Development of Auto Photo Biomodular Therapy Robot

S. Umamaheswari 1, Vijay Ananth 2, Mallidi Manikandha Reddy 3, Mathew Rajan 4, Reshmi S Kumar 5, Ruban Shaji 6

1 Assistant professor, EIE, SRM Institute of Science and Technology, Kattankulathur, Chennai, India.
2 Assistant professor, ECE, SRM Institute of Science and Technology, Kattankulathur, Chennai, India.
3, 5 B.Tech Student, ECE, SRM Institute of Science and Technology, Kattankulathur, Chennai, India.
4, 6 B.Tech Student, EIE, SRM Institute of Science and Technology, Kattankulathur, Chennai, India.

E-mail: 1 uma.success53@gmail.com, 2 vidhuranila@gmail.com, 3 reddymanikantha644@gmail.com, 4 mathewandrajan@gmail.com, 5reshmi724@gmail.com, 6ruban.shaji101@gmail.com

Abstract. The Automatic photo bio-modular therapeutic robot is a device which radiates infrared light to the muscles with chronic pain, muscle spasms, joint pains etc. with the help of x-y robotic plotter. The robot uses the x-y robotic plotter for the motion of infrared bulb, thus offering the bulb an omnidirectional mobility. In contrast to traditional system of therapy, this device uses a robotic arm to perform the infrared therapy and minimize the human interaction and reducing the time. Also with the help of thermal camera we can pinpoint the pain area to the exact spot and sent the coordinate to the xy robotic arm. This project adopts a model-based approach for combining infrared therapy with automation. Various pilot experiments were performed during the proceedings to study the movement of the infrared bulb and some mechanical modifications were done to overcome the constrains of the xy robotic arm. The results of the model which was built and is compared with the real-time behaviour of the system and its significance is analysed. A control algorithm is built in a micro-controller and tested for optimal results. At the moment, this device is a new concepts. The advantage of this type of mobile robot is its Omni-directional capabilities and reduction of human interaction with the patient which could prove to be useful in hospitals which are trying to reduce the manual labour and time of interaction between the doctors and the patients. For instance, infrared light is a best mode of therapy because it penetrates to the inner layers of the skin at about 3-7 centimetres deep. Thus it can be applied to muscles, nerve points and bones for efficient treatment. Studies show that infrared light with wavelengths ranging from 700 to 1000 nanometres can be used to treat inflammatory conditions and muscle spasms.

Keywords: X-Y plotter, Chronic pain, Infrared light, Thermal imaging
1. Introduction

Today, one of the most common and anguished problem, faced by the society is chronic pain. The main cause of a chronic pain is usually the result of an injury or disease. According to the Study based on the 2016, The Global Burden of Disease, we can infer that one of the major causes of disability is the protruding pain and pain-related diseases. The cases of chronic pain has been increasing globally. Recent reports show that 8/10 individuals suffer from tension type headaches which is in turn the most common symptomatic chronic condition. When looked into the bigger picture it’s 1.9 billion affected people globally. Lifestyle of people also contributes as a major factor for chronic pain. Posture plays an important role here, poor posture causes muscle pain and tension, as uncomfortable body positions strains the muscles and soft tissues. Some of the poor positions may include slouching in a chair, putting weight on one leg or arm, uncomfortable sleeping positions etc. If we measure years one lived with disability, lower back and neck pain have been the consistent and leading cause of disability worldwide.

