Chapter 01: Bees and Varroa

1.1 Bees

1.1.1 Introduction

Big tasks for little insects: the work done by honey bees is of great importance to humans. The honey bee is essential for pollination of a wide number of crop plants, making them an important part of food production. A large proportion of our food is produced, to some extent, with the help of bee and other insect pollination. That is why protecting and improving the health of bees is so important.

1.1.2 Definition

Bees (Anthophila) form a clade of hymenopteran insects of the Apoid superfamily. At least 20,000 species of bees are listed on the planet, including about 2,000 in Europe. Europe, the most well-known species is Apis mellifera, which,
like most honey bees, belongs to the genus Apis. However, the majority of bees do not produce honey, they feed on the nectar of flowers.
A winter bee can live up to 10 months, while a summer bee can live up to 1 month. Bees can be classified according to their way of life: honeybees, wild, solitary or social, etc. They are distinctly distinct from wasps by their morphology and behaviour, including their diet. Bumblebees, on the other hand, are a particular group
of bees[1] [2] [3] [4].

1.1.3 Bees in Algeria

The Algerian beekeeping herd is made up of two breeds:

-Apis mellifera -.intermissa, known as "tellian bee" or "black bee of the Tell"

-Apis mellifere-saharanis, still known as the "Saharan bee" in southwestern Algeria (Bechar , Ain Sefra) [5].
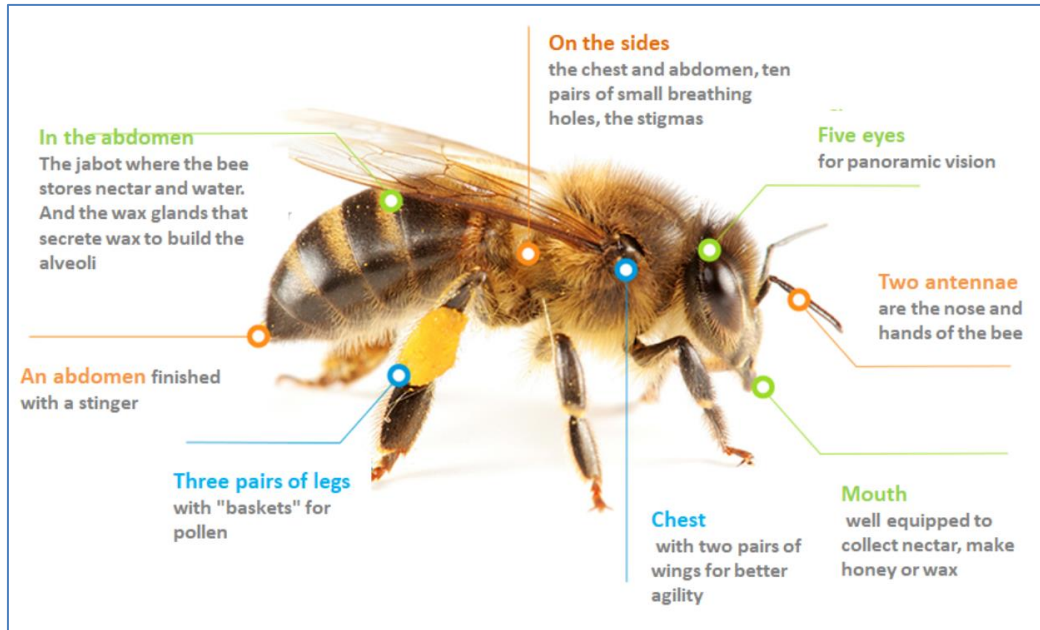
1.1.4   Honey Bee Anatomy

Figure 1.1. Honey Bee Anatomy.
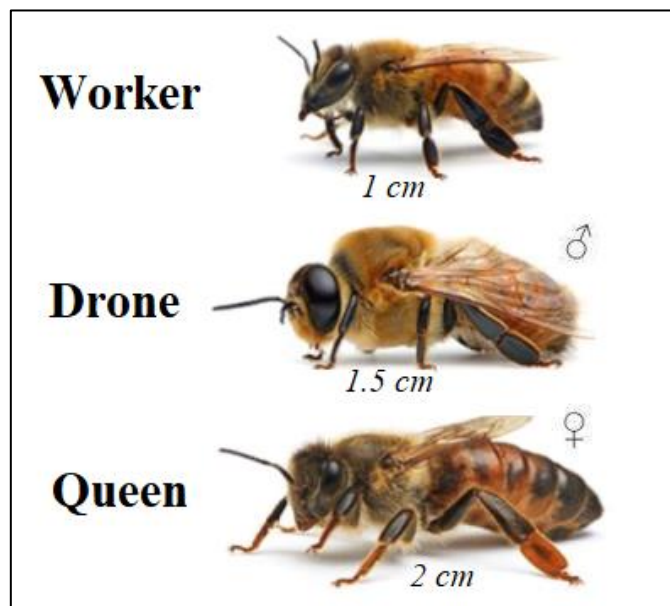
### 1.1.5   The Castes of Bees

There are three castes:

Figure 1.2. The three Castes of bees**.**

1.1.6   The Role of Bees in the Planet

a. Pollination

Pollination is the transport of pollen from the male organs of the plant to the female organs.

Pollination has a fundamental role, both for bees and for the planet, it guarantees the balance of our environment. Bees feed on pollen and nectar found in flowers. In addition, 80% of flowering plants must be pollinated to produce fruit and, therefore, grow properly. If the bees disappear, 40,000 species of flowering plants will wither out. By impact, livestock could no longer be fed properly and, little by little, 1 third of the world's food supply would dry up. It is, therefore, a major issue that affects flora and fauna as well as humanity. [9]
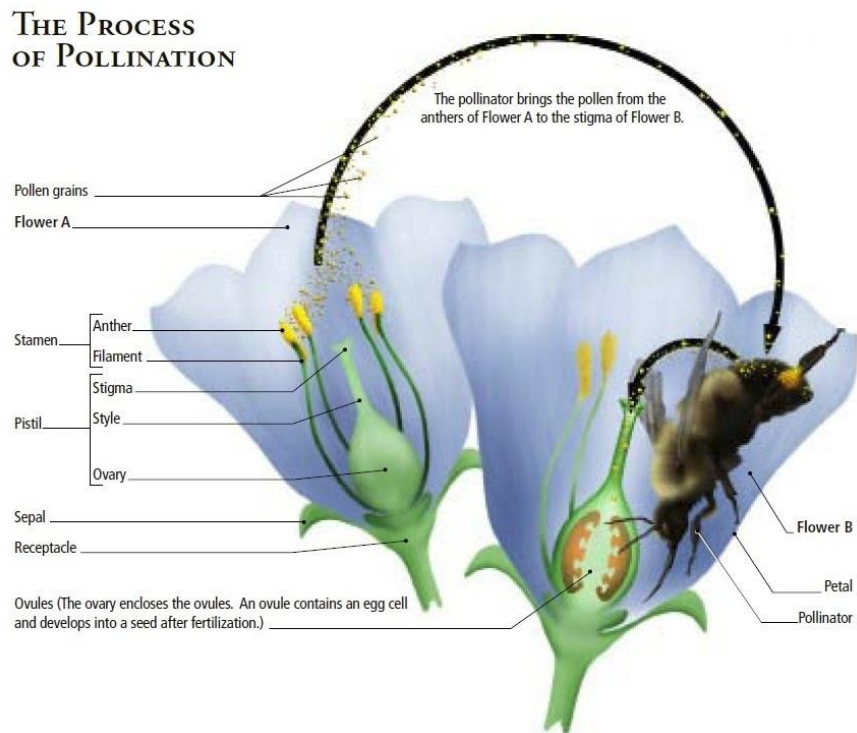
Figure 1.3. The Process of pollination.

b. Economic impact

It is estimated that in North America around 30% of the food humans consume is produced from bee pollinated plant life. The value of pollination by bees is estimated around $16 billion in the US alone. We would be unable to enjoy most of our favorite fruits, vegetables, or nuts without these pollinators. Bees also pollinate crops such as clover and alfalfa that cattle feed on, making bees important to our production and consumption of meat and dairy. Honey production from around 135 thousand American beekeepers caring for approximately 2.44 million colonies totaled almost 148.5 million pounds in 2007. This production was worth over $150 million with a per pound cost of all honey at 103 cents (National Agricultural Statistics Service)[10].

The global economic value of insect pollination has been estimated at $235-577 billion. (IPBES 2016 report).

| Crop	Value in billions(2006)	% Bee Pollinated
Almonds	2.2	100
Apples	2.1	90
Cotton	5.2	16
Blueberries	0.5	90
Grapes	3.2	1
Oranges	1.8	27
Peanuts	0.6	2
Peaches	0.5	48
Soybeans	19.7	5
Strawberries	1.5	2
from:USDA; RA Morse & NW Calderone(Cornell University)		

Table 1.1. Bee pollinated crops.

"According to a UN study published in 2016, the equivalent of 507 billion euros of food grown each year depends directly on pollinators. The volume of food produced that depends on pollinators has increased by 300% over the past 50 years[11].

1.1.7 Bee Hive

a. *Langstroth hive*

In modern beekeeping, a Langstroth hive is any vertically modular beehive that has the key features of vertically hung frames, a bottom board with entrance for the bees, boxes containing frames for brood and honey (the lowest box for the queen to lay eggs, and boxes above where honey may be stored) and an inner cover and top cap to provide weather protection. In a Langstroth hive, the bees build honeycomb into frames, which can be moved with ease. The frames are designed to prevent bees from attaching honeycombs where they would either connect adjacent frames, or connect frames to the walls of the hive. The movable frames allow the beekeeper to manage the bees in a way which was formerly impossible [1] [2].
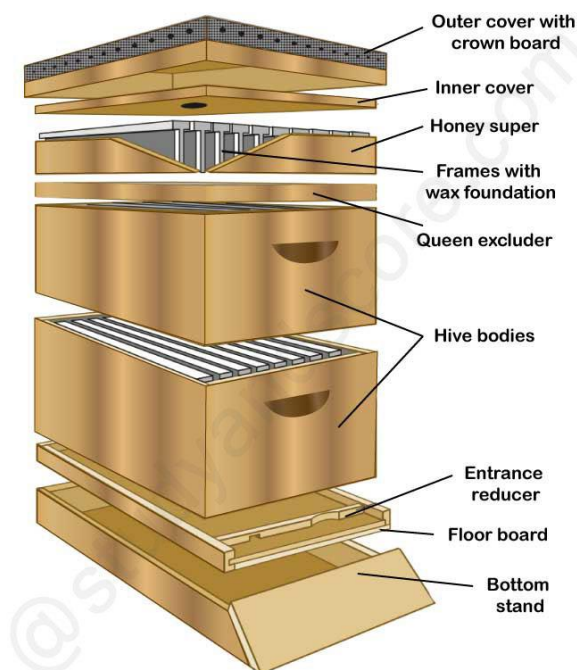
MODERN METHOD OF APICULTURE: MOVABLE ARTIFICIAL HIVE

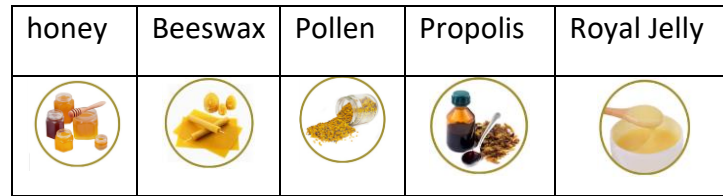**Figure 1.4**. Langstroth hive model.

b. Beehive products

honey	Beeswax	Pollen	Propolis	Royal Jelly

Figure 1.5. Beehive products.

1.1.8   Circle and Lifestyle

a.   From the egg to the worker bee

The egg or the bee? That is the question.

Let's start with the egg, the starting point of four stages of development before reaching the adult bee. The first stage begins with the laying an egg fertilized by a queen. The fate of the fertilized egg will be to become either a queen in turn or a worker. If it is an unfertilized egg, it will become a drone.

The egg is easy to recognize because of its white color, length and curved shape. It is deposited vertically in the alveoli when laid.

During the 3 days after laying, the egg gradually tilts to the bottom, dissolves its membrane and turns into a larva. Under the same climatic conditions, all specious have the same process.

Table 1.2. Evolutionary cycle of the three bee castes.

b. The larva

Similar to a worm, the larva has only one digestive tract and thus, has limited role which is feeding. Food bees leave them with food in the alveoli. The development of the larva is done on 5 successive mutations. Its weight increases depending on its nature. For example, a worker will gain 900 times her original weight while the queen will gain 1,700 times her weight.

The drone gains up to 2300 times its weight. After 9 days at this stage, the larva is closed in the alveola by a wax operculum. This is the operculation phase, varying according to caste.

c. The pupa and the imago

These last two stages see the creation of antennae and other sensory organs: eyes, mouth... The organs of the chest and abdomen, as well as the legs and wings form at this stage. The mandibles form, allowing the imago to pierce the wax operculon. As an adult, it emerges from the alveoli and flaps its wings. The cuticle formed outside dries gradually for 12 hours, and the bee begins its work. It weighs between 80 and 292 mg depending on its caste, the queen being the heaviest. However, there are some variations in this development cycle according to caste.

1.1.9   The Life of Bees

On every ordinary day of its life, a bee forages 25 km from one flower to another to obtain 0.5g of nectar, which is required for a tenth of a gram of honey. By browsing 1500 flowers, she gets 2 cg of nectar. In honeyseason , a foraging bee can even record 4000 flowers on its counter. The worker lives between 13 and 38 days during the summer season, between 30 and 60 days in spring and 140 days in winter. Drones can live up to 90 days in the warm season and about 30 days in the spring. As for the queen, her lifespan can be up to 3 years, with a record of 8 years.

1.2   The Varroa

1.2.1   Definition

Varroa mites (Varroa destructor and V. jacobsoni) are tiny red-brown external parasites of honey bees.

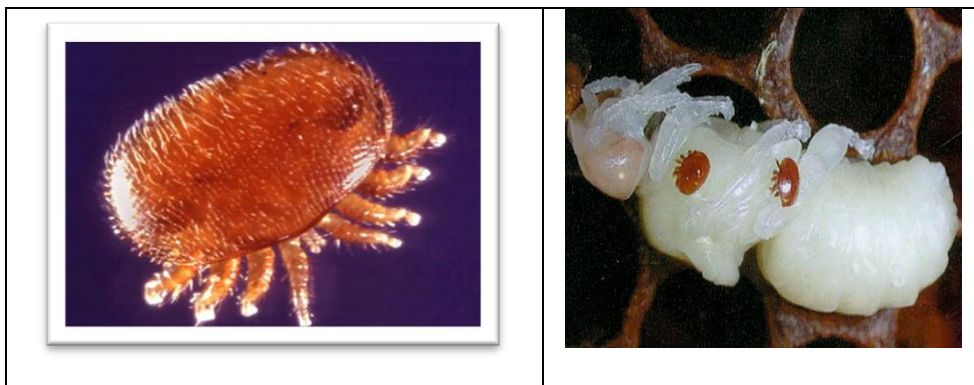**Figure 1.6.** Two Varroa mites on two bees.

Figure 1.7. Varroa destructor.

Although Varroa mites can feed and live on adult honey bees, they mainly feed and reproduce on larvae and pupae in the developing brood, causing malformation and weakening of honey bees as well as transmitting numerous viruses.

Figure 1.8. Varroa impact on Bees[12].

Colonies with low infestation generally show very few symptoms, however as the mite population increases symptoms become more apparent. Heavy Varroa mite infestations can build up in 3–4 years and cause scattered brood, crippled and crawling honey bees, impaired flight performance, a lower rate of return to the colony after foraging, a reduced lifespan and a significantly reduced weight of worker bees. Colony symptoms, commonly called parasitic mite syndrome, include an abnormal brood pattern, sunken and chewed cappings and larvae slumped in the bottom or side of the cell. This ultimately causes a reduction in the honey bee population, supersedure of queen bees and eventual colony breakdown and death.Varroa It is native to Southeast Asia, where it lives at the expense of the Asian bee Apis cerana which resists its attacks, unlike the European honeybee Apis mellifera. This parasite causes significant economic losses in beekeeping and is one of the causes of the decrease in the number of bees (CCD). Having colonized almost all the areas where Apis mellifera is present, varroose is now a global problem.

1.2.2   The CCD phenomenon

Colony collapse disorder (CCD) is the phenomenon that occurs when the majority of worker bees in a colony disappear and leave behind a queen, plenty of food and a few nurse bees to care for the remaining immature bees. While such disappearances have occurred sporadically throughout the history of apiculture, and were known by various names (disappearing disease, spring dwindle, May disease, autumn collapse, and fall dwindle disease),[1] the syndrome was renamed colony collapse disorder in late 2006 in conjunction with a drastic rise in the number of disappearances of western honey bee (*Apis mellifera*) colonies in North America. Most European countries observed a similar phenomenon since 1998, especially marked in Belgium, France, the

Netherlands, the UK, Greece, Italy, Portugal, and Spain, Switzerland and Germany; the Northern Ireland Assembly received reports of a decline greater than 50%.The phenomenon became more global when it touched some Asian and African countries as well [14] .
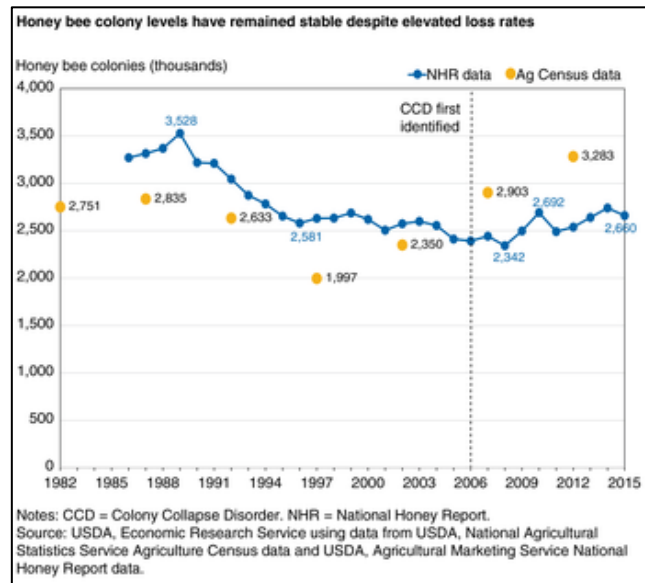

Figure 1.9. Evolution of Honey bee colonies chart

1.2.3 varroa in the world

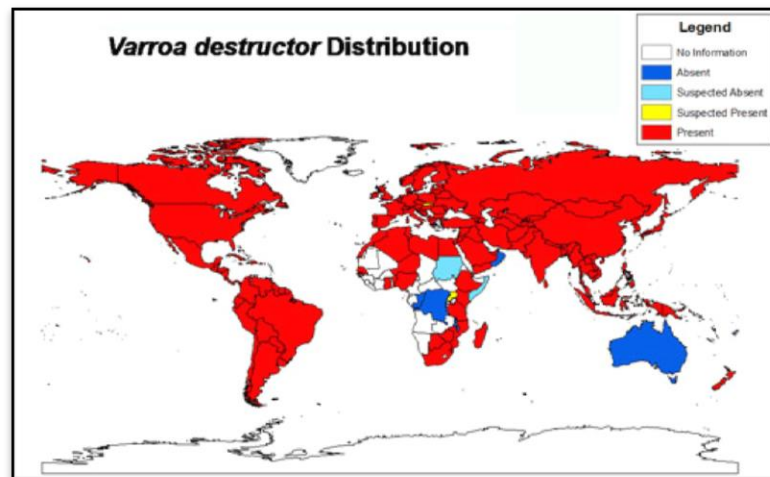*Varroa* distribution reported in peer-reviewed scientific literature as of 2014.

Figure 1.10. Varroa word distribution (2014), the world map layer is from Natural Earth and the data was acquired from a review of the scientific literature.

Australia is currently the only major honey producing country in the world to remain free of Varroa mites. Freedom from Varroa means that Australian beekeepers do not

have to use the variety of management methods to control the mite, which are not only very costly, but also time consuming [15].

However, as the last major honey producing country in the world to have Varroa mite, beekeepers in Australia should be more prepared than anyone for Varroa mite's eventual arrival in Australia, as well as the dramatic change in management practices that this pest will cause. For this reason, monitoring and management methods that are commonly used overseas have been listed below to provide some preliminary information about how other beekeepers around the world are managing Varroa mite [16].

1.2.4 Varroa in Algeria

Varroa destructor was registered for the first time in Algeria in 1981 through the Algerian-Tunisian border to the east. Since then Algeria has approved the use of several products to control varroa, in order to minimize the impact of this parasite on the bee colonies and honey production. This experiment was conduted in order to study current effectiveness of varroa treatments registered in Algeria,varroa resistant to these treatments ,The trials were conducted in the region of Mitidja (central Algeria) on 75 hives spread over three apiaries. All colonies where equipped with a mesh tray with insert as a diaper greased roasting for counting dead mites. The control treatment is performed with oxalic acid drip; effectiveness was measured by comparing the mites killed during the experimental treatments to mites killed during a control treatment. The results showed a variation in efficacy between the treatments used Bayvarol saves the efficiency ratio is the most important (94.33%), followed Apistan and Apivar with 87.54% and 82.67% respectively. We note a decrease in the efficiency of these products, tests for resistance in vitro are needed to confirm this decline and to detect possible problem of resistance. Natural treatments based on thymol record the lowest with 79.34% for and 72.65% for Thymovar and Apigaurd. Thymol as Apiguard and Thymovar can be regarded as complementary therapies to be integrated into a control program because the success rate is low and thus the beekeeper is required to use an alternative treatment. The information obtained from this study concerning drug efficacy and resistance acaricides are essential for defining

the control strategies adapted to the therapeutic treatment of Varroa disease in

Algeria[21].
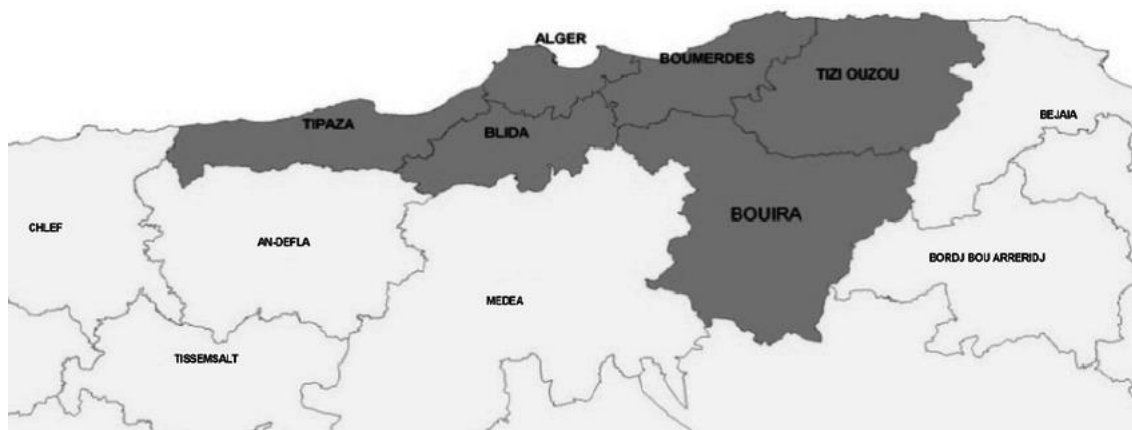
Figure 1.11. Area of north-central Algeria. Apiary 1, 2 and 3 (Area of Blida), Apiary 4, 5 and 6 (Area of Tizi Ouzou).

Location	Colony sampled	Mean (% mortality) ± SE
Blida		
Apiary 1	10	46.45+5.34 a
Apiary 2	10	36.23+3.65 a
Apiary 3	10	41.20+6.87 a
Tizi Ouzou		
Apiary 4	10	89.54+3.90 b
Apiary 5	10	91+55+5.76 b
Apiary 6	10	87.45+67 b

Table 2.3. Percentage of varroa mortality obtained with the fluvalinate application.

1.2.5 Varroa life

a. Life cycle

Understanding the life cycle of the Varroa mite

1 The queen is the largest in the beehive. She lays up to 2,000 eggs per day in the brood cells.

2 Worker bees often carry Varroa mites with them into the hive. Despite being deaf and blind, these mites can find their ways to the brood chambers thanks to their olfactory sense and numerous fine sensory hairs on the legs. Shortly before the workers cap the brood cells, the female mites slip unnoticed into the cells with the bee larvae.

3 A few days later, the mites lay the first eggs. The first to hatch is always a male. It is followed by up to five more eggs from which female mites hatch.

