Pamantasan ng Lungsod ng Maynila

FIXTRATE: AN IOT-BASED POSTURE DETECTION AND CORRECTION SYSTEM

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CHAPTER ONE

INTRODUCTION

1.1 Background of the Study

According to an article, posture is described as the attitude acquired by the body either with support or as a result of the coordinated motion done by a set of muscles attempting to preserve stability. The alignment of the spine is essential to having proper posture. The spine has three natural curves: in the neck, in the mid/upper back, and in the lower back. Proper posture should keep these contours but not accentuate them. The top of the shoulder should be over the hips, and the head should be above the shoulders. Good posture can help to prevent back discomfort and headaches, maintain higher lung capacity and energy levels, exercise with better form, and boost confidence (*Posture*, n.d.).

On the other hand, postural dysfunction, often known as "poor" posture, occurs when the spine is positioned in unnatural positions, emphasizing the curves and placing the joints, muscles, and vertebrae in stressful positions. This prolonged inadequate posture causes pressure to build up on these tissues (Clarke, 2019). As reported by the American Chiropractic Association, over 31 million suffer from poor posture at any given moment. Based on the article, five of the most prevalent causes of poor posture include occupation, muscle strain, injury, inadequate footwear, genetics, and weight (*Top 5 Most Common Causes of Poor Posture*, n.d.). A person's health can be negatively impacted by poor posture for a number of reasons. It is one of the leading causes of low back pain, affecting more than 25 percent or a quarter of the working population each year. Long periods of slouching can impose undue strain on the spine's discs, ligaments, and muscles, resulting in low back pain. It can also cause the lungs to collapse, leading to difficulty breathing and decreased respiratory function. Because it impedes blood circulation and puts bones and joints out of alignment, bad posture can make a person feel exhausted and less energetic (*Importance of Good Posture*, 2021).

There are several methods for keeping a healthy posture without seeking medical attention. Maintaining proper posture while performing routine tasks such as watching television, doing dishes, or walking. Any sort of exercise can assist improve posture, but certain routines are especially beneficial. eg. Yoga, tai chi, and other classes emphasizing body awareness Exercises that strengthen the core are also recommended. Extra weight can weaken abdominal muscles, exacerbate pelvic and spine difficulties, and lead to low back pain. Wear low-heeled, comfy shoes. High heels, for example, might throw a person off balance and require them to move in a different manner. This puts additional strain on muscles and impairs posture. Whether the user is sitting in front of a computer, cooking dinner, or enjoying a meal, make sure the work surfaces are at a comfortable height. Avoid static postures such as prolonged sitting; instead, get up from the chair and move around every 30 minutes. During difficult exercises, make sure to activate the core (for example, deep abdominal and pelvic floor muscles) and exhale as the user lift. This aids in the stabilization of the spine. Maintaining a neutral posture allows the body to function properly (*Posture*, n.d.).

There are also existing posture correctors in the market that help people to positively change their posture in a short period of time. The majority of posture correctors function by gently pushing the shoulders back and straightening the spine. This helps to train the muscles to maintain excellent posture even when the device is not used. Many posture correctors have adjustable straps, allowing you to choose the level of support you require. The ideal posture corrector for women, according to this article, is a brace that supports the clavicle, chest, and back. It simply slides over the shoulders and wraps over the upper back. This gadget works to offset the effect of the breast's weight pulling the chest and front side forward. This device gives the lightest support of any physical posture support device, yet it is also the most comfortable and least apparent under clothing. For added lumbar support and comfort, there is a product with a double-strap back brace that contains a waist strap and an additional elastic belt. It also includes two auxiliary support bars in the padded back strip for increased structure. A smart posture corrector is now the greatest option for long-term improvement. This ergonomic elastic and nylon material posture corrector goes over the shoulders. It also has a sensor that vibrates when the user's posture is out of alignment, assisting them in developing muscle memory and a habit of straightening with a gentle reminder (Andersen et al., 2022). Although there are no guaranteed effects of these practices and gadgets due to them being just reminders to not neglect proper posture, their main advantage is that they make the users more conscious of their posture, which by itself can lessen pain and boost self-esteem.

Numerous researchers also conducted studies to create automated and less expensive solutions than those available on the market. According to Sahani et al. (2020), posture detection may vary depending on the approach as some have applied machine learning through training neural networks for standard postures while others focused on sensor-based applications by using different sensors that detect angle deviations and microcontrollers that process these to perform necessary adjustments for correction. For example, Pratheep et al. (2021) created an automatic body posture corrector designed for spinal cord patients wherein the device vibrates or outputs a voice command, depending on the user's preference, when it detects improper posture. However, this approach is not purely automatic as it still requires the user to manually adjust their posture according to the right reference angle.

Lakshmi et al. (2017) and Lim et al. (2017) attempted to apply full automation using DC motors in their Posturector: posture corrector and wearable posture identification system for those who suffer from the effects of improper posture due to prolonged sitting. Both devices utilized a buzzer to alert the user when he/she deviates from the correct posture angle and when no feedback is detected, the device will reset itself back to the right reference angle. While the device prototypes yielded positive results in automation, the researchers recommended further improvements to have a more accurate and well-performing device such as considering additional axes and the use of wireless communications, especially mobile phone application systems, to help control the device and collect data from the user.

Because of the indicated research gaps, the researchers decided to propose Fixtrate: a posture detection and correction system that utilizes IoT to address the core limitations of the existing studies and products. The device recognizes the need for a fully automated design that covers both the x and y axes of the proper sitting posture. Moreover, IoT technology will be implemented as a mobile application will be connected to the actual device through the internet to monitor and record the posture angles of the user. These records are stored inside the mobile application and are readily accessible in case the user needs to keep track of his/her posture improvements through time.

1.2 Statement of the Problem

The study Fixtrate: An IoT-based Posture Detection and Correction System aimed to determine whether a compact wearable device can efficiently detect and correct the body back posture of its user. Specifically, it intends to measure the project's capabilities by answering the following questions:

1. How accurate is the device in detecting back posture changes in terms of:
    a. X Axis
    b. Y Axis
2. Are there any significant changes in body posture the users have after using the posture detection and correction system?
3. Evaluate the level of acceptability of the proposed project in terms of:
    a. Comfortability
    b. User Friendliness
    c. User Experience

1.3 Objective of the Study

The research is proposed to help improve an individual's posture by using a sensor and IoT-based posture system that could detect and monitor changes from the user's stance. To attain the goals of this study, the researchers intend to follow the set of objectives as stated below:

1.3.1 General Objective

To develop an IoT-based posture detection and correction system that detects and corrects improper posture caused by prolonged sitting.