This project involves the integration of various streams of engineering such as automation, electrical and electronics. The groundwork for the project was laid by an article from MIT and preliminary analysis was conducted by keeping the article as base. Complete automation wasn’t considered as the primary objective then. The model was treated as a test bench and various experiments were performed on it. Thus, the model was built keeping in mind any future scope for modifying it and adding essential parts according to the need. Robots are gaining popularity day by day. Due to their Omni-directional capability many tech and robotic companies have started investing in research into these therapeutic systems. Over the past decade, chronic therapy treatment uses the infrared lamp which is manually applied by the therapist to a patient. This requires a lot of human interaction and it has not been an efficient way for the treatment of chronic pain treatment. A lot of research and studies are ongoing in this field for the mineralization of human interaction. This project incorporates automation into the field of therapy, which is now trying to minimalize human interaction with the patients. Thus only an operator is required for the functioning of device. Due to the Omni-directional capability of these robots and higher accuracy, it is considered to be an efficient way for the treatment of chronic pain. The treatment for chronic pain has been expensive as it takes a lot of diagnosing and the current machine is expensive hence the treatment is very costly and may not be affordable by everyone. Hence aims to build to build a device which can be affordable and hence reducing the cost and making it efficient. This device can also be used in small clinics and for individual use.

Following are the advantages of this project

1. Ease of operation- This device has Omni-directional capability which helps in more accurate treatment.
2. Reduction of human interaction- Infrared radiation is applied to the patient by using a XY plotter.
3. Portable device- The device is portable and can be moved easily.

2. Main Components

2.1 Thermal Camera

This project consists of a various number of hardware and software codes integrated to make this device work efficiently and smoothly. A thermal camera is a gadget which allows us to detect the heat radiating of an object itself. Thermal cameras record the temperature of a given object and displays it in a screen in different colour patterns. Lower temperatures are often shown in shades of blue and higher temperatures are shown in shades of red. These cameras detect and capture different levels of infrared light which
cannot be detected by a naked eye. Infrared radiation lies in between the visible and microwave portion of the electromagnetic spectrum. Infrared waves can be used to measure the heat of an object, i.e. higher the temperature more the infrared wave it produces. If the radiation is large enough it can be felt as heat. A thermal camera contains small measuring devices that capture infrared radiation. These are known as micro bolometers. A thermal camera has lenses which focuses on the infrared waves and directs them into the sensors. A thermal camera has a low resolution compared to modern displays. This is because each pixel is assigned with a micro bolometer which records and assigns an appropriate colour to that pixel.

Initially, the image detection code is developed in python v2.8. Various python packages such as Numpy, open CV, pip install and panda are used. The image detection library Numpy is used to locate where the pain is in the body using the thermal camera and the exact coordinates can detected.

2.2 X-Y Plotter

Arduino UNO shown in Figure is an open source hardware and software computing platform which uses ATmega328 microprocessor. The board is equipped with sets of 13 digital and 6 analog input/output (I/O) pins, out of these pins, digital pin is used to communicate with the motor driver; the analog pins are used to take input from tuners. The boards feature serial communications interfaces, Universal Serial Bus, this is used for communication between IMU and Arduino.

Nema 17 stepper motors are the most commonly used stepper motors. The stepper motor is a 4 phase unipolar permanent stepper motor. It has a revolution of 200 steps per revolution and the shaft turning 1.8°. This is used in various industrial control.

For this project, it is used to move the drive belt so that the belt driver head can move in X-Y direction.

2.3 Infrared Bulb

Infrared lamps, otherwise known an IR-lamps are incandescent lamps which are used to produce infrared rays. They have a power rating of 100 watts. Infrared bulbs are manufactured from quartz glass which ensures the longevity of them. The infrared lamps are used for two purposes,
1. Short wave applications.
2. Long wave applications.

Most of the infrared lamps also emit waves in the visible region of electromagnetic spectrum (red, orange and yellow). An infrared bulb consists of different parts. The main part is the outer covering, which is made of quartz glass. Inside the quartz glass is the tungsten filament. When the current is applied through the filament, it heats up to a certain temperature point which produces infrared waves.

The quartz glass enclosure is sealed tightly to ensure no gas leak happens. This also provides the electric contact for the filament. The filament is supported by small wires in the stem.

The bulb is filled with an inert gas or it is made vacuum to ensure that the filament doesn't burn out or gets evaporated.