4 To feed its offspring, the mother mite pierces a feeding hole in the bee pupa which has developed in the meantime. Before the bee hatches, the mites mate again – during the bee season, the Varroa population in a hive can double every four weeks.

5 By the time the bee hatches, it is already severely diseased and weakened, because mites also transmit dangerous viruses such as Deformed Wing Virus, for which there is still no effective treatment available. As well as the bee brood, Varroa can also infest adult bees.

Figure 1.12. Varroa life cycle.

b. Targeting areas
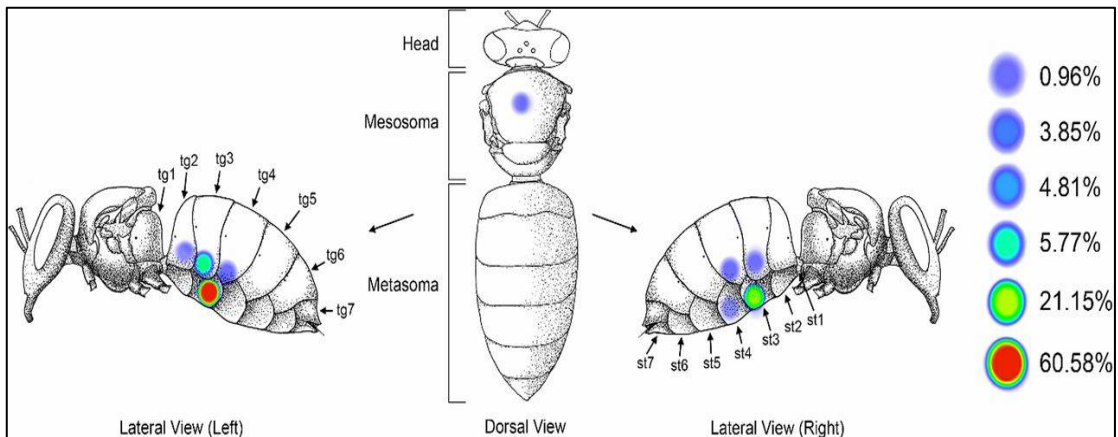
Figure 1.13. Preferred feeding location of Varroa destructor mites on adult host bees.

1.2.6   Management options

Varroa mites have had a major negative affect in every country where they have been introduced. After the first detection in a country, there are usually intense activities by industry and government officials, as well as research scientists in order to control the spread of the mite and prevent the collapse of colonies. However, despite these efforts, many countries have reported that in the initial stages of a Varroa incursion, honey bee colonies collapsed very quickly if beekeepers didn't intervene with management methods, such as chemical treatments. This has usually been due to a lack of knowledge about Varroa mite's life cycle and biology, as well as effective control methods.

Even in areas where Varroa mites have been present for a considerable time (10-20 years), beekeepers still have to be diligent in their control and management of the mite, or risk losing large numbers of hives. Some areas still report losses of up to 30% during winter. Accurate estimates of the overall world impact on beekeeping are difficult to estimate, but it is safe to assume that Varroa mites have killed hundreds of thousands of honey bee colonies, and continue to do so, resulting in major economic losses for both beekeepers and growers of crops which rely on pollination. Considering the impact that Varroa mite has on honey bee colonies, the role of the beekeeper is to keep the mite population below the level where harm is inevitable (threshold level), therefore, maintaining health colonies of honey bees for the production of honey and other hive products and for pollination services. It is not necessary to kill every mite for effective control and it is not usually desirable to attempt this. However, the more mites that are left behind, the quicker they will build up again to damaging levels. In order to determine the most appropriate management options, beekeepers must consider some of the following issues [18][19]:

The cost of control : this includes not only the cost of buying product being used but also the time and work involved in treating hives. This will mean that some options may be more suitable for hobbyists than commercial bee keepers.

- **Chemical residues:** the need to ensure honey has acceptable chemical residue levels will limit when some chemicals can be applied.

  Resistance: Varroa mites may be able to build up resistance to particular chemicals. By swapping between chemicals and always applying chemicals correctly (do not under dose) the development of chemical resistance in Varroa mites can be minimised

- **Other concerns :** there are a number of other issues that individual beekeepers will have to consider. For example some may not like to use particular chemicals and prefer to manage Varroa mites in their colonies using alternative methods, such as biotechnical methods or breeding from 'survivor stock'.

1.2.7 Varroa traitements
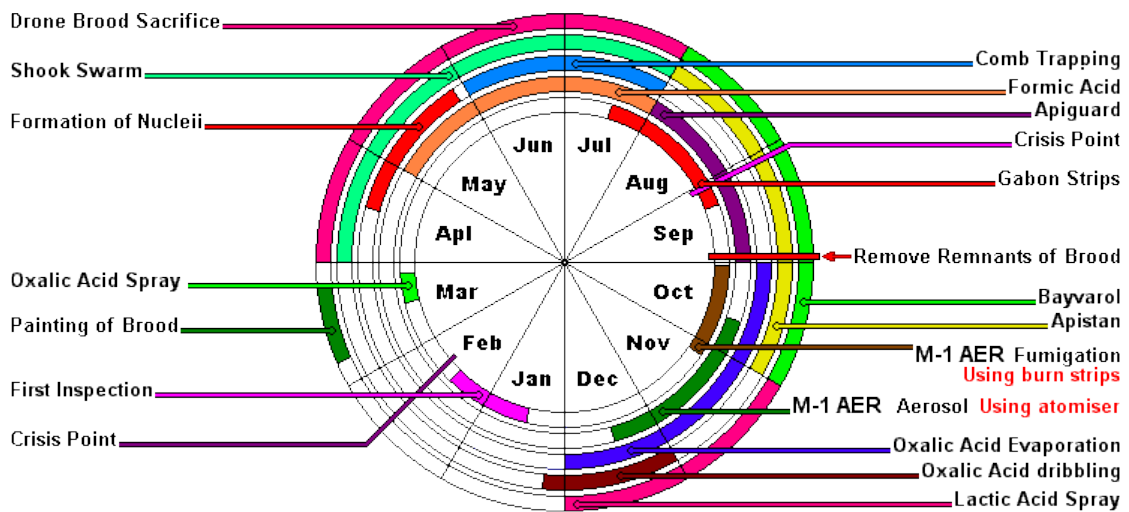
Figure 1.14. Varroa treatments .

1.2.8   Economic impact

Picking up on the government report, the Australian Herald Sun says, that the State Government's Department of Primary Industries warns that bee losses caused by Varroa could have a disastrous impact[20]:

- $60 million losses alone in field crops such as canola, beans and peas through the absence of bees for pollination
- a further $22 million from the lucerne seed industry
- an estimated maximum loss of $261 million for horticulturecrops
- total losses would be up to $410 million, as packing sheds and processing facilities would close, causing inevitable job losses.

1.3   Conclusion

Varroa is a global problem that leads to catastrophic results and severely affects the human food chain.

The Varroa entered Algeria early and algerian beekeepers suffer from it like most countries in the world, and cause significant losses every year.

Researchers have not arrived for a definitive and effective treatment yet, what is being marketed are chemical treatments that may harm honey produced and therefore human, in addition to the problem of drug-resistant Varroa strains.

Research and technological solutions are limited so far, and most of them stop when monitoring the Varroa through computer vision and artificial intelligence techniques, while projects that work to exclude the Varroa have been found only one complex and expensive project using laser technology.

By studying the life cycle of The Varroa with the bees shows that the discovery of the Varroa and the attempt to exclude it is not enough, there must be a clear strategy to deal with it, for example it is useless to make a system that works inside the cell to search for the Varroa and deal with it, so the best places for it is the entrance of the hive as we will see in the next chapter.

Varroa has specific and fixed color and formal properties.

1.1   Bees

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1.1.2   Definition

1.1.3   Bees in Algeria

1.1.4   Honey Bee Anatomy

1.1.5   The Castes of Bees

1.1.6   The Role of Bees in the Planet

a.   Pollination

b.   Economic impact

1.1.7   Bee Hive

a. Langstroth hive

b. Beehive products

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a.   From the egg to the worker bee

b.   The larva

c.   The pupa and the imago

1.1.9   The Life of Bees

1.2   The Varroa

1.2.1   Definition

1.2.2   The CCD phenomenon

1.2.3   varroa in the world

1.2.4   Varroa in Algeria

1.2.5   Varroa life

a.   Life cycle

b.   Targeting areas

1.2.6   Management options

1.2.7   Varroa traitements

1.2.8   Economic impact

1.3   Conclusion

Chapter 02: Proposed strategy

VARROA FIREWALL
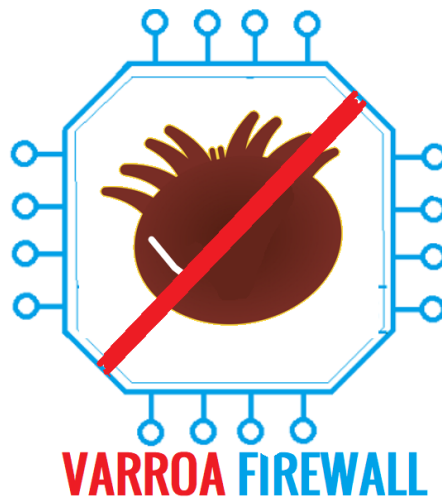
2.1   Introduction

The study of the life cycle of VARROA and its relationship to the life cycle of bees and the way he lives offers several possible solutions and varies among them in efficiency, speed, cost and adaptability. The common solution today is the chemical solution, which is an endless and constantly changing solution and is faced with the challenges of resistance to VARROA specie every time and with the highly important time factor and observation, and since our study field is the embedded systems and specialization allowing the introduction of technology in all fields we have decided to introduce a solution based on an integrated system that uses the computer vision and an electromechanical device to isolate the VARROA mites carrying bees.

2.2   Related works

Despite the rare resources in this subject, there were few attempts and research papers to use computer vision technology on bees in general and the Varroa mites in particular, there were also projects used to count the bees entering and exiting the hive [20].
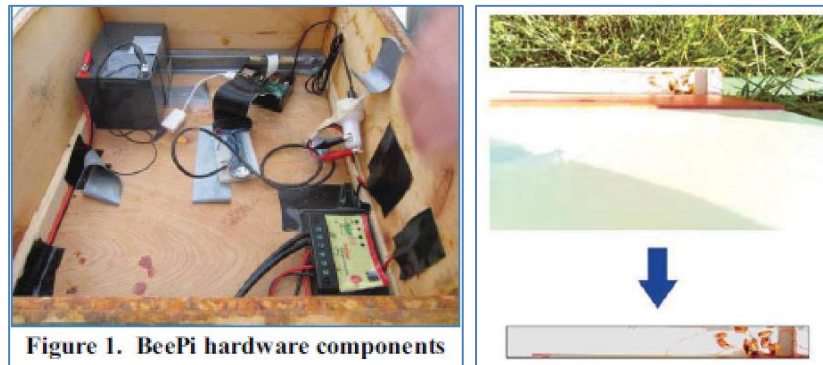
Figure 2.1. A Computer Vision Algorithm for Omnidirectional Bee Counting.

The majority of the projects and applications are focused on discovering the Varroa, and there was only one project on dealing with Varroa to kill it using the guided laser [],This project is very complicated, slow and expensive also it's impossible to manage multiple bee to be infected at the same time.
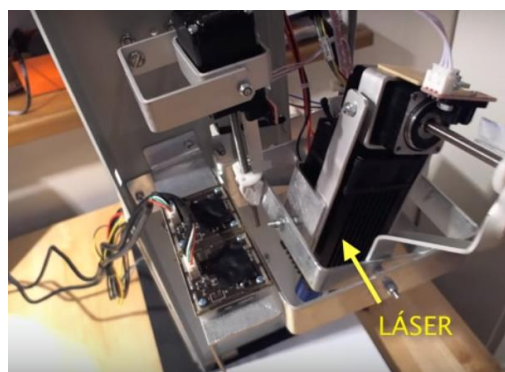
Figure 2.2. Varroa laser elimination system.

There were many different techniques used from one research to another. however, all of them were directed to discover which usually requires the use of more than one camera or multispectral cameras.

another project is the application "VarroaCounter" which facilitates the counting process of the fallen Varroa on the beehive's floor to estimate the injury percentage, where it's captured by a phone a picture of a panel placed at the bottom of the beehive that has varroa falling naturally on it, so the application counts the varroa immediately instead of the old tiring ways.
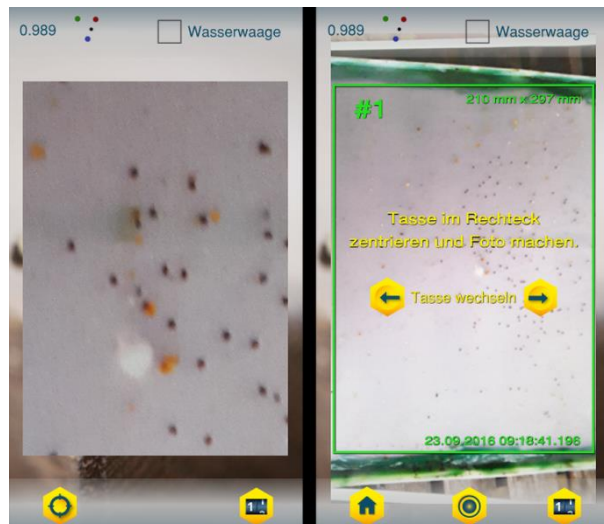
Figure 2.3. VarroaCounter mobile application**.**

in addition, there is a research paper **(*Sensor Study for Monitoring Varroa Mites on Honey Bees (Apis mellifera)*)** with the purpose to find the right setting for a raspberry PiCamera which we worked on its output to isolate the Varroa from the picture and the result was positive, which means the possibility of implementing this project without the expensive cameras or the ones with special properties, only setting the focal dimension and characteristics of sensitivity and the intensity enough to display a picture can help us to work effectively [21].
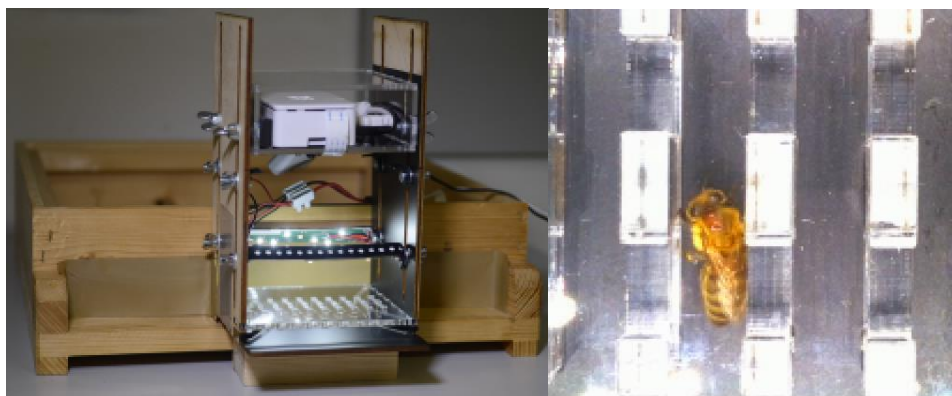
Figure 2.4. This project goal is to find a camera setup for detecting bees infected with Varroa.

2.3   Strategy description

Our project strategy lies in the design of the concept of the firewall, where unwanted lements are prevented from entering a specific place; in our project we will only guard the entrance of the cell to isolate the bees that the system discovers to be carriers of dust VARROA mites.

2.3.1   First case

If the cell is intact, it does not contain Varroa disease the effectiveness and protection of this system depends on the accuracy and effectiveness of the firewall, which must be fully effective 100%, Reaching this ratio requires a well-programed system that works in real time with more than one camera Different angles and different camera types multicast (RGB-IR) and a turned wey, In that case the system will be ideal for long-term cell protection, the following diagram shows that:
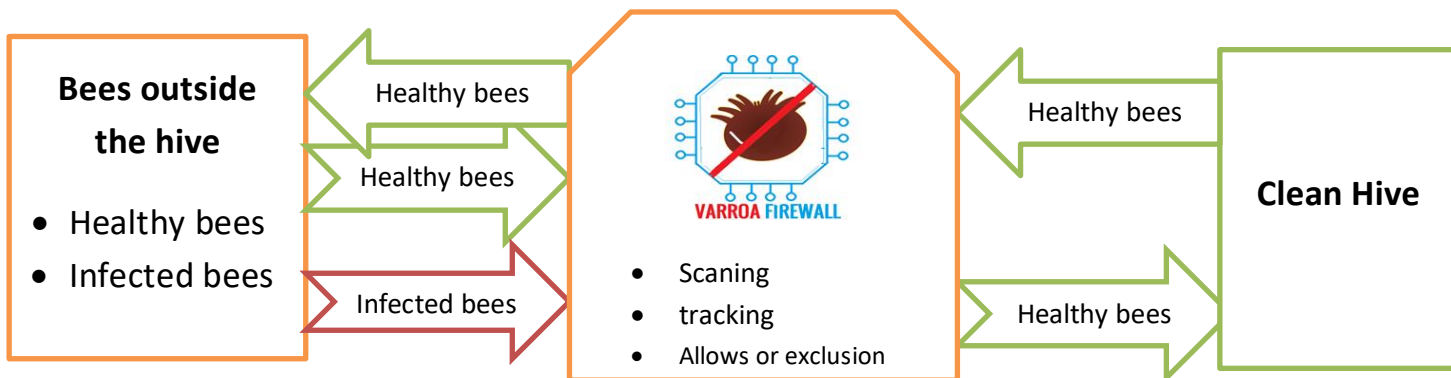
5 Figure 2.5. Synoptic diagram of first case.

2.3.2   Second case

However, if the system is used to protect an infected cell, it contributes to curbing the speed of the growth of the VARROA by calculating the probability of the departure of the VARROA from the cell on the outside bees from the cell, the VARROA mite chooses two ways :

- reproduction and staying inside the cell on the nursing bees

or

- stick to the mobile bees and get out with it When entering it is eliminated, there is currently no study on the calculation of the percentage of VARROA the Boxes output in terms of total number, and since it needs a research paper alone, we will calculate the possibilities by dividing the whole ratio into parts and counting the results.
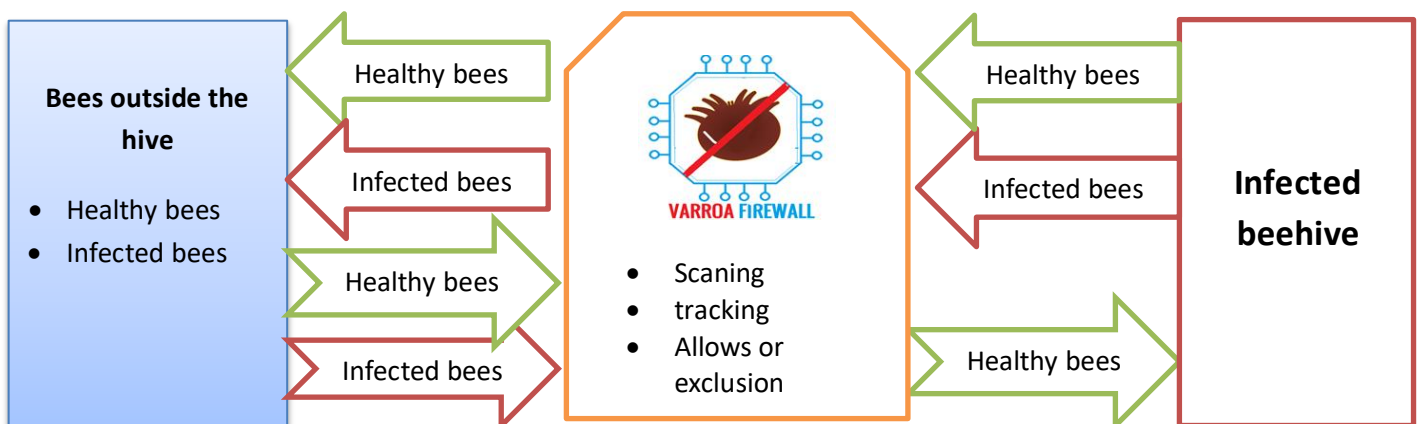
6 Figure 2.6. Synoptic diagram of second case.

a. Initial parameters

Initial Number of varroa=1000 .

Varroa augmentation = 3x .

system efficiency percentage= 90% (0,9).

N Days for reproduction = 9 (Moy).

b. Formulas

Number of varroa = 1000.

producer varroa = 3 .

theorical Total = initial number of varroa* producer varroa =1000*3 = 3000.

NV : number of varroa=1000.

OVP : varroa outlet percentage .

NVE : number of varroa Exited.

SEP : system efficiency percentage=0,9.

Day i = -(INV*OVP *SEP/100%) +NV .

Dead = day 9 * 3.

Dead% = dead *100% / 3000.

Living = 3000 – dead.

Living% = living * 100% / 3000.

Algorithm for Theorical calculation for estimate the varroa reduce :

N_Day = 9
NV = 1000
for i=1 **to** N_Day **do**
begin
        NV= NV-(INV*OVP*SEP)
end
result = NV

Figure 2.7. Algorythm for estimating varroa

sample size varroa	out	N Out	efficacy of system	Day1	Day2	Day3	Day4	Day5	Day6	Day7	Day8	Day9	isolated	living	dead	living
1000	05%	50	0,9	955	912	870	830	792	756	721	688	567	1299	1701	43.3%	56.7%
1000	03%	30	0,9	973	946	920	895	870	846	823	800	778	666	2334	22.2%	87.8%
1000	10%	100	0,9	910	828	753	685	623	566	515	468	425	1725	1275	57.5%	42.5%
1000	20%	200	0,9	820	672	551	451	369	302	247	202	165	2505	495	83.5%	06.5%

Table 2.1. Theorical calculation for estimate the varroa reduce.

In the case of use the Firewall, the speed of the growth of the Varroa decreases by at least one-third, if the system is used on a directly infected Box.

2.3.3   Third case

The third case is the most important and most successful and in which the firewall is used to filter the bees from the infected cells towards new cells free of Varroa according to the following scheme:

Figure 2.8. Synoptic diagram of third case.

2.4   Conclusion

The strategy described in this chapter is quite successful compared to
the chemical solutions currently used because the device works with the principle of
fill and forget , and its advantages are that it does not consume time and
does not affect the quality of honey produced by chemical treatments and that it
maintains the lowest percentage of Varroa inside the cell and inhibits the speed of
their reproduction, it also allows the collection of data on
the number of bees entering and exiting and the rate of infection.
The strategy has three use cases, each one depends on the success rate of the
system, and of these cases we find that the third case gives the best result.

Proposed strategy   Chapter 02

Chapter 03: Computer Vision

3.1   Working environment

3.1.1   Introduction

In this section we will review the side of the software where the main goal will be to identify and localizing the Varroa mite on the body of the bee before entering the hive, we will review various techniques ranging from the built-in embedded computer "Raspberry pi" and the camera and taking pictures and Reading videos, to programming using python and a Open source computer vision library "OpenCV", passing through the various algorithms used in object recognition and data extraction about the presence of the Varroa and tracking down to sending the order to isolate the bee infected with Varroa mite.

a.   *Difficulties*

While the previous part "strategy" was the most important, this part is

the most difficult stages of the project and we faced several difficulties, where

the work required several trips to the hives in the mountain, which we were not

experts in beekeeping and with stings, as the search for the

Varroa within the cells takes time, and constipation 5

infected bees that sometimes took 5 hours or more to prepare and go towards the

beehives and work on the cells and catch the bees and then try to captured them

later, each time we had problems in getting a good picture of the bees affected by

the Varroa, then the samples obtained weaken and die within two days,

and sometimes they We used several cameras, from raspberry camera to webcam ,

phone, then two professional cameras, then a high-resolution phone camera, as it

required cutting videos and getting pictures for classified training, as it required us to

study the field of computer vision and learn the python and prepare the working

environment on Windows and on Linux, for programming required programming tool

to check the color field and then work on three Parts: Discovering bee bodies,

chopping images to extract Varroa, tracking and sending an isolation order.

3.1.2   Hardware

a. *Raspberry pi*

Computers embedded under the Linux operating system are massively present in modern technologies (Transportation, multimedia, mobile telephony, cameras...). The Raspberry Pi is an ARM processor mono card nano-computer designed by professors in the Computer Department at the University of Cambridge as part of the Raspberry Pi Foundation.

