DEVELOPING AN ACUPRESSURE POINT-DETECTING ROBOT USING LEGO NXT MINDSTORMS 2.0

A Research Paper Presented to
The Faculty of
Philippine Science High School – Western Visayas Campus
Bitoon, Jaro, Iloilo City

In Partial Fulfillment
of the Requirements for
SCIENCE RESEARCH 2

by

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Fourth Year – Tau

March 2013

APPROVAL SHEET

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DEVELOPING AN ACUPRESSURE POINT-DETECTING ROBOT USING LEGO NXT MINDSTORMS 2.0

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ABSTRACT

Acupressure is a type of massage (an ancient healing art) that uses the fingers to press key points on the surface of the skin to stimulate the body's natural self-curative abilities. Pressure points are sensitive areas of the body where pressure can be applied to cause certain effects or sensations. With rapid advancement of industrial society comes cutthroat competition that leads to stress, usually accompanied by body pains such as headaches. On the forehead, four pressure points are massaged to counter headaches; they are located between the eyebrows, on the temples and on the intersection of the hairline and the line that symmetrically divides the face into two. However, difficulties arise in performing acupressure such as the availability of the massager and the level of comfort the massager gives to the client. These hinder the effectiveness and readiness of the massage. This study introduces robots as the solutions to these issues, with the objectives of constructing and programming the robot capable of locating the four pressure points against headache. Six prototypes were developed in the process. The final design uses a light sensor, a brick (the brain), three motors and beams and it was programmed using the Lego NXT Mindstorms Programming Software, all of which were provided by the Lego NXT Mindstorms 2.0 kit.

Keywords: acupressure massage, headache, lego nxt mindstorms 2.0, massage robot, pressure points on forehead

ACKNOWLEDGEMENT

We would like to thank and acknowledge the following persons, for without them, this research would not be completed:

To our parents, for providing the necessary materials and showing support!

To our interviewees, thank you for sharing information needed in our study!

To our batchmates, for sacrificing their time to become the test subjects for our robot!

To Sir Edward Albaracin, the research adviser we are very proud of, for guiding us in our research, for supporting us and for being patients with us!

And to God the Almighty, for giving us knowledge, strength and supporting us as well!

Mark Lexther T. Ame

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BACKGROUND OF THE STUDY

A. Introduction

Massage is a "hands on" treatment in which a therapist manipulates muscles and other soft tissues of the body to improve health and well being. Varieties of massage range from gentle stroking and kneading of muscles and other soft tissues to deeper manual techniques. Massage has been practiced as a healing therapy for centuries in nearly every culture around the world. It helps relieve muscle tension, reduce stress, and evoke feelings of calmness. Although massage affects the body as a whole, it particularly influences the activity of the musculoskeletal, circulatory, lymphatic, and nervous systems (University of Maryland Medical Center).

Acupressure is a type of massage (an ancient healing art) that uses the fingers to press key points on the surface of the skin to stimulate the body's natural self-curative abilities. When these points are pressed, they release muscular tension and promote the circulation of blood and the body's life force to aid healing. Acupressure uses the gentle but firm pressure of hands. All acupressure massage techniques, methods and styles use the same ancient acupressure trigger points. They vary in using different rhythms and pressures for stimulating the acupressure points, using not only the fingers, but also the hands, arms, legs and even feet (Acupressure.com).

Pressure points are sensitive areas of the body where pressure can be applied to cause certain effects or sensations. Properly applying pressure to these spots can cause pleasure, relief of pain, relief of stress or healing, as in acupuncture and reflexology. These points also can be used to cause pain, injury or incapacitation in certain forms of martial arts and other types of combat. In modern medicine, pressure points are defined as areas of the body that have high nerve density. The concentration of nerves in one area of the body results in hypersensitivity in that area. (Wisegeek.com)

A robot is a mechanical or virtual intelligent agent that can perform tasks automatically or with guidance, typically by remote control. In practice, a robot is usually an electro-mechanical machine that is guided by computer and electronic programming (Wikipedia).

Massage robots are robots that are designed and programmed to perform massage. One existing model is a multi-fingered robot hand (Kazuhiko and others 2005) that uses complex

programming functions and sensors that enable it to effectively massage the client and adapt to changes in his/her position. The robot is only focused on performing massage at the back of the client's body.

Another massage robot that is based on the human arm is WAO-1" (Waseda Asahi Oral Rehabilitation Robot 1) which is designed to treat jaw and facial disorders (Pinktentacle.com).

Another existing model is the wheeled-robot named WheeMe (Wheeme Dreambots). It consists of four spiked-wheels that give bodily pleasure as it travels across the body. The robot also uses tilt sensor technology to prevent it from falling and to achieve a continuous massage session. However, it can only perform effectively at the back of the body, the abdomen and the chest.

B. Statement of the Problem

The purpose of this study is to develop a robot capable of locating acupressure points on the forehead using Lego NXT Mindstorms Kit 2.0.

C. Objectives

General Objective:

To develop a robot capable of locating the acupressure points on the forehead using Lego NXT Mindstorms Kit 2.0

Specific Objectives:

1. To construct a robot suitable for locating the acupressure points on the forehead using Lego NXT Mindstorms Kit 2.0
2. To program the robot to locate the acupressure points on the forehead using Lego NXT Mindstorms 2.0 Programming Software.

D. Significance of the Study

With rapid advancement of industrial society comes cutthroat competition. This leads to enormous job pressures which require a lot of mental concentration or brainstorming and in effect long-sitting hours. Physical activities (such as exercise) are curtailed which eventually lead to poor blood and lymph circulation. This in turn causes musculoskeletal pains and stress in various parts of the body.

One way to lessen the stress while keeping up with work is through acupressure massage (Acupressure.com). It is effective in helping relieve headaches, eyestrain, sinus problems, neck pain, backaches, arthritis, and muscle aches. There are also great advantages to using acupressure as a way to balance the body and maintain good health. The healing touch of acupressure increases circulation, reduces tension, and enables the body to relax deeply. By relieving stress, acupressure strengthens resistance to disease and promotes wellness (Herbalshop.com).

In the forehead there are a lot of acupressure points, each point represents the effects of stress. Most prominent points refer to headaches. As described above, due to physical stress, mental fatigue, and things that need mental concentrations our body's response is headache and some are sinus problems. We chose the region of the forehead because this is the most vulnerable area of the "ache syndrome" (Fenis). Working on the principle of acupressure, our robot will help reduce headache problems.

