Impact Factor (SJIF): 5.158 E-ISSN: 2583-7206

International Journal of All Subject Research

Received: 10/November/2024 IJASR: 2024; 3(6):28-30 Accepted: 22/December/2024

Tech-Knee: An Active and Assistive Device

*[1]Ramakrishnan Sriram, [2]Pavithraa VK and [3]Archana M

*[1, 2, 3]Student, Department of Electronics and Communication, Sri Sairam Engineering College, Anna University, Tamil Nadu, India.

Abstract

Many of the people whose age ranges from 45 and above are facing with knee problems and knee pains. Most of them are choosing surgery and spending their money lavishly for those surgery. Few of them are not even ready to go for operation since they are afraid of it and their bodies can't even support it. This paper presents an active and assistive knee device which is wearable by the senior citizens to overcome the knee ailments and knee stress. This makes the people to walk or climb or jog without stress. This paper describes the electronic and electrical requirements of knee device and how it is going to treat the knee joint using pressure points in our knee. The device includes a microcontroller ESP8266. It includes force sensor and Transcutaneous Electrical Nerve Stimulation module (TENS). It also has got some technical stacks such as mobile application, Arduino IDE.

Keywords: Knee problems, surgery, knee device, electrical requirements, force sensor, ESP8266, TENS.

1. Introduction

The population of India in the last twenty years keeps on increasing exponentially. The people who are on the age group from 45-60 are facing many difficulties in their bodies such as headache, stomach pain, body pain etc., due to their ageing and lack of appetite. One of the most important pains is knee pain. Two syndromes namely Knee Osteoarthritis and Patello-Fermal Pain Syndrome (PFPS) are the main causes of knee pain.

Knee Osteoarthritis is the burning of muscles in knee cap and legs. Due to this syndrome, muscles get tight and eventually more stress to be given on those muscles which leads to pain on knees and legs too. This leads to knee pain, lack of movement.

Patello-Fermal Pain Syndrome (PFPS) is a specific syndrome which affects the kneecap. This is prevalent in sportspersons and women. Due to this, the person feels chronic knee pain and they can't work and they can't walk for longer time.

Apart from this, there are many factors such as ageing, body weight, prolonged idleness, more stress etc. But all these leads to acute or chronic knee pain. Many people are visiting the hospitals for surgery or operation. Some are wasting their money on that so lavishly. To overcome this, many devices like crutches, canes, prosthetic legs are used. But they are giving extra weight to those who are using and they are passive i.e., the devices do not work for the given task and it gives even more trouble. For example, Eksa Biovics constructed the gait mechanism during 1990s but does not work out well due to the mechanism's weight. So, in this paper, we are going to see a lightweight and active knee device. Here active means the device which we are designing uses sensors and microcontrollers. It will be more of an embedded system and an Internet of Things device. In this paper we are going to see the sensors used, how they are simulated, how it is implemented in the TENS Module and other applications. We have categorised our project into 2 different parts: electronic and electrical.

2. Force Sensor

The electronic part of our knee device is the force sensor. Force sensor or force sensitive resistor is a transducer that converts mechanical forces such as weight, tension, pressure and compression into an electric signal. It is a typical resistor which works inversely based on the force applied on it i.e. if the force applied increases, the resistance of the sensor decreases.

This force sensitivity is optimized for use in human touch control of electronic devices such as automotive electronics, medical devices and in industrial and robotic applications. As per standards, the standard 402 sensor is a round sensor 18.28 mm in diameter. Custom sensors can be manufactured in sizes ranging from 5 mm to over 600 mm.

There are numerous varieties of force sensors, for our particular project, we have a force sensor with the following specifications.

***Corresponding Author:** Ramakrishnan Sriram

Table 1: Specifications of FSR FA402

Parameters	Measurements
Thickness	= 0.3mm
Dimension	17.471*18.3mm
Force measuring range	100g-10kg
Sensing Dimension	Φ14.68 mm
Force repeatable	Thickness
Working Temperature	Thickness

We have designed a circuit with ESP8266 microcontroller and force sensor which helps to detect the amount of force exerted on the kneecap.

