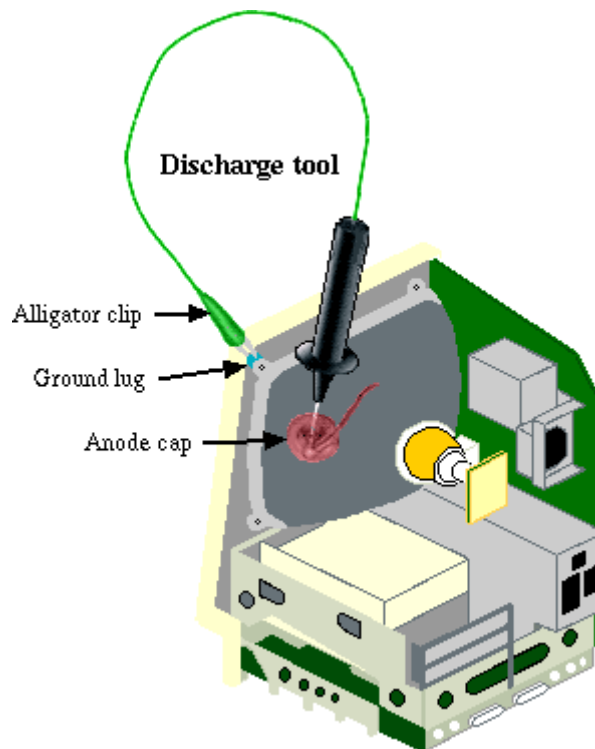


Figure 11 Describe how to remove an old FBT from TV set safely.

Here task with FBT is to find 3 pins out of 10-20 pins. One of the three pins will be high voltage ground and others two pins belongs to primary coil that will connect to CFL electronics Ballast. To finding those 3 pins we need to perform a separate task as follows:

- First have a look of FBT pin chart, to understand this, how it's look and how to find it required 3 pin.
- **Finding High Voltage Ground:** To identify this connect negative terminal voltage of a 9 V battery to a high voltage lead and the voltage at pins 6-10 on the bottom of the transformer. Measure the reading with the help of DMM. All pins will give a same reading except High Voltage Ground, in our case its pin 8 from fig. 10.

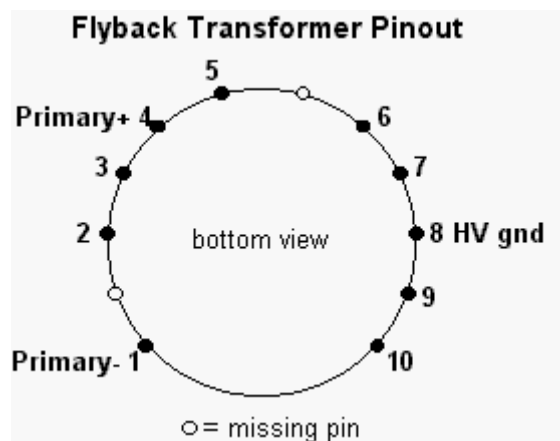


Figure 12 FBT pin Chart indicating HV ground and Primary pins

- **Finding Primary Winding:** In FBT usually Primary winding from others is always odd comes out. To finding this we again will use DMM. And we have to only measure the resistance between two pins one by one and need to write down on paper. You need to look for which two pair has higher reading. According to fig.10 the primary pins are 1 and 4 that means that reading of resistance between this pair is higher than other pairs. [12]



Figure 13 Setup to find the Primary pins in FBT.

### 3.3.3 The Final Setup:

The final setup would be something look like this as shown in fig. 13

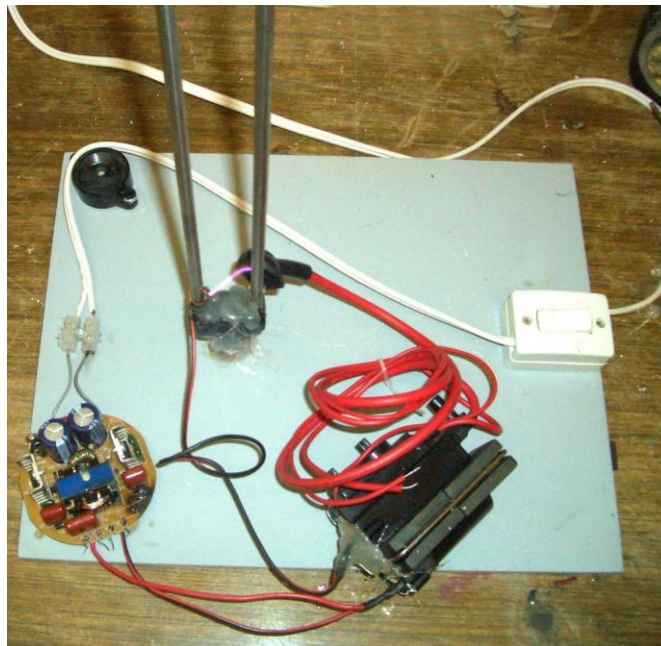
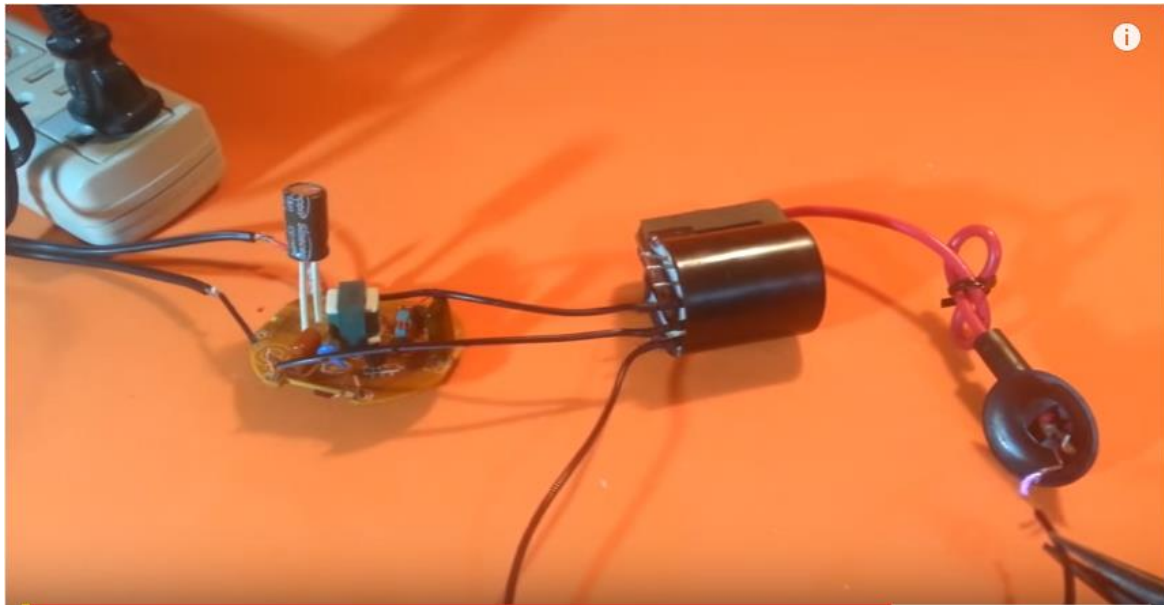


Figure 14 final setup for Performing Flyback Performance test.

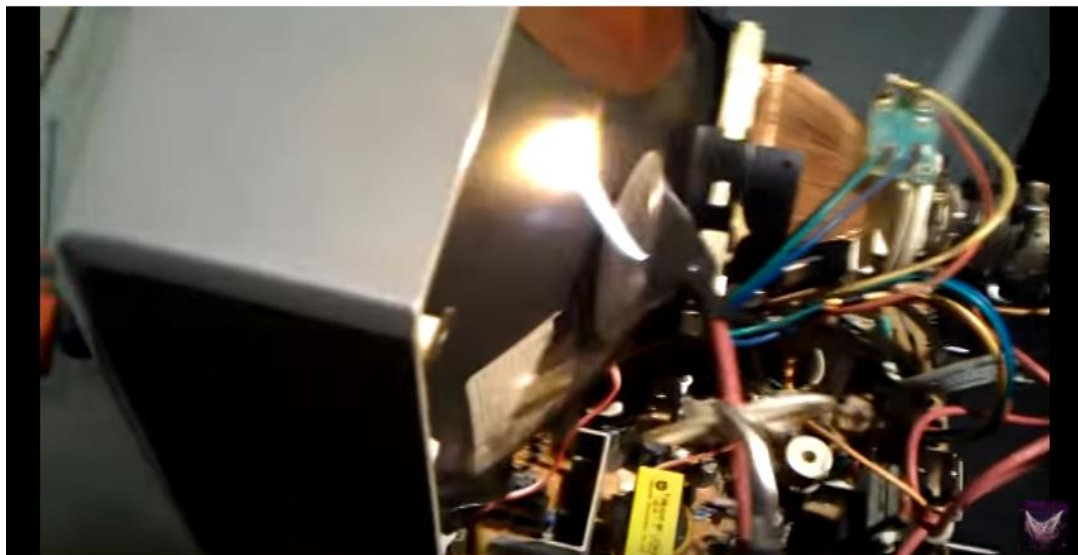


In this case, there is DC supply to FBT the output from red wire is positive but in case, of TVs and CRTs there is high voltage drive negative electrons from filament to Screen. The whole working can be seen from fig. 14



*Figure 15 Arc Producing from Setup with a small Setup*

But still this is not as powerful as it should be or the one I had August 2015, in India. To see that you can watch an equivalent here in fig. 15



*Figure 16 The FBT setup with arc effect*



### 3.4 Material Suggestion for Fencing

When the questions come in the mind that which metal should we choose for to fence here, then there is huge list of materials run in mind, some metals are highly conductive materials such as Silver and Copper, but these are very expensive material. Silver Price is 477.29 Euro / Kg. although Copper price lower than silver but it's still expensive. here you can find the list metals that are easily found around us in Table 6.

Table 6 Metal Conductivity Chart

Ranking	Metal	% Conductivity
1	Silver (pure)	105
2	Copper	100
3	Gold (Pure)	70
4	Aluminum	61
5	Brass	28
6	Zinc	27
7	Nickel	22
8	Iron (Pure)	17
9	Tin	15
10	Phosphorous Bronze	15
11	Steel (stainless Included)	3-15
12	Lead (Pure)	7
13	Nickel Aluminum Bronze	7

From table. 6 you can see that Silver, Copper and Gold are top three ranked Conductive material but the Price ranked are like Gold, Silver and Copper, and even Copper is expensive material for this project. But conductivity of Aluminum is juts right after gold and can be good choice from Conductive material under budget point of view.

The most commonly material for barbed wire fence is steel and steel as it's an iron alloy with small amount of carbon. The amount of carbon decided it's Mechanical Properties and influence its strength. To convert pig iron into steel we need to remove impurities and reduced amount of carbon content cause too much carbon makes it more brittle but removing all carbon

will also make it weak. And we need a flexible and ductile material which can bear lot more impact. Also, barbed wire coated with Zinc and Aluminum increases its conductivity comparatively high [13].

A steel wire with, aluminum or zinc galvanized give barbed wire long life by protecting it from Rusting and it has all mechanical strength need for barbed wire material because of steel. And aluminum is 4<sup>th</sup> most conductive material as mentioned in Table 6. As we haven't performed any conductivity test over this barbed wire yet, but we are assuming that, conductivity of Aluminum Galvanized steel would be same as Aluminum 67%.

By this we can save a more cost, as All aluminum barbed wire comes from a vendor in a price of \$239.98 for a roll of 1000' on another hand Galvanized wire is of \$145.86 for a roll of 1320' which means equivalent 1000' is of about cost of \$ 110.5. there is the \$129.48 difference on per 1000' roll. Which is more than the twice. [14].