There are advantages in using robots to perform massage. They are portable. They can be used anytime and anywhere at one's convenience. They eliminate the hassle of finding a massage parlour, hiring a human massager and prevent the uneasiness of massager-client relationship.

The beneficiaries of this study are people of all walks of life, nine to ninety years old. This is most suitable for executives and other white-collar job workers whose career requires so much mental activities. This is also of help to the night shift workers who experience headache due to lack of sleep. This can as well be used if the person feels like having a forehead massage.

E. Scopes and Delimitations

This study focuses on locating the acupressure points on the forehead. Two kits of NXT Mindstorms 2.0 are used to construct the robot. It is programmed with only one algorithm. The robot is only adjustable to a limited size of the forehead. It is equipped with a total of six Energizer dry cell batteries.

F. Definition of Terms

Robot refers to a mechanical device or machine performing specific kinds of tasks (Wikipedia).
In this study the term robot refers to the massage robot.

Massage is a kind of treatment which is usually performed by humans in order to release stress or improve the well being of their clients.
In this study the kind of massage that will be performed is acupressure using the massage robot.

Acupressure is a type of massage which uses the pressure to press the surface of skin to stimulate the body's natural healing abilities (Acupressure.com).
In this study acupressure means the same.

"Degrees of Freedom" (DoF) refers to the freedom of movement of a rigid body in three-dimensional space (Wikipedia).
In this study it means the same.
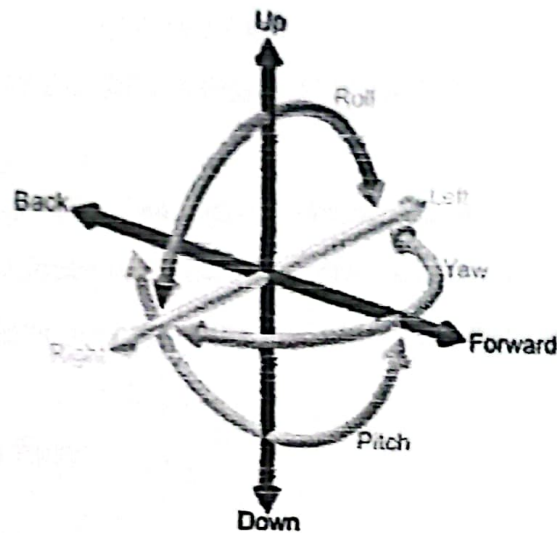
Figure 1. Six Degrees of Freedom (Wikipedia)

Brick is a rectangular block of something (Encarta Dictionaries).
In this study the term refers to the rectangular block that acts as the brain of the robot.

Mark is a model or variety, e.g. of a car, aircraft, or weapon, usually distinguished from earlier or later models by a number (Encarta Dictionaries).
In this study mark means the same.
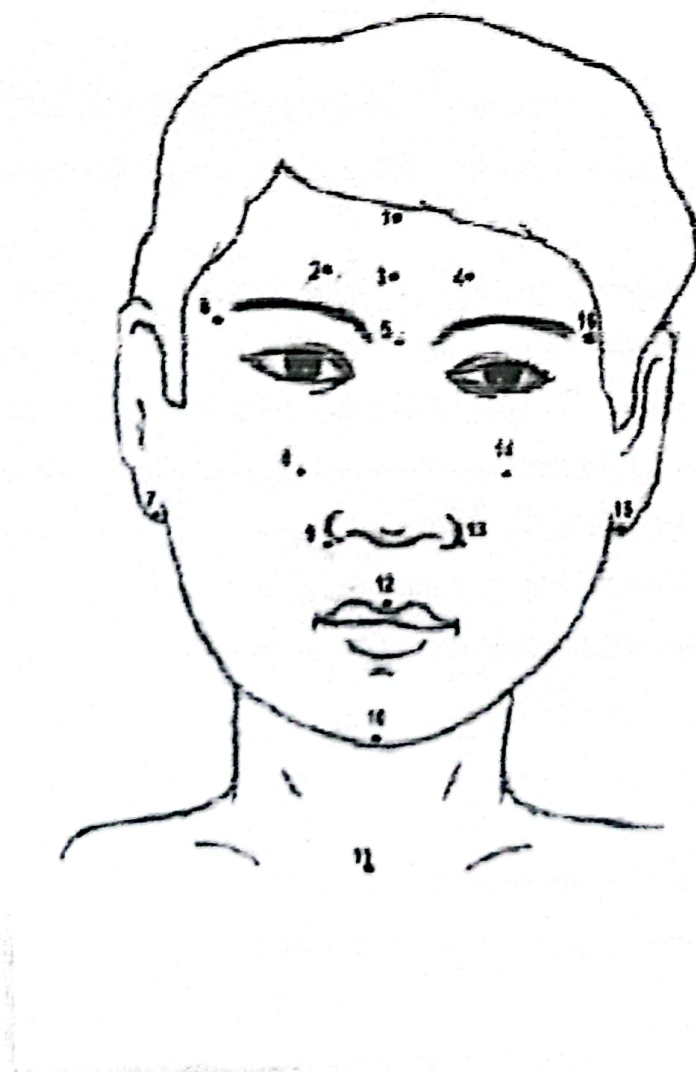
CHAPTER 2
REVIEW OF RELATED LITERATURE

This chapter comprises the following topics: pressure points on the face, pressing or reducing points, acupressure techniques and measurement, acupressure massage on forehead, errors, considerations and precautions in acupressure and other massage robots.

A. Pressure Points on the Face

Figure 2. Pressure Points on the Face (Rajan Jolly)

B. Pressing and reducing points

There are two ways that acupressure points are manipulated: pressing (reinforcing) and reducing them. To press points, use something blunt. Usually the fingers are used to press, but for many points the fingers may be a bit too thick, so press quite long and firmly. Ideal would be something 3 to 4 mm thick, like a (preferably used) pencil eraser that's on the other side of a pencil. Some points can be pressed using a fingernail (Eclectic Energies).

Pressing points for less than half a second can already have a distinguishable effect. So for just trying out a point, press it only briefly. To get a full effect however, pressure should be applied for at least half a minute, but preferably longer. One to two minutes should do (Eclectic Energies).

To reduce a point, turn a finger over it in counter-clockwise direction, also for one to two minutes. It's a good idea not to get into the habit of doing the same points every day. (Eclectic Energies).