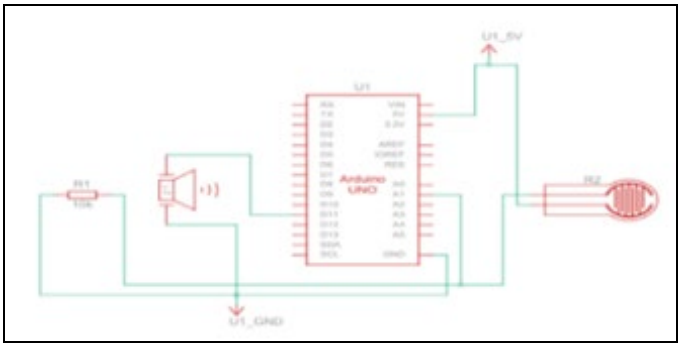

Fig 1: Circuit with force sensor and ESP8266

3. Transcutaneous Electrical Nervous Simulation

Transcutaneous Electrical Nervous Simulation abbreviated as TENS module and microcontroller constitute the electrical part of our knee device.

TENS module is a method of pain relief involving the use of a mild electrical current. This module consists of a control device and stick pads. TENS module works in any environment irrespective of the temperature and other factors. For each variety of pains, the stick pads are fixed in such a way that it produces the apt amount of current by controlling the control device using our microcontrollers.

TENS module can be used to help reduce pain and muscle spasms caused by a wide range of conditions which includes arthritis, knee pain, sports injuries etc…By nature, TENS machines are small and lightweight, so we can use them while walking or jogging.

The Basic Diagram of TENS Module is as Follows

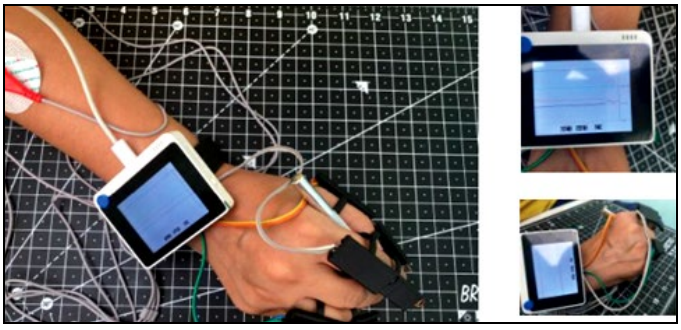

Fig 2: Enlarged image of TENS Module

For our knee device, this module is adhered outside the brace and the pads are connected in 4 directions of knee like a diamond and by using our ESP8266, we are going to control the device of TENS and thereby, we are giving the minimum current which gives a tingling sensation that helps to reduce the pain by resisting the pain signals to reach the brain of human body.

This TENS module is widely used as a pain reliever for various types such as pelvic, periodic, knee pains etc…,

The amount of current to be passed depends on the amount of pain felt by an individual. The following table shows the various units of TENS module.

Table 2: Various TENS units

Product	Type of Pain	Benefits	Features
Touch TENS	General Pain	Simple to use.	Preset functions.
Target TENS	General Pain	Traditional style.	Wide range of settings.
TENS 7000	General Pain	Powerful and effective.	Either low or high frequency modification.

The module can be used in many body parts and each part are to be treated differently. The following diagram shows the placement chart of various body parts.