1.3.2 Specific Objectives

- To construct hardware that determines any significant changes in the user's body posture before and after using the posture detection and correction system;
- To create a mobile application that gives control to the patient to monitor and adjust their body posture based on the proper angle.
- To test the accuracy of the IoT-based posture detection and correction system caused by prolonged sitting using the percent error of the accelerometer produced after comparing it to a fixed goniometer at different angles.

1.4 Significance of the Study

This research is proposed with the goal of providing crucial information and knowledge regarding any related issues in concern with the chosen title; Fixtrate: An IoT-based Posture Detection and Correction System. Benefiting the study are the various sectors as follows:

Individuals with Poor Posture. As this research addresses the problem of proper posture in an individual, those individuals who are dealing with improper posture will be the direct recipients of the study. Any output and results generated by this project can be used to reduce the number of individuals with poor posture and identify its importance for each individual, which can eventually help them to work effectively in their own working environment.

The General Public. Although this research was conducted with the intention of benefiting the medical field, specifically the patient diagnosed with poor posture, it will also benefit the public by raising awareness of proper posture, which is supported by medical facts, as well as raising their awareness of proper healthcare.

The Future Researchers. The output of this study will also benefit the vast majority of future researchers who will conduct similar and related research about monitoring and correcting the proper posture of an individual. It can serve as a supporting study as well as a catalyst to generate another research idea that can help in medical health care and contribute to the growth of the medical industry.

1.5 Scope and Limitations

This study focuses on the effectiveness of an IoT-based Posture Detection and Correction System which supports a 2-dimensional axis. The basis of the data needed for posture correction is obtained from the interviews conducted by the researchers with professionals who have in-depth knowledge in the field. As stated earlier, the proposed project is an IoT-based device. This means that the posture detection and correction system can be connected to a mobile application in order to track the user's progress. In the technicalities of the device, the researchers decided to use accelerometers to measure the angle difference between the lumbar and cervical points to distinguish if the user is approaching improper posture. The researchers also decided to create the proposed device using Arduino since the majority of the related studies gathered involving posture correction have used Arduino as a microcontroller. Once the proposed device is done, participants who has an age that varies around 20 to 39 years old will test the device in order to know its effectiveness. The testing for each participants will undergo for around 2 weeks in order to see significant changes to the user's posture. It's important to note the limitations of the posture correction system. The proposed device only supports a 2-dimensional axis. These are the x and the y axis. Any data outside the said axes are beyond the coverage of the study. Also, the testing procedure will be done for the testers while they were sitting. The proposed device focused on the age group in which improper posture most frequently occurs. This means that the posture detection and correction system are only applicable to 20 to 39 years old. Other age groups are outside the scope of the said device. By doing this, the researchers can create an IoT-based 2-dimensional posture detection and correction system.

CHAPTER TWO

REVIEW OF RELATED LITERATURE

2.1 Medical Aspect of the Study

2.1.1 The overall importance of good posture

Posture, or the relative disposition of the body at any given time, is a composite of the positions of the body's various joints at that time (*Posture*, n.d.). There are two types of posture, according to the article, (*Guide to Good Posture*, n.d.): dynamic and static. Dynamic posture is how one holds oneself while moving, such as walking, running, or bending over to pick something up. Static posture refers to how one holds oneself when one is not moving, such as when one sits, stands, or sleeps. An article by Max Well Therapy (n. d.) claims that having a good posture has numerous health advantages in addition to helping one look good. It encourages proper alignment of joints and bones. It promotes the effective and efficient use of the body's muscles and reduces abnormal wear and tear on joint surfaces. It reduces stress on the spine's ligaments and prevents abnormal spine positioning and muscle fatigue. It reduces the likelihood of back pain, strain, and sprain injuries.

The alignment of the spine is fundamental to ensuring good posture. The spine has three natural curves: at the neck, in the mid/upper back, and in the lower back. Correct posture should keep these curves but not accentuate them. The top of one’s shoulder should be over one’s hips, and the head should be above one’s shoulders. The line of gravity should pass through specific points on the body in an ideal posture. This is easily observed or evaluated by using a plumb line to determine the body's midline. The vertical line passing through the body's center of gravity should theoretically divide the body into two equal halves, with the body weight distributed evenly between the two feet, when viewed from either the front or the back. Asymmetry and rotations/tilts should be observed in the anterior, lateral, and posterior views when assessing posture. In addition to that, head alignment, cervical, thoracic and lumbar curvature, shoulder level symmetry, pelvic symmetry, and hip, knee, and ankle joints should be assessed. When sitting, shoulders should be relaxed and elbows close to the sides of the body, the angle of the elbows, hips, and knees is approximately 90 degrees, feet flat on the floor, forearms parallel to the floor with wrists straight, and feet should rest comfortably on a surface (*Posture*, n.d.).

A study conducted by Sidlauskiene et al. (2019) included 532 children ranging in age from 11 to 14 years. The Hoeger visual posture assessment method was used to evaluate spinal posture. A 6-minute walking test (6 MWT) and maximum oxygen consumption were used to assess physical capacity (VO2 max). The European Fitness Test was used to assess other aspects of physical fitness such as general balance, flexibility, explosive leg power, and abdominal muscle endurance (Eurofit). The sample was divided into two groups based on the amount of time spent doing moderate to vigorous intensity physical activities (MVPA) - a low activity level group and a moderate to vigorous intensity physical activity level group. The duration of MVPA, the outcomes of the spinal posture evaluation, and the physical fitness parameters were compared between groups, as well as correlations between these variables. According to the study, 22.2% of teenagers had low physical activity levels, and 16% of teenagers had incorrect postures. Teenagers in the low physical activity group were less fit and had poorer postures than those in the MVPA group. During the 6MWT, teenagers in the low physical activity group walked 63.2 m less ($p = 0.002$) and had 0.8 mL/kg/min lower VO2 max ($p = 0.006$) than teenagers in the MVPA group. When compared to the MVPA group, teenagers in the low physical activity group performed worse in the explosive leg power and abdominal muscle endurance tests. The correlations between the duration of MVPA, the results of spinal posture evaluations, and some physical fitness parameters were extremely weak.