### 3.5 Effect of Current on Human

The major purpose of this project to stay away invaders or other illegal immigrants from border for which we are using High Voltage current in fencing with the help of FBT. So, first understand what is current, voltage and resistance in reality.

- **Electric Current** is nothing but a flow of flow charge carried by electrons moving in wire. In case of electrolyte this charge carried by ions. It is also being consider as flow of charge per unit time. ( $I = Q/T$ ).

To better understand what is 1Amp lets have taken a look for calculation.

$$1 A = \frac{1 \text{ Coloumb}}{1 \text{ Second}} \dots\dots\dots (6)$$

A unit positive charge =  $1.6 * 10^{-19} C$

Hence, 1 Coulomb contains  $\frac{1}{1.6 * 10^{-19}} = 6.25 * 10^{18} \text{ Unit charges.} \dots\dots\dots (7)$

In other words, 6,250,000,000,000,000,000 electrons

In 1 Amp  $6.25 * 10^{18}$  electrons move in 1 sec.

- **Electrical Voltage:** voltage is difference in potential. We measure one volt when the difference between two points is equal to 1 C of electrons or  $6.25 * 10^{18}$  *electrons*.
- **Resistance:** As the name suggested it resist and it resist to flow of electrons but it in another word basically it is opposing the force that applied on electrons to flow, so basically it opposing the voltage

Now we have to understand that what actually kills or shock human when we touched a naked potentially wire. It's a current not a voltage. But voltage also play a significant role. Let's have a discussion over it.

Let's take a lead acid battery, it's of 12 V in most case, and can produce several amps, and when you touch it's both pole together with dry hand, nothing will happen. Cause there is no enough electromotive force that can push the electron into your body through your dry skin (as human dry skin has as much as 10,000 ohms' resistance). [15]

There is no particular value for voltage that can be dangerous, it depends on the scenario, how conductive you are, e.g. sometimes 50 V is hazardous and another time not, DC or AC (Frequency applied on it). Even though male and female as well as s deciding factor. [16]

Here is table.7 that tell every aspect we mentioned above:

Table 7 Index of Human intensity to bear the current. [16]

Bodily Effect	Direct Current	60 Hz AC	10 KHz AC
Slight Sensation felt at hand(s)	Men = 1.0 mA Woman = 0.6 mA	0.4 mA 0.3 mA	7 mA 5 mA
Threshold of Perception	Men = 5.2 mA Woman = 3.5 mA	1.1 mA 0.7 mA	12 mA 8 mA
Painful but voluntary muscle control maintained	Men = 62 mA Woman = 41 mA	9 mA 6 mA	55 mA 37 mA
Painful, unable to let go of wires	Men = 76 mA Woman = 51 mA	16 mA 10.5 mA	75 mA 50 mA
Severe pain, difficulty breathing	Men = 90 mA Woman = 60 mA	23 mA 15 mA	94 mA 63 mA
Possible Heart fibrillation after 3 secs	Men = 500 mA Woman = 500 mA	100 mA 100 mA	

In electric shock an electric current pass through the body, it takes, a path of least resistance and has a both entry and an exit point. The body resistance causing heating often resulting an external burn as well as a nerve and an internal tissue damage.

When the body becomes the path of an electric path the severity of shock depends on three elements:

- The Path of the current.
- The Amount of the current.
- The time in contact in current.

In this chapter I had described to design an electrical fencing with specially a Flyback Transformer which is very small and light weight to produce a huge amount of voltage with enough amount of current to keep away any human or living species (Invaders) from its set up with fencing. In this designing part, I mentioned what type of material we can use for making

fencing, to give strength and conductance power all together. Also, what shape we can use, what flyback parameter we need to keep in mind to use in practical use of it in electrical Fencing and how it works. Also, I described here electrical shock on human body both male and female with different amount of current.

In this electrical fencing designing part, I have shown here only theoretical assumption part as I wasn't allowed to make a physical setup for this, cause it's dealing with high voltage current, which need special take care in terms of human life. It's an Engineering challenge as well as challenge to a human life.

For thesis task, I compromise to make a physical setup but I made an alternative way to show the effect by showing this from research work and from YouTube video that it can actually work and how intense is flyback transformer.

## 4. FACE RECOGNITION

### 4.1 Introduction

Face Recognition system is a programming way to recognize human face, from a digital image or from a live video stream. Database of images of human face is play significant role in this technique. This is almost similar to human eye and brain combination. In human case when we see a person with very good interaction for certain period of time. We actually focused on his/her face and our eye works as camera to capture the image of that person. And rest work Is brain. It processes that image and stored in human database memory. So, when we see next time the same person. Our brain again capture the image of that person and our brain automatically start matching this new image with already stored database.

As if you we had good interaction with a particular person for a certain period of time so lest assume that our brain acquires lots of image of that person meanwhile whole interaction and brain made a separate folder for all his/her image in database folder. Our brain also does training with all these images to evaluate these how was the color, size, shape, expressions etc.

Now Face Recognition Techniques also works on same Principle we have Camera and Processor, a kind of artificial brain which can perform all the other task, such as processing Image, Store image (In a Separate memory), Train itself with all images and all other calculation.

In artificial or computer way of Facial Recognition techniques, we of course would need Hardware Equipment such as camera, Processor, cables, memory chip (Memory card or Hard Drive), apart from that we would also needed software tools, to support and run our main program Face Recognition. These supportive programs are known as Interpreters, Libraries, Packages, and all together they will help to write code to work together.

## 4.2 Method Use for Face Recognition

Face Recognition techniques always use for input as an Image or a Live Video stream. And an output always depends on database and training. Here database work as a reference to match and training works a for calculations between and input and reference picture. Face recognition system in simple terms have three step process shown in fig.17.

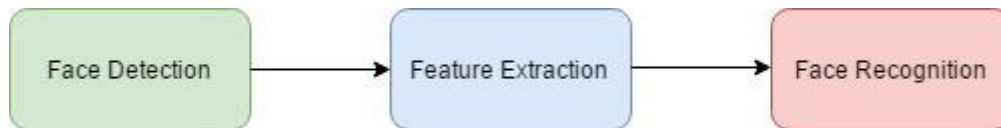


Figure 17 Process of Face Recognition

- **Face detection/ Face Tracking** is to extract face/s from a live video stream, it can be stable or it can be moving. In program output you see like a boundary around face can be rectangle or circle that we can easily defined in our program. See in fig. 18
- **Feature Extraction** names suggested that it extract feature of human face such as color complexity over different region, angle from point to point, distance from one point to another point.
- **Face Recognition** involves takes reference help from database after done above mentioned steps and if they found that features are matching from database document (image) it shows positive result otherwise negative.

Face recognition techniques somehow related from human ability to recognize near and dear one. When we first meet a stranger then his/ her face is totally fresh for us and we don't know anything about them, we meet them, we see them and capture their face image, extract their face feature, create a data set where and note down their entry with their details such as name, and other information they share. When we meet them again we capture their image and data set immediately start matching their face with stored images. In human brain this process is so fast that we don't realize this processing interval but older sometime do take time to remember even some known faces. It's deeper into Biological phenomenon, but we do almost similar in programming sense. [17]

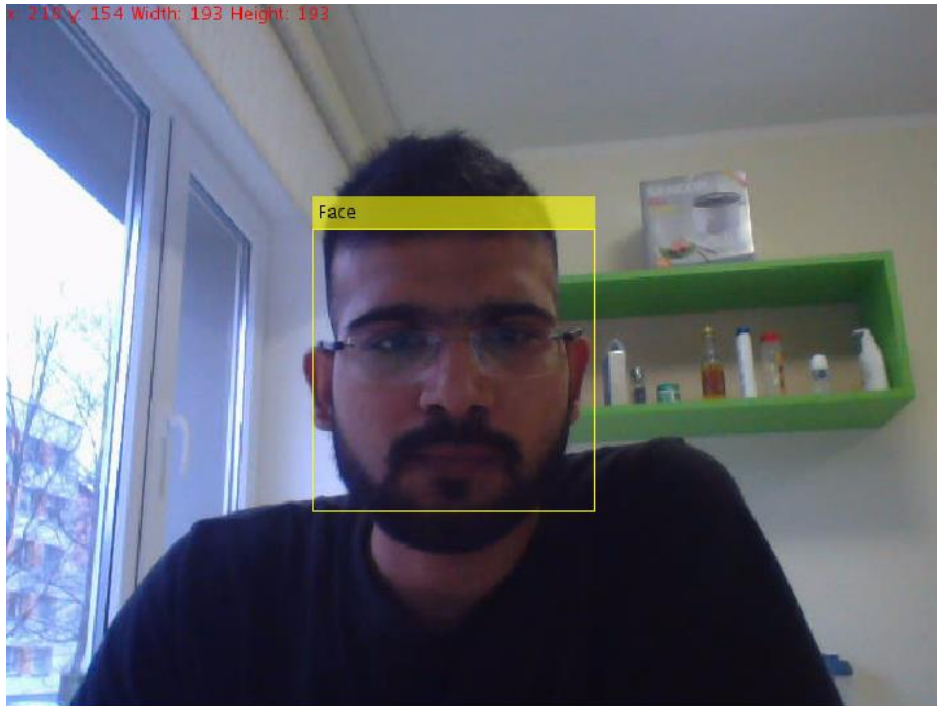


Figure 18 Face detect through live video stream

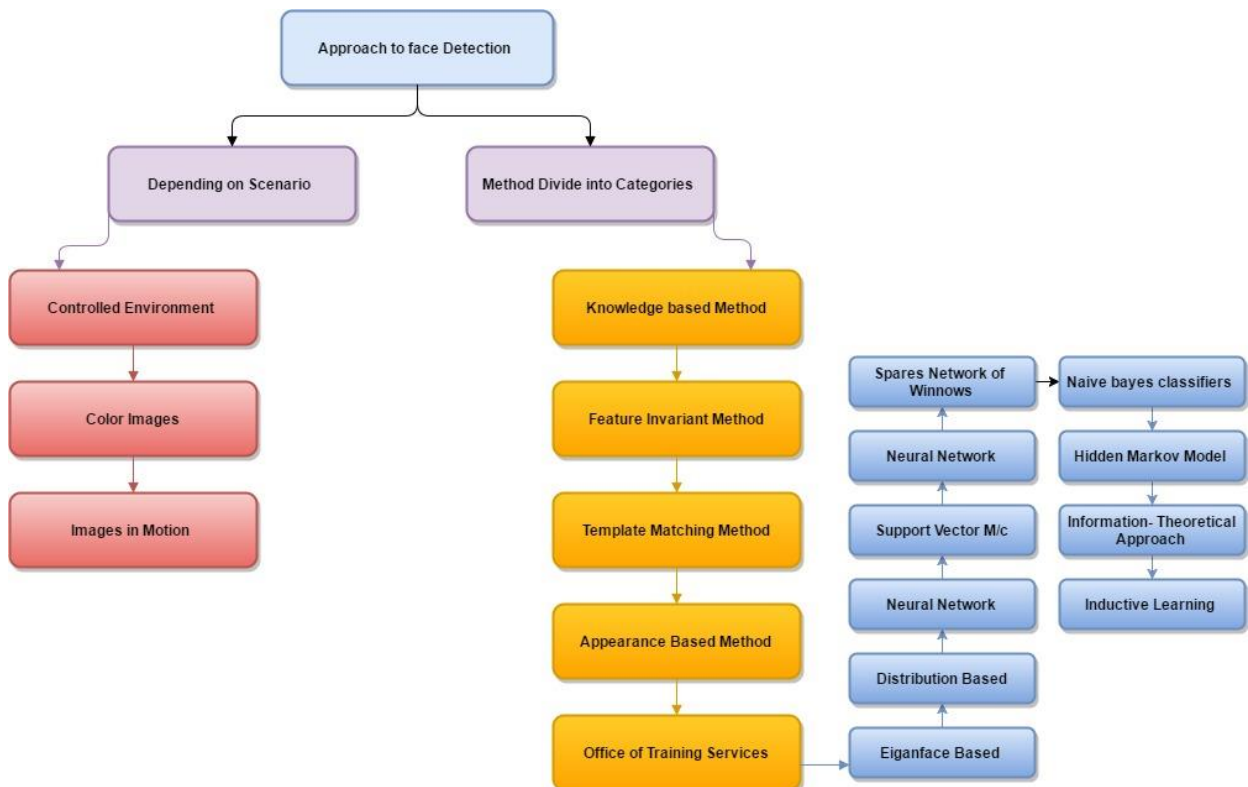


Figure 19 Face Detection Approach Chart



## 4.3 Software Using (Programming)

As I already mentioned in previous subchapter that, for this we would need a lot of many different supportive software which is also known as, IDE, Libraries, Packages. To support the main written program. It's all depends on:

- **OS system I am choosing:** *Windows*, Mac OS, Linux, or Android
- **Programming Language:** *Python*, MATLAB, C++, C, C#, Java.
- **IDE:** *IDE*, Visual Studio, MATLAB, Android Studio.
- **Packages:** Numpy (Numerical Configuration for Python Only),
- **Libraries:** *OpenCV*, EmguCV, Computer Vision Toolbox.