This credit card-sized computer is designed to encourage learning computer programming; it allows the execution of several variants of the GNU/Linux free operating system, including Debian, and compatible software. But it also works with the Microsoft Windows OS: Windows 10 IoT Core and Google's Android Pi.
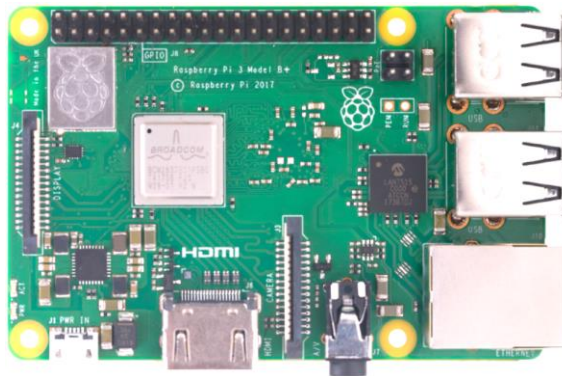
Figure 3.1. Raspberry pi 3B+.

a.1. *Specification*

The Raspberry Pi 3 Model B+ is the final revision in the Raspberry Pi 3 range.

- Broadcom BCM2837B0, Cortex-A53 (ARMv8) 64-bit SoC @ 1.4GHz

- 1GB LPDDR2 SDRAM

- 2.4GHz and 5GHz IEEE 802.11.b/g/n/ac wireless LAN, Bluetooth 4.2, BLE

- Gigabit Ethernet over USB 2.0 (maximum throughput 300 Mbps)

- Extended 40-pin GPIO header

- Full-size HDMI

- 4 USB 2.0 ports

- CSI camera port for connecting a Raspberry Pi camera

- DSI display port for connecting a Raspberry Pi touchscreen display

- 4-pole stereo output and composite video port

- Micro SD port for loading your operating system and storing data

- 5V/2.5A DC power input

- Power-over-Ethernet (PoE) support (requires separate PoE HAT)

a.2. GPIO pins and blocks description
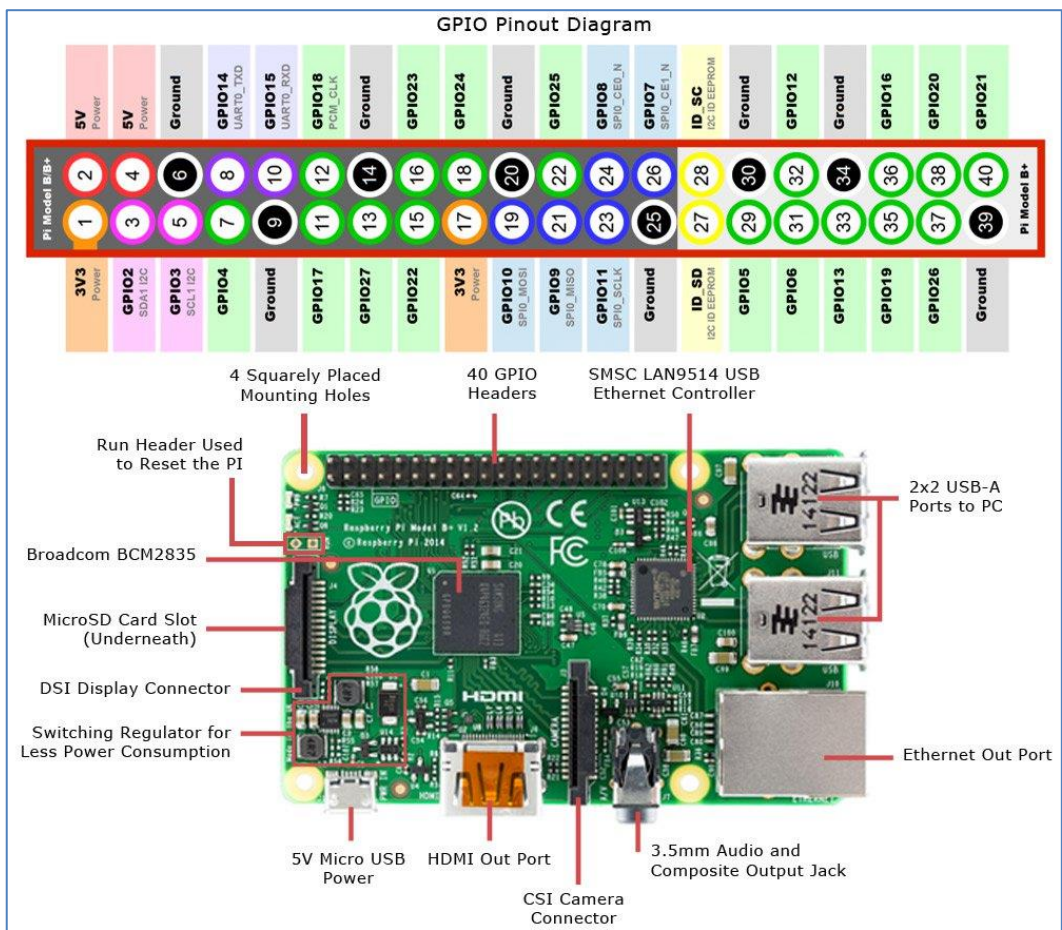
Figure 3.2. Raspberry Pi 3B+ GPIO diagram and external blocks description.

a.3.   Power / Energy

	Zero /mA	Zero W /mA	A+ /mA	A /mA	B+ /mA	B /mA	Pi2B /mA	Pi3B /mA	Pi3B+ /mA
Idling	100	120	100	140	200	360	230	230	400
Loading LXDE	140	160	130	190	230	400	310	310	690
Watch 1080p Video	140	170	140	200	240	420	290	290	510
Shoot 1080p Video	240	230	230	320	330	480	350	350	520

Table 3.1 Raspberry Pi power usage table incorporating Pi 3B plus.
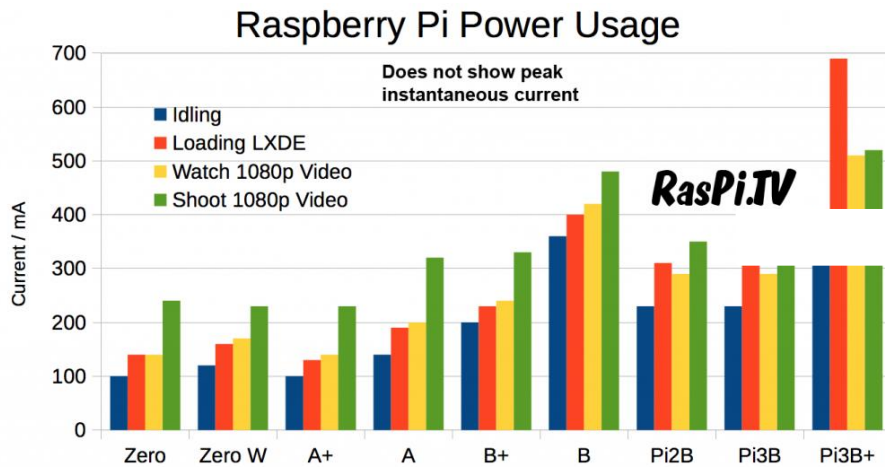
Figure   3.3. Raspberry Pi power usage chart incorporating Pi 3B plus(RasPi.TV).

b. The Camera : Raspberry Pi Camera Rev 1.3

Figure 3.4. Raspberry Pi Camera Rev 1.3.

b.1 The   Pi Camera Features:

- Fully Compatible with Both the Model A and Model B Raspberry Pi

- 5MP Omnivision 5647 Camera Module

- Still Picture Resolution: 2592 x 1944

- Video: Supports 1080p @ 30fps, 720p @ 60fps and 640x480p 60/90 Recording

- 15-pin MIPI Camera Serial Interface (CSI) - Plugs Directly into the Raspberry Pi Board

- Size: 20 x 25 x 9 (LxWxH) mm

- Weight 3g

- Fully Compatible with many Raspberry Pi cases
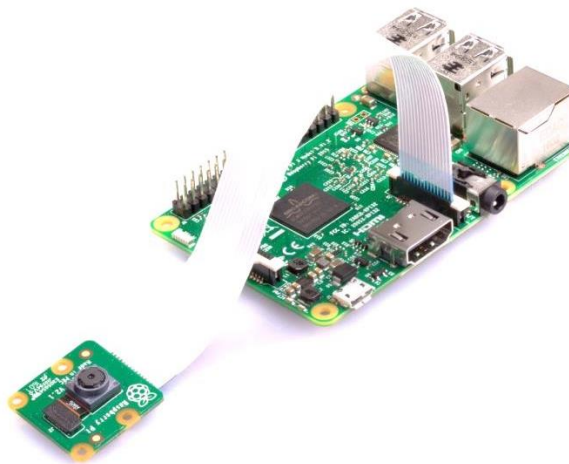
Figure 2.5. PiCamera in the Raspberry pi board.

We can Configure the PiCamera with many vision parameters with the "piCamera library" in python .
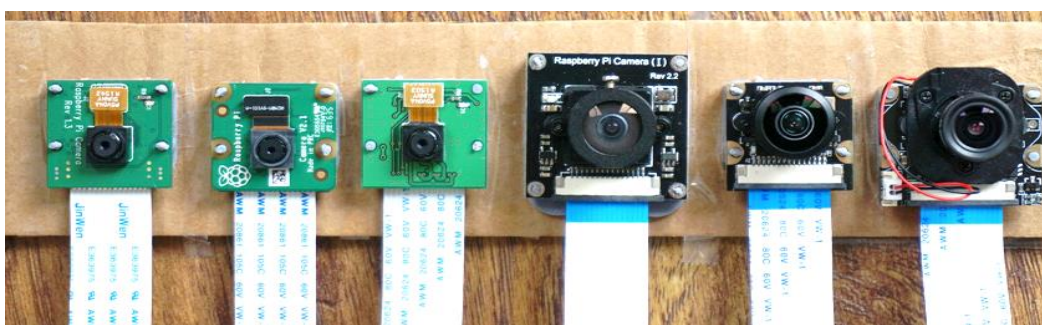
Figure 3.6. Deferent Raspberry pi cameras Models.

Model	Chipset	Megapixels	Advertised FOV
Raspberry Pi Camera	OV5647	5MP	54° (h) x 41° (v)
Raspberry Pi v2 Camera	IMX219	8MP	62.2° (h) x 48.8° (v)
Arducam 5MP RPi Camera	OV5647	5MP	54° (h) x 41° (v)
Waveshare RPi Camera (I)	OV5647	5MP	170°
Waveshare RPi Camera (J)	OV5647	5MP	222°
Waveshare RPi Camera IR-CUT	OV5647	5MP	75.7°

Table 3.2. Raspberry pi cameras characteristics .

b2. Other cameras used

- WebCam 5 Megapixel.
- Camera Samsung Galaxy S6.
- Panasonic-Leika digital Camera.
- Canon Camera.

3.1.3   Software

a. *Raspberry pi*

Python is a high-level programming language designed to be easy to read and simple to implement. It is open source, which means it is free to use, even for commercial applications. Python can run on Mac, Windows, and Unix systems and has also been ported to Java and .NET virtual machines.

Python is considered a scripting language, like Ruby or Perl and is often used for creating Web applications and dynamic Web content. It is also supported by a number of 2D and 3D imaging programs.

Scripts written in Python (.PY files) can be parsed and run immediately. They can also be saved as a compiled programs (.PYC files), which are often used as programming modules that can be referenced by other Python programs.

b. *OpenCV*

OpenCV (Open source computer vision) is a library of programming functions mainly aimed at real-time computer vision. Originally developed by Intel, it was later supported by Willow Garage then Itseez (which was later acquired by Intel). The library is cross-platform and free for use under the open-source BSD license.
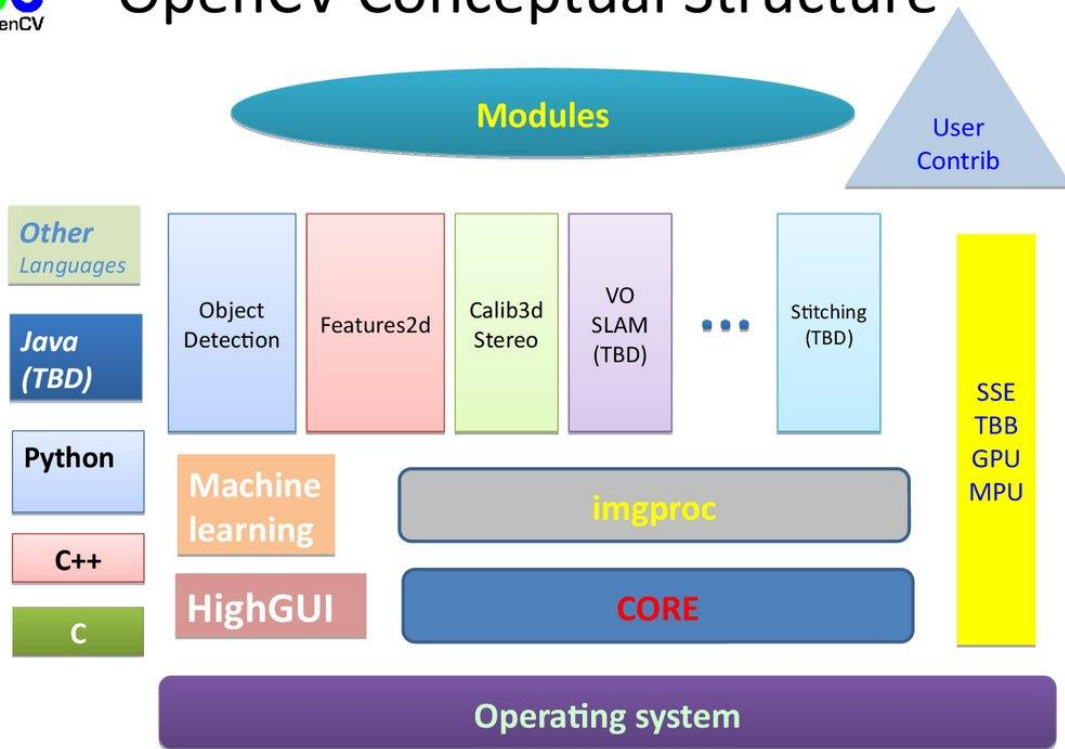
Figure 3.7. OpenCV Structure.
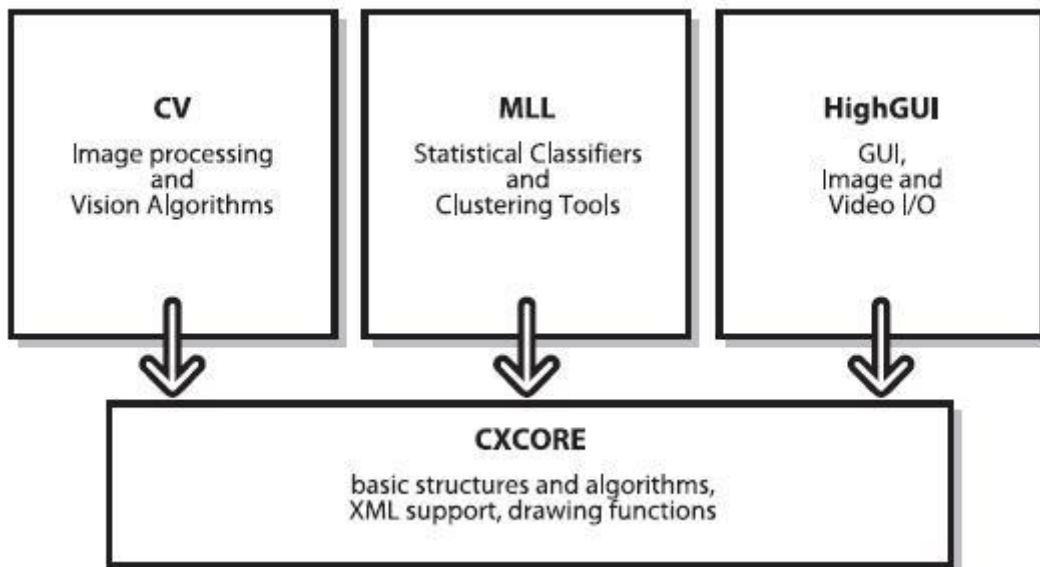
Figure 3.8. OpenCV core.

3.1.4   Global diagrame
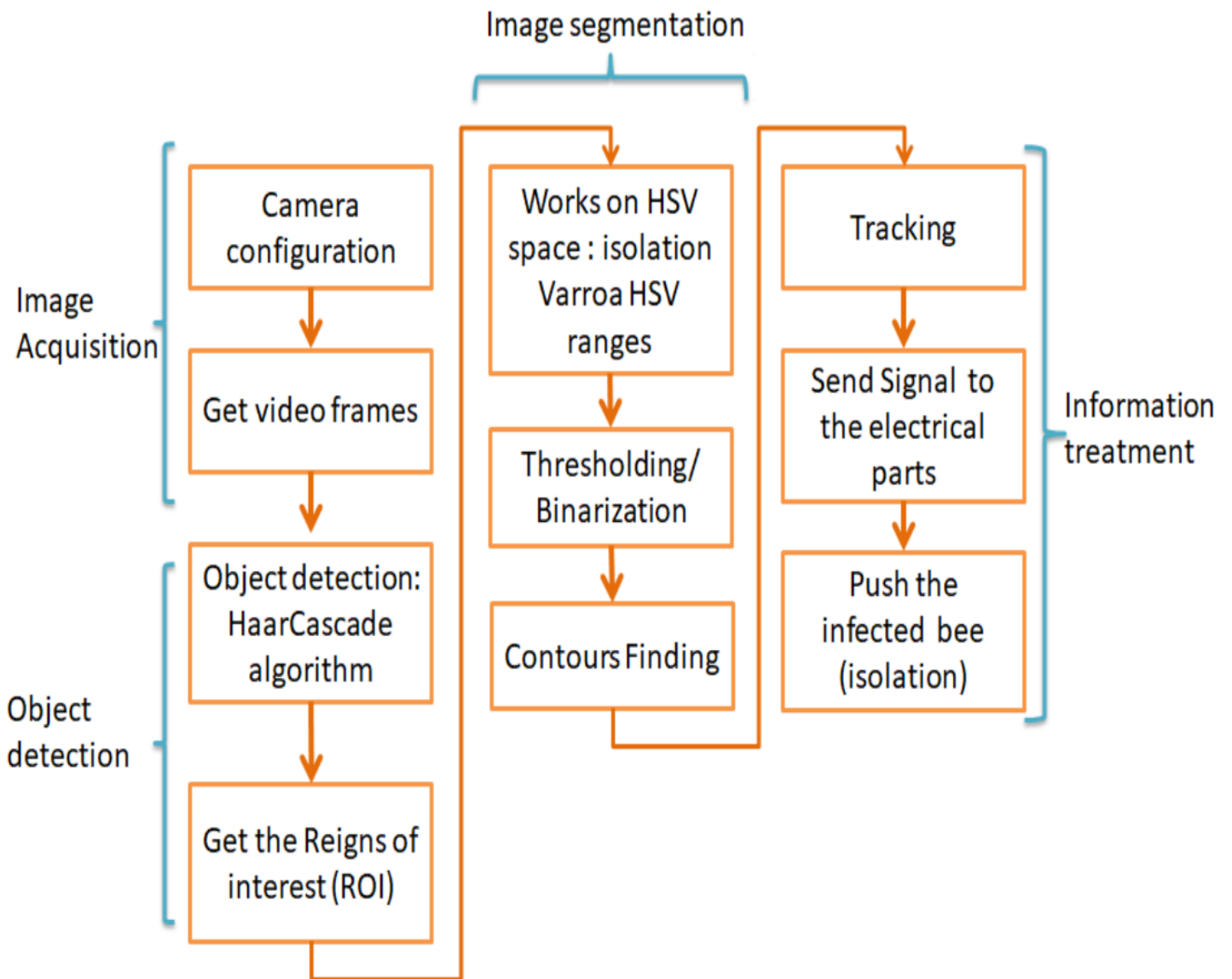
Figure 3.9. Global diagrame of the project.

3.1.5 Algorithm of Detection and Tracking
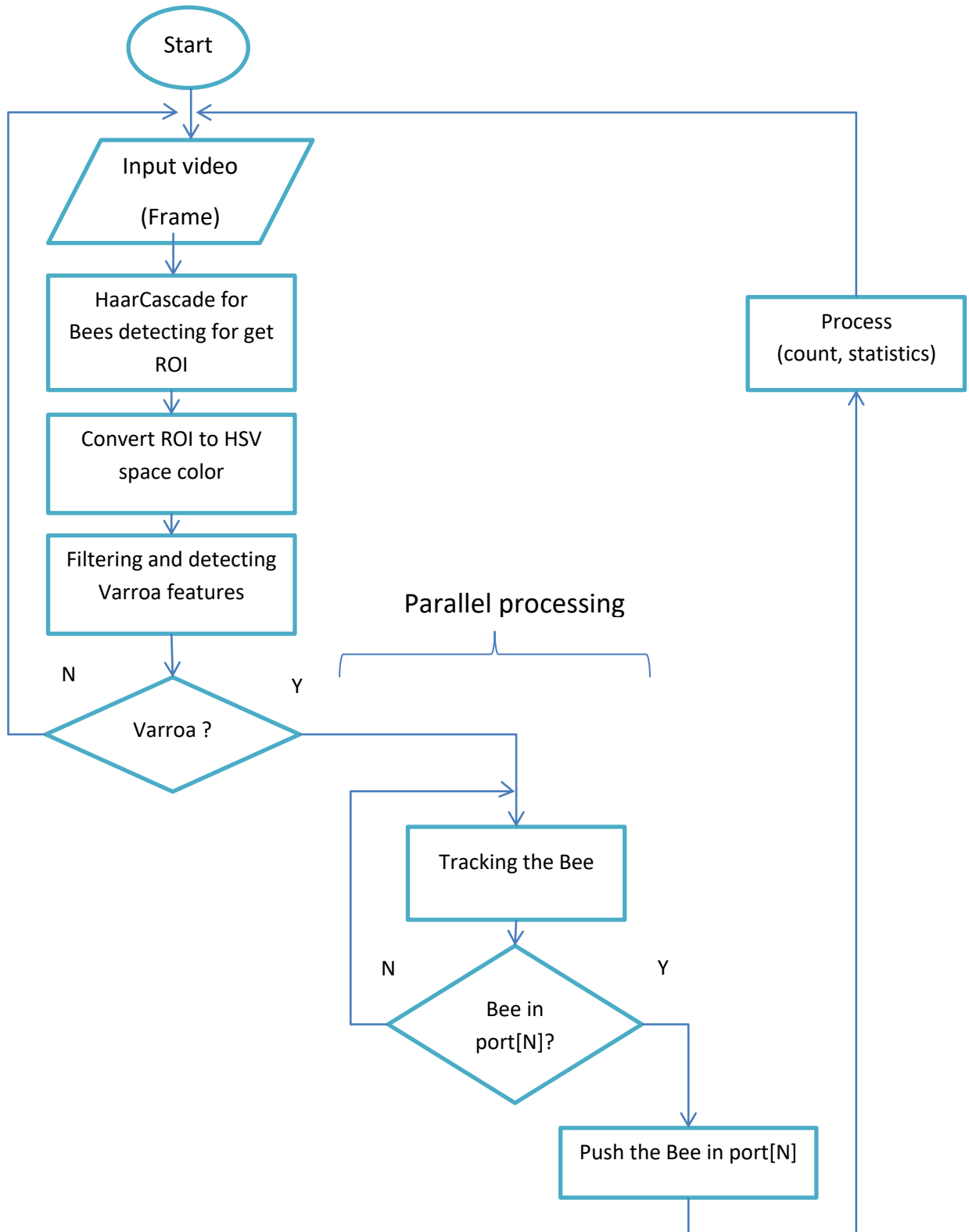
Figure 3.10. Global Algorithm of project.

3.1.6   The process of Computer Vision

Computer vision is a field of informatics, which teaches computers to see. It is a way computers gather and interpret visual information from the surrounding environment.

Usually the image is first processed on a lower level to enhance picture quality, for example remove noise. Then the picture is processed on a higher level, for example detecting patterns and shapes, and thereby trying to determine, what is in the picture [22] [23].

Acquisition
• Real World

Process
• Image

Analysis
• Information

Action
• Decision
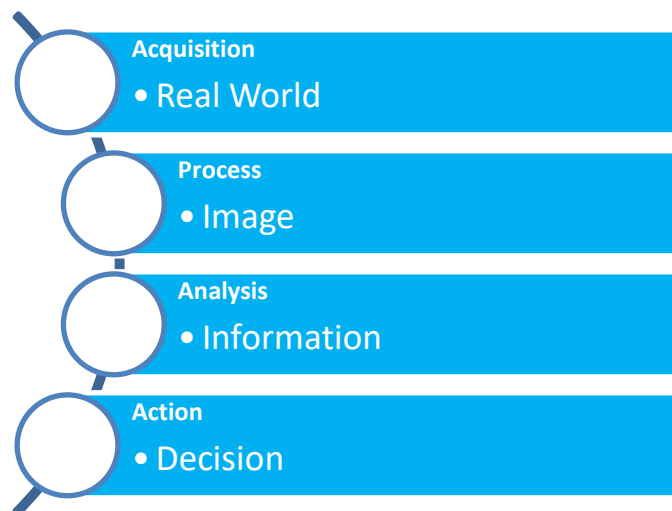
Figure 3.11. The process of Computer Vision.