Another study by Gong et al. (2019), assessed the parameters of standing body posture in the global sagittal plane and determined the dynamics of changes in standing body posture occurring with age and differences between men and women in their study. The measurements were taken on 226 people ranging in age from 20 to 89 years. The subjects were divided into seven groups based on their ages: 20-29, 30-39, 40-49, 50-59, 60-69, 70-79, and 80-89 years. All subjects were ambulatory and able to perform tests while standing. Height, weight, and posture were all measured. Body posture was assessed using the photographic method. The participants were instructed to stand normally, with their heads relaxed and their eyes fixed straight ahead. There are some noticeable height and body weight differences between men and women in some life stages, and within the same gender, there are some noticeable height or BMI differences between different life stages. However, there is no discernible relationship between height, body weight, or BMI and any of the five angles that were measured. The neck (132.8187.4 degree) > knee (165.3204.3 degree) > thorax (141.5179.9 degree) > hip (164.2191.3 degree) > waist (153.4179.9 degree) is the variation range of the angle. Furthermore, the coefficient of variation is as follows: neck (5.68%), thorax (4.13%), knee (3.07%), waist (2.72%), and hip (2.35%). According to the data, the neck changes the most among these five segments in the current population, while the middle segments of the body, waist and hip are relatively stable. There were significant differences between men and women in the angles of the neck ($p = 0.006$), thorax ($p = 0.001$), and hip ($p = 0.010$). Men have smaller neck and thorax angles (155.7 0.7 and 156.0 0.5, respectively) than women (158.9 1.0 and 160.8 0.7). These differences indicate that men have deeper cervical lordosis and thoracic kyphosis than women. It implies that men raise their heads higher and bend their shoulders forward more than women. The fact that men have a smaller hip angle (175.8 0.4) than women (177.2 0.4) suggests that men's pelvic shifts forward, tilts backward, or hip joints extend more than women's.

Good posture is important for a person's overall health. There are numerous ways to maintain good posture, according to MedlinePlus (n. d.). The first step is to be aware of posture while doing everyday activities such as watching television, washing dishes, or walking. Staying active and engaging in any type of exercise can help improve posture, but certain types of exercises can be especially beneficial. Yoga, tai chi, and other classes focusing on body awareness are among them. Exercises that strengthen the core are also recommended (muscles around the back, abdomen, and pelvis). Maintaining a healthy weight because excess weight can weaken abdominal muscles, cause pelvic and spine problems, and contribute to low back pain. In addition to that, wearing low-heeled, comfortable footwear can ensure a good posture. View of the fact that wearing high heels, for example, can throw the balance off and force one to walk in a different way. This puts additional strain on the muscles and harms posture. Finally, whether sitting in front of a computer, cooking dinner, or eating a meal, make sure that the work surfaces are at a comfortable height.

2.1.2 Negative effects of bad posture

In the study of Susilowati et al. (2022), they observed the prevalence of bad posture and musculoskeletal symptoms originating from using gadgets as an impact of the work-from-home program. The researchers created a cross-sectional survey using an online based questionnaire. In their results, they found out that 34.6% of the population that answer the survey agreed that the typical posture of an individual when using a mobile device was a reclining position on a sofa or mattress for as long as 1 to 3 hours. Moreover, the team also noticed that 70.5% of the respondents had experienced musculoskeletal discomfort, especially in the neck area with a percentage score of 86.4%, lower back with 75.9%, and right & left shoulders with an average of 76.2%. After analyzing the results obtained, the researchers concluded that it is essential to limit the usage time of mobile devices. They also suggested looking away every 20 min at an object that is about 20 feet away for a full 20 seconds when using a gadget and having a much-needed rest time to mitigate musculoskeletal problems.

In the works of Wang H. et al. (2019) entitled the sitting posture monitoring method based on notch sensor. They stated that the sitting posture is the longest-maintained posture for humans. This means that if a person has an improper sitting posture position, it can lead to serious harm to human health. Along with their study, they found out that 70% to 80% of Chinese people work and study while being seated with improper posture. Some of the effects of improper sitting posture included in their paper are uncoordinated spinal muscles and ligaments due to stress and lateral bending. In addition to this, it is also stated that the number of cervical spine bending due to poor sitting posture has over 50%. It also increases the chance of students getting myopia by 6%.

Similarly, Yoshikawa M. et al. (2020) created a study where it examines the correlation between improper sitting posture and tongue pressure. It is stated in their study that improper sitting significantly affects the patient’s posture resulting in sacral sitting. When your body is in a position of sacral sit, it increases systemic enhancement of muscle tension, coughing, and difficulty in expectoration. It also reduced the swallowing capabilities of the patient and increased the risk of aspiration. With this, they present a study that investigates the effects of good and poor posture while being in a bed or a reclining wheelchair in order to examine the swallowing function of the patient. In their results, they examine 4 positions, the good and bad postures while being in bed and in a wheelchair. Using statistical analysis, the researchers found that the median tongue pressure in posture 1 is significantly higher compared to all of the positions. It’s also important to note that posture 3 was significantly higher than all of the postures. With this, the researchers conclude that posture during eating can potentially affect tongue pressure.

Another study was conducted by Chin et al.(2019), entitled A posture recognition model dedicated to differentiating between proper and improper sitting posture with a Kinect sensor. Along with the solution, the team presents the bad effects of improper sitting posture. They stated that in the long run bad sitting posture will surely take a toll on the person. And it can bring numerous side effects. The commonly known side effects are back pain, hunched back, increase in fatigue, etc. It is also stated in their study that a slumped sitting posture is more prone to inducing negative emotions, anxiety, anger, and sadness compared to a person with a proper and upright sitting position. Statistics 3 in 2018 as cited in Chin et al. (2019) shows that more than half of Americans with lower back pain spend most of their workdays sitting in an improper sitting posture. In addition, it is reported that 31% of males and 20% of females who are experiencing back pain states that it affects their ability to work efficiently.

2.1.3 Current Solutions to Improve Posture

A study by Kashuba et al. (2019) assessed the effect of exercise on the prevention and management of postural disorders in young women. Sociological methods, pedagogical observation, pedagogical experiment, pedagogical testing, anthropometrics, measurement of muscular strength using the Back Check 607 system, video recording and biomechanical analysis of the biogeometrical profile of the individual's posture (using the Torso software), and mathematical statistics methods were all used in their study. The study included 94 women between the ages of 22 and 24. The results show that only 25% of the participants had normal postures, and the majority of the women displayed various postural problems. The development of a program for the repair of postural abnormalities included the use of health-improving physical exercise. The characteristics of women's physical growth and fitness were improved, and frontal plane postural anomalies were corrected, after a year of program participation.

In order to achieve the goals of the fitness classes, special static/dynamic exercises were combined with breathing exercises in a variety of starting positions, strength exercises that contributed to the muscular system's strengthening, corrective exercises that combined the generation of muscle contractions with further relaxation and stretching, and exercises that improved coordination of movements and developed the body's stability in the standing position. The exercises were performed three times a week for a total of 60 minutes. The exercises in the lessons comprised fundamentals of aerobic gymnastics, dancing combinations, fitball exercises, free weight exercises, yoga pose, breathing exercises, and stretching.