To write the face Recognition program there are almost all popular language for code writing are available such as C, C++, C#, Java, Python, MATLAB etc. but there is one very important thing which is almost common in all these languages to write this code is Computer Vision Library, which is also known as OpenCV or EmguCV. EmguCV is also OpenCV library but it just for .Net languages so for .Net languages there is a .Net wrapper on OpenCV.

### 4.3.1 OpenCV (Library)

OpenCV (Open Source Computer Library) is an open source computer vision machine learning software library. it provides an infrastructure for computer vision applications. Initially it was built by Intel Research Centre Novgorod, Russia.

OpenCV Library has more than 2500 algorithm related to Computer Vision and machine learning, which includes, Face detect and Recognition. Object Identification, Human Movements, Moving Object, Extract 3D models of objects, find similar image from database. Eye detection and trace eye movements etc. it's purely written in C++ but support almost all other languages to use. Another good feature of it is that, it runs on all popular Operating system. Such as Windows, Linux, Mac OS, and Android. [18].

### 4.3.2 IDE (Integrated Development Environment)

Integrated Development Environment is a software application that provide numerous feature that helps a programmer to develop the other software's. the basic features of an IDE are Source Code Editor, build automation and debugger. The good thing about IDE is that it can be customized by user according to requirements.

Some basic features of an IDE are: [19]

- Source Editor
- Debugger
- Compiler
- The Explorer
- Data File Viewer
- Data Dictionary
- The Form Builder

Here are some IDE which I dealt during learning Image Processing,

- IDLE – Python
- Microsoft Visual Studio – C#, C++
- Android Studio – Java
- MATALB – MATLAB

## 4.4 Hardware Use

In Hardware section, I manly will talk about all those hardware that will directly involve to our requirement here, such as the motherboard we are going to use, which includes all its major specifications, such as processor to RAM / ROM, Graphical Unit. Apart from it, another most important hardware is Camera.

### 4.4.1 Motherboard:

As this Project is dedicating for defense need, so the final product which would be different from what we are doing here, we can't strictly suggest a microcontroller for that requirement,

but it would be better that an advanced processor with Higher clock speed, enough RAM, and ROM, GPU is most advisable.

With Technology , it's sure that, it's going to be obsolete, but as we are using for only one purpose "Image Processing" we don't need to worry about obsolete of this.

Almost all big armies have separate research department which can better help to design and customized their requirements with consideration of future aspects to save from obsolete problem.

The Configuration of my laptop under which I build and run this Face Recognition Program is as follows:

- Intel Processor I5 3<sup>rd</sup> Gen processor with 2.5 GHz speed with 64 bits OS.
- 8 GB Overall RAM, out of which
- With no graphic Card, only Graphic supported by Processor.
- Camera VGA 1.3 MP.

The other good option for prototyping is a separate mother board such raspberry pi 2 (just for prototype) and later. As it has ability to install almost all type of OS except Mac OS. Which makes it is easy to work on all other things as well. Such as Open CV, IDE and other packages.

Feature of Raspberry pi 3 B: [20]

- CPU: Quad-Core 64-Bit ARM Cortex A53 Clocked at 1.2 GHz
- GPU: 400 MHz VideoCore IV Multimedia
- Memory :1 GB LPDDR2 RAM at 900 MHz
- Video Output: HDMI, Composite video (PAL and NTSC) via 3.5 mm jack
- Network: 10/100 Mbps Ethernet and 802.11n Wireless LAN
- Bluetooth: 4.1
- Power - 1.5 W idle to 6.7 W under high load. Via Micro USB.



Figure 20 Raspberry Pi 3B

One more good thing about is, that you can attach a separate screen or better you can add your tablet or phone with the help of Bluetooth and can modify anything in raspberry pi itself. With the help, of Bluetooth keyboard-mouse combo (shown in fig.18) you can make changer in code from anywhere, within its without even go near to system.



Figure 21 Promini wireless Keyboard with trackpad

#### 4.4.2 Camera

In my working I used only laptop cam but another prototype cam with Raspberry PI can be Raspberry PI cam or Raspberry PI spy cam both are tiny and very tiny. I would recommend spy cam as we are using this for security purpose and this cam is smaller than my thumb nail.



*Figure 22 Raspberry Pi spy cam*

It features are as follows: [21]

- HD video camera for raspberry pi model A/B/B+ Pi 2 & 3.
- 5 MP Sensor with Omni vision OV5647 sensor in a fixed focus lens.
- Integral Infrared filter.
- Angle of View: 54 x 11 degrees
- Field of view: 2.0 x 1.33 at 2 m
- Full frame SLR lens equivalent: 35mm
- Fixed Focus: 1 m to infinity
- Still picture resolution: 2592 x 1944
- Max video resolution: 1080P
- Max frame rate: 30fps
- Size: 300x16 mm flex cable, neck wide is 6 mm

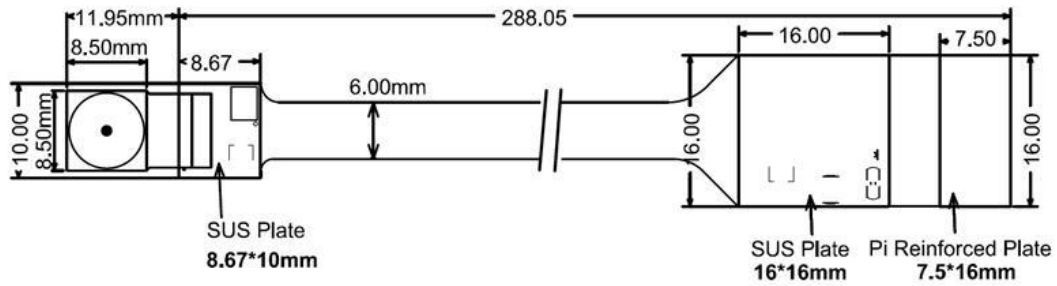


Figure 23 Mechanical design of pi spy cam

From fig. 20 you can have an idea how compact it is, so at least this spy cam project can work in house or college to detect faces and notifying activities. To better have faith of its ability, let's have a look for on its picture quality, I took a snap from a video made by it (shown in fig.24) this video was made from a moving car on road from its front glass, so there was movement as well but still it was working fine.

The quality of live stream video was little dim under shadow which you can see from another part of fig.25. which is may not being a satisfactory result for this type of Project.

As this is just a prototype so here we can compromise with different weather face, but for real scenario on border, we need to choose something better camera according to geographical location and weather related to it.



Figure 24. Pi spy cam video resolution test result (With good lighting)



*Figure 25. Pi spy cam video resolution test result (Under Shadow or Low Light Intensity)*

#### **4.5 Algorithm Use (Description):**

An algorithm is nothing but a formula or computational method to solve a problem, and in our case, the problem is to recognize a face. In programming, it is widely used to solve the problem and then rest in code is just structure, classes, and syntax, then the main thing is algorithm work behind the program.

There are many algorithms for image recognition, but OpenCV provides three methods for face recognition and those three most popular algorithms are as follows:

- Eigenfaces
- Fisherfaces
- Local Binary Patterns Histogram.



### 4.5.1 Eigenfaces:

It's a set of eigenvectors use for computer vision program for face recognition. It was developed by developed by Sirovich ad Kirby and used by Mathew Turk and Alex Pentland first time for face classifications.

Facial recognition involves deviation of image data into several classes. Sometimes these input signals are highly noisy due to different lighting conditions, pose, etc. still these images are not totally random and despite of their difference there are patterns which occurs in any input signal. All the pattern which can be visualize in every signal could be in signal of facial recognition. The presence of few objects such as (eyes, mouth nose etc.) and relative distance between this objects in any face is considered as eigenface in face recognition program. It is also known as principal components generally. [22]

With the help of PCA we can transform original image into Eigenfaces. it's another feature is that you can again reconstruct an original image by combining of eigenface from training set. It's actually a group of features extracted from face image in terms of computational. Once you divided in the form of eigenfaces and can again reconstruct by combining in the appropriate proportion like a childhood game Jigsaw puzzle shown in fig. 26



Figure 26 Jigsaw Puzzle describing the Eigenface Pattern



From the above you can see not all the broken pieces are combined, but we can still find that it's a horse picture. Same applied here sometime without even combine all eigenfaces.

**A. Calculation for Eigenfaces: PCA**

Let  $X = \{x_1, x_2, \dots, x_n\}$  be a random vector with observations  $X_i \in R^d$ .

1. Compute the mean  $\mu$

$$\mu = \frac{1}{n} \sum_{i=1}^n x_i \dots \dots \dots (8)$$

2. Compute the Covariance Matrix S

$$S = \frac{1}{n} \sum_{i=1}^n (x_i - \mu)(x_i - \mu)^T \dots \dots \dots (9)$$

3. Compute the eigenvalues  $\lambda_i$  and eigenvectors  $v_i$  of S

$$Sv_i = \lambda_i v_i, i = 1, 2, \dots, n \dots \dots \dots (10)$$

4. Order the eigenvectors descending by their eigenvalues. The K principal components of the observed vector x are given by:

$$y = W^T(x - \mu) \dots \dots \dots (11)$$

Where  $W = (v_1, v_2, \dots, v_k)$

The reconstruction from the PCA basis is given by:

$$x = Wy + \mu \dots \dots \dots (12)$$

Where  $W = (v_1, v_2, \dots, v_k)$

Face recognition from eigenfaces method is performed by:

- All the training samples projecting into PCA Subspace.
- All the query image projecting into PCA Subspace.
- Finding nearest neighbors between the projected training images and projected query images.