3.2   Image acquisition

3.2.1   Pi Camera parameters

The camera hardware allows many settings with the most important ones in this case being: frame rate, exposure time, ISO, saturation and brightness.

 In Figure 3.13 different combinations of settings are shown.

The frame rate was se to the maximum possible value of 30 fps at a resolution.

All images are individual frames from different videos captured with a resolution of 1920x1080 at 30 fps and with different camera setups. The two main properties saturation='sat' (default=0, from -100 to 100) and brightness='bright' (default=50, from 0 to 100) are listed beneath each image. (a) shows the full view of the camera. This is what the camera actually films. Figures (b) to (g) are zoomed results with manually marked mites. (b) is the same frameas (a) only zoomed.

(a) sat=65, bright=65   (b) sat=65, bright=65   (c) sat=50, bright=55

(d) sat=60, bright=50   (e) sat=75, bright=60   (f) sat=50, bright=50   (g) sat=0, bright=50
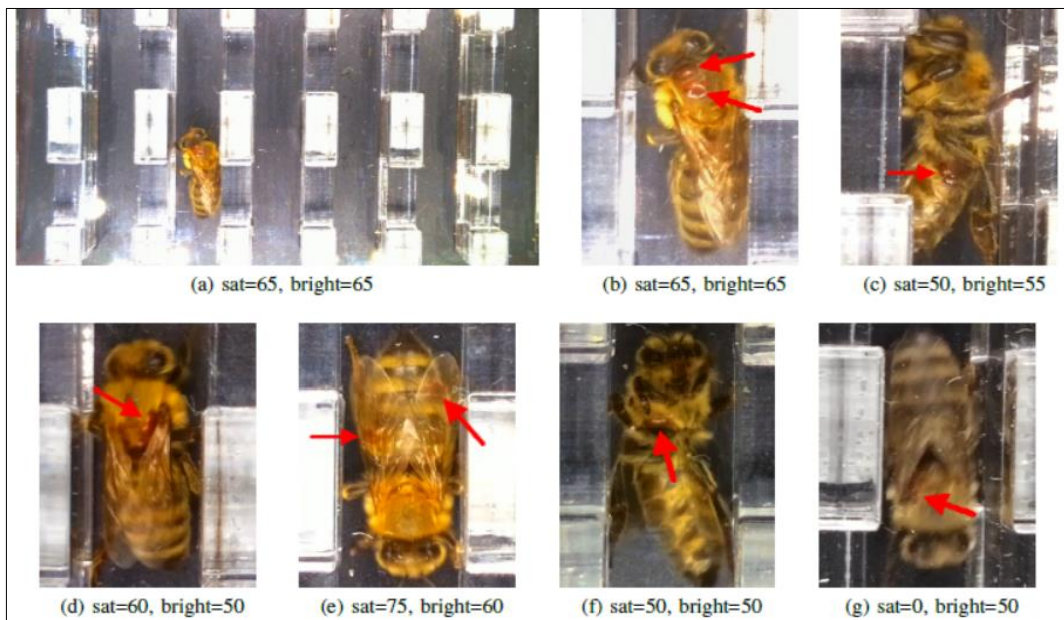
Figure 3.12. PiCamera Setting.

a.   The Best parrameters

Figure 3.13. The best capting of bees was with Saturation = 65, Brightness = 65.

3.3 Bee detection

3.3.1 Object detection

Object detection is commonly referred to as a method that is responsible for discovering and identifying the existence of objects of a certain class. An extension of this can be considered as a method of image processing to identify objects from digital images.

3.3.2 Haar-cascade *Classifier* Algorithm
a. Definition

Haar Cascade is a machine learning object detection algorithm used to identify objects in an image or video and based on the concept of features proposed by Paul Viola and Michael Jones in their paper "Rapid Object Detection using a Boosted Cascade of Simple Features" in 2001.

It is a machine learning based approach where a cascade function is trained from a lot of positive and negative images. It is then used to detect objects in other images.

The algorithm has four stages:

a.1 Haar Feature Selection

A Haar feature considers adjacent rectangular regions at a specific location in a detection window, sums up the pixel intensities in each region and calculates the difference between these sums.
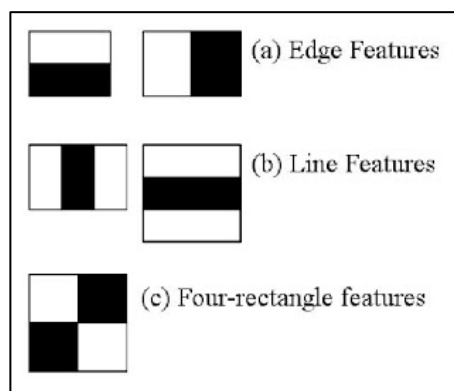
Figure 3.14. Simple features.

a.2. Creating Integral Images

An integral image is summed-area table is a data structure and algorithm for quickly and efficiently generating the sum of values in a rectangular subset of a grid,Integral Images are used to make this super-fast.

a.3. Adaboost Training

Problems in machine learning often suffer from the curse of dimensionality — each sample may consist of a huge number of potential features (for instance, there can be 162,336 Haar features, as used by the Viola–Jones object detection framework, in a 24×24 pixel image window), and evaluating every feature can reduce not only the speed of classifier training and execution, but in fact reduce predictive power, per the Hughes Effect [24]. Unlike neural networks and SVMs, the AdaBoost training process selects only those features known to improve the predictive power of the model, reducing dimensionality and potentially improving execution time as irrelevant features need not be computed.

a.4. Cascading Classifiers

The cascade classifier consists of a collection of stages, where each stage is an ensemble of weak learners. The weak learners are simple classifiers called decision stumps. Each stage is trained using a technique called boosting. Boosting provides the ability to train a highly accurate classifier by taking a weighted average of the decisions made by the weak learners. It is well known for being able o detect faces and body parts in an image, but can be trained to identify almost any object.

Lets take face detection as an example. Initially, the algorithm needs a lot of positive images of faces and negative images without faces to train the classifier. Then we need to extract features from it.
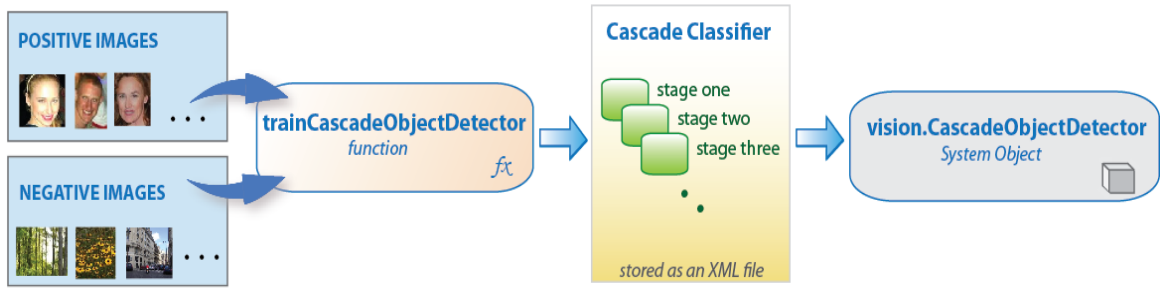
Figure 3.15. HaarCascade training steps.

b. **Works Steps**

Video Capturing	• Save a video with bees moves(Camera)
Video segmentation	• Extract frames from the video(VLC)
Marking	• Markin bees with ObjectMaker tools (cut positives and negatives images)
Training	• Train the classifire with positives and negatives images
Get the trained file	• an .xml file
Testing	• use the .xml file with Haar Cascade algorithm - python/OpenCV
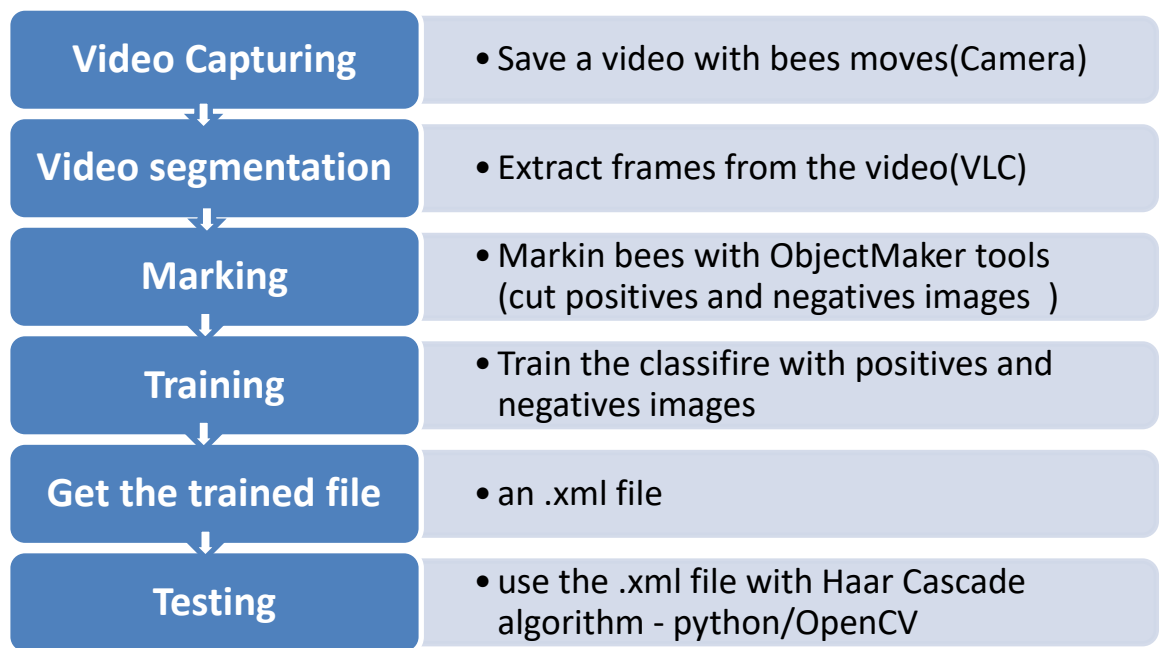
b.1.   **extract frames from video with VLC player**
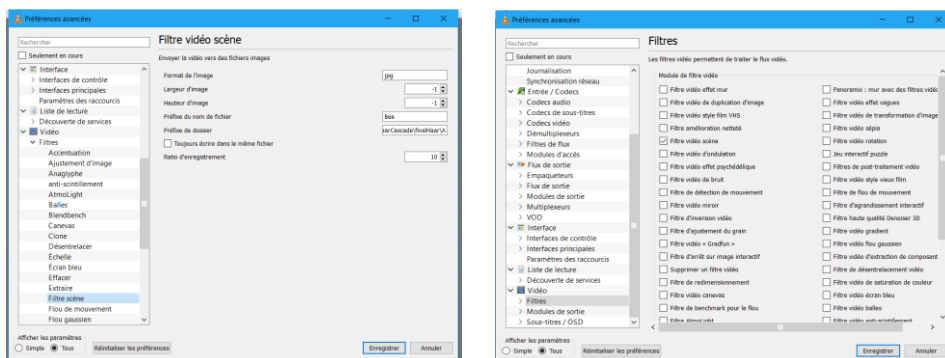
Figure 3.16. VLC parameters for video frame extraction (Get frames).

b.2   Training the classifier :

Figure 3.17. HaarCascade training stages.

b.3   Classifier Test


```python
1   import cv2
2   import time
3
4   Bee_cascade = cv2.CascadeClassifier('myBeeDetector.xml')
5   cap = cv2.VideoCapture('20190427_163413.mp4')
6   while(True) :
7       ret,frame = cap.read()
8       gray=cv2.cvtColor(frame,cv2.COLOR_BGR2GRAY)
9       bee = Bee_cascade.detectMultiScale(gray, 1.3, 5)
10      for (x,y,w,h) in bee:
11          frame = cv2.rectangle(frame,(x,y),(x+w,y+h),(255,0,0),2)
12          frame = cv2.rectangle(frame,(x+(w//2-2)-2,y+(h//2-2)-2),
13      cv2.imshow('Bee | ESE',frame)
14      if cv2.waitKey(1) == ord('q'):
15          break
16  cap.release()
```

Figure 3.18. Simple code part of Haar cascade classifier.

Results:

If the bee is detected, we get 2 pints of the rectangle, the object inside this rectangle.
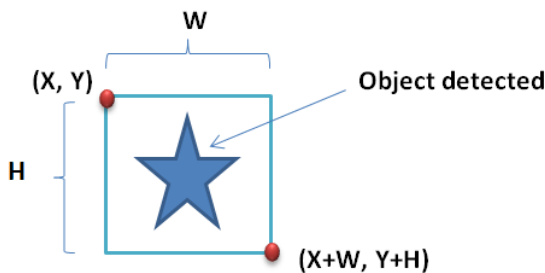
Figure 3.19. HaarCascade Output result " ROI " .

Bees detected	
Bees not detected	

Table 3.3. HaarCascade Algorithm test.

We use this rectangle as ROI (region of interest) for more image processing, we need now find search for Varroa mite into that ROI ,will use technics of color finding.

3.4 Image segmentation: HSV thresholding

3.4.1 Definition:

in computer vision, image segmentation is the process of partitioning a digital image into multiple segments (sets of pixels, also known as super-pixels). The goal of segmentation is to simplify and/or change the representation of an image into something that is more meaningful and easier to analyze. Image segmentation is typically used to locate objects and boundaries (lines, curves, etc.) in images. More precisely, image segmentation is the process of assigning a label to every pixel in an image such that pixels with the same label share certain characteristics.

The result of image segmentation is a set of segments that collectively cover the entire image, or a set of contours extracted from the image (see edge detection). Each of the pixels in a region are similar with respect to some characteristic or computed property, such as color, intensity, or texture. Adjacent regions are significantly different with respect to the same characteristic(s). When applied to a stack of images, typical in medical imaging, the resulting contours after image

segmentation can be used to create 3D reconstructions with the help of interpolation algorithms like Marching cubes.

The simplest method of image segmentation is called the thresholding method. This method is based on a clip-level (or a threshold value) to turn a gray-scale image into a binary image.

3.4.2 Color space

A range of colors can be created by the primary colors of pigment and these colors then define a specific color space. **Color space**, also known as the color model (or color system), is an abstract mathematical model which simply describes the range of colors as tuples of numbers, typically as 3 or 4 values or color components (e.g. **RGB**). Basically speaking, color space is an elaboration of the coordinate system and sub-space. Each color in the system is represented by a single dot.
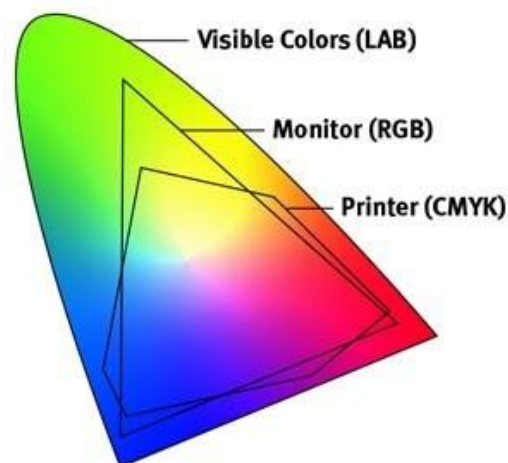
Figure 3.20. Deferent Color Space

A color space is a useful method for users to understand the color capabilities of a particular digital device or file. It represents what a camera can see, a monitor can display or a printer can print, and etc. There are a variety of color spaces, such as RGB, CMY, HSV, HIS.

a. RGB color space

The RGB color model is a color model used largely in display technologies that use light. In this model, the colors red (R), green (G) and blue (B) are added together at

different intensities to produce millions of different colors on modern video display screens.

The RGB color model is based on a the science of the human eye perceives light and translates it into brain waves. This model is extremely common for TV and video displays, video game console displays, digital cameras and other types of light-based display devices.The RGB model is as an "additive" model: as colors are added, in the form of light, the result becomes lighter. For instance, the full combination of red, green and blue produces white.
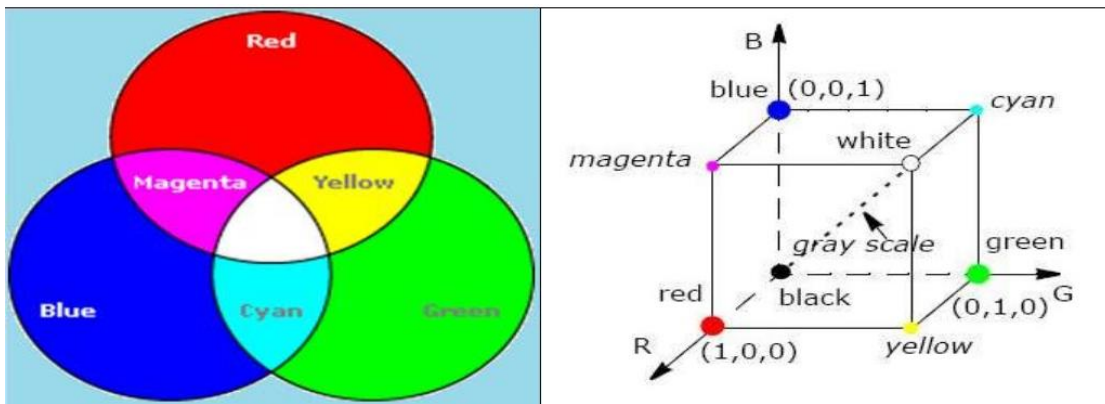
Figure 3.21. RGB-CYMK model.

An alternative model to the RGB model is the CMYK model, which is used for color printing. This model uses the colors cyan (C), magenta (M), yellow (Y) and black (K), which is called the "key." Whereas RGB is additive, CMYK is subtractive. This is because the CMYK system uses colored inks to mask colors on a white background and "subtracts" brightness from that white background.

b. HSV Color Space :

The RGB (red, green, blue) color model is the most well-known way to mix and create colors. If you deal with commercial printers, you know about CMYK (cyan, magenta, yellow, key). You might have noticed HSV (hue, saturation, value) in the color picker of your graphics software. These are all schemes that describe the way colors combine to create the spectrum we see.

Unlike RGB and CMYK, which use primary colors, HSV is closer to how humans perceive color. It has three components: hue, saturation, and value. This color space describes colors (hue or tint) in terms of their shade (saturation or amount of gray) and their brightness value. Some color pickers, like the one in Adobe Photoshop, use the acronym HSB, which substitutes the term "brightness" for "value," but HSV and HSB refer to the same color model.
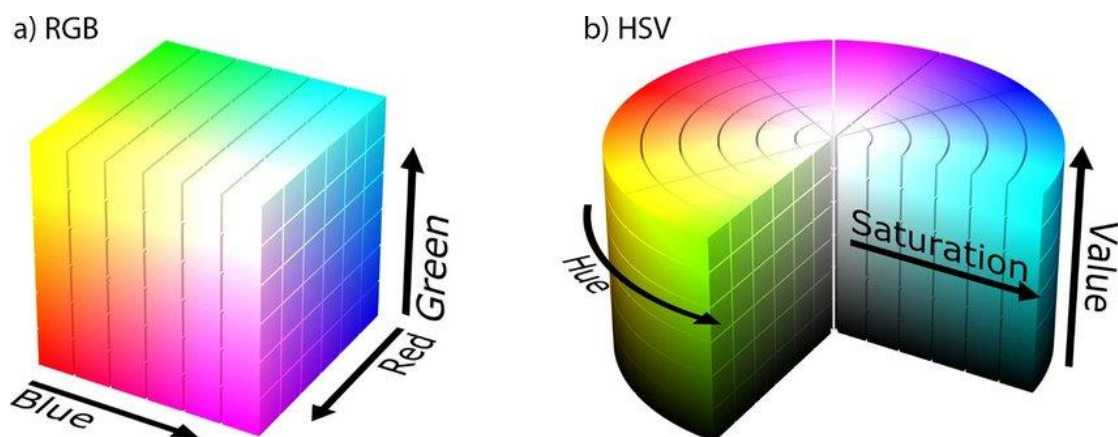
Figure 3.22. HSV modul .

The HSV color wheel sometimes appears as a cone or cylinder, but always with these three components:

c.1. HUE

Hue is the color portion of the model, expressed as a number from 0 to 360 degrees:

- **Red** falls between 0 and 60 degrees.
- **Yellow** falls between 61 and 120 degrees.
- **Green** falls between 121-180 degrees.
- **Cyan** falls between 181-240 degrees.
- **Blue** falls between 241-300 degrees.
- **Magenta** falls between 301-360 degrees.

c.2. SATURATION

Saturation describes the amount of gray in a particular color, from 0 to 100 percent. Reducing this component toward zero introduces more gray and produces a faded effect. Sometimes, saturation appears as a range from just 0-1, where 0 is gray, and 1 is a primary color.

c.3. VALUE (OR BRIGHTNESS)

Value works in conjunction with saturation and describes the brightness or intensity of the color, from 0-100 percent, where 0 is completely black, and 100 is the brightest and reveals the most color.

d. Uses of HSV

Designers use the HSV color model when selecting colors for paint or ink because HSV better represents how people relate to colors than the RGB color model does.

The HSV color wheel also contributes to high-quality graphics. Although less well known than its RGB and CMYK cousins, the HSV approach is available in many high-end image editing software programs.

Selecting an HSV color begins with picking one of the available hues and then adjusting the shade and brightness values.

e. RGB to HSV Conversion:

The universal model for convertion:

- colour cone

  hue

  0   60   120   180   240   300   360

  - H = hue / colour in degrees $\in$ [0,360]

  - S = saturation $\in$ [0,1]

  - V = value $\in$ [0,1]

- conversion RGB $\rightarrow$ HSV

  - V = max = max (R, G, B),   min = min (R, G, B)

  - S = (max – min) / max   (or S = 0, if V = 0)
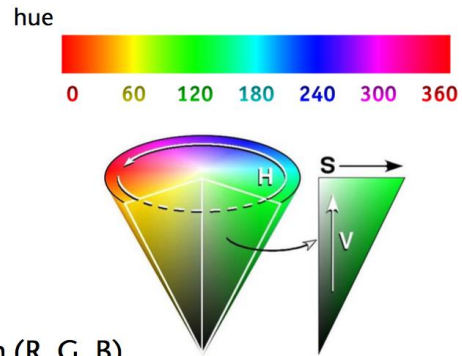
  - $H = 60 \times \begin{cases} 0 + (G - B) / (max - min), & \text{if } max = R \\ 2 + (B - R) / (max - min), & \text{if } max = G \\ 4 + (R - G) / (max - min), & \text{if } max = B \end{cases}$

  H = H + 360, if H < 0

We use this model to create(programming) a software application with graphical interface for converting RGB values of pixels image to the HSV values:

3.4.3 *RGB to HSV Color Space Converter*

This software can show the RGB color of a Pixel,conversion it to HSV

and show his value,or show a list of range between two points selected:
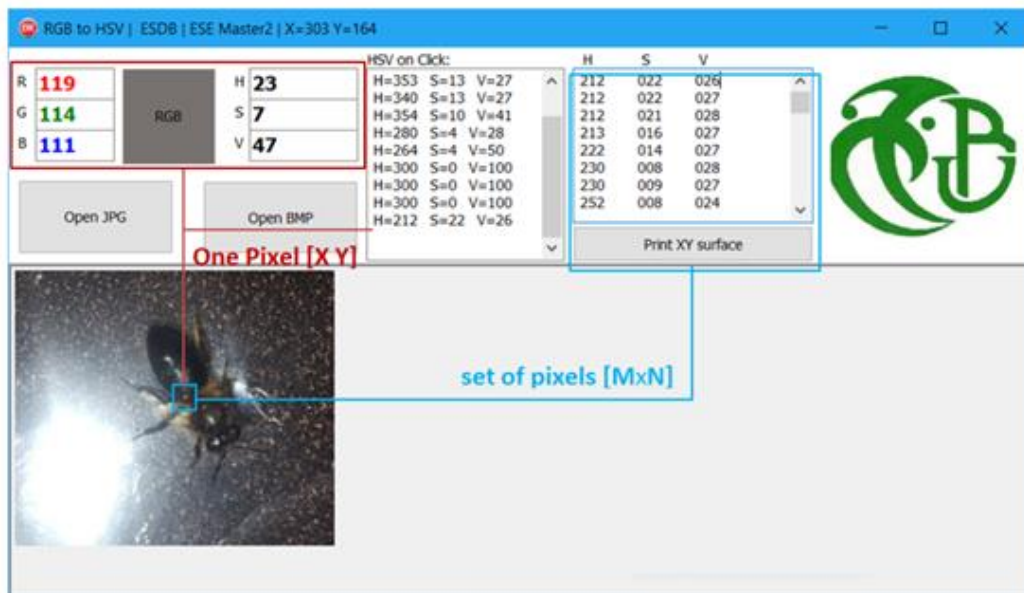
Figure 3.23. RGV to HSV color spave Converter software , USDB ESE 2019.