Simpson et al. (2019) looked at the capabilities of the most recent tools for measuring spinal posture. When appropriate, they remarked on the clinical viability of integrating such devices into routine care and cited research utilizing such devices in the clinical context. Following the Preferred Reporting Items for Systematic Reviews and Meta-Analyses Guidelines (PRISMA), a thorough systematic review was carried out using the databases PubMed, MEDLINE, EMBASE, Cochrane, and Scopus. Among all published studies dating from 1980 and on, articles relating to wearable systems that can measure spinal posture were chosen. A preset checklist that included device kinds, study objectives, findings, and constraints was used to capture the extracted data. The final assessment included a thorough review and analysis of 37 articles. The underlying technology for the proposed wearables was most frequently Inertial Measurement Units (IMUs). The following applications for wearables that measure spinal posture have been suggested: post-operative rehabilitation, treatment of musculoskeletal disorders, diagnosis of pathological spinal posture, tracking Parkinson's disease progression, fall detection, workplace occupational health and safety, and comparison of interventions. The results indicate that devices that are currently on the market can accurately determine the spinal position in a clinical setting. For commercialization, additional evidence regarding the long-term viability of these technologies and advancements in their usability is needed.

Gur et al. (2015) examined the effects of a spinal brace on Cobb angle and postural stability. To take part in the study, 13 pediatric patients with adolescent idiopathic scoliosis (AIS) between the ages of 12 and 17 were included (10 girls and 3 boys). X-ray analyses were used to determine the Cobb angle, and computerized dynamic posturography was used to examine postural stability in both braced and unbraced states. For the subjects, a polyethylene underarm corrective spinal brace was made. The result reveals that following bracing, the thoracic and lumbar curvatures were reduced to 18.88° and 17.70°, respectively. Higher composite balance scores for the sensory organization test were also seen in the braced condition, although lower equilibrium scores were seen in the "eyes closed" condition and higher scores in the "eyes closed with a swaying support" condition. For the "toes-up adaptation test," lower results were seen in the braced condition. On the boundaries of the stability test, in the braced condition, the reaction time was slower in the right-backward direction and the movement velocity was higher in the right-front direction. Additionally, the braced condition showed a lower on-axis velocity during forward/backward dynamic balance control. They came to the conclusion that individuals with AIS who wore a spinal brace had improved postural stability in terms of improved proprioception, equilibrium performance, and rhythmic movement capability.

In a novel method, published by Ribeiro et al. (2020), permanent magnets are combined with accelerometer, gyroscope, and magnetometer sensor data to create a wearable device that can monitor spine position in real-time. Each user must have the gadget independently calibrated. A probabilistic classification algorithm analyzes the sensor data by comparing the real-time data with the calibration result and determining if the data point falls within the computed threshold-defined regions of confidence. If the posture is classified as improper by both the accelerometer and the magnetometer, it is determined to be incorrect. One adult test subject underwent a pilot experiment. The accuracy of posture classification was significantly higher when the magnetometer and accelerometer were combined (89%) than when the accelerometer data alone (47%). Additionally, an accuracy of 89% was attained in a test where the user alternated between a straight-back position and a crooked one. Image analysis was used as the foundation for this method's validation.

2.2 Technical Aspect of the Study

2.2.1 Introduction to IoT and its Applications in the Medical Field

In today's society, progress is evident in terms of infrastructure, industrial aspects, and technological aspects. This advancement, especially in technology, boosts production in different fields within the community. One of the innovations produced by years of research and exploration in technology is the Internet of Things. It refers to a global collection of network-enabled devices that do not include traditional computers such as laptops and servers (Kenton, 2021). The Internet of Things is making the fabric of the world around us smarter and more responsive, merging the digital and physical universes. According to the ZDNET website (2020), IoT technology integrates the interconnectedness of human culture, which is referred to as "our things," with the interconnectedness of our digital information system, which is the internet. The IoT is an important part of the future Internet. Many new prospects await not just businesses and marketers, but also society as a whole.

Kevin Ashton coined the term "Internet of Things" in 1999, and since then, this ubiquitous connectivity network has paved its way into our everyday living and has been vividly used for real-world applications such as defense, healthcare, business, agricultural production, power generation, and the creation of smart cities, homes, and devices. The usage of IoT in healthcare is rapidly expanding across several applications. IoT applications have been widely used by patients, physicians, hospitals, and health insurance companies in recent years. It replaces physical labor, allowing clinicians to focus their efforts where they are most needed. The Internet of Things presents a world of creative prospects for the healthcare business (Pelaez, 2021). Various study and project concepts had been offered to aid individuals with their medical needs. There have been microcontroller-based, IoT-based, and RFID-based projects completed that will notify patients when it is time to take their medication. According to the project titled "Internet of Things (IoT)-Based Smart HealthCare Medical Box for Elderly

People" by Al-Mahmud et al. (2020), Internet of Things technology can contribute to building a monitoring system within the medical box of a patient where the daily data gathered by the system is being accessed by both patient and doctor to continuously monitor the daily medicine intake of the patient as well as its health condition. It also has various functions, such as an automatic lock system when the patient misses the time of intake and a notification function when the patient is away and it is time to take the medicine. This notification will be received by the patient via email messages. They maximize the usage of microcontrollers such as Arduino Uno and a Node MCU wifi module, where the Arduino Uno is responsible for the overall control of the medical box and the Node MCU is responsible for controlling the sensors as well as the connection of the overall system to the server.

Another research study conducted by Nayak et al. (2017) showcases the use of the Internet of Things in the medical field by integrating the technology into a wheelchair for the controlling purpose of the system. Their project uses an Android phone and a manual joystick attached to the wheelchair to provide a two-way control system for the wheelchair. The IoT technology was maximized during the monitoring process of the system and during the data transfer from the sensors attached to the wheelchair for the obstacle detection feature of the system. The researchers' system structure includes a microcontroller, a wifi module, and sensors, all of which are common components in the design of the Internet of Things.

Furthermore, IoT technology can assist and broaden its scope to include a more specific and critical component of medical diseases, such as cardiovascular diseases. Palma et al. (2018) demonstrate the wide range of Internet of Things applications in the healthcare field by integrating this technology into the E-Medicine precision medicine platform in a research study. The "Medical Assistance in Contextual Awareness" (AMICO) initiative seeks to build an infrastructure that allows patients to fully integrate the hospital rehabilitation paradigm at home. This infrastructure is an "instrumented environment," consisting of the home environment and the person, both of which are outfitted with sensors, a telemedicine service platform (on the Internet of Things, or IoT), and a robot acting as an intermediary between the person, the surrounding environment, and the outside environment. The Internet of Things implementation takes place between the controlling and monitoring of the robot as well as the patient within the suggested home environment using various connected sensors within the home and the robot. The project is unique in the national and worldwide sectors since it will enable significant contact between expert structures and doctors of general medicine from the patient's home, even in emergency and/or urgent situations. The efficacy of this approach may result in a reduction in the occurrence of cardiac problems and, as a result, a reduction in hospital access, resulting in savings for the National Health Service.