To better understand this let's take an example, suppose we have 300 images dataset, each sized 100 \* 100 pixel. PCA solves covariance matrix  $S = XX^T$ , where size (X) = 10000 \* 1000 matrix, it not feasible to solve this problem, so we will use a linear algebra to solve this, that M \* N matrix with M > N can only have N -1 non-zero eigenvalues. Now it's possible to take the eigenvalues decomposition  $S = XX^T$  of size N \* N instead:

$$X^T X v_i = \lambda_i v_i \dots\dots\dots (13)$$

And get the original eigenvectors of  $S = XX^T$  with a left multiplication of the data matrix:

$$XX^T (X v_i) = \lambda_i (X v_i) \dots\dots\dots (14)$$

10 to 15 eigenvectors are not good enough to reconstruct an image, 50 can be good enough but it's still depend on input data that what are the conditions of an input image. For AT&T Face database at least 300 Eigenvectors are required. [2]

**B. Overview of the algorithm: Flow chart**

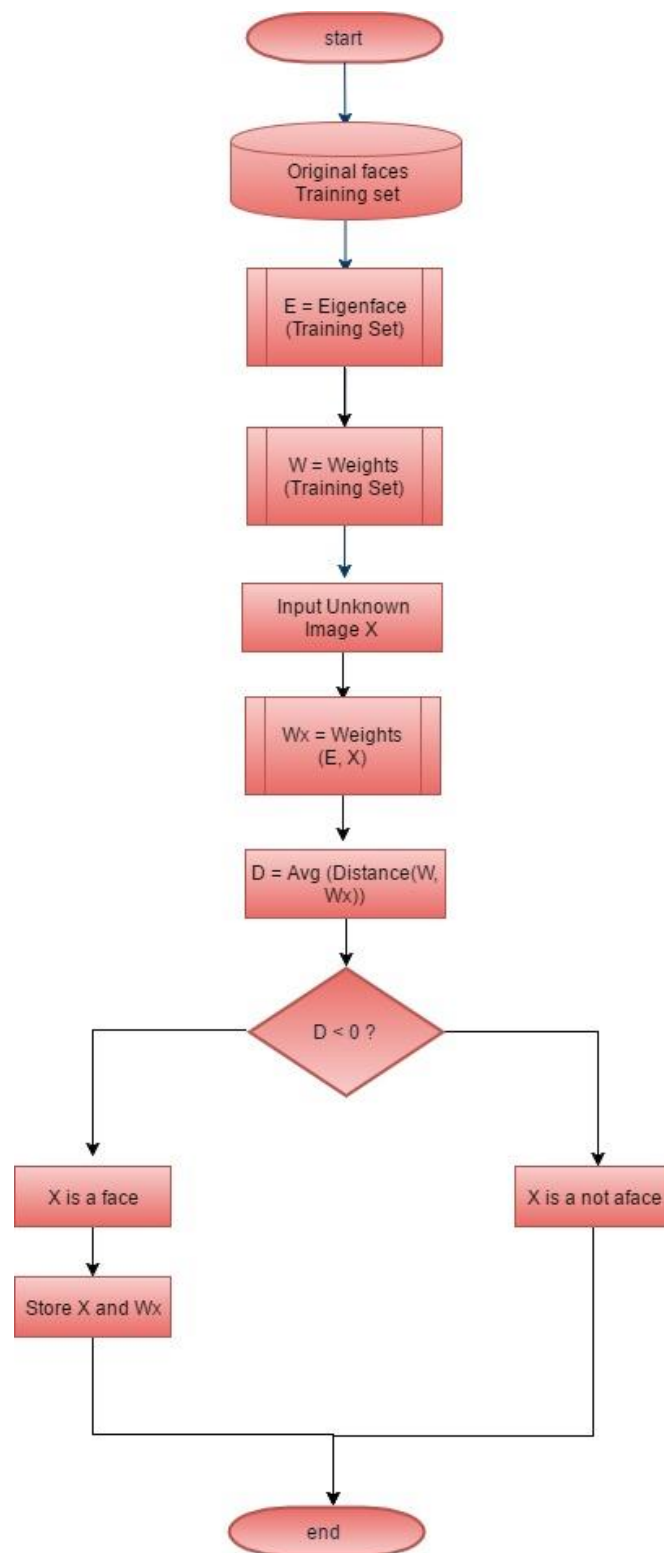


Figure 27 Flowchart of Eigenfaces Algorithm

### 4.5.2 Fisherfaces:

The major functionality in computer vision, pattern recognition and machine learning is to represent an appropriate data for given problem.

It can be done by using PCA method when using on face image. This method takes a set of eigenfaces and these eigenfaces are connected with largest eigenvalues of covariance matrix of the training data. So, the eigenvectors found more near to least-square (LS) solution. it's a strong way to represent the data as it is make sure the data variance is maintained while removing unusual existing correlations among the original features in sample vectors.

But when our goal is classification rather than representation, the LS solution may not give the best desirable results. Then the solution is to find a subspace the locate the sample vectors of the same class in a single spot of the feature representation and those of different classes as far apart from each other as possible. This technique use, to achieve this goal is known as Discriminant Analysis (DA) also known as Linear Discriminant Analysis (LDA), which was suggested by first R.A. Fisher in 1936.

When this method is used to find subspace representation of a set of face images, then the resulting vectors presenting the space which is known as Fisherfaces. [24]

#### A. Algorithm calculated Method

Let  $X$  be a random vector with samples drawn from  $m$  classes:

$$X = \{X_1, X_2, \dots, X_m\} \dots\dots\dots (15)$$

$$X_i = \{x_1, x_2, \dots, x_n\} \dots\dots\dots (16)$$

Now scatter matrices  $S_B$  and  $S_w$  are calculated as:

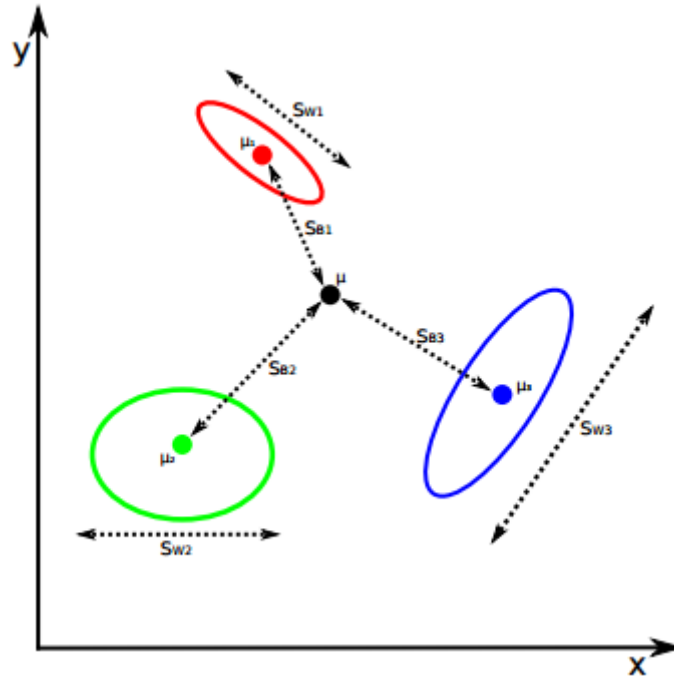


Figure 28 Scatters matrices  $S_B$  and  $S_W$  for a 3-class problem

From Figure 28 you can see the scatter matrices  $S_B$  and  $S_W$  for 3 class problems,  $\mu$  represents the total mean and  $[\mu_1, \mu_2, \mu_3]$  are the class means.

$$S_B = \sum_{i=1}^c N_i (\mu_i - \mu)(\mu_i - \mu)^T \dots\dots\dots (17)$$

$$S_W = \sum_{i=1}^c \sum_{x_j \in X_i} (x_j - \mu_i)(x_j - \mu_i)^T \dots\dots\dots (18)$$

Where  $\mu$  is the total mean:

$$\mu = \frac{1}{N} \sum_{i=1}^N x_i \dots\dots\dots (19)$$

And  $\mu_i$  is the mean of class  $i = \epsilon \{1, \dots, c\}$ :

$$\mu_i = \frac{1}{|X_i|} \sum_{x_j \in X_i} x_j \dots\dots\dots (20)$$

Fisher's classic algorithm now looks for a projection  $W$ , that maximizes the class separability criterion:

$$W_{opt} = \arg \max_w \frac{|W^T S_B W|}{|W^T S_W W|} \dots\dots\dots (21)$$

By solving this General Eigenvalue problem, we could give a solution for this optimized problem:

$$S_B v_i = \lambda_i S_W v_i \dots\dots\dots (22)$$

$$S_W^{-1} S_B v_i = \lambda_i v_i \dots\dots\dots (23)$$

In above equation, the value of  $S_W$  is at most  $(N - C)$ , with  $N$  samples and  $c$  classes. In pattern recognition problems, the number of samples  $N <$  the dimensions of input data (number of pixels). so, the scatter matrix  $S_W$  becomes singular. This was solved by PCA on data and projecting and samples into the  $(N - C)$  dimensional space.

A LDA was then performed on reduced, because  $S_W$  isn't singular anymore.

Now the optimization problem can be written as:

$$W_{pca} = \arg \max_W |W^T S_T W| \dots\dots\dots (24)$$

$$W_{fld} = \arg \max_W \frac{|W^T W_{pca}^T S_B W_{pca} W|}{|W^T W_{pca}^T S_W W_{pca} W|} \dots\dots\dots (25)$$

The transformation matrix  $W$ , that projects a sample into the  $(c-1)$  dimensional space is then given by:

$$W = W_{fld}^T W_{pca}^T \dots\dots\dots (26)$$

Although  $S_W$  and  $S_B$  are symmetric matrices, but the product of two symmetric matrices is not always symmetric. So, we have to use an eigenvalue solver for general matrices. [25]

## B. Overview of algorithm: Flowchart:

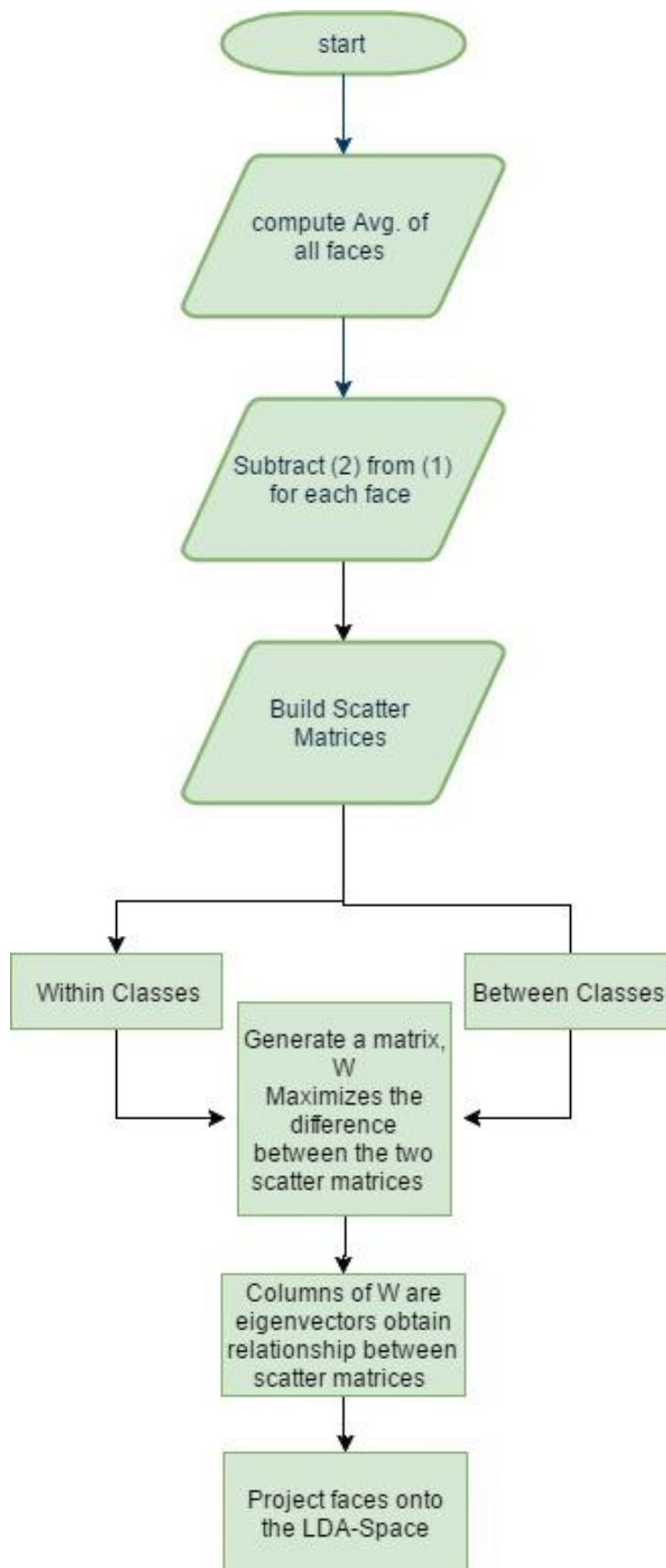


Figure 29 Fisherfaces Flowchart

### 4.5.3 Local Binary Pattern Histogram:

Eigenfaces and Fisherfaces notice most dominant feature of the training set by calculation method. While LBPH analysis each face image separately and independently. The LDA approach from Fisherfaces algorithm, maximizes the total scatter which “we discussed in previous sub chapter” which generate problem if the variance is generated by external source. To save some discriminative information we had used linear Discriminative Analysis method and optimized in Fisherfaces algorithm. Fisherfaces worked well but you can’t say if it will work in all type of lightning condition in Image Dataset of let’s say 10, but what If there is no dataset of 10 images, just one image? Covariance estimates for subspace can be go wrong.