47

The Varroa mite color in range of the Red color , we see it as a brown reddish

In HSV space color, all time, the varroa in red range (-30° to +30°)

The Bee color is in blue range or red, we see her as black or in red degrees, the bees color variant from species to species.
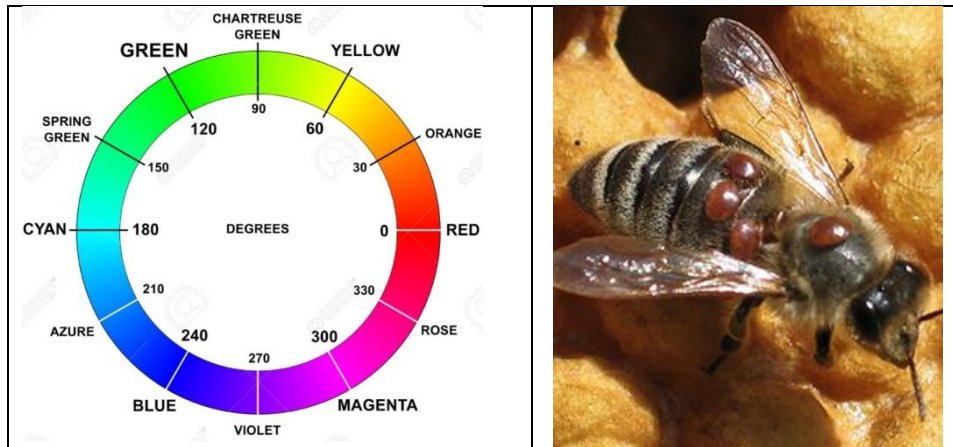
Figure 3.24. Varroa Color range "Hue".

3.4.4 Get HSV Color space

Now we can start the study the coloration of varroa mites in HSV space color.

Initial steps:
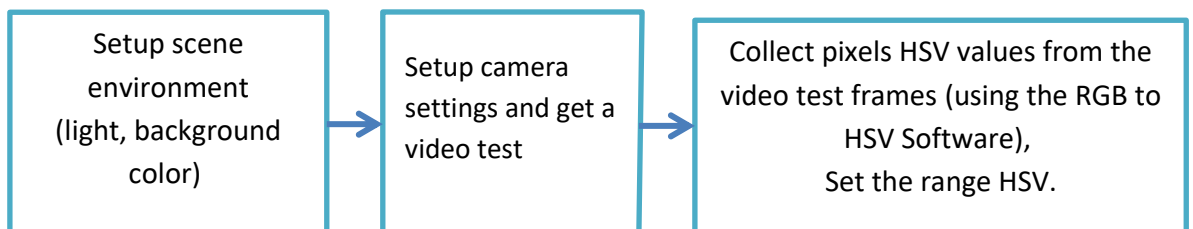
Isolation varroa color range and binarisation :

In this part , we try to isolate varroa from the bees by HSV color space , The Images is taken by PiCamera with deferments settings (images source : publication [*Sensor Study for Monitoring Varroa Mites on Honey Bees (Apis mellifera)*]) .

3.4.5 image processing

After applying HSV color threshulding there are still some random free pixels, or so-called noise , to filter them we apply the Erosion and then the Dilatation.

a. *Dilatation:*

- This operations consists of convoluting an image A with some kernel (B), which can have any shape or size, usually a square or circle.

- The kernel B has a defined *anchor point*, usually being the center of the kernel.

- As the kernel B is scanned over the image, we compute the maximal pixel value overlapped by B and replace the image pixel in the anchor point position with that maximal value. As you can deduce, this maximizing operation causes bright regions within an image to "grow" (therefore the name *dilation*). Take as an example the image above. Applying dilation we can get:

The background (bright) dilates around the black regions of the letter.

To better grasp the idea and avoid possible confusion, in this another example we have inverted the original image such as the object in white is now the letter. We have performed two dilatations with a rectangular structuring element of size $3x3$.

The dilatation makes the object in white bigger.

b. Erosion :

- This operation is the sister of dilation. What this does is to compute a local minimum over the area of the kernel.

- As the kernel B is scanned over the image, we compute the minimal pixel value overlapped by B and replace the image pixel under the anchor point with that minimal value.

- Analogously to the example for dilation, we can apply the erosion operator to the original image (shown above). You can see in the result below that the bright areas of the image (the background, apparently), get thinner, whereas the dark zones (the "writing"(gets bigger.

In the same manner, the corresponding image resulting of the erosion operation on the inverted original image (two erosions with a rectangular structuring element of size $3x3$.

The erosion makes the object in white smaller.
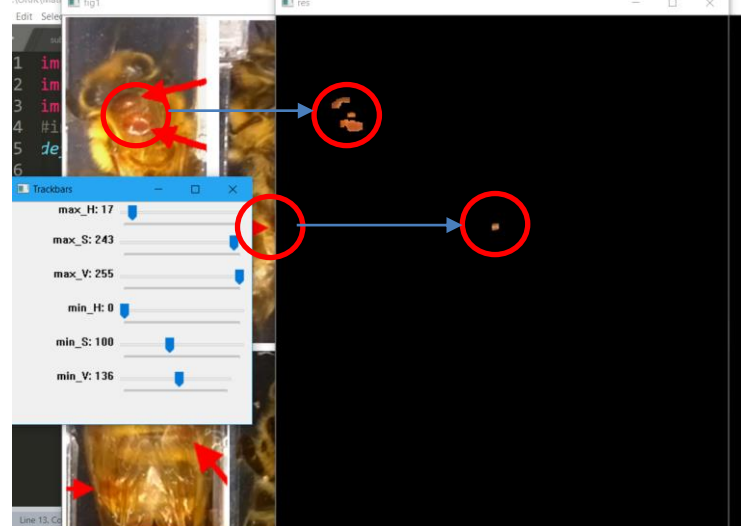
3.4.6   Testing Part

a.   Test 01

Camera and settings	PiCamera Saturation : 65 Brightness : 65
Target	Bee N°1
HSV Range	H: [0 18] S: [169 255] V: [134 239]
Result: get the two Varroas bee N°1 Varroa only	
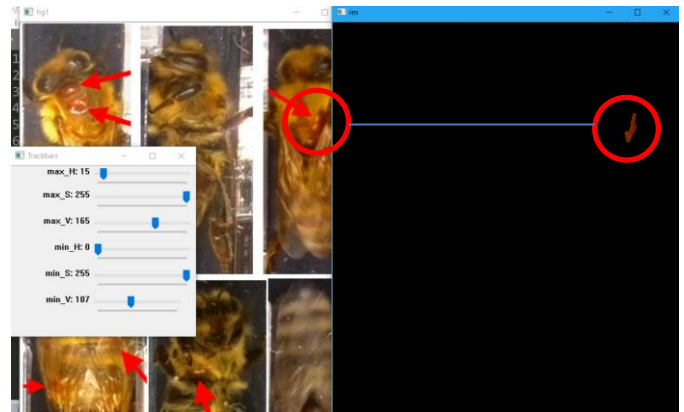
Table 3.4. Result image segmentation N°1.

b.   ***Test 02*** :

Camera and settings	PiCamera Saturation : Variant (6 images) Brightness : Variant(6 images)
Target	Bee N°2
HSV Range	H: [0 17] S: [100 243] V: [136 255]
Result get , three Varroa on two bees N°1 and N°2 . Varroa only	

Table 3.5. Result image segmentation N°2.

c.   ***Test 03***

Camera and settings	PiCamera Saturation : Variant (6 images) Brightness : Variant (6 images)
Target	Bee N°3
HSV Range	H: [0 15] S: [255 255] V: [107 165]
Result Get One Varroa on bee N°3. Varroa only	

Table 3.6. Result image segmentation N°3.

d. Test 04

Camera and settings	PiCamera Saturation : Variant (6 images) Brightness : Variant (6 images)
Target	Bee N°4
HSV Range	H: [9 21] S: [208 255] V: [128 255]
Result Get Five Varroa on bees N°1 , N°3, N°4 . Varroa and Noise	

Table 3.7. Result image segmentation N°4.

e. Test 05

Camera and settings	PiCamera Saturation : Variant (6 images) Brightness : Variant (6 images)
Target	Bee N°5
HSV Range	H: [19 23] S: [255 255] V: [68 107]
Result Get One Varroa on bee N°5 . Varroa and Noise	

Table 3.8. Result image segmentation N°5.

f. Test 06

Camera and settings	PiCamera Saturation : Variant (6 images) Brightness : Variant (6 images)
Target	Bee N°6
HSV Range	H: [0 19] S: [144 206] V: [85 255]
Result Get One Varroa on bee N°6 . Varroa and Noise	
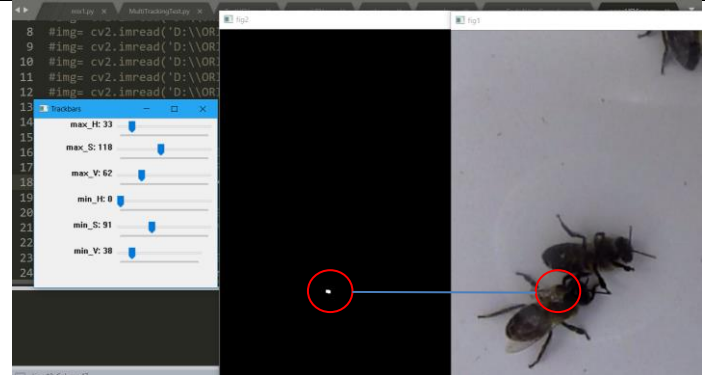
Table 3.9. Result image segmentation N°6.

g. Test 07

Camera and settings	Camera PANASONIC – LEIKA , Unknown.
Target	Varroa
HSV Range	H: [146 255] S: [0 28] V: [69 213]
Result Get the Two Varroa(in the bee ,and the Free one). Varroa only	

Table 3.10. Result image segmentation N°7.

h. Test 08

Camera and settings	Camera Phone Xiaomi Redmi Note 7 , Unknown.
Target	Varroa
HSV Range	H: [0 33] S: [91 118] V: [38 62]
Result Get One Varroa. Varroa only	

Table 3.11. Result image segmentation N°8.

i. Video *testing*

T1	T2	T3	T4
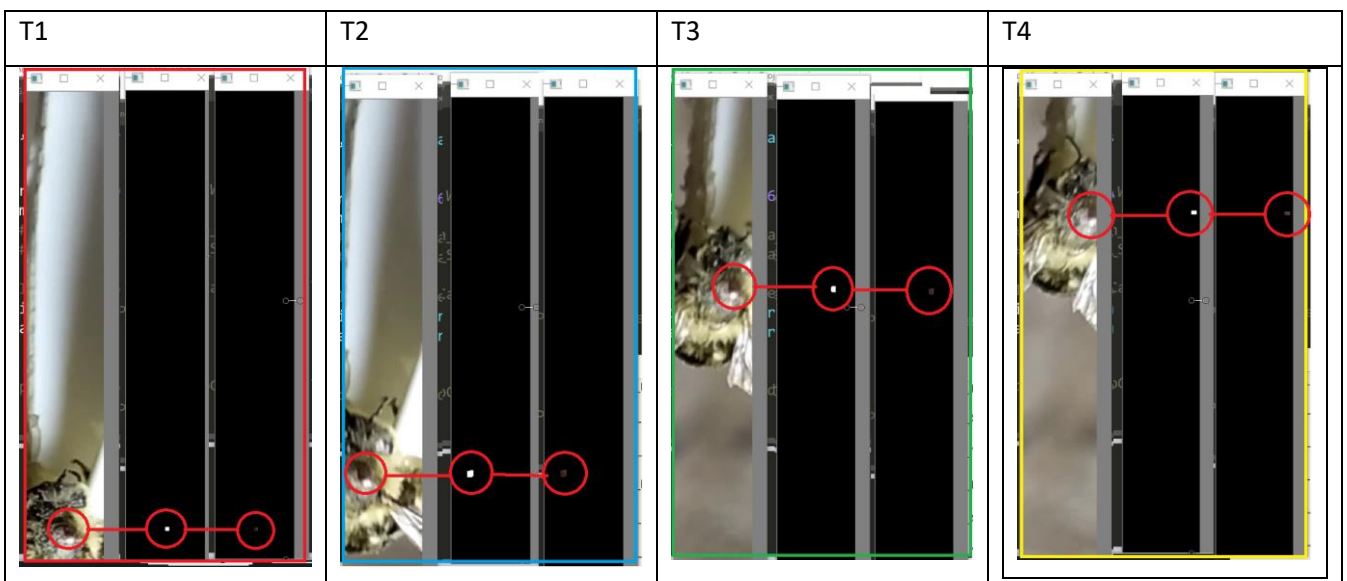
12 Table 3.12. Chronogram of Varroa detection (From Video 80 frames).

frames result	Total video Frames	Varroa is detected	The Varroa isn't detected
Counted frames	**80**	**19**	**61**
Percentage	**100%**	**23.75%**	**76.25%**

Table 3.13. Video Test result

3.5   Tracking

3.5.1   Overview

The video is a sequence of frames separated by a certain time period, movement within the video and changes caused by the light intensity and changes in the level of the camera's sensitivity all lead to uncertainty that prevent detection either of the bee or the presence of the Varroa on it, but there is always a chance of success of the capture in several Frames in the video, and this is what should be exploited, proving the presence of the bee and the Varroa on it in one fine means that that bee must be excluded, and therefore we have to apply a tracking algorithm on the infected bee until it reaches the isolation mechanics.The principle of the work of tracking algorithms:

3.5.2.   The Goal of object tracking

The goal is to keep track of an object in a video sequence. A tracking algorithm is initialized with a frame of a video sequence and a bounding box to indicate the location of the object we are interested in tracking. The tracking algorithm outputs a bounding box for all subsequent frames.

3.5.3   tracking part Algorithm
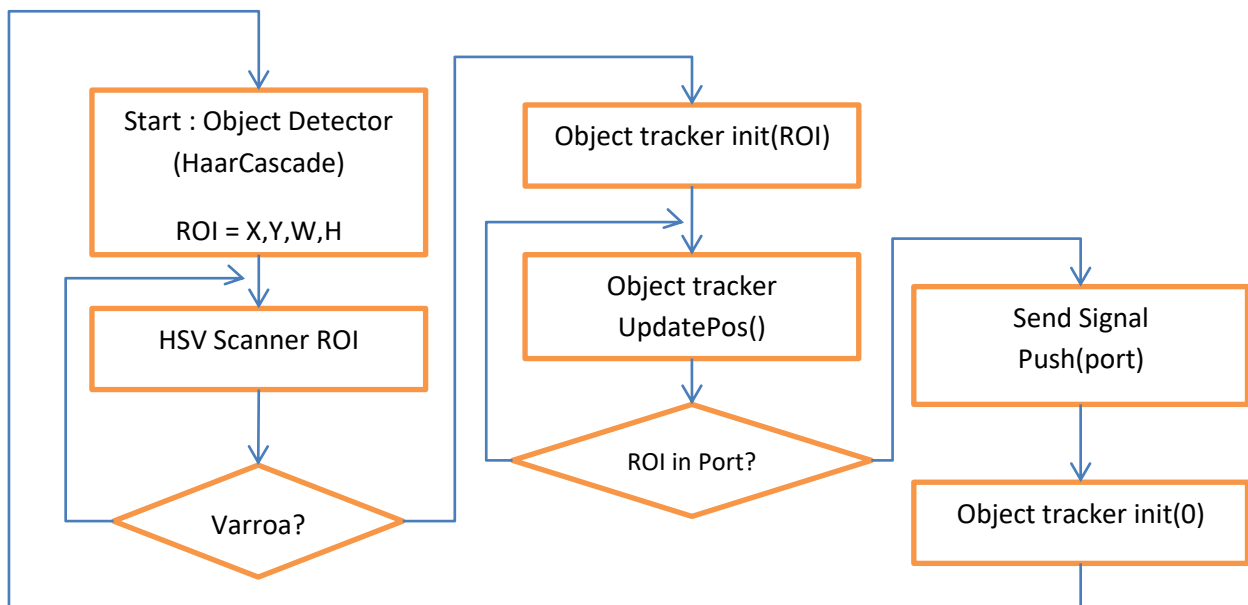
Figure 3.25 Tracking Algorythm.

3.5.4   Object tracking Algorithms in OpenCV

OpenCV includes eight separate object tracking implementations can use in computer vision applications:

1. **BOOSTING Tracker:** Based on the same algorithm used to power the machine learning behind Haar cascades (AdaBoost). This tracker is slow and doesn't work very well. Interesting only for legacy reasons and comparing other algorithms. *(minimum OpenCV 3.0.0)*
2. **MIL Tracker:** Better accuracy than BOOSTING tracker but does a poor job of reporting failure. *(minimum OpenCV 3.0.0)*
3. **KCF Tracker:** Kernelized Correlation Filters. Faster than BOOSTING and MIL. Similar to MIL and KCF, does not handle full occlusion well. *(minimum OpenCV 3.1.0)*
4. **CSRT Tracker:** Discriminative Correlation Filter (with Channel and Spatial Reliability). Tends to be more accurate than KCF but slightly slower. *(minimum OpenCV 3.4.2)*
5. **MedianFlow Tracker:** Does a nice job reporting failures;   if there is too large of a jump in motion, such as fast moving objects, or objects that change quickly in their appearance, the model will fail. *(minimum OpenCV 3.0.0)*
6. **TLD Tracker:** TLD tracker was incredibly prone to false-positives. not recommend using this OpenCV object tracker. *(minimum OpenCV 3.0.0)*
7. **MOSSE Tracker:** Very fast. Not as accurate as CSRT or KCF but a good choice for pure speed. *(minimum OpenCV 3.4.1)*
8. **GOTURN Tracker:** The only deep learning-based object detector included in OpenCV. It requires additional model files to run. *(minimum OpenCV 3.2.0)*

Tracker	OpenCV 3.0	OpenCV 3.1	OpenCV 3.2	OpenCV 3.3	OpenCV 3.4+
CSRT	N/A	Could not compile	No	No	Yes
KCF	N/A	Could not compile	Yes	Yes	Yes
Boosting	N/A	Could not compile	Yes	Yes	Yes
MIL	N/A	Could not compile	Yes	Yes	Yes
TLD	N/A	Could not compile	Yes	Yes	Yes
MedianFlow	N/A	Could not compile	Yes	Yes	Yes
MOSSE	N/A	Could not compile	No	No	Yes

Table 2: OpenCV object trackers and which versions of OpenCV they appear in.

3.5.5 Test MOSSE Tracker :

Figure 3.8. initialisation of MOSSE Tracker

Run the Video with MOSSE Tracker :

Time	T1	T2	T3	T4	T5	T6	T7
State							

Table 3.3. Chronogramme of MOSSE Tracker Test

3.6   Conclusion

In this part it was proved that the possibility of finding Varroa on bees in the simplest possible way, there is no need to use multispectral cameras, and no requirement to use more than one camera, a PiCamera is enough to get a high-resolution image of the bees, but the lighting and intensity must be adjusted and the place is adjusted and adjusted After the focal point in proportion to the clarity of the image and the dimensions necessary for detection.

The use of image shredding via HSV space color succeeded with all kinds of cameras we used.

The picture should be close and clear for the best results, the photography area of 15 cm by 10 cm is enough for that.

The use of a glass layer between bees and the camera requires the installation of the places of light sources on both sides of the camera with a dimension does not show the source of light in the picture, as it forms a white spot that hides the bees if passed directly under them, can use a transparent mesh if necessary or enough good positioning of the light source, and better to be on the sides and its source is from two or more sides.

None of the image processing techniques such as histogram Equalization or increased clarity were used prior to HSV Threshulding to maintain color characteristics and natural distribution.

The adult Faroa has a uniform color between brown and red, and has a flat spherical body that is always heard by a point that reflects the light on the camera, and can be exploited in monitoring applications as a further evidence that it is Varroa.

Free space and light change form either a negative or positive aspect as it changes the color gradients from one place to another in the scene, while it comes out of its installed color range, it gives an opportunity to the Varroa at least once and this has been exploited through the application of tracking and not content with exploration Only.

The most appropriate tracking algorithm in OpenCV was MOSSE algorithm being working in real time and in a modest environment of possibilities such as Raspberry pi for example, without slowing down with a relatively small margin of error.

The algorithms of detecting simple objects such as the thresholding and background subtraction are not used because we need to monitor that the discovered body is already a bee and nothing else as it allows to improve the quality of discovery by training the algorithm on new images and renewing the training file only, as it allows to change the dimensions of photography without affecting The basic algorithm, this is because most of the algorithms for detecting trained objects allow objects to be detected even by changing their sizes and position.

Chapter 04: Mechanical Part

4.1 Introduction

In this Chapter we review the design of the mechanical part of the project integrated of the whole system, which is divided into two parts, the monitoring, analysis and decision-making part Vision Box and the action box, where together they form one device called Varroa Firewall System, the principle of work is similar where the arrival of viruses is prevented before entering A protected area.

4.2 Object

Conception a Mechanical design provides a simple and inexpensive mechanism for protection, provides maximum parallel processing - i.e. multiple exclusion at the same time mechanically, and provides a scene or an imaging environment that allows for a good amount of footage (frames) before entering the bee hive, and allows normal movement at the horizontal level only, and the device is Applicable to the type of Hives common to beekeepers: the Langstroth beehive.

4.3 Tools used

4.3.1 Software

SolidWorks is a solid modeling computer-aided design (CAD) and computer-aided engineering (CAE) computer.

According to the publisher, over two million engineers and designers at more than 165,000 companies were using SolidWorks as of 2013.[1] Also according to the company, fiscal year 2011–12 revenue for SolidWorks totalled $483 million.[2]
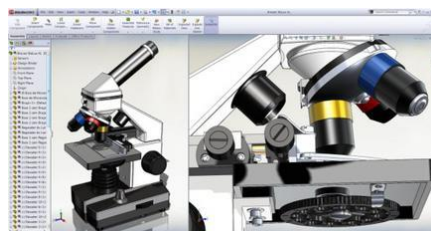
Figure 4.1. SolidWorks CAD Software.

4.3.2 Hardware
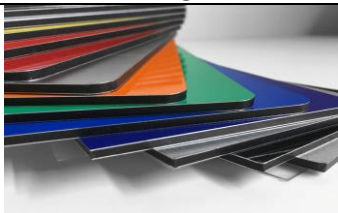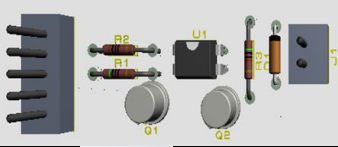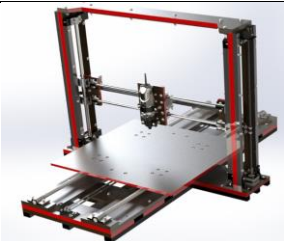
	Material	Image	Uses
Stricter	Composit Panel Alucobond 4mm		Stricter
Vision Box	Glass 3mm		Allows normal bees movement at the horizontal level only, Transparency for the Camera
	LED light		Lighting the Scene
	Raspberry		The main Computer for Embadded System
	Camera		Get a real Time Video
Action Box	Electromagnet		Act the Isolation mechanism
	Power Card		Electrical amplifier
	Port ,Isolation mechanism		Push infected bees
Tools	CNC Machine (DZ inventors)		Numerical Cutting

Table 4.1. Materiel used in Varroa Firewall project.