Reinforcing is simply pressing a point. Energy increases in areas that the point influences. Reducing a point is actually not the opposite of reinforcing it. Reducing can remove blockage of energy. A blockage may be felt as tension, pain or heat. Energy accumulates there which starts moving again after removing the blockage. Reducing a point after reinforcing it will remove the energy blockage; it doesn't cancel each other (Eclectic Energies).

In acupressure, reducing a point can be done by continuously moving the finger counter clockwise. An acupuncturist will turn his needle immediately after insertion (Eclectic Energies).

C. Acupressure Techniques

Several different kinds of acupressure are currently practiced, but the same ancient trigger points are used in all of them. Varying rhythms, pressures, and techniques create different styles of acupressure (Acupressure.com).

C.1. Shiatsu

Shiatsu is a physical therapy that supports and strengthens the body's natural ability to heal and balance itself. It works on the whole person - not just a physical body, but also a psychological, emotional and spiritual being. Shiatsu originated in Japan from traditional Chinese medicine, with influences from more recent Western therapies. Although shiatsu means 'finger pressure' in Japanese, in practice a practitioner uses touch, comfortable pressure and manipulative techniques to adjust the body's physical structure and balance its energy flow. It is a deeply relaxing experience and regular treatments can alleviate stress and illness and maintain health and wellbeing.

Today, Shiatsu has a number of different styles, philosophical approaches and theoretical bases and practitioners around the world are still evolving new approaches to treatment. Some concentrate on acupressure (acupuncture) points, while others emphasise more general work on the body or along the pathways of energy to influence the KI that flows in them (Shiatsu Society).

C.2. Jin Shin Jyutsu

Jin shin Jyutsu is a disarmingly simple style of acupressure. It works with a set of 26 points (called Safety Energy Locks or SELs) along energy pathways. When a pathway becomes blocked, energy stagnates. This initially affects the local area of stagnation, but has the potential to create imbalance along the entire pathway. The 26 Energy Locks are the locations on the body where energy tends to become stuck. (Acupressurists and acupuncturists, by comparison, learn over 300 points.)

Practitioner uses both hands (referred to as "jumper cables") to hold a combination of SELs. The simplicity and gentleness of the process allow clients to relax and receive the work. As the SELs release and balance is restored, the client experiences physical, mental, and spiritual harmony.

The belief that we can help ourselves through a process of knowing ourselves is integral to Jin Shin Jyutsu. At its heart, the work embodies a life of simplicity, calmness, patience, and self-containment. Practitioners of the work regard Jin Shin Jyutsu not simply as a style of

bodywork, but as a philosophy of life. Ultimately it is the philosophy and spirit of the work, not the technique that attracts clients and practitioners to Jin Shin Jyutsu (BalanceFlow Health & Bodyworks).

C.3. Tui Na

To those who have experienced both acupressure and Shiatsu, a Tui Na session may seem like a cross between the two. Like Shiatsu, Tui Na uses rhythmic compression along energy channels of the body, as well as a variety of techniques that manipulate and lubricate the joints. Like acupressure, Tui Na directly affects the flow of energy by holding and pressing the body at acupressure points.

To a Westerner, Tui Na is the form of Asian bodywork most closely resembling conventional western massage. Many of the techniques are similar — gliding (known as effleurage or Tui), kneading (petrissage or Nie), percussion (tapotement or Da), friction, pulling, rotation, rocking, vibration, and shaking. Despite the similarities, the intent of Tui Na is more specifically therapeutic than the simple relaxation of a Swedish-style massage. One of Tui Na's advantages over simple massage is its ability to focus on specific problems, especially chronic pain associated with the muscles, joints, and skeletal system. It's especially effective for joint pain (such as arthritis), sciatica, muscle spasms, and pain in the back, neck, and shoulders. It also helps chronic conditions such as insomnia, constipation, headaches (including migraines), and the tension associated with stress.

Tui Na does not simply work on the muscles, bones, and joints. It works with the energy of the body at a deeper level. As the practitioner senses the client's body with her hands, she is able to assess the distribution of energy and affect its flow.

Tui Na is designed to prevent problems, not just correct them. By keeping the body's energy in balance, health is maintained. This is true not just for physical health, but for mental and emotional well-being as well (BalanceFlow Health & Bodyworks).

D. Unit of Measure in Acupressure

The definition of cun is essential to be able to use information from other sources for locating points. The "cun" is the standard unit of measurement for the body used in acupressure. As everyone's body has different dimensions, it is defined according to the person whose body is to be treated.

One cun equals the width of the thumb, in the middle, at the crease. Three cun is equivalent to the combined breadth of the 4 fingers, at the level of the pinky finger's first joint above the palm of the hand. 12 cun is the distance from the elbow crease to the wrist crease (Eclectic Energies).

E. Performing Acupressure on Forehead

The massage involves the use of two fingers from two different hands and the repetition of strokes in the different layers of the forehead. The first layer represents the path from the pressure point in the center of the eyebrows, then tracing the eyebrows up to the temples. The second layer begins from the center of the forehead but one cun above the point where the first layer began, then tracing the skin above the eyebrows up to the temples. The remaining layers also follow the description of the two first layers, but the point of beginning and the path to be massaged is located above the previous layer. The left finger will massage the forehead from the center to the right temple of the client while the right finger will massage the forehead from the center to the left temple of the client.

The stroke is performed by applying pressure on the layer then giving a rotary massage on the temples (Austria).

F. Errors in Acupressure

When the effects do not occur from pressing, several things may be the case.

The pressing might not be on the right spot (acupuncture points are about 0.5 mm diameter). Try different spots around the location.

If the effect becomes very little or unnoticeable, it means that the point is used quite often (Eclectic Energies).

G. Considerations and Precautions in Acupressure

According to Acupressure.com, the points to be considered in acupressure are:

- **Apply finger pressure** in a slow, rhythmic manner to enable the layers of tissue and the internal organs to respond. Never press any area in an abrupt, forceful, or jarring way.

- **Burns & Infections:** Do not work directly on a serious burn, an ulcerous condition, or an infection: for these conditions, medical care alone is indicated.

- **Scars and Injuries:** Do not work directly on a recently formed scar. During the first month after an injury or operation, do not apply pressure directly on the affected site. However, gentle continuous holding a few inches away from the periphery of the injury will stimulate the area and help it heal.

- **After an acupressure session,** the body heat is lowered; thus the resistance to cold is also lower. Because the tensions have been released, the body's vital energies are concentrating inward to maximize healing. The body will be more vulnerable, so be sure to wear extra clothing and keep warm when an acupressure routine had finished.