In order to get desired result for recognition pattern, you will need at least more or less 8 images for each person, and here Fisherfaces method really don’t help much.

The general working idea of Local Binary Patterns is as follows:

- Summarize the local structure in an image by comparing each pixel in its neighborhood.
- Take a pixel as center and compare its intensity with its neighbor’s pixel.
- If the intensity of pixel is greater or equal assign a 1 else assign a 0.
- You will get a binary number for each pixel e.g. 11001111.
- For 8 surrounding pixels, you will get  $2^8$  possible combinations.
- The above process is known as Local Binary Pattern or LBP codes.
- To understand above statements, refer fig. 30 to see the how it works.

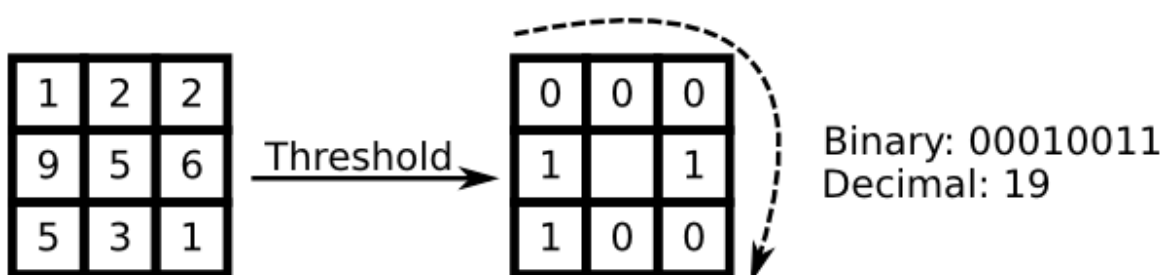


Figure 30 Basic LBP Operator.



**A. Algorithm Calculations:**

A general equation of LBP operator is known as:

$$LBP(x_c, y_c) = \sum_{p=0}^{P-1} 2^p s(i_p - i_c) \dots \dots \dots (27)$$

Where  $(x_c, y_c)$  as central pixel with intensity  $i_c$  and  $i_n$  being intensity of neighbor pixel.

And  $s$  is the sign function defined as:

$$s(x) = \begin{cases} 1 & \text{if } x \geq 0 \\ 0 & \text{else} \end{cases} \dots \dots \dots (28)$$

This method enables us to find tiny amount of detail in images. The idea here is to align an arbitrary number of neighbors on a circle with a variable radius, which make it to capture following neighbor pixel.

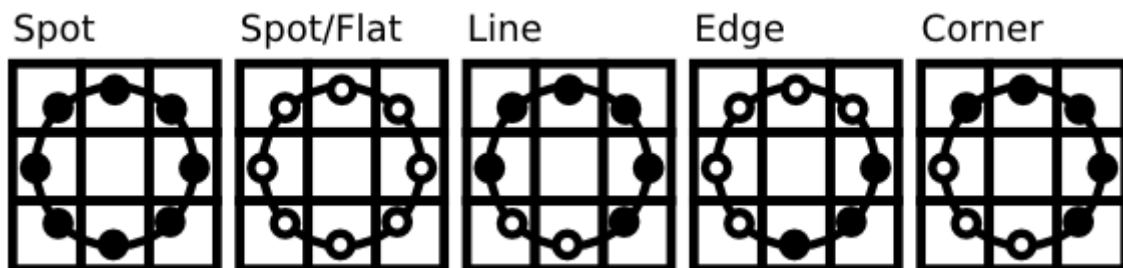


Figure 31 LBP pixel Spot Pattern

So, for given point  $(x_c, y_c)$  the position of the neighbor  $(x_p, y_p), p \in P$  can be calculated by:

$$x_p = x_c + R \cos\left(\frac{2\pi p}{P}\right) \dots \dots \dots (29)$$

$$y_p = y_c + R \sin\left(\frac{2\pi p}{P}\right) \dots \dots \dots (30)$$

Where  $R$  is the radius of the circle and  $P$  is the number of sample points.

From the fig. 31 it can be seen, If the point coordinate on a circle doesn't correspond to image coordinates then these get interject. Computer technology has few interpolation schemes and OpenCV use bilinear interpolation.

$$f(x,y) \approx [1-x \ x] \begin{bmatrix} f(0,0) & f(0,1) \\ f(1,0) & f(1,1) \end{bmatrix} \begin{bmatrix} 1-y \\ y \end{bmatrix} \dots\dots\dots (31)$$

From LBP definition, you will notice that it's robust against monochromatic, gray scale transformations. You can see this in fig. 32. [25]

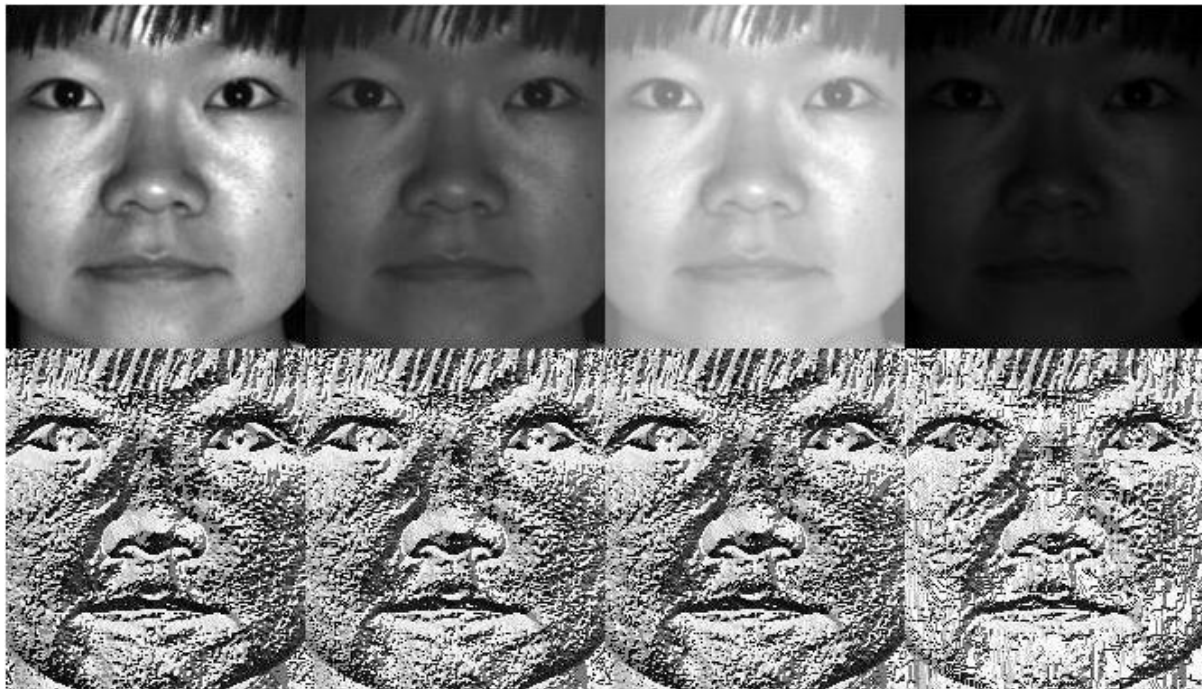


Figure 32 Effect of grey scale image in different light with correspond LBPH

## B. Flow chart of LBPH Process:

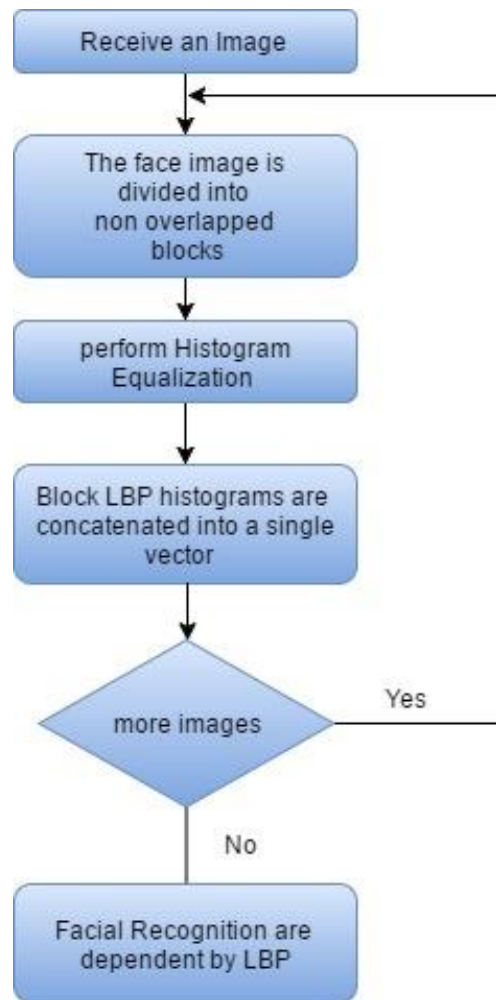


Figure 33 Flow Chart of LBPH Process

## 4.6 Task Procedure:

In this sub chapter I am going to perform the whole task, how it should be done and what I have done, related from face recognition. As I have done all my programming work only on my laptop, with following configurations.

- HP Pavilion G6, 2221TU, i5 3<sup>rd</sup> Gen, 2.5 GHz, 8GB RAM,
- Window 10, 64 Bit
- OpenCV 2.4.11
- Python Shell (IDLE), 2.7.13

But here in procedure I am also going to explain you with the following upgradation in prototype with Raspberry PI

- Raspberry PI 3 B, with Pi Spy cam.
- Linux (Ubuntu MATE)
- OpenCV
- Python Shell (IDLE)

#### 4.6.1 Setup in Windows: (Windows 10 + Laptop)

##### A. Installing Python 2.7

- I downloaded Python for my Windows version from [here](#). There are two versions 3 Series and 2 Series, and I used 2 Series with 2.7.13 latest version available.
- Now install the Setup which is not a big deal just click and next and next and so on.

##### B. Installing OpenCV:

- Download OpenCV from [here](#) the Series and Version you need, in my case I am using Python 2.7.13 so its series 2. OpenCV is also available in series 2 & 3, So I choose OpenCV 2.4.11
- You can now extract this, as it is like a zip file of Library, but set the path of C:\ drive so there you will a separate folder with name OpenCV.
- Now open this *OpenCV— build — python — 2.7 — x64 — “cv2.Pyd”*. copy that file “*cv2.Pyd*”.
- Go to C:\ — *Python27 — Lib — site-packages* and paste this file here. It will ask whether you want to replace the file, press *yes*.