The quality of the Internet of Things as an immersive technology was demonstrated during the COVID-19 pandemic. Various technologies and innovations were developed to battle and confront the virus, which substantially aided the community's medical field in continually monitoring and detecting an individual with symptoms and providing immediate medical support. Choyon et al. (2020) conducted a research study that focuses on a systematic approach to combat the COVID-19 virus during the pandemic. It encompasses the monitoring and detection of the severity of coronavirus in the human body. The researched health monitoring system was created using a mix of Internet of Things characteristics and ML algorithms, and it is accessible via a cloud-based network. Several embedded sensors are used in the system to remotely monitor the patient's health. It is also capable of predicting the severity of COVID-19 based on symptoms and real-time biological data. Based on their system architecture, the Raspberry Pi was their central processing unit for maintaining the connectivity between the patient, the cloud network, and the healthcare professionals. At the end of the paper, they conclude that the suggested IoT-based solution has the potential to save lives and be of enormous help in the health sector. It could be a useful tool for healthcare providers and authorities in fighting the infection because it is capable of providing necessary healthcare to infected and suspected individuals while also monitoring them. This is possible because of the excellent accuracy results of the sensors used in the system, as well as the efficient processing of the microcontrollers and embedded systems used. Additionally, due to the wireless monitoring provided by the system using the IoT, the researchers infer that the chance of healthcare service providers becoming infected while treating any patient is lowered since the physical distance may be maintained with the aid of the system while delivering treatment.

2.2.2 Studies on Posture Corrector Systems

In a study by Lim et al. (2017), a wearable monitoring for sitting posture system was developed using an interfaced Arduino UNO microcontroller and two accelerometers–one placed on the cervical spine and the other on the lumbar spine as this is where back pain from strain and higher motion happens. To generate an angle from the accelerometers, the researchers computed for both the inverses of x-axis sine and y-axis cosine then added 180 degrees to make the resulting angle positive. This angle was tested for accuracy by comparing it initially to a static device called a goniometer, and then to an electrogoniometer when the accelerators were placed on the backs of three subjects. Both testing procedures resulted in an error of less than 3% enabling the researchers to proceed with the actual analysis test using various movement conditions. Their device was able to perform its purpose by ringing the buzzer every time the user's y-axis angle deviates from the set 100-135 degrees range for best sitting posture.

Another study conducted by Pratheep et al. (2021) also made use of a sensor, called a gyroscope 6050, to create an automatic body posture corrector designed for spinal cord patients. The gyroscope can give values for changes in a multidimensional x, y, and z axis. A vibrating motor that indicates deviations in the posture is connected to an Arduino microcontroller. Whenever the patient needs to adjust his/her posture, the device can direct the right posture to the user through a voice command that can play on a connected headset or a vibration mode. These settings are interfaced using Arduino Nano and are connected with a mobile phone via Bluetooth module (HC-05). This study, however, did not indicate any user feedback from the device as it mainly focused on prototype creation alone. Testing was done by having the device used by three users.

A device called Posturector was created by Lakshmi et al. (2017) to address the same problem of correcting posture. Components such as a PIC microcontroller that determines if the user's posture is correct, a flex sensor to gather information on user movements, a buzzer to alert the user for posture angle deviations, an LCD for displaying posture information, a flexible belt to make the device wearable, and a DC gear motor to correct the user's posture were all integrated together to form the device. To test the device, a simulation of the prototype was done through Proteus software where ranges of values for the flex sensor, represented as 20%, 40%, 60%, and 80%, were manipulated to see variations in its response. During actual testing, one flex sensor was placed at the lower back of the user. The threshold values for the flex sensor were recorded as these were used as a basis to determine if the posture is still correct. Furthermore, the response time of the DC motor was documented and was deemed quick and accurate.

In the works of Ozgul et. al (2022) entitled Wearable sensor device for posture monitoring and analysis during daily activities: A preliminary study. The researchers designed a vest that is able to detect and control posture disorders. The first thing they did was locate what part of the spine dramatically affects the person's posture. The researchers created 5 pockets naming from A to E respectively. With these pockets, optional sensors such as pulse, temperature, etc. can be placed and data measurements can be collected, accordingly. The team used an Arduino UNO R3 processor as their microcontroller. In addition, they've also used an HC05 Bluetooth module. This module will be used in order to connect to a mobile application. For the input data, the researchers used the MPU6050 module. The module comprises a 3-axis accelerometer and also a 3-axis gyroscope in a single chip. The said chip will be used in order to monitor and analyze the posture of the person using the system. The said module uses an I2C communication protocol that enables efficient retrieval of data from both sensors. The sensors are used to send feedback through a gateway when unequal pressure is sensed. At the end of the study, the proposed system is successful in monitoring and also analyzing a person's posture. The researchers pointed out the efficiency of the cost of the project compared to any existing methods or devices in the hospitals, especially at the time of the pandemic. For future recommendations, the team recommended focusing on the ergonomic side of the system to make it comfortable for daily use.

Finally, a posture detector that features the internet of things (IoT) was designed by Karanth et al. (2020) using almost similar components as the other above-mentioned studies. An Arduino UNO was used to interface the Inertial Measurement Unit (IMU) sensor, Bluetooth module HC-05, mini piezo buzzer, and three LEDs. The posture detector's main circuit, unlike the others, was only connected and tested on a single breadboard that is placed at the back of the user where the spine curves. A wristband containing the mini piezo buzzer was provided to alert the user whenever a bad posture is detected for a prolonged period of time. Additionally, an android application connected via Bluetooth where the smart posture detector can be switched on and off and the posture feedback is displayed using a pie chart of the recorded posture category was programmed for monitoring purposes.

Summary of the RRL

Year	**Authors**	**Title**	**Methodology**	**Findings**	**Conclusion**	**Future Work / Recommen dation**
2021	V. G.	Autom	Gyroscope,	The	The spinal	Lower leg

	Pratheep E. B. Priyanka S. Thangavel K. Heenalisha M. Ariya Manickam A. P. Logaram	atic Body Posture Corrector for Spinal Cord Patients	SD card module, and Arduino Uno controller circuit can all be used to operate the entire model. The patient's posture is measured by the gyroscope and the x, y, and z axis changes are communicated via the Arduino Uno. The SD card module also triggers another action that instructs the patient to speak through a headset using instructions from the controller program. To control the voice command through a mobile phone, a Bluetooth module is used to interface with an Arduino Uno.	gyroscope has a power source that is activated when the patient turns on the belt. It is completed once the power supply is installed. The gyroscope measures changes in the x, y, and z axes' values. The belt must have an indicator to alert the patient to changes in posture. The first actuating mechanism for indicating the patient is to produce a vibrating mechanism. The system vibrates to	posture habit can also distinguish between low (likely speaking to detached firmness) and high (apparently reflecting dynamic solidity) movement speed. High-speed solidity estimations generally related to identical firmness estimations obtained by a torque engine. When used with the foot, the practical device has high intra-regulators, better adaptive control quality, and is adaptable enough to distinguish controls from neurological members.	solidity can be measured using a small device that was originally designed to measure elbow firmness. Using printed circuit board (PCB) on circuit connection, a single Arduino mega is a good replacement for both the Arduino Uno and Arduino nano.