H. Other Massage Robots

There are various existing designs of massage robots. They are based on how they perform the massage or what part of the body is being massaged.

WheeMe is a palm-sized robot that gently massages and caresses as it moves slowly across the body. Embodying a unique tilt sensor technology, WheeMe automatically and silently steers itself over the body without falling off or losing its grip. As it moves, WheeMe's patented fingerettes gently stroke and caress providing a delightful sense of bodily pleasure. WheeMe doesn't require any adjustments or the assistance of another individual (Wheeme Dreambots).

Figure 3. WheeMe robot (Dreambots)

WAO-1" (Waseda Asahi Oral Rehabilitation Robot 1), is a robot designed to treat jaw and facial disorders by using therapeutic massage. It is equipped with two arms bound to a chair sized aluminium box. It performs massage by applying pressure on the patient's face. The direction, angle and pressure applied are controlled by complex systems of software and fuses. It is also equipped with a torque limiter function which allows the robot's arms to bend back in order to limit the exertion of force. The kind of control technology used can be also found in other humanoid robots (Pinktentacle.com).
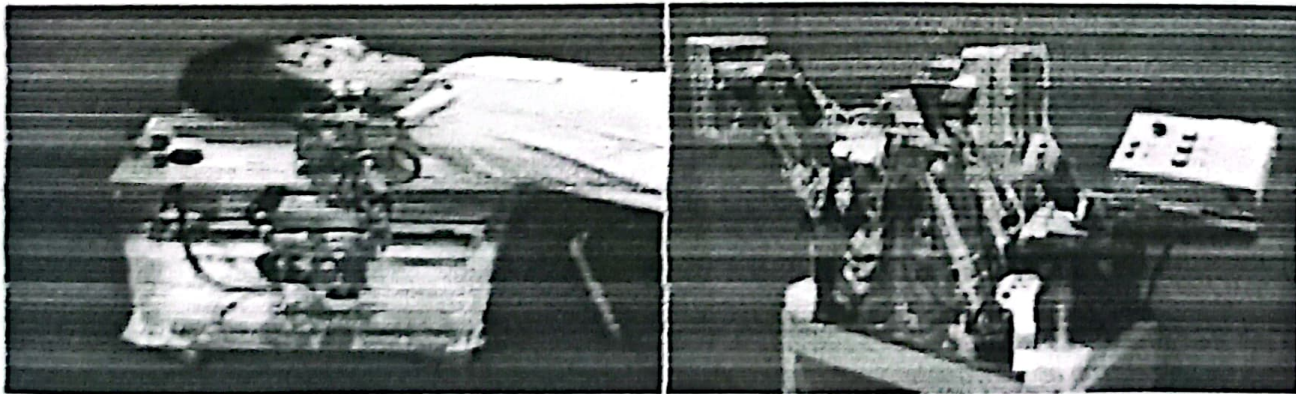
Figure 4. WAO-1 robot (Pink Tentacle)

An article has presented a model of human skin muscle by using multi-fingered robot hand to know impedance of human skin muscle and control strategy by means of impedance control to implement adaptive control system, even if human condition is changed, or massage position is shifted, and person to be massaged is different (Kazuhiko and others 2005).

**Figure 5. Multi-fingered robot (Terashima and others 2006)**

CHAPTER 3
METHODOLOGY

A. Overview of the Study

The objective of this study is to develop an acupressure point-detecting robot using the Lego NXT Mindstorms Kit 2.0.

The construction and programming of the robot were conducted in Philippine Science High School Western Visayas Campus in the years 2012 and 2013.

B. Design of the Robot

● — servo motor
● — touch sensor
— light sensor
● — NXT brick
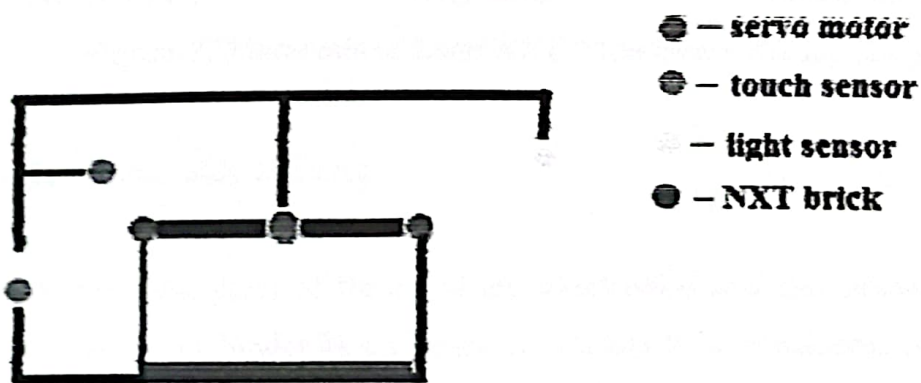
Figure 6. Framework of prototype design

The prototype is based on a crane-like system, consisting of a base for support, motors for movement and sensors for locating pressure points.

B.1. Materials

The materials used are provided by the Lego NXT Mindstorms Kit 2.0.

Touch Sensor   Light Sensor   Ultrasonic Sensor

Servo Motor   NXT Brick   Connector Cables
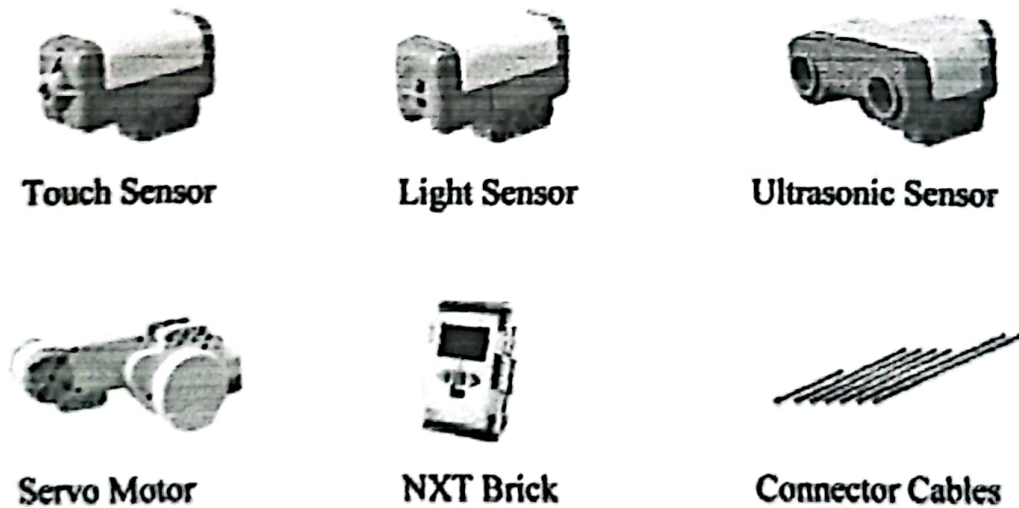
Figure 7. Materials of Lego NXT Minstorms Kit 2.0 (Lego)

B.2. Assembly of Parts

Based on the design, parts of the robot are constructed and assembled using selected materials of the kit that do not hinder its performance. Factors to be considered are the weight of the materials, the structure of the materials and the simplicity of the design.