4.4 Langstroth Bee hive:

The standard beehive used in many parts of the world for beekeeping is based on the Langstroth hive.

| classic Langstroth hive | Normalized dimension * | Modern Langstroth hive |
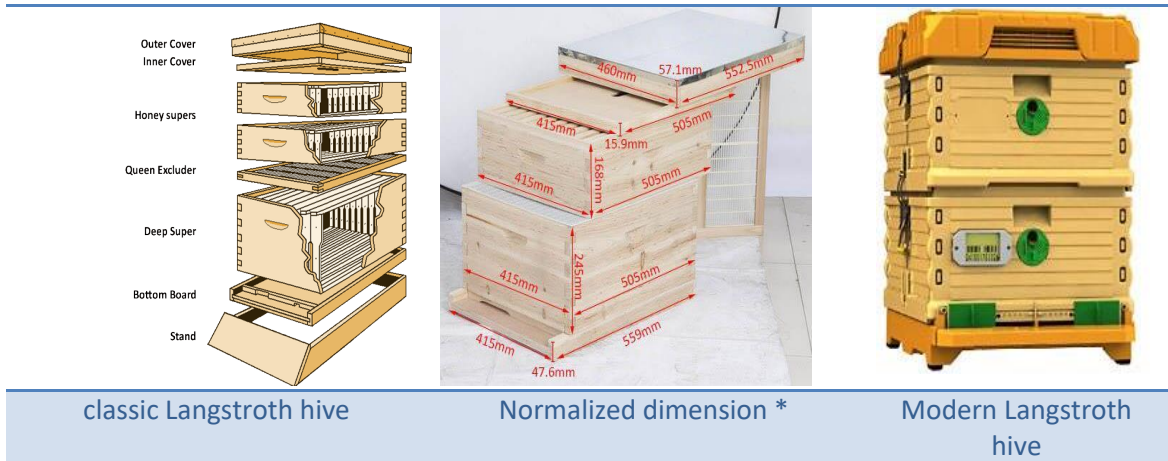
Figure 4.2. Bee hive langstroth.

4.5 Conception

4.5.1 Methodology of prototyping steps
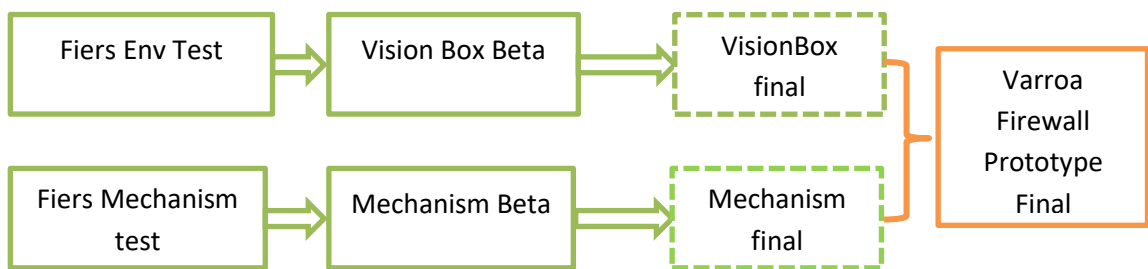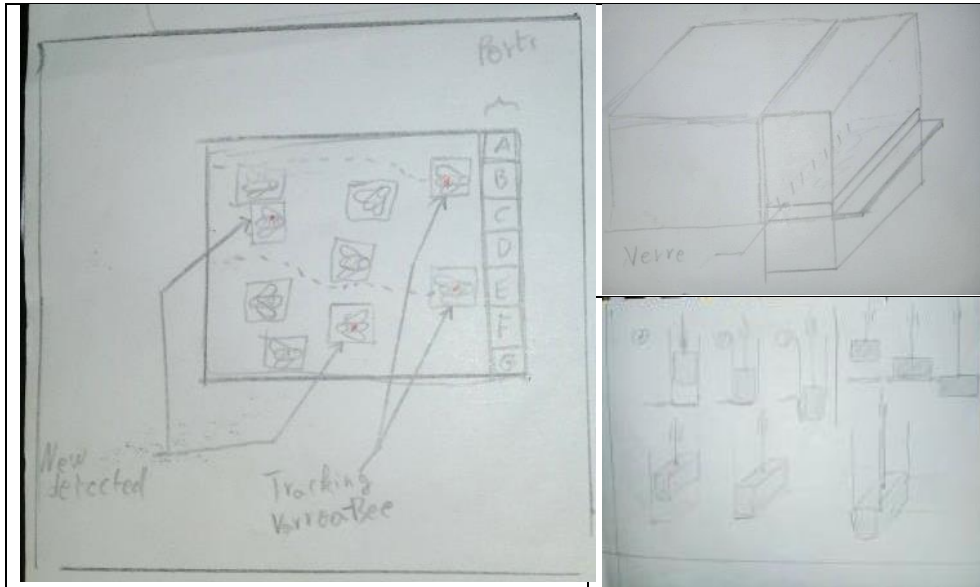
Figure 4.3. hand drawing.

4.5.2   Prototype Realization Versions For test

a. *VisionBox :*

The vision box has dimensions related to the photography area, in which the bees are monitored inside and out of the hive where it provides a suitable imaging environment, consisting in a box at the bottom of which is a bottle parallel to its base and above it by 0.8 cm, a distance that allows the passage of bees in it, form a rectangular tunnel opened and closed manually and has a platform for landing And flying bees, but the rear opening all pass through the gates allowing the passage of only one bee in each gate and it is located, above the vision box there is another box with a camera opening at its base, adjustable height to adjust the focus, and inside it is installed raspiri and its accessories, there are two openings to install Spot LED can be matched to distribute the led on it to distribute the light evenly, the rear lane opening of the bee pass passes through the ActionBox gates.

Camera Hole

Camera Hole

Exit Bees

Glass 3mm

Tunnel H=8mm

Enter Bees
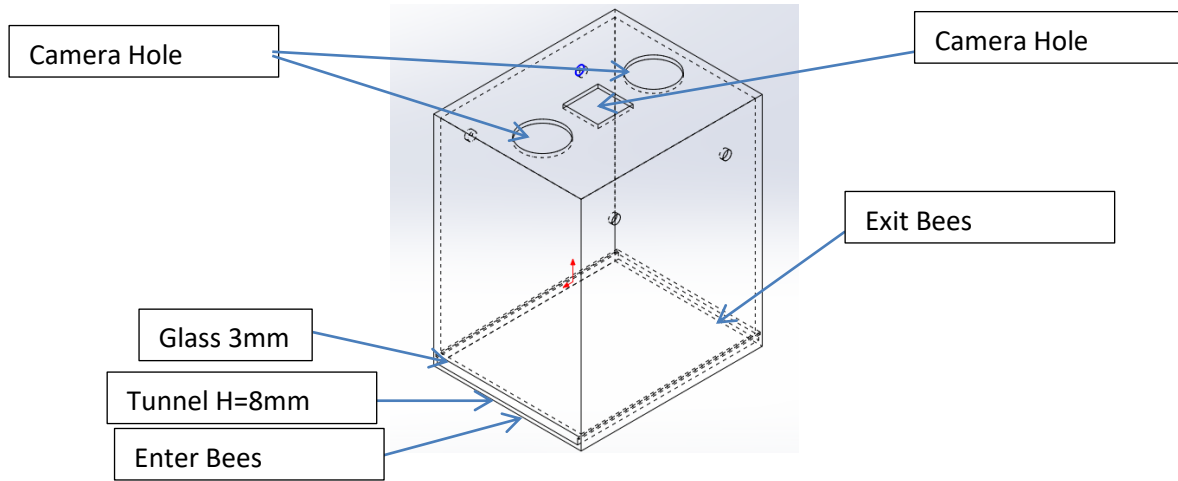
Figure 4.4 Vision Box Prototype Beta for test videos.

a.1.   Conception CAD

| 1 | 2 | 3 | 4 | 5 | cut |
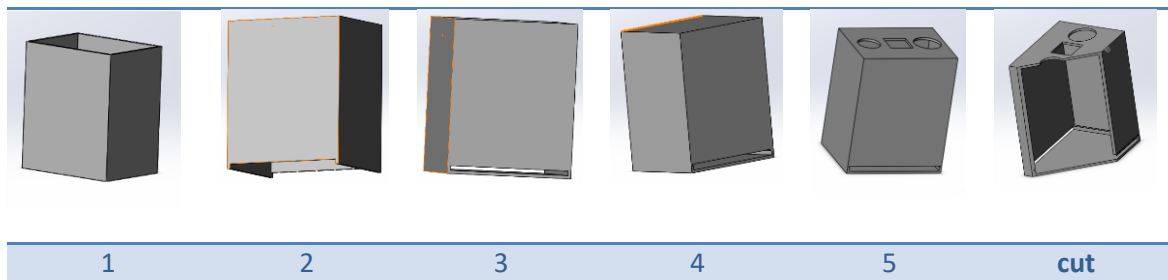
Figure 4.5. VisionBox beta development - SolidWorks.

a.2.   Realization

Figure 4.6 Vision Box Prototype Beta Realization.

b.   ActionBox :

This part of the device will contain the moving mechanical elements involved in the isolation of the infected bees, and will also contain the Power card, and is placed between the beehive and the VisionBox.

b.1.   PushBee mechanism

The PushBee or the gate is a small mechanism within which the pass, the of the walked by the and opens down by the caused by a moving vertically inside the by the applied by the electric magnet, the work as soon as the infected the and you it out to the reservation and when the rises the returns automatically due to the pulsating installed and the proper passage of the again, the operation command from the Raspberry pi (VisionBox).
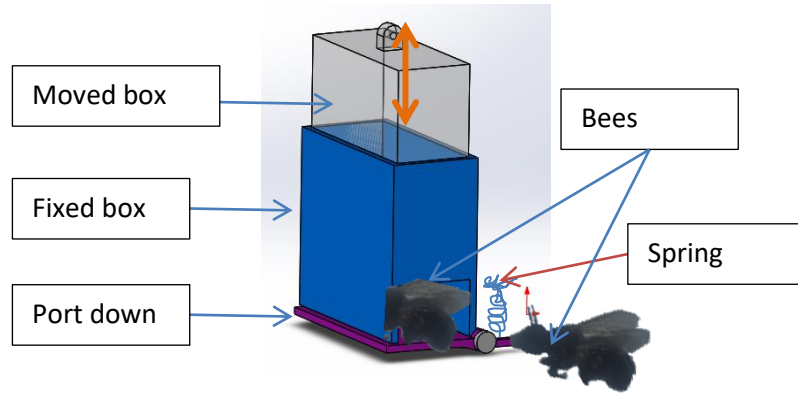
Figure 4.7. PushBee Mechanism description.

b.2. Conception and CAD
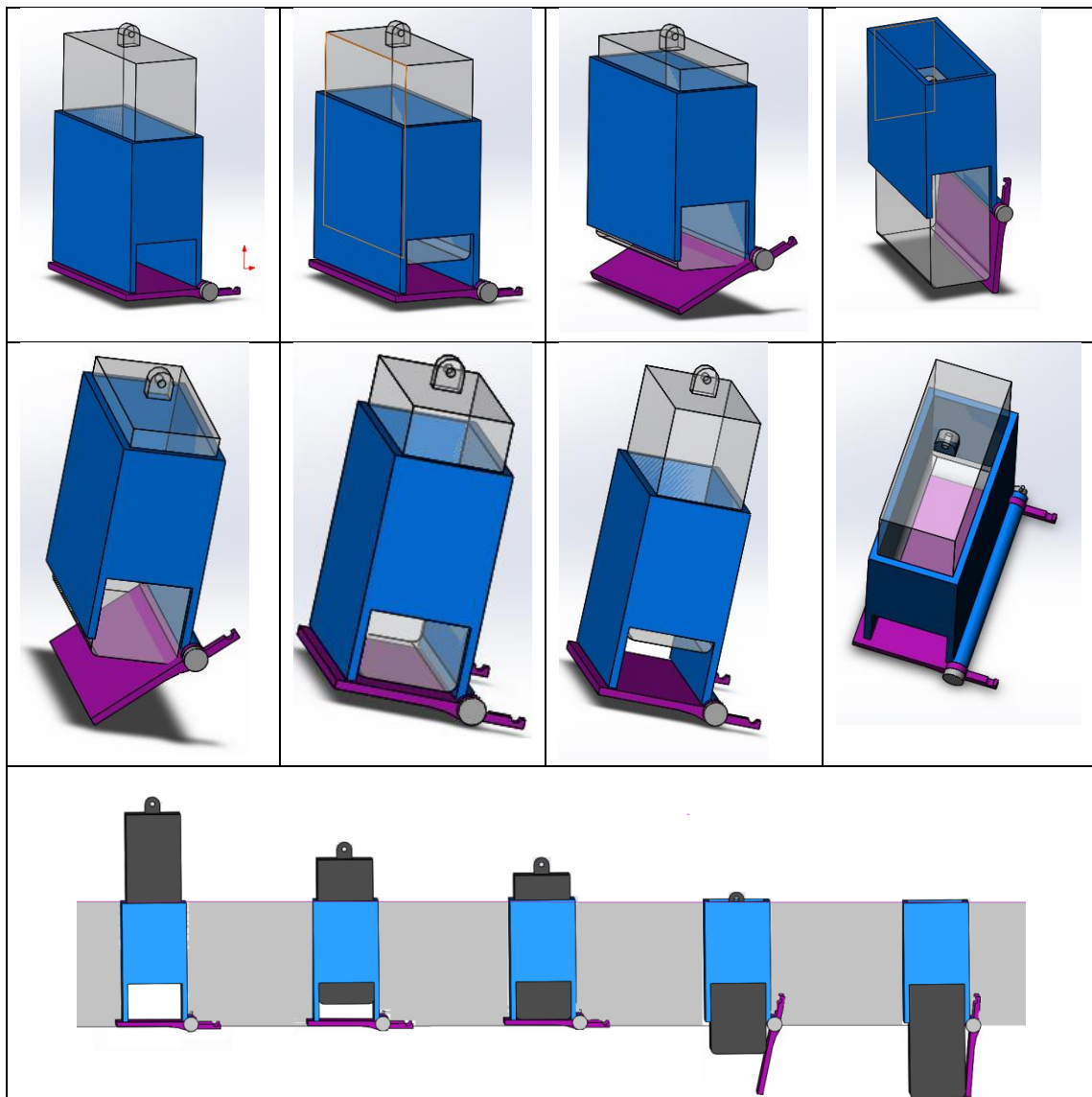
Figure 4.8. PuchBee chronogram**.**

b.3. PowerCircuit
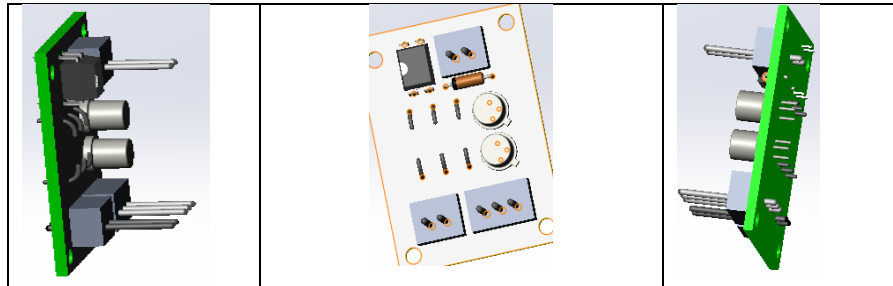
Figure 4.9. 3D modul of PowerCircuit**.**

c. Arm Calculation

There are two types of magnets, one linear and the other angular(Polar), the linear is better but available angular, so the length of its arm must be calculated in order to move a linear distance estimated at 2.5cm.
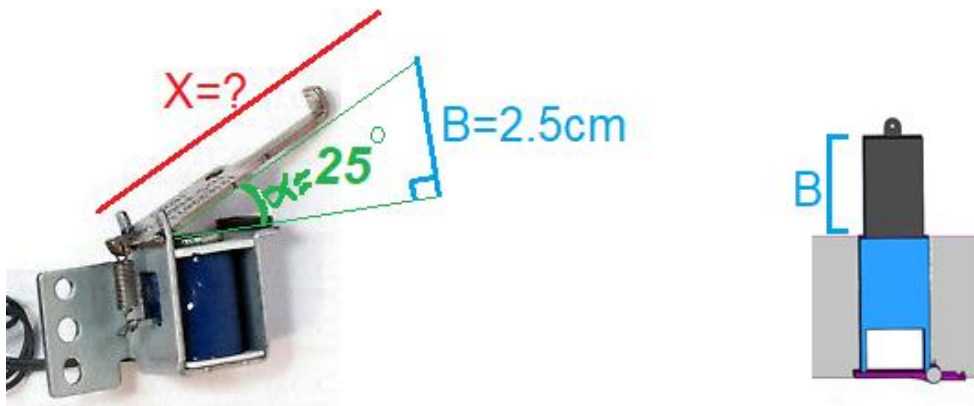
Figure 4.10. PuchBee Arm Calculating.

$$B = 2.5 \, cm$$

$$\alpha = 25°$$

$$x =?$$

$$Sin(\alpha) = \frac{B}{X} \qquad \Rightarrow \qquad x = \frac{B}{Sin(\alpha)} \qquad .... (4.1)$$

$$x = \frac{2}{Sin(25)} = 5.91 \approx 6cm$$

4.5.3 Assembly
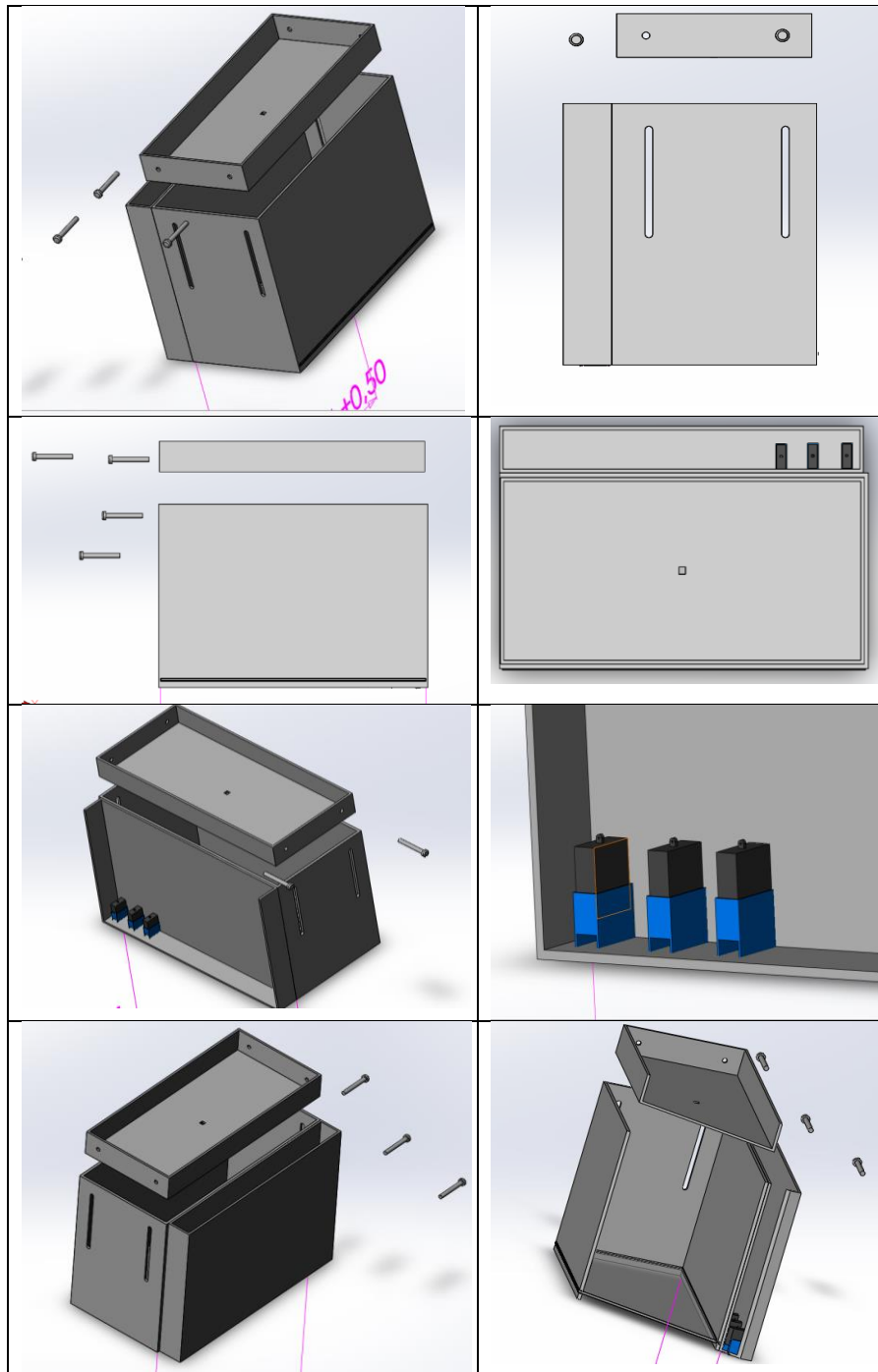
Figure 4.11. complet Varroa Firewall Box and the 3D modul of PowerCircuit.

4.5   Conclusion

There are several ways to design insulation mechanism. We chose the simplest and most suitable for the initial design, but the mechanism remains the same to maintain simplicity and cheap cost.

The dimensions of the device must be proportional to the dimensions of the Langstroth hive.

The dimensions are either identical to the façade and do not touch the ceiling or be smaller, taking into account the mechanism of installation on the box, as the dimensions must be proportional to the installation methods described in the strategy Chapter.

We have not worked to fix the design details because we are still in the stage of studying the project and prototyping.

The goal of the closed box and artificial lighting was to maintain the least amount of light changes during the Vision phase, rather than opening it and leaving it open to sunlight and external changes.

Bees will be forced to pass through the machine, being the only exit and entrance first, as well as taking into account beekeeping techniques in this such as transportation and closure for more than a day or changing to a new box.

The floor of the box should be white or single color and clear and should be of the type that does not reflect the light, in our case we used the sheet of the scanner cover in the printer, it is smooth and white and does not reflect light and solid.

The dimensions of internal isolation mechanism (bee tunnel) must take into account the dimensions of the bee to expand and allow the passage of only one bee, as the external dimensions of it must allow the presence of the minimum and maximum number of mechanisms and this information relates to the study of beekeeping techniques.

Paid bees are booked in an attached box and closed under the device, it has not yet been reported whether they are able to live and clean from the Varroa or not, and this requires a study of that condition, but in any case the reserved number will be ineffectual on the work of the hive, and most importantly they are infected bees will lead to their entry To breed the Varroa inside.

Refirances :

[1] Opening statement by CEO Bertrand Sicot at 2013 Solidworks

World,http://metalworkingnews.info/solidworks-world-2013/

[2] SolidWorks Fact Sheet, July 30, 2012,

https://www.solidworks.com/sw/docs/Corp_FactSheet_2012Q2.pdf

[3] "A Detailed Look at the Langstroth Beehive - PerfectBee". 5 December 2016.

5.1 Global overview

5.1.2 Introduction

After finishing the design of the mechanical part responsible for isolating the infected bee varroa disease, the electronic part responsible for its movement should be designed to form an integrated mechanical unit of the unit, we will see in this chapter the steps of designing the power card that receives the command from the Raspberry Pi and passes the electric power and converts it to mechanical power to operate this mechanism.

5.1.3 Objective

Study, design and execution of the power card responsible for magnifying the signal transmitted by Raspberry the transmitter and converting the electric power to mechanical energy that allows the infected bees to be pushed out.

5.1.4 Tools Used

a Software

ISIS Proteus

b Hardware

b.1 Electronics components: Transistors, Diodes, Resistors, Optocoupler, Terminal Blocs.

b.2 Electro mechanics components (effector): Electromagnet (linear motor like).

Push Pull Linear Actuator Motor Electromagnet.