				signal the spinal cord patient using a vibrating motor. The program for the vibrator is already loaded into the Arduino controller. In the suggested model, the vibrator is activated to indicate spinal cord patients when the Arduino controller receives the signal from the gyroscope 6050.	Despite this, the device's current design does not take the inertial component of impedance into account. This belt is not just for people with spinal cord injuries; if the voice command is turned off, it transforms into a regular belt with a vibrator. Hence, normal people who need to change their posture also can be useful with this belt.	
2017	Santhana Lakshmi.P, Anupam Kumarr, Aravindan C.	Posture ctor - The Posture Correct or	The entire arrangement must be worn by the user. The user starts out in his or her typical position. The	They tested this precision by displaying the outputted numbers from the	Their design, including how the sensor was positioned on the shirt and the software	It is possible to use wireless or Bluetooth technologies so that fewer wires are needed for the flex

			value of the flex sensor changes as the user departs from the default posture. The buzzer is programmed to trigger when the value of the flex sensor changes, acting as feedback and alerting the user to return to the default position. If the user doesn't return to his or her normal position after a wait, the DC gear motors attached to the elastic belt are turned on. They have been programmed to draw the user back to their natural position.	flex sensor and making sure that the motor went on or off accurately. The flex sensor thresholds are established depending on a particular percentage that the user deviates from his or her good posture. The user's posture is accurately measured by the PIC, which is continuously reading values from the flex sensor, and the buzzer responds practically instantly.	used on the TFT, performed as intended in terms of functionality. This means that when a visibly terrible posture was attained, their hardware (a vibration motor) and software (a body image screen + "back breaker" counter) would appropriately identify the shift. This held true for changing from good to poor posture as well as the opposite.	sensors to interact with the PIC and, in turn, the TFT. The TFT can be used to build a wearable device, such as a user watch setup (similar to a Fitbit or Apple Watch configuration), or they can utilize a mobile app to help control the device and collect user data. Feather light circuits can elevate the entire set-up to a higher level of sophistication. A "feather light circuit board," which is extremely thin and weighs as little as a feather, can be used to create the circuit.

2020	Greeshma Karanth, Niharika Pentapati, Shivangi Gupta, and Roopa Ravish	IoT based Smart Posture Detector	To build the device, the researchers utilized an Arduino UNO to interface the Inertial Measurement Unit (IMU) sensor, Bluetooth module HC-05, mini piezo buzzer, and three LEDs. A wristband containing the mini piezo buzzer was also provided to alert the user whenever a bad posture is detected for a prolonged period of time, while an android application was created to identify the overall state of the user's posture while using the SPD. To test its outcomes and feedbacks, the posture of three different	The Smart Posture Detector was tested and has proved to provide successful results. During testing, the mobile application displayed a pie chart with a dominating green signifying that the user has a good posture. The second and the final user's results displayed mostly blue and red, respectively, meaning an acceptable and a bad posture.	The researchers were able to create a wearable device using Arduino microcontroller, sensors, and an Android phone which is a robust and feasible solution for the detection and correction of unhealthy back posture. The device can also identify if a sitting, standing, or walking person's posture is good, okay, or bad via the mobile application.	Future researchers may focus on the device's compactness and its ability to be sold in the public market.

			users were assessed using the device.			
2022	ÖZGÜL, Gizem & Patlar Akbulut, Fatma	Wearable sensor device for posture monitoring and analysis during daily activities: A preliminary study.	The researchers wanted to create a device that will monitor and analyze a person's posture. To monitor the posture of the user, the researchers created a mobile application. For the hardware of the system, the team utilized Arduino UNO R3 as their microcontroller, an HC05 Bluetooth module to connect the system to a smartphone, and lastly an MPU6050 module which will	For the results of the study, the researchers analyzed 3 positions. These are sitting, walking, and running. The experiments were performed by 8 subjects. For the sitting position, the researchers observed that 70% of the participants take the waning system as a basis and change their	At the end of the study, the proposed system is successful in monitoring and also analyzing a person's posture. The researchers pointed out the efficiency of the cost of the project compared to any existing methods or devices in the hospitals, especially at the time of the pandemic.	For future recommendations, the team recommended focusing on the ergonomic side of the system to make it comfortable for daily use.

			measure the user's posture.	posture within 5 seconds. For the 2 positions, data received from the users have a significant amount of noisy data that may interfere with the true data.		
2017	C. C. Lim, S. N. Basah, M. A. Ali and C. Y. Fook	Wearable Posture Identification System for Good Sitting Position	The wearable sitting posture monitoring system was built using two ADXL 335 accelerometers together with an Arduino Uno microcontroller board. The two accelerometers were attached specifically to the neck and the lower	The development of the monitoring posture system is being divided into three experiments: the calibration test, the measurement of performance test, and the real-time analysis test. For	When compared to a static angle of a goniometer, the system is successfully created with an accelerometer percentage error of less than 3%. The accelerometers 1 (lumbar portion) and 2 (cervical	The system only focused on the y axis. As a result, the system's performance can be improved in the future by including the x, y, and z axes in determining bad seat posture. In addition, other technologies will be implemented

			back of the user. The overall monitoring posture system was developed by interfacing the accelerometers with the Arduino Integrated Development Environment (IDE) and transmitting it wirelessly to a portable computer. Based on their flowchart, the process and development of the system were divided into three experimental processes: Experiment I: Calibration Test: Comparing Accelerometer with Goniometer; Experiment II:	the calibration test, the researchers attached two accelerometers to both arms of the goniometer, and the accelerometer reading was recorded. Five times for each degree of a goniometer, with a two-second interval in each data recording. The experiment aims to identify the percentage error by comparing the data from the goniomete	section) provide a modest inaccuracy of 0.48% and 0.35%, respectively, for the performance measurement test. Furthermore, our system can do real-time analysis while monitoring the individuals' sitting posture.	with the system, such as an inclinometer and gyroscope. The enhancement of the system can provide new methods for detecting seating posture. It can also be made to work as a wireless communication system with the mobile system, which gives more flexibility to the users.

			Measurement Test by Comparing Accelerometer Angle with Electrogoniometer; and Experiment III: Real-Time System Analysis The researchers also used various equations to determine the angle between the neck and the trunk of the user's body.	r and the attached accelerometer. The results for both accelerometers are almost identical to the theoretical value of the goniometer. The smallest error of accelerometers is 0.04%, while the highest error is only 2.72%. The second experiment is the measurement performance test, where the comparison of accelerometer data		

				with an electrogon iometer is conducted .		