##### C. Set up python script path under System Environment Variable:

- Right click on *This PC – Properties – Advance System Settings (over land side) – in System properties – Environment Variables – Under System Variables* click on *Path* and *Edit*. as shown in fig. 36

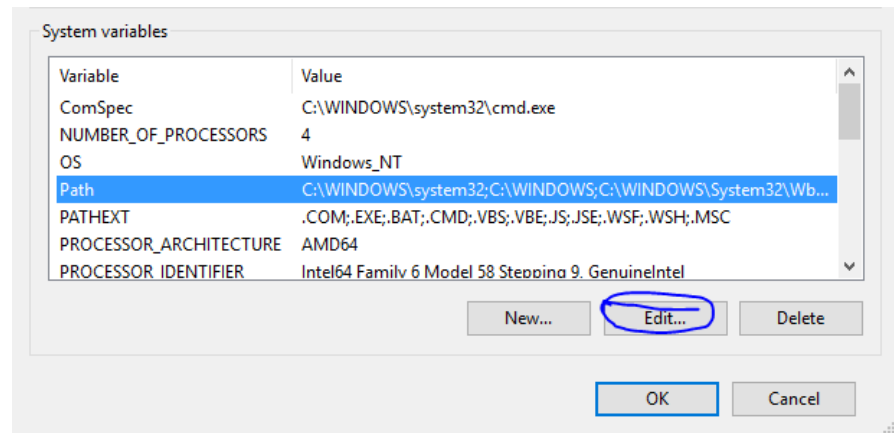


Figure 34 Path Environment

- You will have *edit Environmental Variable* as shown in fig. 37, click on *new* and paste the path of scripts `C:\Python27\Scripts` and Press *OK*.

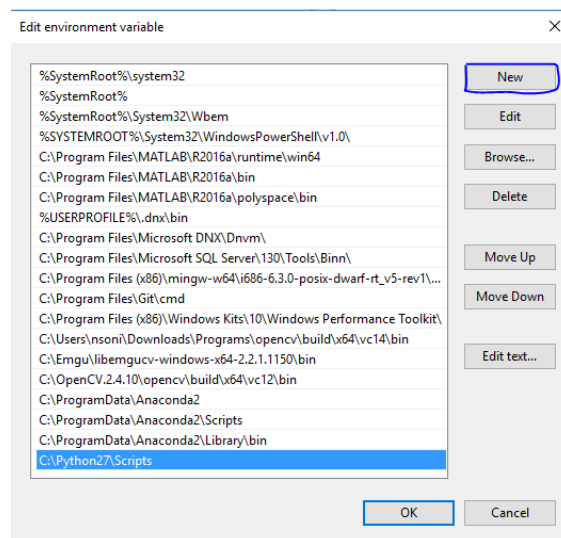


Figure 35 Environmental Edit Console

#### D. Install Packages: **pip**, **numpy**, **scipy**, **matplotlib**

##### **pip**

- First of download **pip** from [here](#) you will see there is a link, just right click over there and *save as* where ever you want.
- Now just run by double click on it.
- Now go to CMD and type pip and if its recognizing it means pip is install successful.

##### **Numpy**

- One method is directly download the setup and run. But there is another very cool method which I like most.
- Go to *C:\python27\Scripts* folder and make a new text file and named it *local.bat*, yes change its file type from *.txt to .bat*.
- Now right click and Edit and type *cmd* in it.
- Close it, and run it, you will have command prompt with python script path.
- Type command “*pip install numpy*” there.
- In the same way, you can download *scipy* and *matplotlib* as well, but sometime it works sometimes not, if it works than good for you, but another alternative way I am going to explain in next point.

### Scipy

- Download scipy from [here](#) there you will find different files, you need to download your working file such as I am working on python 2.7 on windows so I need to choose accordingly.
- Now when you have setup file, just run it like all normal simple software installation, next and next.

### E. SQLite

- Download the setup from [here](#) of latest release of SQLite studio.
- Now extract the zip file and you will get the folder
- Open the folder and double click on *SQLiteStudio.exe* and you will get the respective window. Shown in fig. 36
- Create a database as shown in fig. 37 and set the path of the database wherever you want. Just remember the path of the database. It will help in to connect with program.
- Now in database window on left hand side of SQLite Studio window. **Double click** on it, and you will find a table, now create a table by providing it name as shown in fig. 38
- Rest of the step you can see in fig.38 itself what to do.

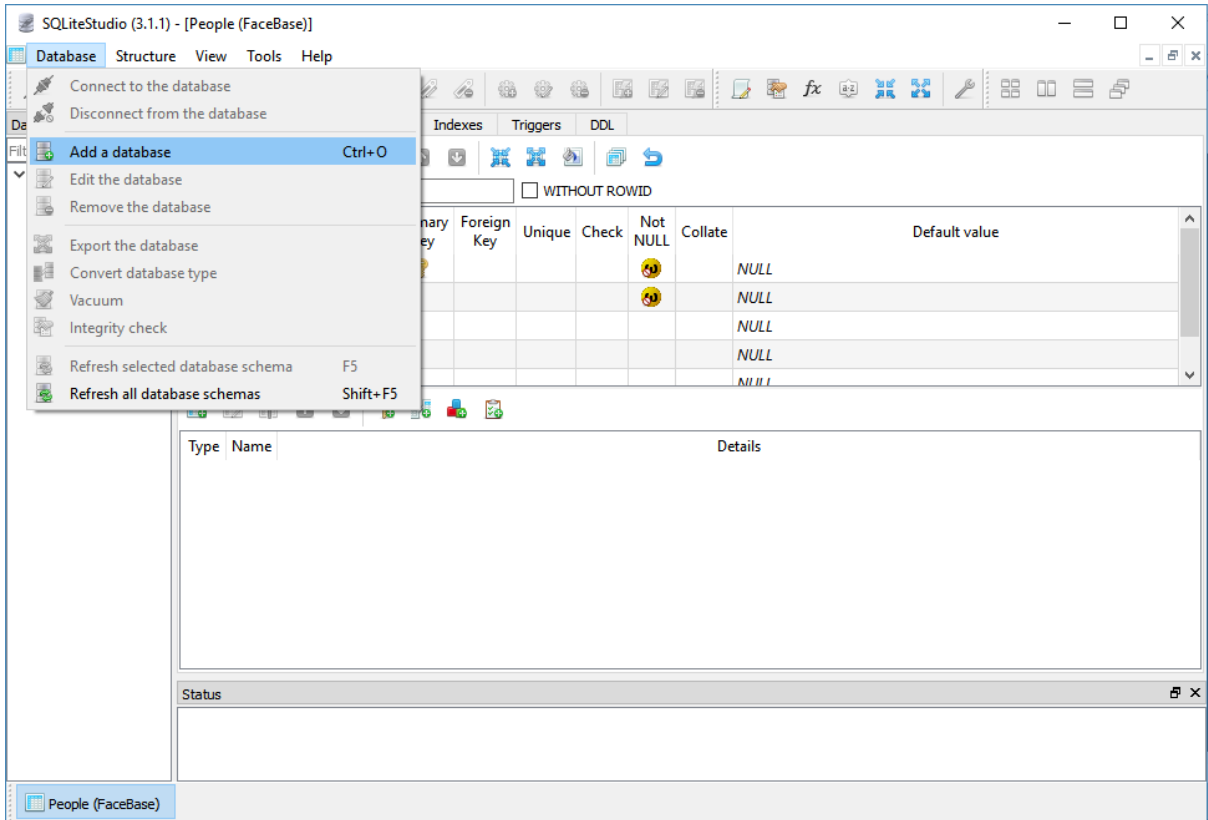


Figure 36 SQLite Studio (Add Data base setup)

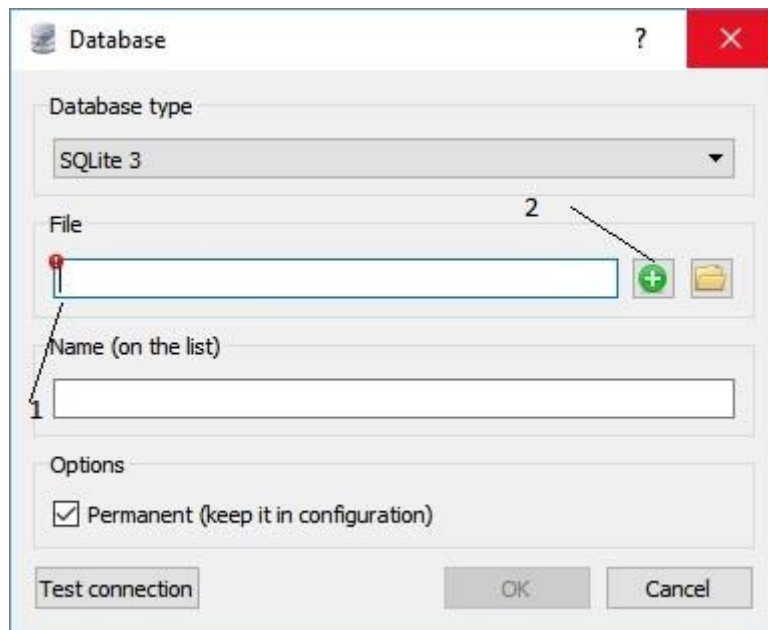


Figure 37 Create a database, 1 add the name of database file, 2 give the path to database where you need to save this data base file

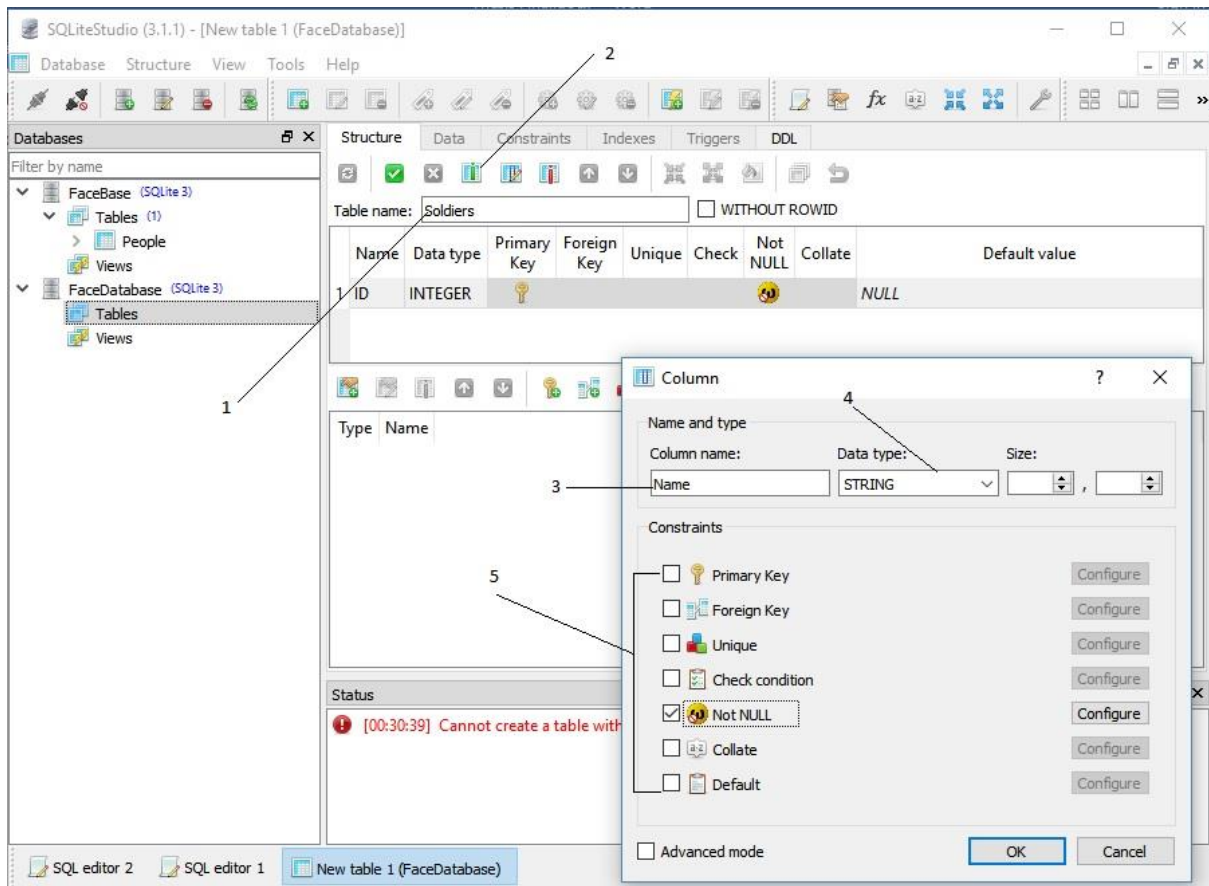


Figure 38 SQLite Database Table Create and Configuration, 1. Assign a table name, 2. Create a column in table, 3. Column Name (Choose as you want), 4. Data Type such as for Age it would be integer as Age is number, 5. Constraints to define its importance.