C. Program of Robot
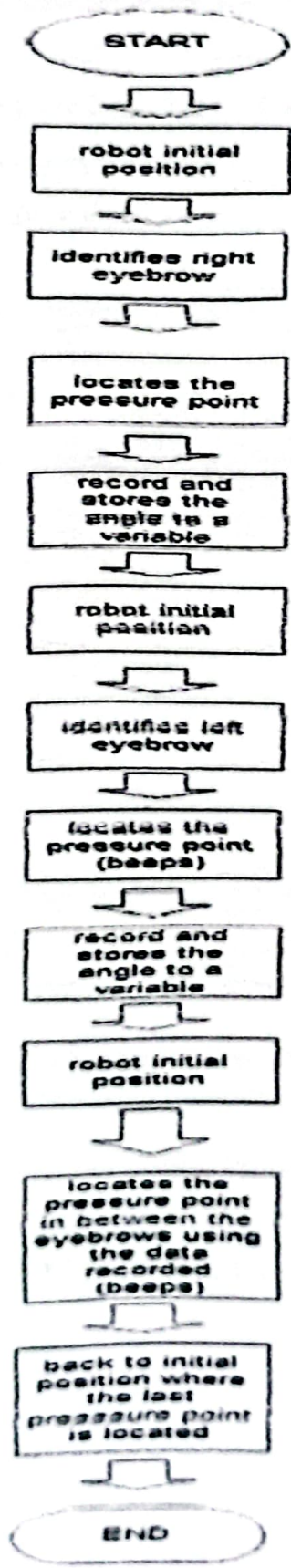
The robot follows the procedure as shown in Figure 8.

Figure 8. Flowchart of program

C.1   Application of Algorithm (Actual) Programming)

The robot is programmed using the Lego NXT Mindstorms 2.0 Programming Software. The software consists of a graphics programming language and uses virtual blocks with predefined commands suitable for the desired actions to be performed by the robot.
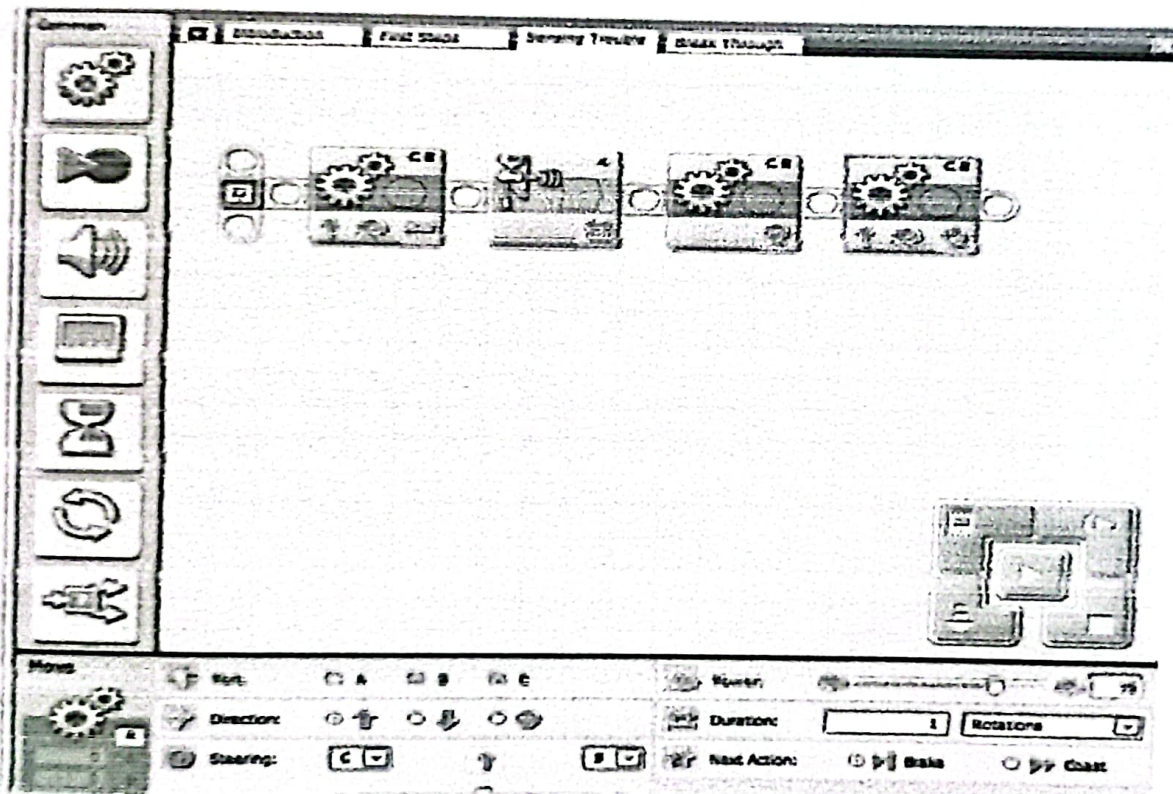