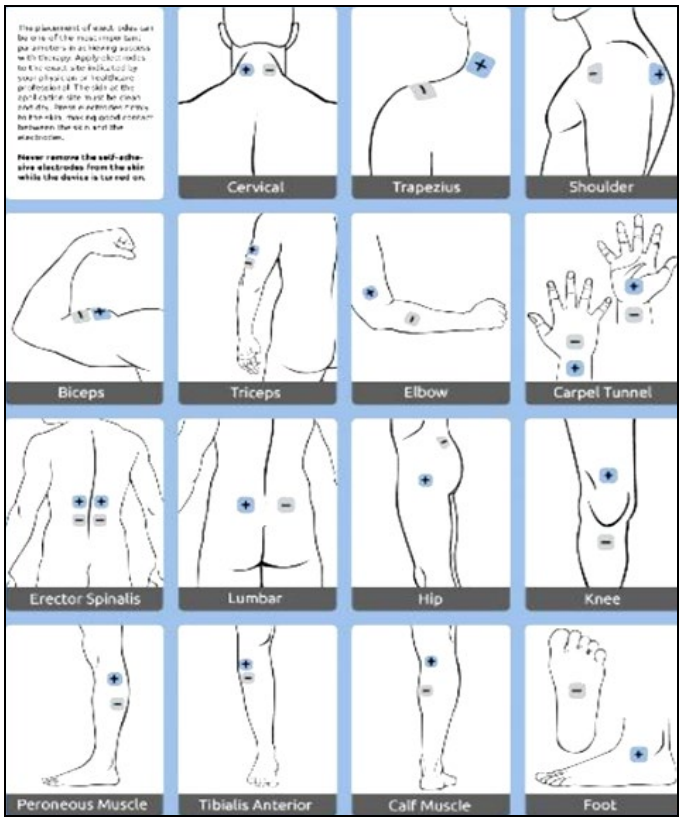

Fig 3: Various regions of body where pads are connected

4. Mobile Application

Our knee device also constitutes the mobile application development to check the weekly vitals of the knee of the people who wears it.

This mobile application uses the data collected by the force sensor and TENS module and analyzes it. We are planning two different types of data which are pre-usage of device and post usage of device, which gives the change in amount of pain signals received by the neurons of brain.

5. Methodology

i). **Fitting the Knee Device:** The knee device is simply a brace which can be adhered to the painful knee as simple as it is. Then, the pads of the TENS module will be adhered in the diamond pattern where the controller will

be at the center of the knee cap. The force sensor inside the cavity of the knee device will gives the pressure on the knee.

ii). **Detecting the Amount of Force Exerted:** The force sensor inside the device will detect the amount of force exerted on the knee and gives the value in decimal and gives the electric signals graph. Our code implemented in ESP micro controller will give us the apt amount of current to be passed. This same data will be shown in the mobile application we developed.

iii). **Implementation of TENS Module:** The important step of our project, once we calculate the amount of current to be passed, the TENS module gets activated by using our code in the controller, this module gets into action and control the pads sticked on the knee cap and gives the current to be given on it. As per the rule of control systems, current is a form of force when we are giving opposite and equal amount of force to an object, both the forces get cancelled and resultant is zero. Same way, the current we are giving manually to the knee arrests the pain signals reaching the brain and thereby, it relaxes the muscle spasms and reduces the knee pain

iv). **Mobile Applications:** Mobile application gives the detailed analysis of pre usage and post usage of the knee device and also instructs the users to take rest, take a walk etc.

6. Final Outcome

We have analyzed the various outputs varying the force exerted on the force sensor. We connected the microcontroller ESP8266 using Arduino Integrated Development Environment (IDE). Those graphs indicate the variation of force acting on the knee of a patient.