- Don't forget to give the table name as it is important to save the data entry as well as to call this data type into your program.
- Once you done with creating table, it's time to feed the data into table by go to **Data** next right to **structure**
- There you can add the entry of you person, such as Name of person, age of person, Gender of Person, & if He/she has a criminal record or not.

For more detail of setup there are more tutorial and blogs over internet. There is no hard reason to choose Linux over windows is that, ease of setting up of Linux with Raspberry pi and OpenCV and Python. I could have used Linux on my own system but I am using windows laptop already, and also with this way I got a chance to learn both way to setup.



## 4.6.2 Setup in Linux (Ubuntu + Raspberry PI)

### A. First of all, make a list what we need for this:

I haven't tried yet this, I really don't know what are the problems I am going to be face, with this setup, I am just mentioning step on the basis of Video tutorials I saw on YouTube. These steps are based just step by step what actually needed. As we know this that Raspberry PI supports Ubuntu and its works same as in laptop. So, I am my all steps are connected from to another by different tutorials.

Table 8 List of Hardware and Software need to build Raspberry setup for face Recognition

	Hardware	Software
1.	A monitor screen/TV	Win32diskImager ( <a href="#">here</a> )
2.	Raspberry Pi 3 B	RASPBIA O.S ( <a href="#">here</a> )
3.	Memory Card (Recommended 64 GB, Class 10)	Ubuntu MATE 16.04.2 LTS ( <a href="#">here</a> )
4.	Keyboard mouse (Better if use Bluetooth Combo)	OpenCV 2.4.11
5.	HDMI cable	Python 2.7 Linux Version
6.	Internet (Ethernet Cable)	

### B. Install Ubuntu

- Install and Open win32diskmanager and inject your SD Card into your system, so that you can detect your card, on top right corner just below the cancel option under “*Device*” fig.34.
- Now Select under “*Image File*” select the path of where “*Ubuntu*” setup is located. and press the button *write* Refer fig.34.

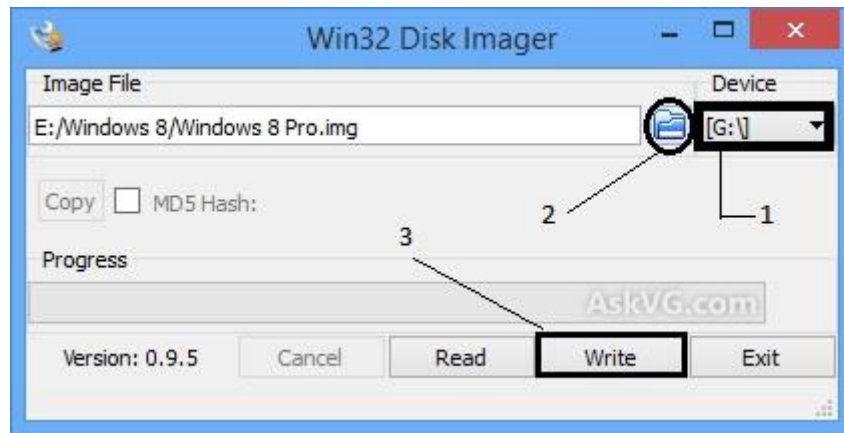


Figure 39 Win32diskManager

- Now a pop up asked if you want to format your SD card, press “Yes”
- Later just will select some bunch of option selection such as region and Wi-Fi.
- You will have GUI for ubuntu as shown in fig. 37

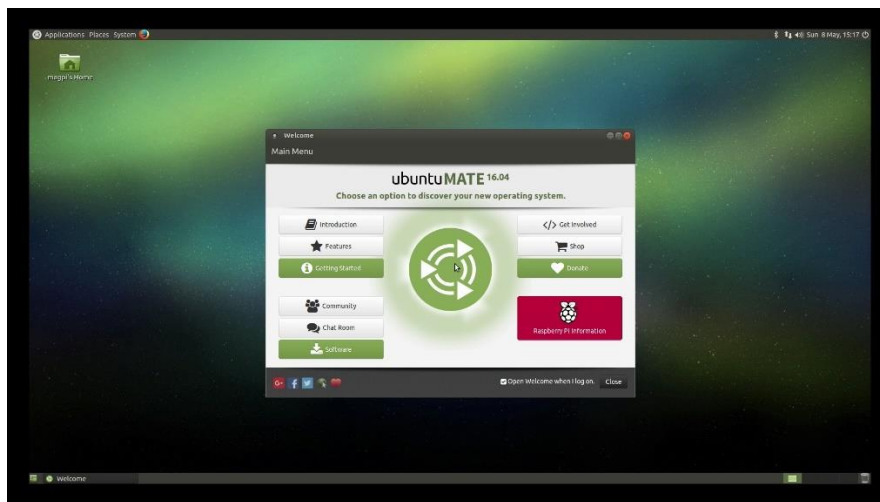


Figure 40 Ubuntu Mate 16.4.2 in Raspberry Pi 3

### C. Python Setup in Linux – Raspberry Pi

- In Linux, it's totally different from Windows, you need to just find the “**Terminal**” to install software, you can just directly find from search box.
- Open Terminal. And paste the bellow commands, these are prerequisites for python

```
$ sudo apt-get install build-essential checkinstall
```

```
$ sudo apt-get install libreadline-gplv2-dev libncursesw5-dev libssl-dev libsqlite3-dev  
tk-dev libgdbm-dev libc6-dev libbz2-dev
```

- Now changing the directories from “terminal” by typing the command.e.g.  

```
$ cd /usr/src
```
- Now Paste the below command to download and install Python directly into you Ubuntu.  

```
$ sudo wget https://www.python.org/ftp/python/2.7.13/Python-2.7.13.tgz
```
- For Extracting first repeat that change the directory command, step 3 here.  

```
$ tar xzf Python-2.7.13.tgz
```
- For compiling  

```
$ cd Python-2.7.12  
$ sudo ./configure  
$ sudo make altinstall
```
- Check the Python version  

```
$ python2.7 -V
```

#### D. OpenCV 2.4.11 for Linux

- Download the version of OpenCV and extract it, wherever you want just remember its location.
- Also download a file opencv.sh from [here](#).
- 
- Now Open “*terminal*” and set the path location where it was extracted. Such as type  

```
$ cd /usr/src
```
- Now type the below command to download the setup and just click Enter.  

```
$ ./opencv.sh
```
- In couple of minutes it will all setup and you will see the message in terminal  
*“opencv2.4.11 is ready to be used”*
- Now add commands  

```
$ . pkg-config --cflags opencv  
$ . pkg-config --libs opencv
```

#### E. Install Numpy

- Clear before begin the new step, just for cure, and now type  

```
$ pip install numpy
```

## 5. FACE RECOGNITION RESULTS

To run this program following are the steps:

1. Run the scripts *DataSetGenerator* which will ask *user id* as well “*Name*” so that when the camera will turn to capture your image it will take all **21 images** under one dataset named *userID 1* or *userID 2* and so on.
2. Now run the second script, *Trainer*, which will train this network and send the all image details into form of matrix into *.yml* file where face feature saved in the form of digits.
3. Now run the third script *detector* where it opens the camera and taking live stream of camera and taking image and extracting facial feature and matching with already saved feature for the same face.
4. For the detail of respective person go to *FaceBase.db* file to save the information for the respective person. Such as his *Age, Gender, His Criminal Record*.
5. By running the script *detector*, it would start detecting the face once you will see live camera screen, if the above all step had done very well.

For the testing propose I used this on twin’s bothers, to just to check this if it work on find with identical faces or not. It was working fine or I can say satisfactory, but with some noise as well, as this face recognition is just all about mathematical calculation it takes lot of computational process which need a strong processor which can process very fatly. For this I even measure the processing time of both the things that my processor speed how fast is my processor is working and to compare this also how fast the CPU is processing my program, as my programs is not a single script I am using the comparison time for all three individually.

In terms of Quality of face recognition, It has some noise effect also due to camera quality, as well as lighting effect, on face. Professional software is done on professional database created by professionals under labs such AT&T face database. But here I used this technique to just capture the face from laptop cam. Which will not give a professional level database.

But overall this was working fine and was able to even recognize twin’s brothers with another non-similar face at the same time for result you can refer the fig. 41 and also can refer the whole video made by me by click the link mention under picture.

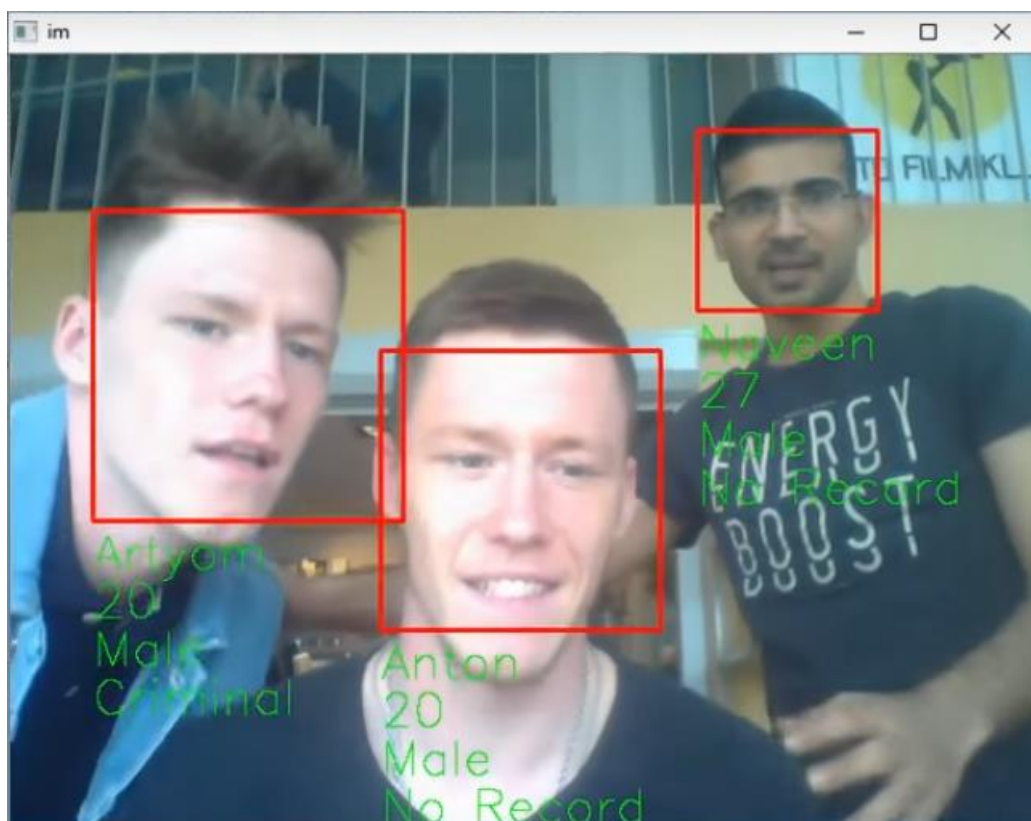


Figure 41 [Face Recognition Experiment](#) result with a Twins pair and a different face, on the very left, Artyom with Criminal Record, with his identical face Brother Anton having no record, and Me with No Record at the same time in face recognition.

```
>>>
RESTART: E:\Study in Estonia\Thesis\Image Processing\OpenCV + Phython\Face Recg
sqlite\datasetgenerator.py
1.23158624614e-06
enter your id DataSetGenerator |

>>>
RESTART: E:\Study in Estonia\Thesis\Image Processing\OpenCV + Phython\Face Recg
sqlite\trainer.py
8.21057497425e-07
1

>>>
RESTART: E:\Study in Estonia\Thesis\Image Processing\OpenCV + Phython\Face Recg
sqlite\detector.py
8.21057497425e-07
Detector |
```