Figure 9. Screenshot of Lego NXT Mindstorms 2.0 Programming Software

C.2   Uploading, Testing and Debugging of Program

The program is uploaded to the NXT Brick from the laptop using a cable provided by the kit. It is then tested by letting the robot perform the detection of the pressure points. If its performance deviates from the expected outcome, the program is debugged until the desired result is executed.
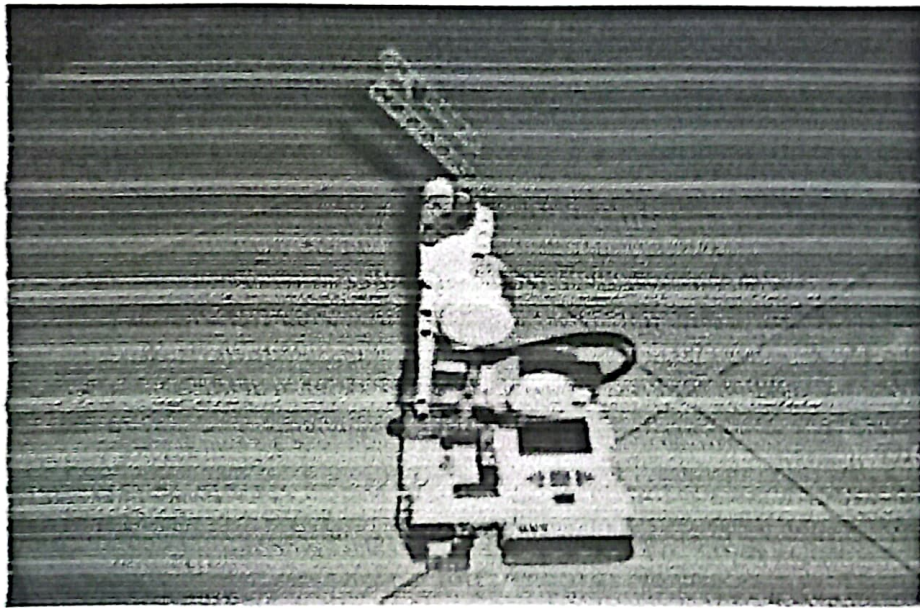
CHAPTER 4
RESULTS AND DISCUSSION

In the development of the robot for its final design, six prototypes are proposed. Each of them requires a lying-down and stationary client to be able to perform efficiently and accurately.
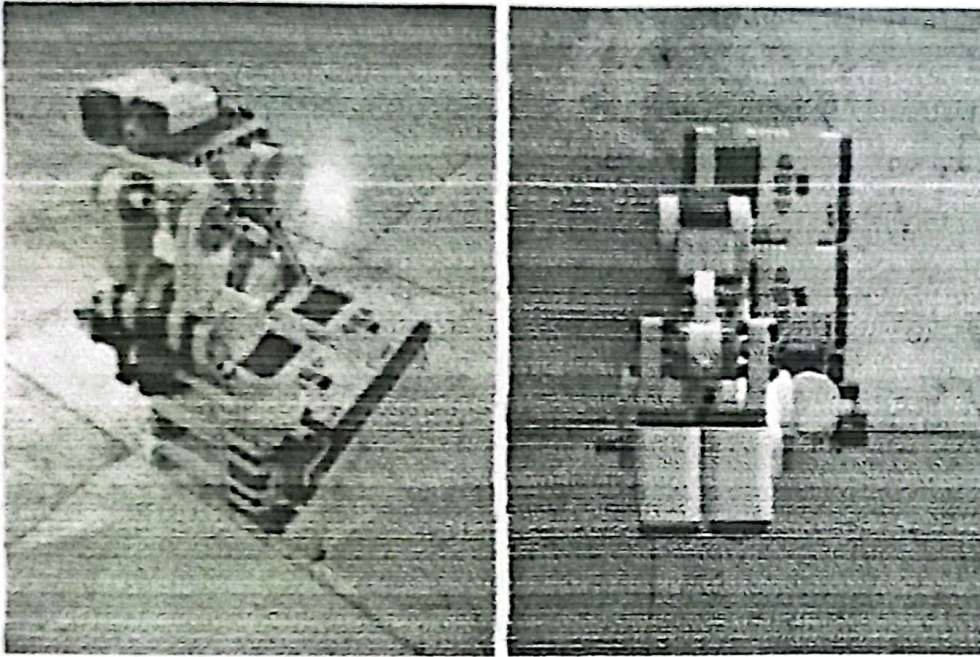
MARK I:

Figure 10. Mark I

The design uses two separate arms located on each side of the head of the client. Each arm consists of one brick as the base, three servo motors as the three joints (one for yaw and two for pitch), and touch and light sensors. A connector that traces the head of the client attaches the two bricks which can be adjusted to fit the size of the head. An ultrasonic sensor reads the distance caused by the adjustment to calibrate the program of the robot. The two bricks communicate via Bluetooth during the program execution.

The design, however, is limited by the area of the forehead that it can reach.
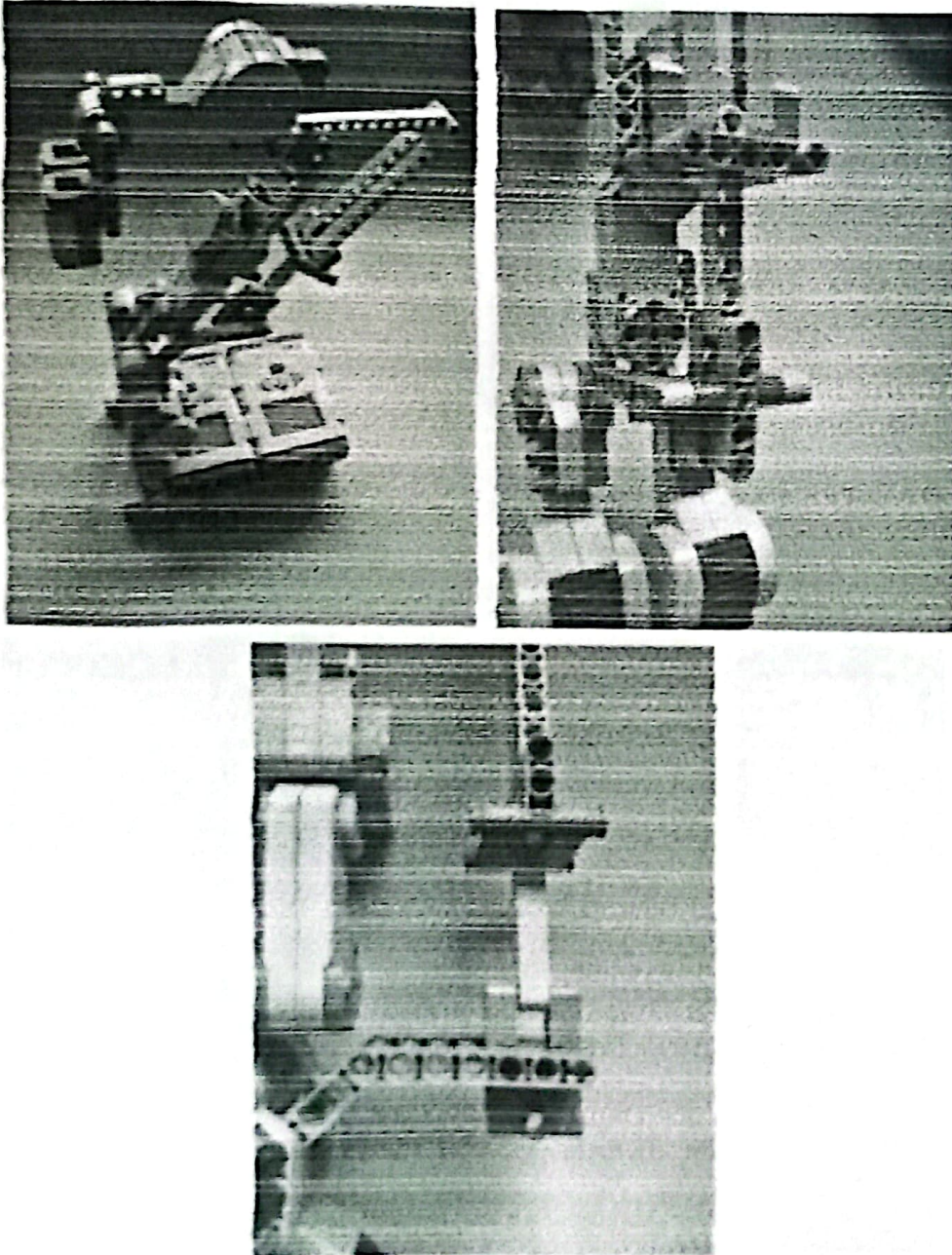
MARK II:

Figure 11. Mark II

The design uses two bricks attached to each other, six servo motors and touch and light sensors. The structure has four joints and it imitates the human arm. The lowermost joint has two servo motors and has a yaw-type movement. The upper joints are composed of a total of four servo motors and have a pitch-type movement.

The arm, however, is heavy and causes itself to tilt slightly, thus affecting the program.

MARK III:

Figure 12. Mark III

This design is equipped with a contraption that maintains the upper arm perpendicular to the base when moving. The base contains two bricks attached to each other. The arm has three joints. The lowermost joint has three servo motors: two for the pitch and one for the roll. The middle joint has a pitch-type movement and is represented by a peg attached to the contraption and the fourth servo motor. The uppermost joint has one servo motor and is connected to the light and touch sensors.

However, the contraption is still not yet finished and disables the robot to perform the roll movement and the arm is too heavy because the power of the two lower servo motors cannot compensate for the combined weights of the two upper servo motors, thus it cannot perform the massage.

MARK IV:

Figure 13. Mark IV

The contraption is transferred to the back of the arm. It is also improved so that it enables the robot to perform the roll movement.

However if the arm is not perpendicular to the base, there is a limit to the roll movement. Since the materials are made of plastic, it is able to surpass this boundary slightly but in the process results to twisting which can be damageable if prolonged and repeated.

MARK V:
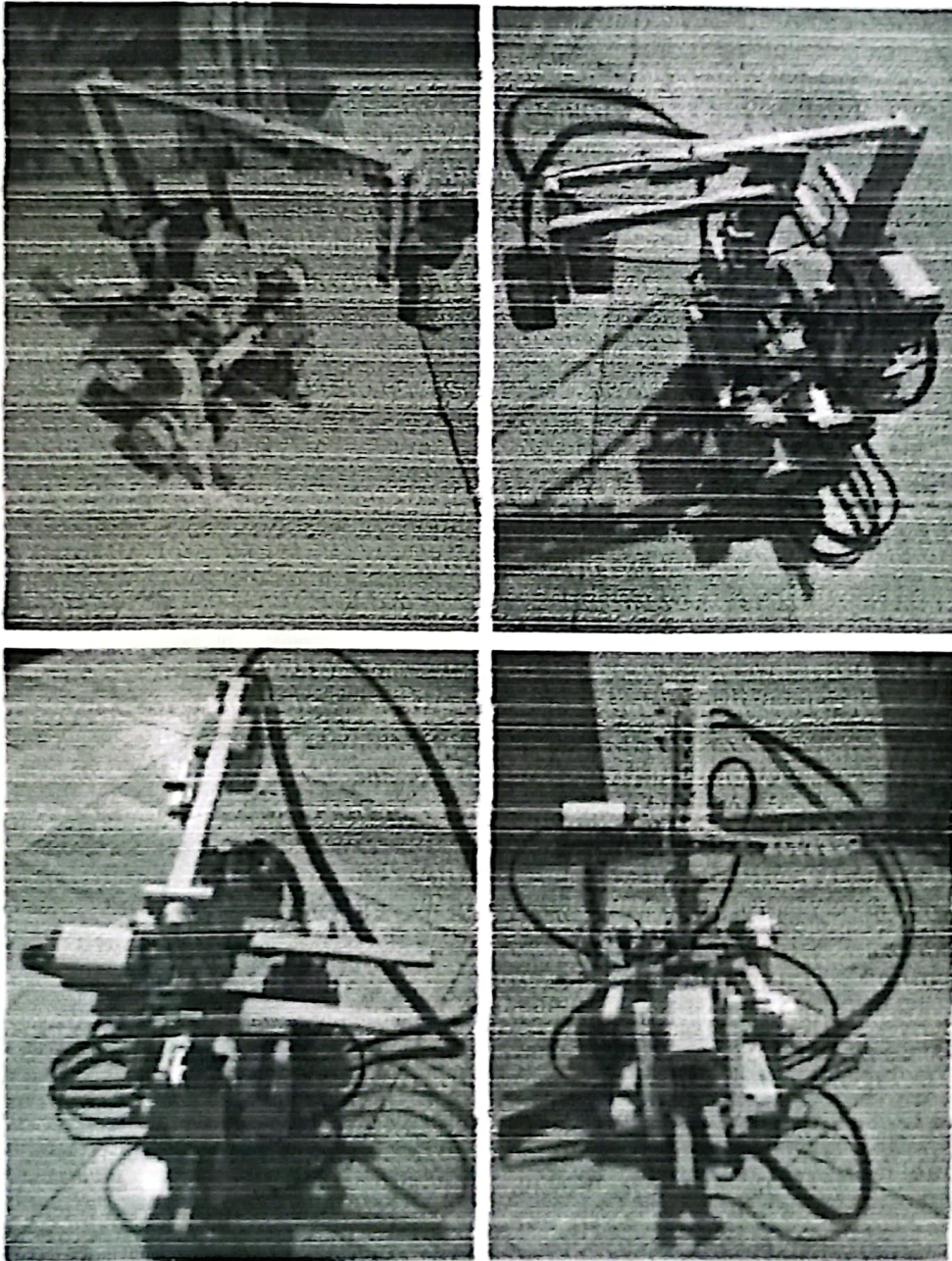
Figure 14. Mark V

A beam (encircled in red) replaced the upper servo motor and synchronizes the angle of the touch and light sensors with the angle of the arm. This greatly lessens the weight. The design only requires a single brick to operate. It is also equipped with two more touch sensors that guide the arm in attaining initial position: one has an extended beam that follows the motion of the arm and it uses two rubber bands (encircled in red) that enables it to return to its original position, and the other is located at the back.