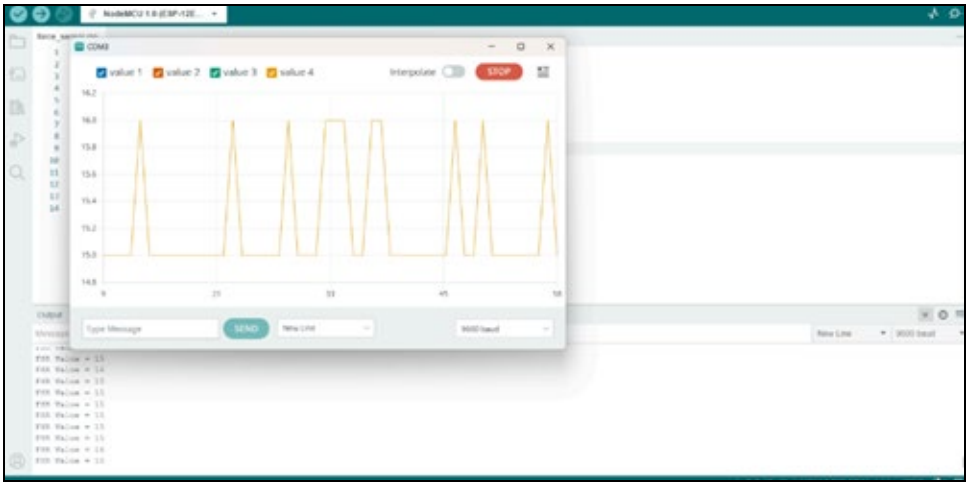

Fig 4: Final Outcome

7. Future Enhancements

As of now, the device gave 40% of desired output to us. In our future enhancements, we are enhancing the performances of TENS module and battery usage of module.

This paper gave an idea of how our knee device works and the innovative ways such as usage of sensors and modules which are proven safe amongst the world.

References

1. Byungjune Choi, Younbaek Lee, Jongwon Lee, Minhyung Lee, Bokman Lim, Young Jin Park, Kyungrock Kim, Yong-Jae Kim, and Youngbo Shi. Development of Adjustable Knee Assist Device for Wearable Robot based on Linkage and Rolling Joint. Joint2019 IEEE/RSJ *International Conference on Intelligent Robots and Systems (IROS) Macau, China, November* 4-8, 2019.
2. Abustan MS, Ali MF, & Talib SH. A case study of energy expenditure based on walking speed reduction during walking upstairs situation at a staircase in FKAAS, UTHM, Johor building. IOP Conference Series: Earth and Environmental Science, 2018, 140(1). doi: 10.1088/1755-1315/140/1/012080
3. Li Zhang, Geng Liu, Bing Han, Zhe Wang, Han Li, Yan JiaoK. Elissa. “Assistive devices of human knee joint: A review”, 2020. DOI: https://doi.org/10.1016/j.robot.2019.103394
4. Jim Hewlett, John Kenney. Innovations in functional and rehabilitative knee bracing, 2019. doi: 10.21037/atm.2019.03.34
5. Sridhar Kashyap, Vasuki Venkatesh, M.K. Pushpa, Sidharth Narasimhan, Vrushali Chittaranjan. Adaptive, AI-based Automated Knee Physiotherapy System, 2023. DOI: https://doi.org/10.1016/j.gltp.2021.08.052
6. Chesterton LS, Barlas P, Foster NE, *et al*. Sensory stimulation (TENS): effects of parameter manipulation on mechanical pain thresholds in healthy human subjects. Pain. 2002; 99:253–262.
7. Wang N, Hui-Chan C. Effects of acupoints TENS on heat pain threshold in normal subjects. Chin Med J (Engl). 2003; 116:1864–1868
8. Tong KC, Lo SK, Cheing GL. Alternating frequencies of transcutaneous electric nerve stimulation: does it produce greater analgesic effects on mechanical and thermal pain thresholds? Arch Phys Med Rehabil. 2007; 88:1344–1349
9. Radhakrishnan R, Sluka KA. Deep tissue afferents, but not cutaneous afferents, mediate transcutaneous electrical nerve stimulation-induced antihyperalgesia. *J Pain*. 2005; 6:673–680
10. Moran F, Leonard T, Hawthorne S, *et al*. Hypoalgesia in response to transcutaneous electrical nerve stimulation (TENS) depends on stimulation intensity. J Pain. 2011; 12:929–935
11. Carol GTVance*, Dana LDailey, Barbara ARakel & Kathleen ASluka. Using TENS for pain control: the state of the evidence.