Synthesis

Posture is the relative disposition of a person's body during a certain time which is directly affected by the alignment of the spine. Maintaining a correct posture leads to several benefits the reduction of abnormal wear and tear on joint surfaces, stress on the spine's ligaments, abnormal spine positioning, muscle fatigue, back pain, strain, and sprain injuries. Due to this, practicing measures that prevent bad posture is highly encouraged by professionals in the field. Studies suggest that neglecting these may cause cases of musculoskeletal discomfort, uncoordinated spinal muscles, and ligaments, cervical spine bending, sacral sitting, hunched back, an increase in fatigue, etc. Moreover, a slumped sitting posture was even found to be directly related to inducing negative emotions, anxiety, anger, and sadness.

Traditionally, posture correction is done through the development of programs involving physical activities such as aerobic gymnastics, dancing combinations, fitball exercises, free weight exercises, yoga poses, breathing exercises, and stretching. There are also commercially available wearable devices that determine the spinal position and spinal braces that reduce thoracic and lumbar curvatures which are being used in a clinical setting for the improvement of the spine. Furthermore, individually calibrated accelerometer, gyroscope, and magnetometer sensors were also implemented to monitor spine position. In this method, image analysis was primarily utilized to validate the results obtained from the sensors. However, because of the presence of the internet and IoT technology, numerous medical interventions, and healthcare procedures were converted into microcontroller-based, IoT-based, and RFID-based IoT projects that significantly lessen the physical labor of healthcare workers while maximizing a system's ability to indicate more accurate detections and findings. Applications like the IoT-Based Smart HealthCare Medical Box for Elderly People (Al-Mahmud et al., 2020) and Medical Assistance in Contextual Awareness (Palma et al., 2018) seek to independently assist patients and provide a hospital rehabilitation paradigm at home, respectively.

As for patients that suffer from bad posture, systems that automate the monitoring and enhancement of their posture are still being investigated and built. These devices often make use of accelerators and goniometers to detect angle deviations from the user in one or more axes. These are also interfaced via microcontrollers like Raspberry Pi and Arduino models. However, there are still insufficient studies that integrate both automation, for correcting bad posture, and IoT technology, for monitoring improvements, in a single device without compensating for the accuracy of the results. Additionally, the potential of using mobile phone applications that yield ease of access to the user is still at its minimum.

Conceptual Framework

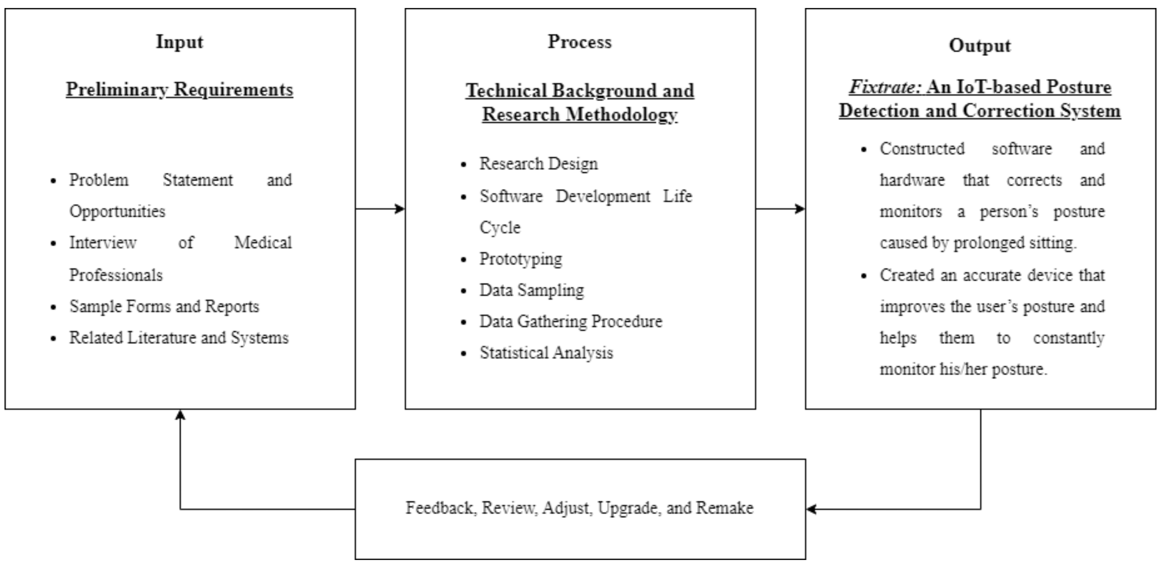

Figure 2.1. Conceptual Framework of the System.

For the conceptual framework, the team followed an IPO model in order to visualize the whole process of the research project. For input, the team must establish the problem they want to address. Conduct a literature review and interviews in order to have in-depth knowledge about the specific problem. For the process, the researchers must conduct multiple processes such as research design, SDLC, or Software Development Life Cycle. In addition, the team also needs to create a prototype of the project in order to gather the data needed for the analysis. For the output, the researchers are expected to construct software and hardware that corrects and monitors a person's postures caused by prolonged sitting.

Definition of Terms

- Accelerometer - an integrated circuit that measures the acceleration or the change in speed of an object per unit of time.
- Adolescent Idiopathic Scoliosis (AIS) - is an abnormal curvature of the spine that appears in late childhood or adolescence.
- Anthropometrics - refers to the measurement of the human individual.
- Arduino - an open-source platform used for building electronics projects composed of a programmable circuit board and a piece of software.
- Bluetooth Module - a basic circuit set of chips that integrated Bluetooth functions and which can be used in wireless network transmission.
- BMI - Body Mass Index (BMI) is calculated by dividing a person's weight in kilograms (or pounds) by their height in meters squared (or feet). Although BMI does not assess an individual's health or body fatness, it does screen for weight categories that may cause health issues.
- Cardiovascular diseases - a group of disorders of the heart and blood vessels.
- Crooked - at irregular or improper angle; askew.
- DC Gear Motor - a device that combines a DC motor and a gearbox.
- Electrogoniometer - an electrical device used to assess the flexibility and mobility of a joint.
- Embedded systems - a microprocessor-based computer hardware system with software.
- EUROFIT - It is a set of tests used to evaluate physical fitness. This battery of tests assesses various aspects of fitness, including balance, speed, flexibility, power, muscle strength, muscle endurance, agility, and aerobic endurance.
- Fitball - dense and large balls used to perform various gymnastic exercises.
- Flex Sensor - a sensor that measures the amount of deflection or bending.
- Goniometer - an instrument that measures an angle or permits the rotation of an object to a definite position.
- Gyroscope - a device that can measure and maintain the orientation and angular velocity of an object.