However, the two servo motors for pitch movement block and thus limit the angle of the roll movement.

MARK VI:
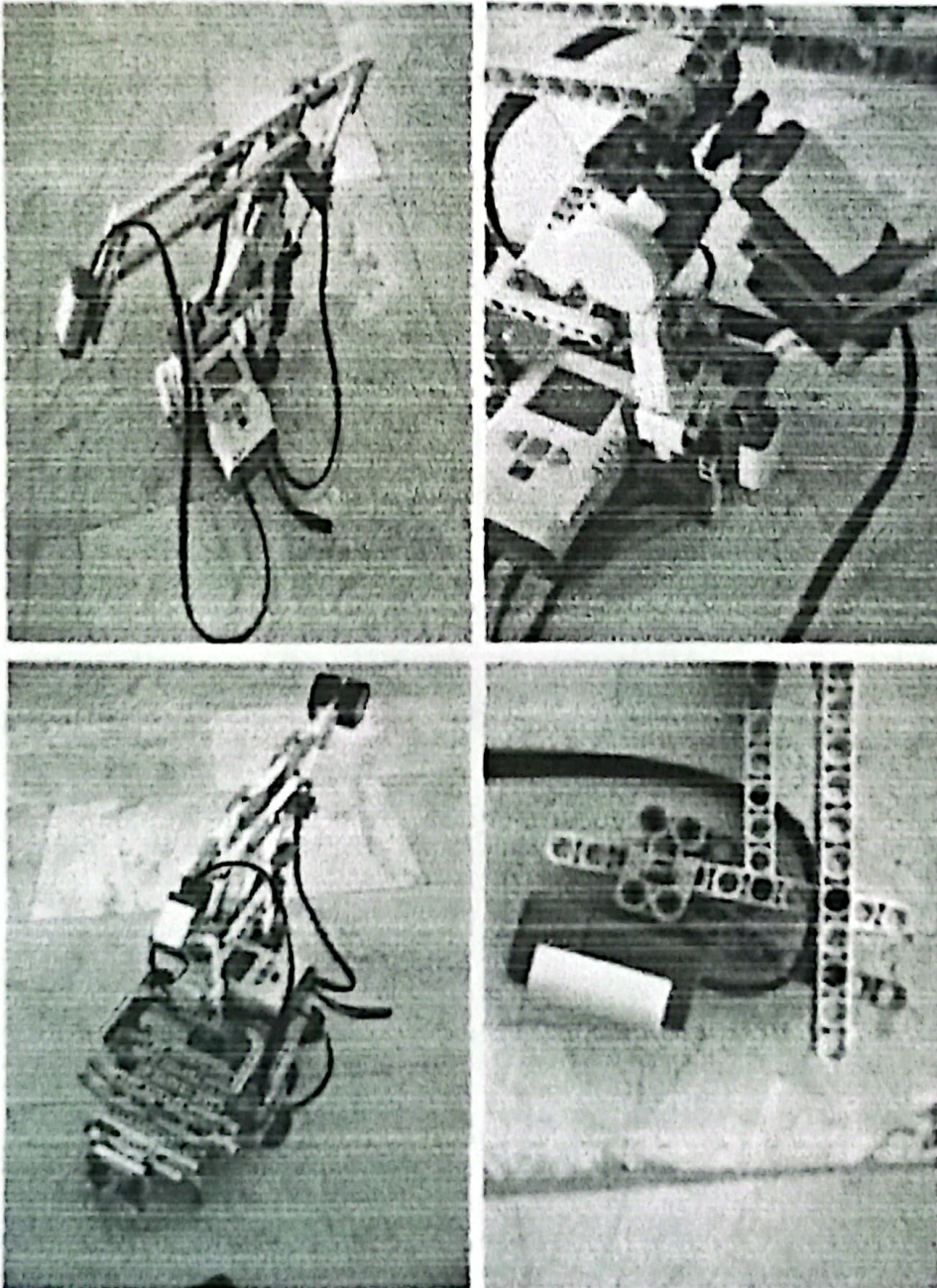
Figure 15. Mark VI

This design uses three servo motors: two for the roll and one for the pitch. This scheme solves the limitation in the roll movement. Two touch sensors are used to guide the arm in attaining initial position. The third touch sensor (which was together with the light sensor and

was purposed to sense the human skin) is removed. A mechanism accompanies the light sensor that pulls and pushes it to keep a slight distance between the sensor and the forehead in every position of the arm. Two wheels are attached to the other end of the arm that act as counterbalance to the weight of the light sensor. The sizes of the beams are strictly chosen in order for the arm to follow the shape of the forehead during its performance. The base is elevated and a head rest is attached to it to adjust the position of the client's head for better execution of the program.

CHAPTER 5
SUMMARY, CONCLUSION AND RECOMMENDATIONS

This study aimed to develop a robot capable of locating acupressure points of the forehead using Lego NXT Mindstorms Kit Version 2.0.

The study specifically aimed to:

1. To construct a robot suitable for locating the acupressure points on the forehead using Lego NXT Mindstorms Kit 2.0
2. To program the robot to locate the acupressure points on the forehead using Lego NXT Mindstorms 2.0 Programming Software

Summary of Results:

1. Six prototypes were constructed in developing the design of the robot as factors such as weight, complexity and energy consumption were minimized in the process.
2. The sixth prototype was programmed to make use of the eyebrows to locate the pressure points in the forehead.

Conclusion:

The final prototype consists of a base and arm. The base is composed of the brick and headrest while the arm is composed of motors and extended beams with a light sensor at the end. The sixth prototype uses its light sensor and motors to locate the eyebrows. The eyebrows are then used as reference to pinpoint the pressure points on the forehead. The brick gives off a sound each time a pressure point is found.

Recommendations:

Future researchers in this area of study are recommended to:

1. Use other programming languages like Java to program the robot
2. Use other materials other than Lego NXT Mindstorms

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