5.1.5 Global Synoptic Diagram
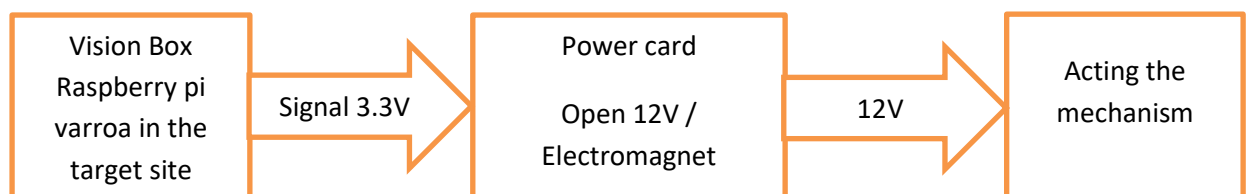
Figure 5.1. Global synoptic diagram.

5.1.6 Synoptic Diagram of the Electronic Part

The block diagram above reproduces the different stages that make up our assembly.

| Commande (Raspberry pi) | → | Power card | → | Actuator (Electromagnet) |

| Digital signal 3.3V Raspberry pi | Power source 5V Raspberry pi | Power source 12V Battery |

Transistor n°1 as a Switch

Optocoupler & Transistor n°2 as a Switch

Linear motor : Electromagnet
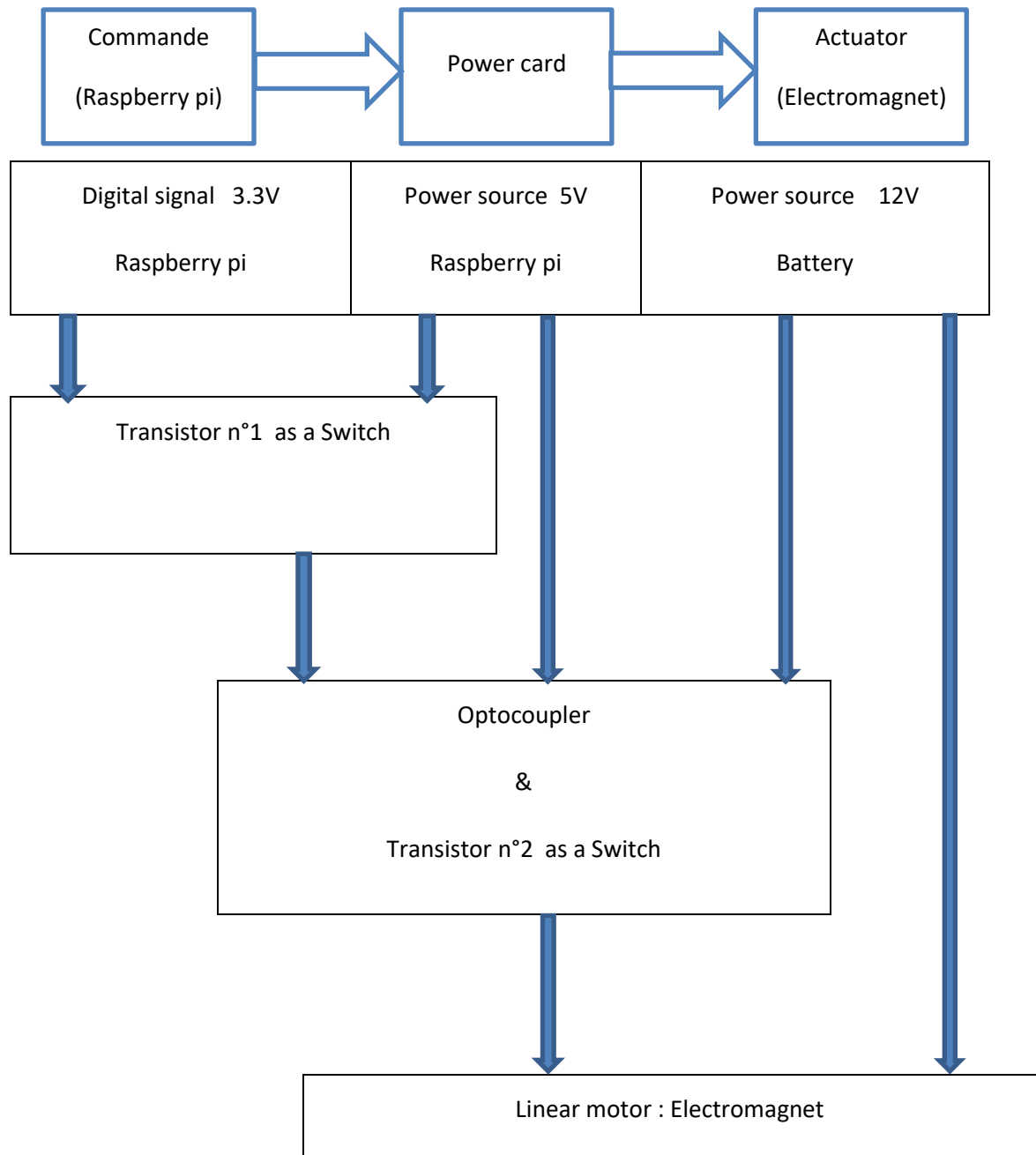
Figure 5.2. Synoptic diagram of the assembly.

5.2 Components Description and Characteristics

5.2.1 Basic electronics components

An electronic circuit comprises of various types of components, which are classified into two types: active components like transistors, diodes, IC's; and passive components like capacitors, resistors, inductors, etc.

In designing of an electronic circuit following are taken into consideration:

Basic electronic components: capacitors, resistors, diodes, transistors, etc.

Power sources: Signal generators and DC power supplies.

Measurement and analysis instruments: Cathode Ray Oscilloscope (CRO), Multimeter [1].

5.2.2 Resistors

A resistor is a two-terminal passive electronic component, used to oppose or limit the current. Resistor works based on the principle of Ohm's law which states that "voltage applied across the terminals of a resistor is directly proportional to the current flowing through it $V=I*R$. (5.1)

The units of the resistance are ohms Where R is the constant called resistance.
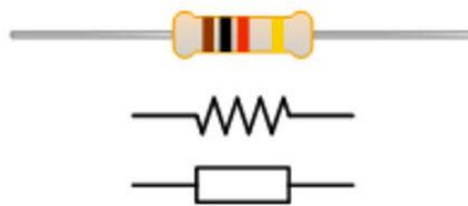
Figure 5.3. Resistors.

Resistors are further classified based on the following specifications such as the power rating, type of material used and resistance value. This resistor types are used for different applications (Fixed resistors, Variable resistors**)** [1].

5.2.3 Inductors

An inductor is also referred as AC resistor which stores electrical energy in the form of magnetic energy. It resists the changes in the current and the standard unit of inductance is Henry. Capability of producing magnetic lines is referred as inductance.

The inductance of the inductor is given as $L = (\mu.K. N2. S)/I$. (5.2)

And I is the Length of the coil in axial direction.
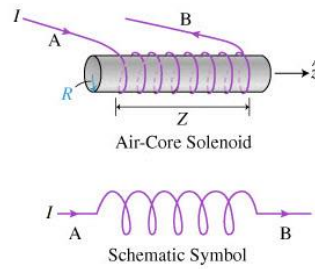
Figure 5.4. Inductors.

Other passive electronic components include different types of Sensors, Motors, and Antennas. To reducing the complexity of this article few of the passive components are discussed above [1].

5.2.4 Electromagnets

An electromagnet is a magnet that runs on electricity. Unlike a permanent magnet, the strength of an electromagnet can easily be changed by changing the amount of electric current that flows through it. The poles of an electromagnet can even be reversed by reversing the flow of electricity.

When an electric current flows in a wire it creates a magnetic field around the wire. By winding the wire into a coil we can strengthen the magnetic field. Electromagnets are made from coils as in (Figure 5.5) [2].
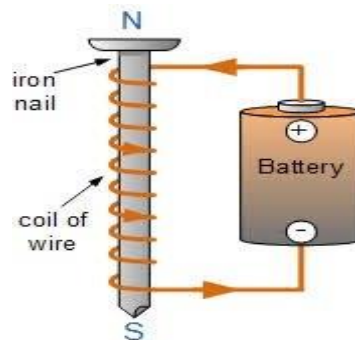
Figure 5.5. Electromagnets.

5.2.5 Active Electronic Components

These components rely on a source of energy and are able to control the electron flow through them. Some of these components are semiconductors like diodes, transistors, integrated circuits, various displays like LCD and LED power sources like batteries, PV cells and other AC and DC supply sources [1].

a Diodes

A diode is a device that allows current to flow in one direction and usually made with semiconductor material.

a.1 Freewheel Diode
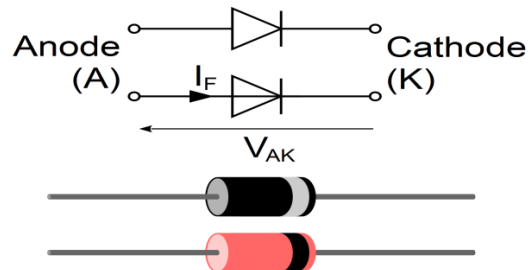
Figure 5.6. Diode symbol.

Diodes appear as small plastic or glass cylinders, and have two outputs called cathode and anode. The ring, usually black or white, on one end of their body, indicates the position of the cathode (Figure 5.6). The diode is the simplest semiconductor component; it can become conductive when the positive pole of a DC voltage is connected to its anode (passing diode). It does not drive if the positive pole is connected to its cathode (blocking diode) [1].

b Transistors

A transistor is a three terminal semiconductor device. Mostly it is used as switching device and also as an amplifier. This switching device can be a voltage or current controlled. By controlling the voltage applied to the one terminal controls the current flow through the other two terminals. Transistors are of two types, namely bipolar junction transistor (BJT) and field effect transistors (FET). And further these can be PNP and NPN transistors [1].
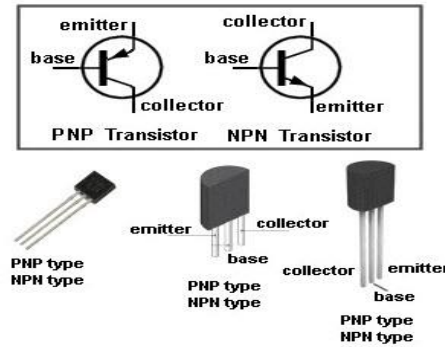
Figure 5.7. Transistors*.*

5.2.6 The optocoupler

a Principle of operation

A optocoupler is based on an LED and a phototransistor or photodiode. When a current is passed through the LED, it shines (emits infrared) in a well-sealed light box. The light emitted by the LED is captured by the phototransistor which then becomes passing. An electrical current can therefore be transmitted while electrically isolating. In principle, the photo coupler makes successive conversions: electric current - infrared light - electric current.

b The electrical characteristics are

b.1 Optocoupler symbol

A photo coupler is represented as follows:
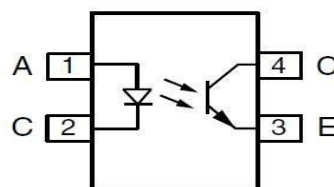
Figure 5.8. Symbol of a optocoupler.

On the left one recognizes the LED and on the right, the phototransistor.

c Role of the optocoupler

A photo coupler is an electronic component capable of transmitting a signal from one electrical circuit to another, without there being any galvanic contact between them.
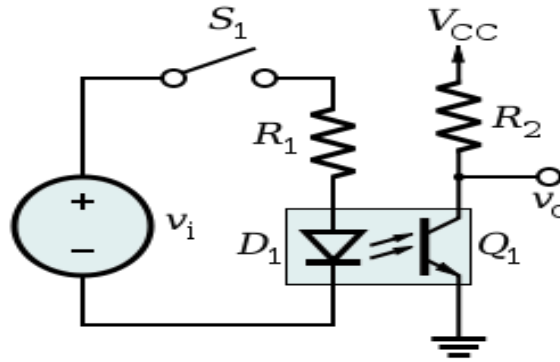
Figure 5.9. Example of implementation of an optocoupler.

d Optocoupler isolation voltage

Some applications require insulation between a low voltage part that is handled (Arduino board, etc.) and the sector. In this case, special attention must be paid to the choice of optocoupler which must have reinforced insulation (insulation reinforced). The optocoupler must have at least these characteristics:

VIORM (maximum repetitive peak voltage input-output): 800VThe VIORM is the peak voltage that the optocoupler can support over the long term. If one wishes to isolate from 230V, the peak voltage reaches 325V.
The optocoupler are also tested in isolation for 1 minute. The voltage applied by the manufacturer for the test is 5000 Volts effective or 5300 Volts effective for one minute [3].

5.3 Theoretical electronics calculation

5.3.1 Purpose

Determination of polarization resistance values R, R2 and R3.

For: * two transistors selected.
       * Power supplies selected.
       * Optocoupler selected.
       * known load.

5.3.2 Theoretical study of the electronic card

We know that:

The load voltage Vc = 12V, the internal load resistance (electromagnet) Rb = 100Ω measured by a multimeter.

Power supply sources: VCC = 12V, Vcc = 5V, Wine = 3.3V.

As we have known all the data on the chosen load we can begin our study of this one.
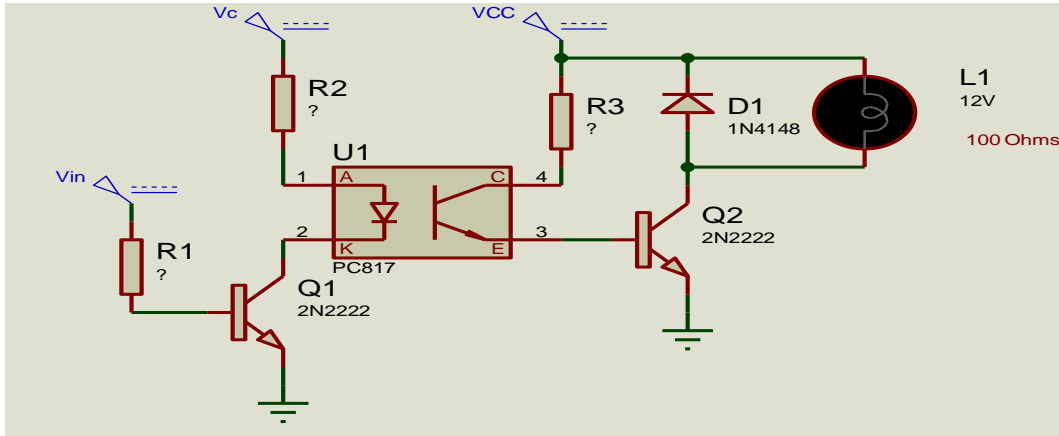
Figure 5.10. Electronic card.

5.3.3 Electronic circuit of the output
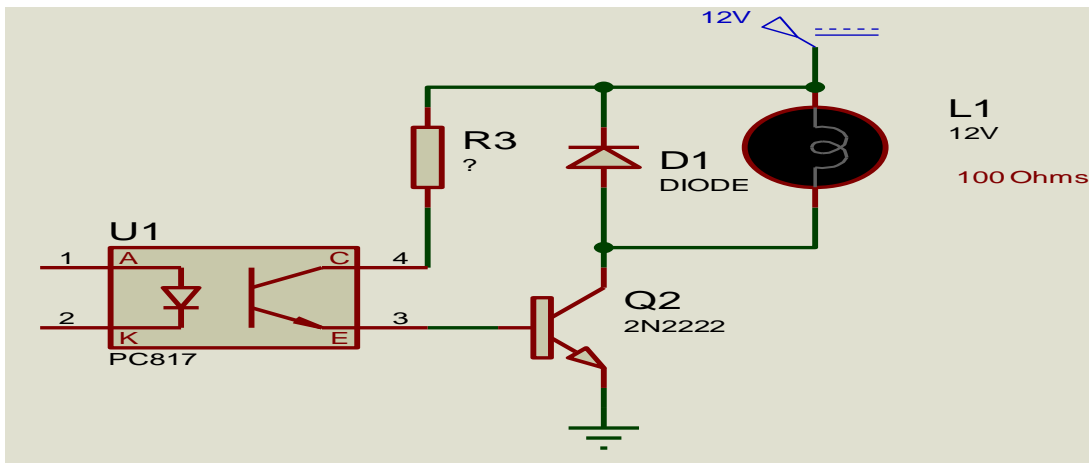
Figure 5.11. Output stage.

Output cell: VCC = (Rb* IC) + VCE.   (5.3)

   a   Blocked transistor

therefore: IC = β * IB   (5.4)

blocking(c-d) VCE = VCC= 12 V, IC = 0A and IB = 0A (the transistor plays the open switch role).

   b   Saturated transistor

In the saturation of the transistor Vcesat < 0.4V so it can be overlooked because it is very low in front of VCC = 12V.

VCC = (Rb*Icsat) + Vcesat (5.5)

VCC = 12V, Rb = 100 Ω so we can deduce Icsat.

VCC = Rb*Icsat (5.6)

Icsat = VCC/Rb. (5.7)

A.N: Icsat = 12V/100 Ω = 120mA. … … … … … … Icsat = 120mA.

In the datasheet:

Icsat =150 mA. Our calculation is 150mA.

c   Deduct the value of Ib and calculate the value of R3:

We based our work at the limit of saturation and this for a VCE of 1V, as indicated in the datasheet, studies of transistor on saturation regime is not the linear regime to ensure the value of VCE and also the coil priming (electromagnet).

D.C. Current Gain	H_{FE} *	35		35		I_C=0.1mA V_{CE}=10V
		50		50		I_C=1mA V_{CE}=10V
		75		75		I_C=10mA V_{CE}=10V
		100	300	100	300	I_C=150mA V_{CE}=10V
		30		40		I_C=500mA V_{CE}=10V
		50		50		I_C=150mA V_{CE}=1V
				35		I_C=10mA V_{CE}=10V T_A=-55ºC

Figure 5.12. Value of HFE, Vce and Ic.

From the datasheet of 2N2222 deduce:

β = 50.

CI = 150mA.

Taking into account the diode in parallel with the relay (10mA), this will give us a current

IB = IC/ β.

(5.8)

A.N: IB = 130mA/50 => IB = 2.6mA.

Condition Give the stitch.

VCC = (R3* IC) + Vce.

(5.9)

So: IB (of transistor N°1) = IC (optocoupler).

To ensure optocoupler saturation, in these conditions, it is necessary to ensure an IF current, such as IF/IC = 20mA/1mA, and therefore with IC =2.6mA, this gives us IF=52mA and therefore we will have to operate our optocoupler for an IF current of 52mA. Note that the Ifmax current = 50mA given in the datasheet corresponds to a direct current. In the event that this 52mA IF current is used, it will therefore be necessary to ensure by using the next curve that the cyclic ratio (Duty cycle) is not larger than that mentioned in the curve, that is to say, for cyclic ratios of 90% or less (for a 100μs pulse width, f>10Khz), we are sure of the safe operation of the optocoupler.
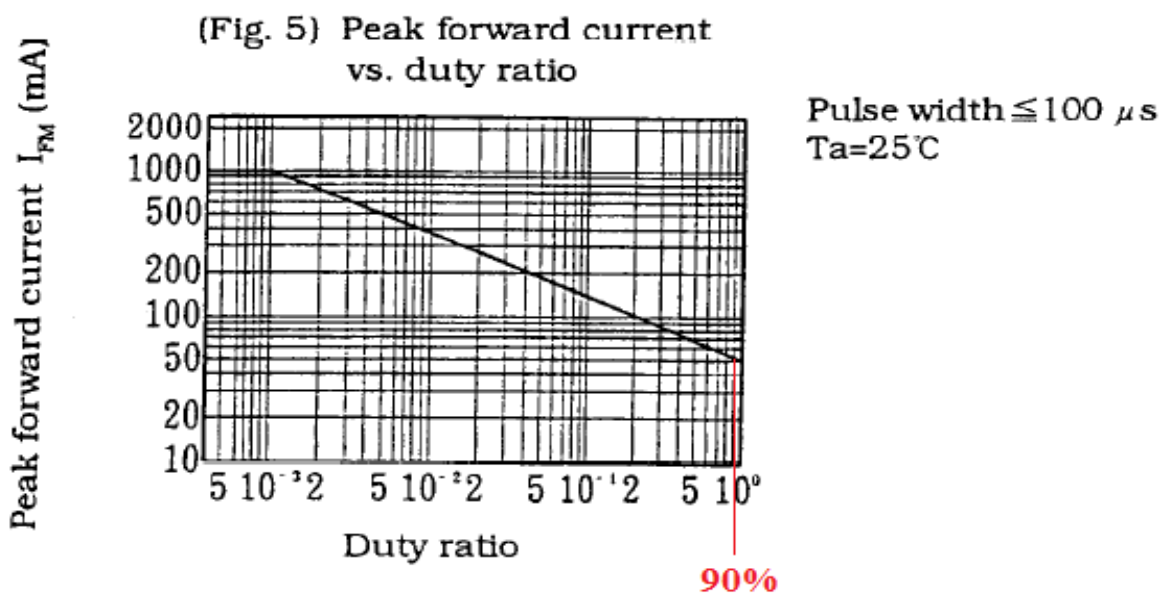
Figure 5.13. IF current of 52mA.

One can deduce the β = IC/ IB.
(5.10)
A.N: β = 130mA/2.6mA = 50 … … … … … … … … … βmin = 50.
R3 = VCC / IC.
(5.11)
A.N: R3 = 12V/ 2.6mA = 4.61KΩ.

Standard value: R3 = 5 KΩ.

5.3.4 Control part input
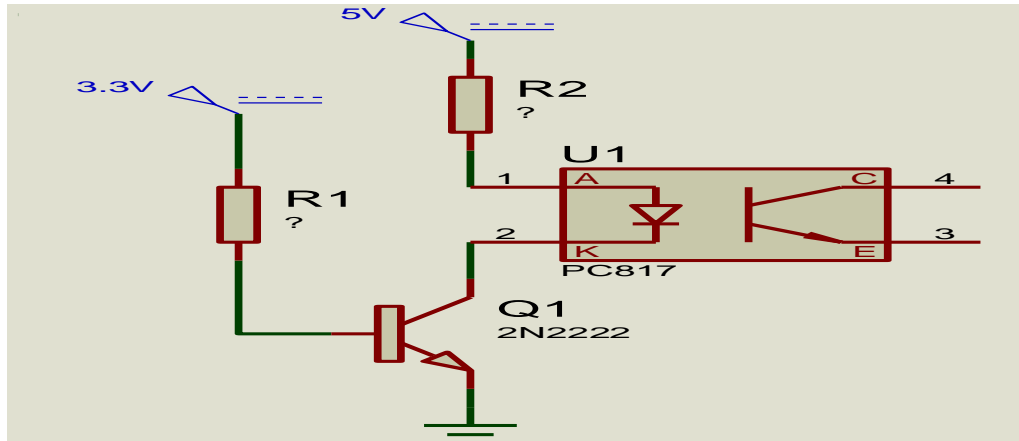
Figure 5.14. Part input.

a Calculation of resistance R2:

Law of cells: Transistor N°1

Cell: Vc = (R2*IF) + VF + Vcesat.

(5.12)

R2 = (Vc-VF) / IF.

(5.13)

In the datasheet, we are given for Ifm = 500mA, Vfm=3V and for IF=20mA, Vfm=1.4V, Choosing Vfm=1.8V for IF=52mA (In the event that the actual voltage is smaller, this is not serious, it will simply mean that the current circulating in the diode will be a little larger.

<u>A.N:</u>   R2 = (5V- 1.8V) / 52m = 62 Ω.

The standard value R2=100 Ω.
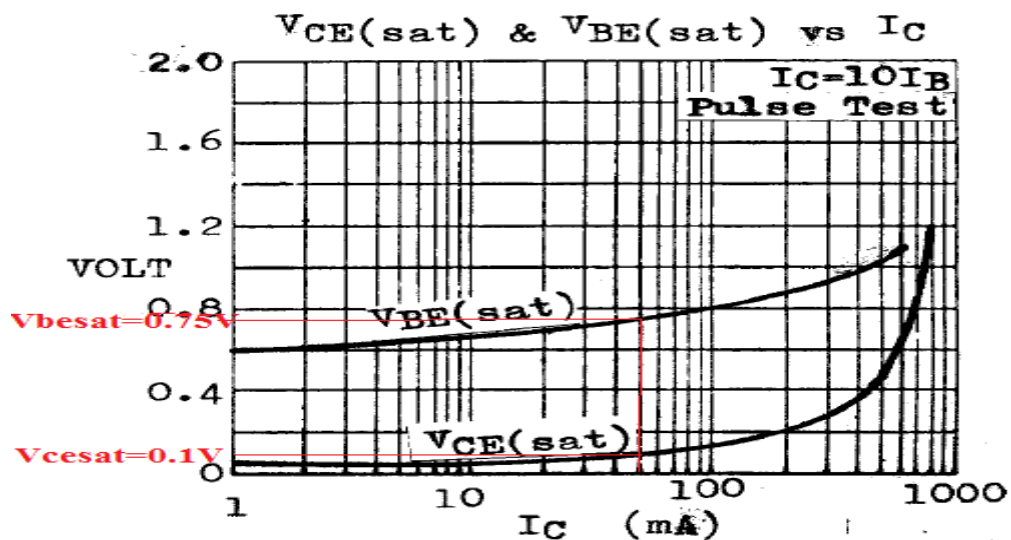
Figure 5.15. Vcesat and Vbesat vs Ic.

b Calculation of resistance R1

Vin = (R1*IB) + VBEsat.
(5.14)

We know that: Icsat = IF =52mA. So:
We work with a gain of 10 to ensure supersaturation and therefore an Ibsat of 5mA, in our case Icsat = IF =52mA and by consulting the curve of the datasheet of the following 2N2222, we draw the voltage Vcesat of 0.1V and Vbesat of 0.75V.
Vbesat = 0.75V. To ensure transistor operation.
R1 = (Vin – Vbesat) / (IC / β).
(5.15)
A.N: R1 = (3.3V – 0. 75V)/ (52mA/10) = 490 Ω.