Figure 42 Time Comparison between all the process of Face Detection (Top) Dataset Generator (Middle) Trainer, (Down) Detector

## CONCLUSION

For writing conclusion for this thesis report I would like to give few point, that what learn most during the learning and Research for this thesis. The conclusion is summarized here in points

- India is having so variant border that with 7 different countries with 5th largest border having and highest battle field in the world. From these border, how much anti national activities is performing every year. How these anti national activities influencing Indian society and Economy growth.
- Not USA having world best border secure system, but its Israel and even USA and India is moving to Israel to learn how to make more secure border. Israel is the only country which is totally fenced from all neighbor's countries. India is on the same path.
- From a simple device in TV, I found an idea that it's can help to build a more and more secure border, as it was passing the current in air which don't let me even touch to its cover shell made up of wooden. With this I came to know that, how powerful device is FBT and this is known as transformer, but it behaves different from other transformer as its stores energy into it.
- Human body influence from current shock, who is more dangerous current or voltage? Its current but voltage give its power to pass through the body. importance of both current and voltage and role of resistance. How much resistance is existing in human body, I also came to knew this, different effect on human body with different amount of current range, and how it, burn and give a heart attack to human body.
- OpenCV works great with Face Recognition with different IDE's, it provides inbuilt three most important Face Recognition algorithm. That can help to build face recognition code easily without doing calculation in code. You just need to call them in your code. With the help of database system attach with this it would be easier to operate the database system remotely from far distance or can say from Head Quarter, as I used SQLite Studio which also able to used remotely through internet.
-

## KOKKUVÕTE

Käesoleva lõputöö kokkuvõttes tahaksin välja tuua mõned punktid, mis ma selle lõputöö koostamise juures teada sain.

1. India on riigipiir seitsme erineva riigiga ja see on maailmas suuruselt viies. Lisaks on India maailma suurim sõjatanker.
2. Isegi USA-l ja India lei ole maailma turvalisem piir, vaid see on Iisraelil. Iisrael on ainus riik, mis on kogu riigipiiri ulatuses aiaga eraldatud. India liigub samas suunas.
3. Lihtsast televiisori seadmest tuli mul idee, kuidas ehitada järjest turvalisem riigipiir. Televiisor oma puudust raamiga ei lasknud mul seda puuduta, vaid andis mulle elektrilöögi. Tänu sellele sain teada, mis seade on FBT, see on tuntud kui transformeer, kuid see salvestab endasse energiat ja seetõttu erineb teistest transformeeritest.
4. Mis on inimkehale ohtlikum ka voolutugevus või pinge? See on voolutugevus, kuid pinge annab võimsuse läbi keha liikuda. Mõlemad on tähtsad ja lisaks ka takistus – kui suur on inimkeha takistus. Lisaks sain ma teada kuidas erinev voolutugevus mõjutab inimkeha.
5. OpenCV töötab hästi näotuvastusel, sellel on sisseehitatud kolm kõige tähtsamat näotuvastuse algoritmi. See võimaldab näotuvastuse jaoks koodi kirjutada üsna lihtsalt, ära jäävad arvutused koodis. Andmebaasidesse saab siseneda ka kaugjuhtimise teel, mina kasutasin SQLite Studio tarkvara, mida on võimalik kasutada läbi internet.

## SUMMARY

India and some few another nation are in the world are suffering from anti-national activities from their neighbor countries. Only India having more than 15000 KM long border with seven different countries and out of that 4 are very dangerous border that we are not even allowed to live near to border as it comes under highly sensitive area. Through these sensitive borders few unethical activities performed because it's not fully fenced and even sometimes on fenced area invaders cut the fence and cross the border easily.

In this thesis, I gave a solution for this problem by providing current High voltage high current which will create a current environment near the fence which will not allow to any invaders to even come closer to border fence.

All time current flowing will increase the power consumption and remove the metal quality as it will create the heating cause of current and resistance. So, to avoiding this, I am adding a face recognition technique which will help to flow the current only and only when there would not be a recognize face from Highly secure data (data base of Soldiers face, guarding on border). Any unfamiliar face will let this system activate.

For this Face Recognition techniques, I made a prototype which was developed under Python coding language with the help of a very popular Image Recognition library OpenCV. This library has all three algorithms "Eigenfaces, Fisherfaces, and LBPH" to recognize face I personally used LBPH algorithm as it's has advantage over both the other algorithm and it's it characterizes each image of data set individually. That makes it more efficient with different facial expression even under different light intensity in background of image.



## FUTURE WORK

Defense sector hold a big area for research and developments. With time, technology changes and things get obsolete. With time people even found hack of one secure technology, here I suggested electrical fence with face recognition techniques, to recognize favorable faces in data set. Otherwise system caught unknown face and activate electrical fence. This system will work no doubt, but still there are area which can be improved to make strong this idea for making more secure this border.

As every border would be different with different environmental condition and also would have all day status like day and night, face recognition will work nice in day light, but would be need to develop a system that can work in night as well. It's hard to find the exact face feature from camera as there is no natural light, this area of face recognition with infrared technology would be a desert dish for this project.

Another area would be Neural Network Approach, this technology is already existing, but with CNN or Deep Learning, this face recitation technique can be more advance and trustworthy. Deep learning not just for Face Recognition but also for networking area to secure the data, as this is more important to secure the database, no one can hack and change the database.

Biometrics Face Recognition with the help of another library OpenBR and Voice recognition will also make stronger field around the border to secure fence border, with the help of Biometric Recognition, you can judge more accurately which may not possible from just face recognition.

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## 6. APPENDCIES

### Appendix 1 – Dataset Creator

```
import cv2,os
import sqlite3
import time
cam = cv2.VideoCapture(0)
detector=cv2.CascadeClassifier('face.xml')

start_time = time.clock()
print (time.clock())

def insertOrUpdate(Id,Name):
    conn=sqlite3.connect("FaceBase.db")
    cmd="SELECT * FROM People WHERE ID="+str(Id)
    cursor=conn.execute(cmd)
    isRecordExist=0
    for row in cursor:
        isRecordExist=1
    if(isRecordExist==1):
        cmd="UPDATE People SET Name="+str(Name)+" WHERE ID="+str(Id)
    else:
        cmd="INSERT INTO People(ID,Name) Values("+str(Id)+","+str(Name)+")"
    conn.execute(cmd)
    conn.commit()
    conn.close()

id=raw_input('enter your id')
name=raw_input('enter your name')
```

```

insertOrUpdate(id,name)
sampleNum=0
while True:
    ret, im =cam.read()
    gray=cv2.cvtColor(im,cv2.COLOR_BGR2GRAY)
    faces=detector.detectMultiScale(gray,scaleFactor=1.2,minNeighbors=5,
minSize=(100,100), flags=cv2.CASCADE_SCALE_IMAGE)
    for(x,y,w,h) in faces:
        sampleNum=sampleNum+1
        cv2.imwrite("dataSet/user."+id +'.'+ str(sampleNum) + ".jpg", gray[y:y+h,x:x+w])
        cv2.rectangle(im,(x-50,y-50),(x+w+50,y+h+50),(225,0,0),2)
cv2.imshow('im',im)
cv2.waitKey(100)
if sampleNum>20:
    cam.release()
    cv2.destroyAllWindows()
    break

```

## Appendix 2 – Trainer

```
import os
import cv2
import numpy as np
from PIL import Image

recognizer=cv2.createLBPHFaceRecognizer();
path="dataSet"

def getImagesWithID(path):
    imagePaths=[os.path.join(path,f) for f in os.listdir(path)]
    faces=[]
    IDs=[]
    for imagePath in imagePaths:
        faceImg=Image.open(imagePath).convert('L');
        faceNp=np.array(faceImg,'uint8')
        ID=int(os.path.split(imagePath)[-1].split('.')[1])
        faces.append(faceNp)
        print ID
        IDs.append(ID)
        cv2.imshow("training",faceNp)
        cv2.waitKey(10)
    return IDs,faces

Ids,faces=getImagesWithID(path)
recognizer.train(faces,np.array(Ids))
recognizer.save('recognizer/trainingData.yml')
cv2.destroyAllWindows()
```

## Appendix 3 – Detector

```
import cv2
import os
import numpy as np
from PIL import Image
import pickle
import sqlite3
import time

start_time = time.clock()
print (time.clock())

recognizer = cv2.createLBPHFaceRecognizer()
recognizer.load('recognizer/trainingData.yml')
cascadePath = "face.xml"
faceCascade = cv2.CascadeClassifier(cascadePath);
path = 'dataSet'

def getProfile(id):
    conn=sqlite3.connect("FaceBase.db")
    cmd="SELECT * FROM People WHERE ID="+str(id)
    cursor=conn.execute(cmd)
    profile=None
    for row in cursor:
        profile=row
    conn.close()
    return profile
```

```

cam = cv2.VideoCapture(0)
font = cv2.cv.InitFont(cv2.cv.CV_FONT_HERSHEY_SIMPLEX, 1, 1, 0, 1, 1)
while True:
    ret,im =cam.read()
    gray=cv2.cvtColor(im,cv2.COLOR_BGR2GRAY)
    faces=faceCascade.detectMultiScale(gray,scaleFactor=1.2,minNeighbors=5,
minSize=(100,100), flags=cv2.CASCADE_SCALE_IMAGE)
    for (x,y,w,h) in faces:
        id,conf = recognizer.predict(gray[y:y+h,x:x+w])
        cv2.rectangle(im,(x,y),(x+w,y+h),(0,0,255),2)
        profile=getProfile(id)
        if (profile!=None):
            cv2.cv.PutText(cv2.cv.fromarray(im),str(profile[1]),(x,y+h+30),font, (0,255,0))
            cv2.cv.PutText(cv2.cv.fromarray(im),str(profile[2]),(x,y+h+60),font, (0,255,0))
            cv2.cv.PutText(cv2.cv.fromarray(im),str(profile[3]),(x,y+h+90),font, (0,255,0))
            cv2.cv.PutText(cv2.cv.fromarray(im),str(profile[4]),(x,y+h+120),font,(0,255,0))
cv2.imshow('im',im)
cv2.waitKey(10)

```