3. Working Overview

Initial stage of this project is to set up the thermal camera in a position that is adjusted to fit the image in the camera viewfinder. The photo of the patient is taken where the pain area is which can be anywhere for e.g. it can be in the back, shoulders, neck, and joints, etc. Thus this specific area is pinpointed in the thermal camera. This project uses FLIR c3 thermal camera as it is compact, sleek and efficient enough capturing the image. The image is taken in top view. This is because the patient is always kept under the infrared light and infrared light is radiated from the above.

However, this requires the patient to be in a stable and a normal environment. This can be in a room of temperature of 26°C or below for getting the perfect thermal image of the body without effecting the external temperature. The external temperature can effect on the surface of the skin which can cause to reduce accuracy of the set-up.

The coordinates are send to the arduino which is the interface for the micro-controller. Input data is then sent to the servo motors so that bulb moves to the desired spot and the infrared bulb gets activated.

There are 2 servo motors for the action of x-axis and y-axis. The head of the xy plotter is attached with the infrared bulb which is powered externally.

The infrared light is radiated to the surface of the body or to the spot for 5-10 which depends on the patient in order to avoid overheating. Infrared light is absorbed by photoreceptors in the cell. When this infrared waves are applied on the cells, they kick-start a chain reaction which triggers several natural processes in cellular level.

4. Result

The thermal camera was able to capture the origin point of chronic pain. The image was entered to the computer, which processed the data and fed it to the robot. The robot which is equipped with an infrared bulb was moved to the point of origin of the pain. The infrared bulb was then applied to the given point in circles for 5 minutes duration and taken back. The patient's pain is again diagnosed and the infrared bulb is applied again accordingly. After the pain is relieved, immediate check-ups are done on the patient to confirm the reliability of the system. The device functions perfectly and it relieves chronic pain.

5. Conclusion

Infrared therapy is an innovative way for treating the patients with chronic pain. This therapy makes use of the ability of infrared waves to penetrate the skin layers, thus able to provide an efficient pain relief. Infrared therapy can also be used to treat wide array of conditions. It is considered to be safe, effective and drug-free way to provide relief for people with chronic pain. Infrared waves improve the circulation of oxygen rich blood in the blood vessels, which promotes to faster healing of deep tissues.
6. Acknowledgments

We are deeply grateful to Dr. S Umamaheshwari, Assistant Professor, Department of Electronics and Instrumentation, whose comments and suggestions were of inestimable value for my study. Special thanks also go to Dr. P A Sridhar who gave us invaluable comments and warm encouragements. We would also like to thank our parents and friends for their continuous support and encouragement during the course of our project. We would like to extend our gratitude to the lab in charges and the lab assistants for their continuous support through the course of our project. Finally, we would also like to thank SRM Institute of Science and Technology and The Department of Electronics and Instrumentation for providing a chance to work on our project.

References

[1] Gardner EN, et al. The cost of Medicaid-covered services provided to disabled adults with neurologic disorders: implications for managed care. The American Journal of Managed Care. 1999;5(11):1417–1425.

[2] Richardson C, Maciver K, Wright M, Wiles JR. Patient reports of the effects and side-effects of TENS for chronic non-malignant pain following a four week trial. Pain Clin. 2002;13:265–76.

[3] Smith KC. The photobiological basis of low level laser radiation therapy. Laser Ther. 1991;3:1–7.

[4] E Lisa Laaksol, Carolyn Richardson and Tess Cramond, Pain Sores And Side Effects In Response to Low Level Laser Therapy, 1997

[5] Akinori Masuda, Yasuyuki Koga, Masato Hattanmaru, Shinichi Minagoe, Chuwa Teid, Effects of Repeated Thermal Therapy for Patients with Chronic Pain, 2005

[6] Susan Hunter, MSN, RN; Diane Langemo, PhD, RN, FAAN; Darlene Hanson, MS, RN; Julie Anderson, PhD, RN, CCRC; and Patricia Thompson, MS, RN, Monochromatic Infrared Energy in Chronic wound healing, 2007