The standard value R1=500 Ω.

5.4 Practical achievement

5.4.1 Schematic Conception CAD (Computer Assisted Design)

The electrical diagram of the device realizes and given by the figure 5.14.
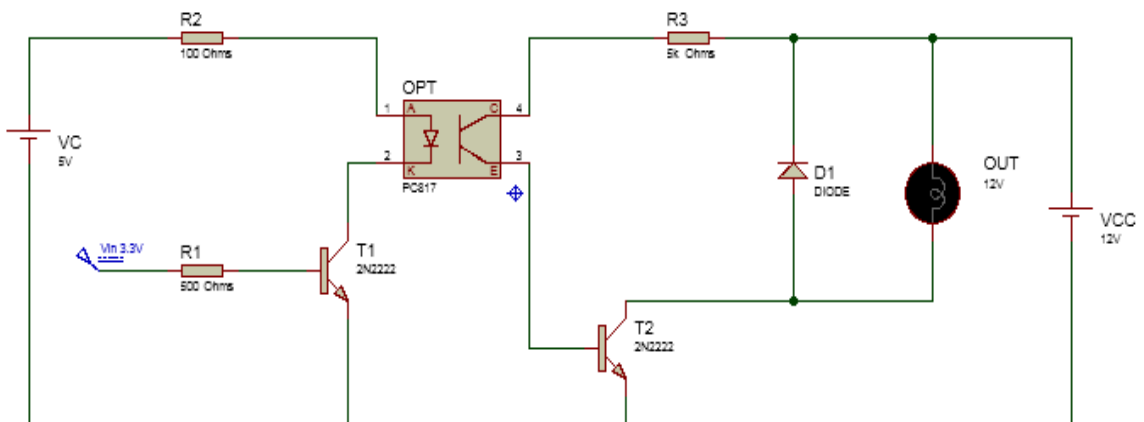
Figure 5.16. Assembly electrical circuit.
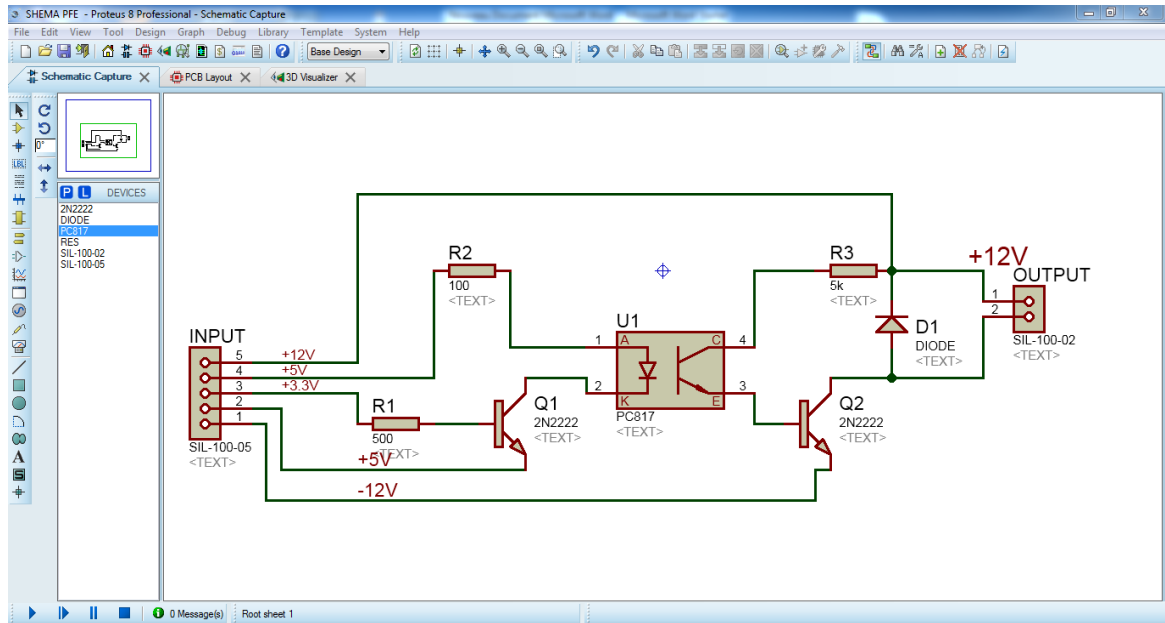
Figure 5.17. Assembly electrical circuit (Proteus).

5.4.2 Printed circuit board construction
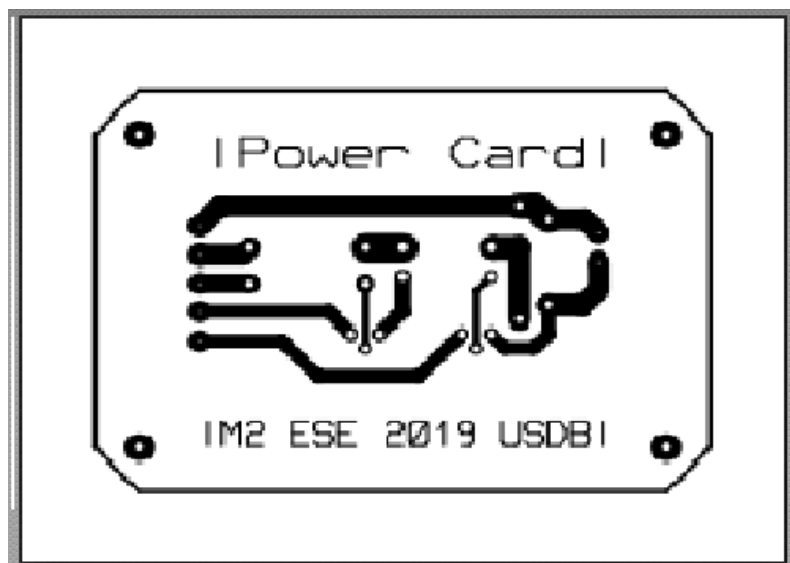
Figure 5.18. Electronic card printed circuit.
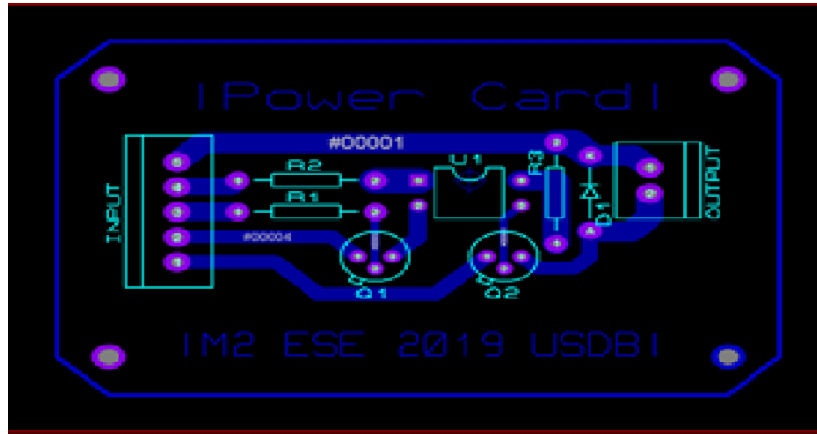
Figure 5.19. Electronic plate circuit with implanted components*.*

5.4.3   practical measures and tests

Simulation of the electronic map on proteus 8 software. to compare the measurements with our results.
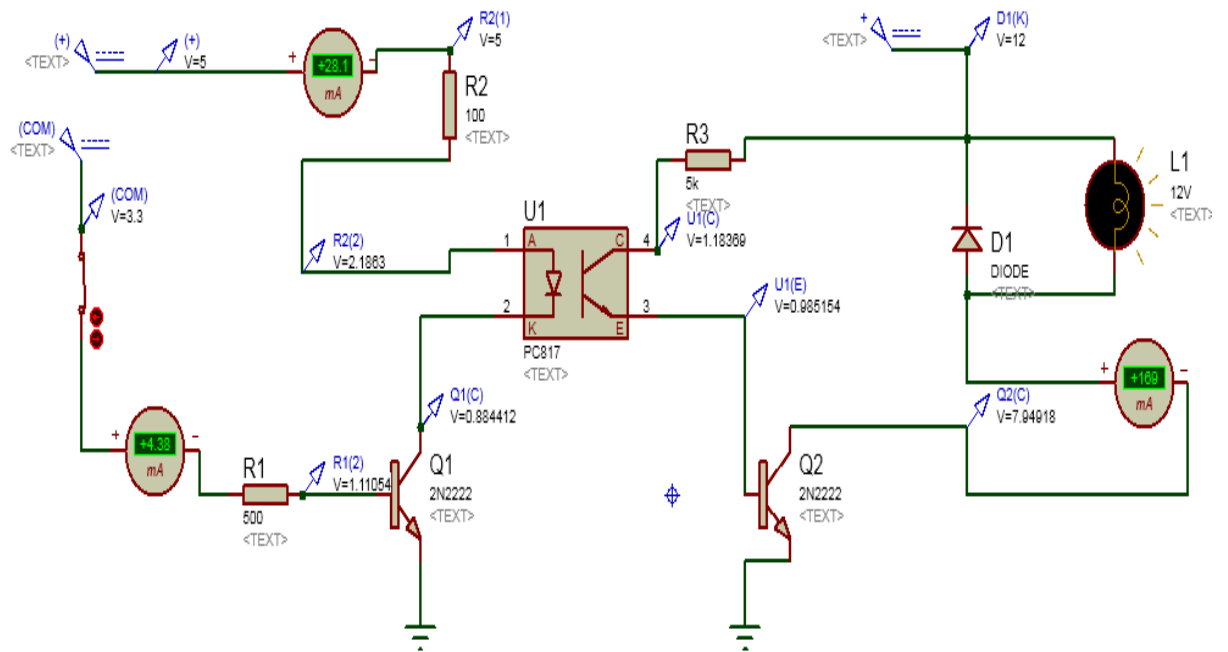
Figure 5.20. Current and voltage values after simulation.
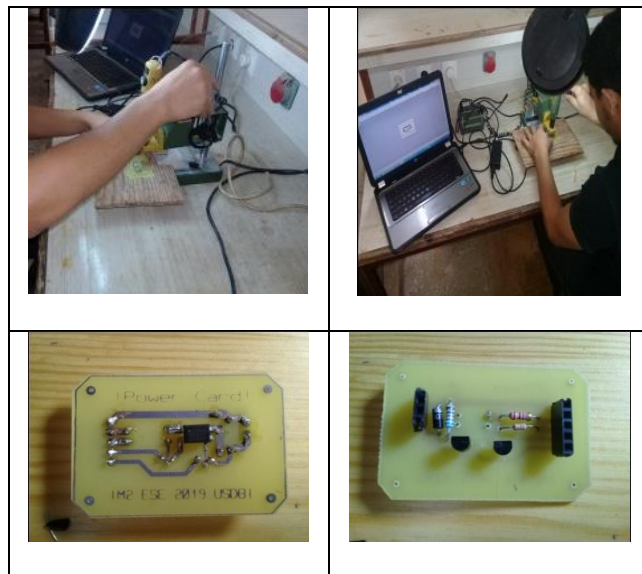
Figure 5.20. Making and drilling the circuit prints in the laboratory*.*

Ensure the safety of the electronic elements and then complete them on the breadboard to ensure the success of the study.
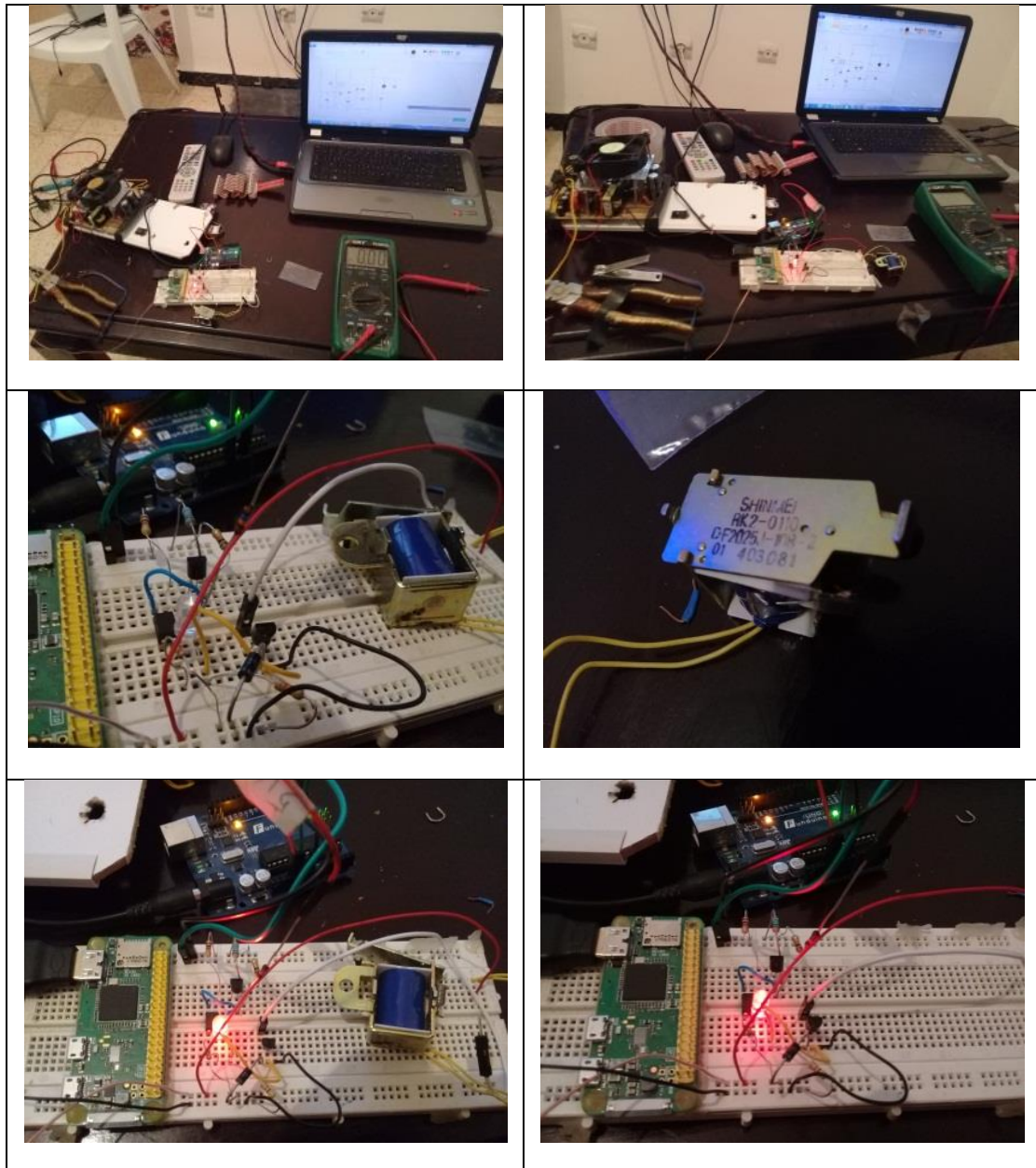
Figure 5.21. The different stages of testing.

5.5 Conclusion

The main purpose of this electronic circuit is to design the final base upon which any subsequent design adds new features, the card works well and approach to theoretical calculations, taking into consideration this design size, cost, energy consumption and life, from the imperfections of this design, that it works within an open control ring, mean it receives and executes without returning the feedback to the main control, and this needs to be put in a sensor to make sure that the mechanical process is completed, so this design is also used as a simple and every element of this one that is to be use in this Raspberry , and all of the electronic platform, and that there is a simple and all of this one that there should be an electronic platform. The most appropriate solution is to integrate a microcontroller that communicates with a Raspberry data transfer protocol such as I2C or a wireless protocol, to increase flexibility and cost savings and make the board a single board easier to maintain and reprogram as needed, i.e. make it an integrated system alone.

Annex
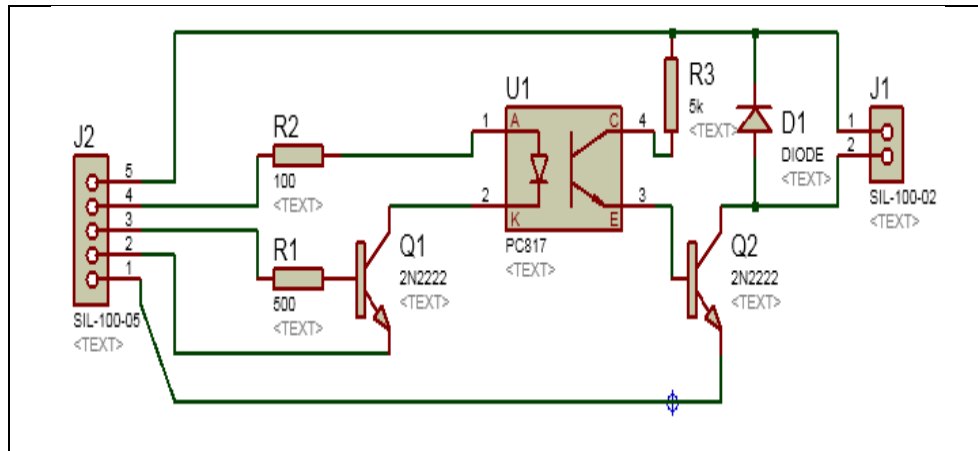
Schematic capture
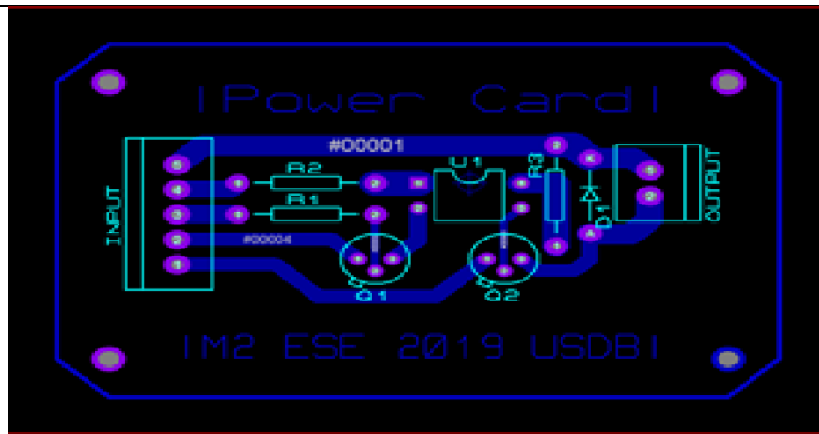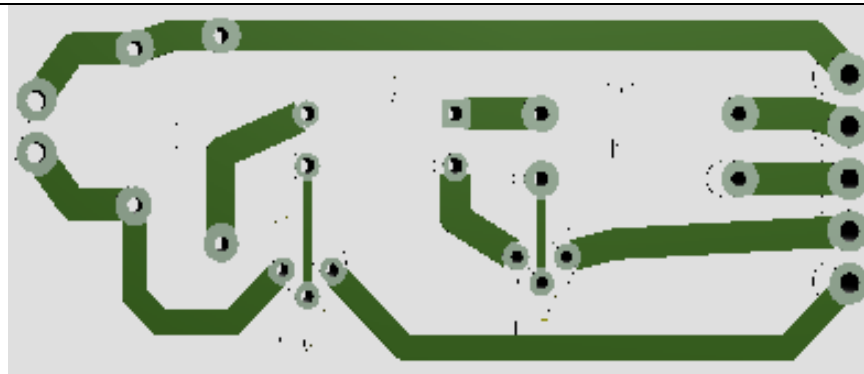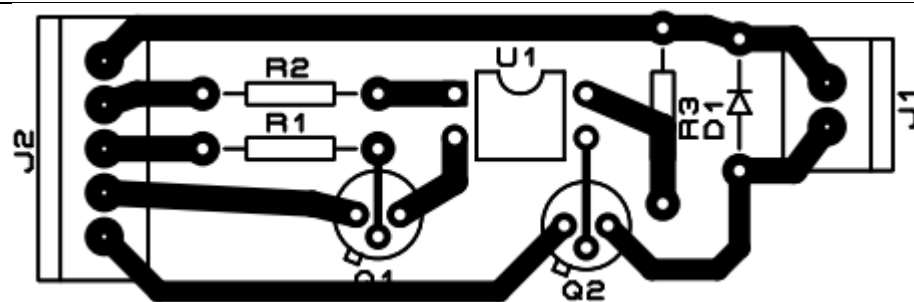

PCB layout
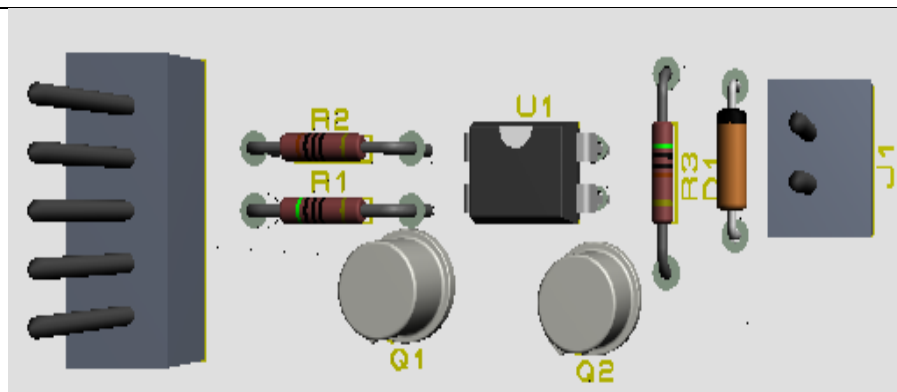
3D visualizer
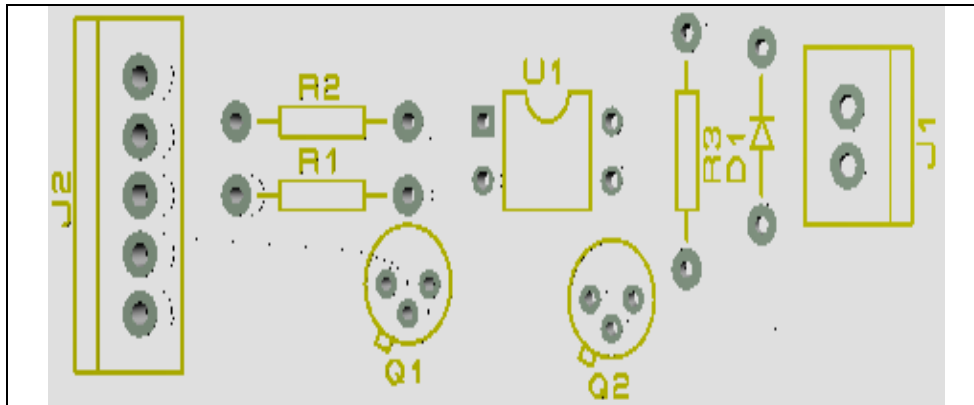
Show the components
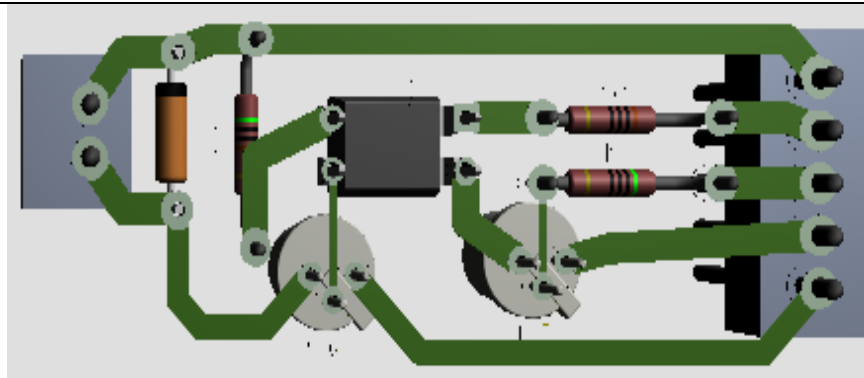
Show the components

Show the components

Data sheet

Bibliography

[1] Horowitz, Paul, and Winfield Hill. *The art of electronics*. Cambridge Univ. Press, 1989.

 [2]Kawaguchi, Kensuke, and Kazuchika Hiroki. "Electromagnet device." U.S. Patent No. 8,179,217. 15 May 2012.

[3] Johnston, A. H., et al. "Single-event upset effects in optocouplers." *IEEE Transactions on Nuclear Science* 45.6 (1998): 2867-2875.