- Hoeger Visual Posture Assessment Method - it is used to evaluate spinal posture.
- Inertial Measurement Unit (IMU) sensor - a sensor that tracks the acceleration and angular velocity of an object over a period of time.
- IoT - an acronym for Internet of Things.
- Magnetometer - a compass or a navigation device that measures the strength of the magnetic field or magnetic dipole moment.
- Microcontroller - embedded inside a system to control a singular function in a device.
- Musculoskeletal - the human body system that provides our body with movement, stability, shape, and support.
- Network-enabled devices - refer to equipment that connects to a network.
- Piezo Buzzer - a device used for making beeps, tones, and alerts.
- Posture - It is the position or bearing of the body whether characteristic or assumed for a special purpose.
- Posturography - a technique used to quantify postural control in an upright stance in either static or dynamic conditions.
- Preferred Reporting Items for Systematic Reviews and Meta-Analyses Guidelines (PRISMA) - an evidence-based minimum set of items for reporting in systematic reviews and meta-analyses.
- Proteus - a software toolset, mainly used for creating schematics, simulating embedded circuits, and designing PCB layouts.
- RFID - Radio Frequency Identification.

CHAPTER THREE

METHODOLOGY

3.1 Research Design

The output provided by the population chosen to use the device will be the only factor considered in this quantitative study's findings. Numerous quantitative studies are swift, limited in scope, accurate, and understandable. The research serves to test the initial theory and ascertain whether it is true or false, and the goals and design of the study are predetermined from the beginning. As a result, when the proposed device is tested, its proponents will gather user feedback using a data collection technique, analyze the resulting information, and determine whether the study's goal was met. The proponents will proceed with the experimental research design for this quantitative study. Before conducting the study at larger scales, experimental research enables the researchers to test the objective in a controlled setting. This study will evaluate the usefulness of the extra features for the posture detection and correction system because it is based on guidance from another study.

3.2 Research Locale

The research prototype will be constructed at Pamantasan ng Lungsod ng Maynila located in Intramuros. Manila. The testing will be implemented on the sample participants aged from 20 to 39 years old who often experience prolonged sitting. Data will be recorded using the mobile application to monitor and correct deviations from their correct sitting posture. Each participant will bring and use the *Fixtrate* prototype at their homes with the supervision of the researchers. Data collection will take place for two weeks per participant to collect adequate information from the user.

Population

A research population is defined as a large group of people or things that are the focus of a scientific inquiry. Research is carried out for the benefit of the general public.(*Research population* 2018) In the case of this study, the researchers wanted to know what will be the population of Fixtrate, the researchers conducted an online interview with three physical therapists to know which age group is the best fit for the proposed project. According to the data collected from the interview, the researchers decided to focus the population of the study on adults who has an age ranging from 20 to 39 years old since all three professionals stated that the majority age group who suffers from posture problems are adults.

Sampling Technique

The researchers decided to use convenience sampling as the sampling technique of the study due to time constraints. By definition, convenience sampling is a method where researchers gather data from a conveniently available pool of respondents (*Convenience sampling: Definition, advantages and examples*, 2021). It includes individuals who happen to be the most accessible to the researcher. There are no criteria required to be part of the sample meaning that all components of the population are eligible or can be a candidate for being a sample in the study.

Research Instruments

The researchers will utilize the quantitative data obtained from the sampled users before and after they used the final *Fixtrate* prototype. Research participants will be provided adequate informed consent wherein the researchers will provide the research description, benefits, and risks to each potential user (National Human Genome Research Institute, 2022), before proceeding with the data collection. All significant data displayed on the mobile application used for monitoring will be collected within two weeks set for device testing. This includes the initial standard angle set by a professional, the exact posture angles of the participant recorded on the mobile application, and the frequency of the user's posture deviations from good to bad posture.

An online survey questionnaire will also be disseminated to the following participants after using the device. The researchers will be utilizing Google Forms as the platform for the questionnaires which the respondent can answer at their most convenient time. This will be divided into three sections containing the respondent's consent, the user information, and the questions regarding their experience with the device in terms of comfortability, user-friendliness, and overall user experience. The questionnaire will have ten statements for each category which can be answered using the provided 5-point Likert scale. The choices reflect the individual satisfaction rating of each respondent based on the given statement. Furthermore, the respondents will also be given a space where they can provide their detailed personal experiences while using the device. The researchers will conduct face-to-face consultations with the research adviser for further improvements and approval before distributing the questionnaires and collecting responses.

3.3 Procedures

3.3.1 Software and Hardware Integration

The Fixtrate System is composed of hardware and software parts that are used to properly gather and process the data from the user. The hardware part is responsible for the data collection from the user by integrating various types of hardware components, such as sensors, microcontrollers, and many more. On the other hand, the software part of the Fixtrate system is responsible for processing the data gathered by the hardware section of the system. It maximizes its function through code implementation as well as data analysis from the sensor within the hardware section of the system.

3.3.1.2 Hardware Components

For the hardware part of the Fixtrate system, the researchers differentiate the components based on their functionality, which is being centralized using a microcontroller. The hardware components are classified into three groups representing their individual functionality: the Sensor and Adjustment Module, the Internet of Things Module, and the Vibrating Indication Module.

A. Sensor and Adjustment

The sensor and adjustment module of the fixtrate system is composed of an **Arduino Uno microcontroller**, an **MPU6050 sensor**, and **DC motors**. According to Badamasi (2014), Arduino is an open-source platform used for the construction and programming of electronics. It contains 14 digital I/O pins, six of which are PWM outputs; six analog inputs; a 16 MHz ceramic resonator; a USB connection; a power connector; an ICSP header; and a reset button. The Arduino Uno board was used as the system's main component, taking in and processing every function of the connected components. On the other hand, to properly distinguish the accurate body posture of the user, the researcher uses an MPU 6050, which is an electromechanical system consisting of a three-axis accelerometer and three-axis gyroscope that helps to measure velocity, orientation, acceleration, displacement, and other motion-related features (*What is MPU 6050?*, 2019). This integrated circuit is attached to the center of the back of the user and gives six data quantities corresponding to each axis of the accelerometer and gyroscope. Together with the MPU6050, two DC motors were connected to the Arduino Uno board that will automatically adjust the step of the prototype system when the data readings are below the threshold reading.

B. Internet of things

The Fixtrate posture detection and correction system is an IoT-based system where the user has control over the necessary adjustments needed for correcting posture using a mobile application. And for the data to be processed and transferred to the internet of things, the system used an **ESP8266 Wifi Module**. This WiFi module is a self-contained SOC with an integrated TCP/IP protocol stack that can provide access to your WiFi network to any microcontroller. To be specific, this module is supported by WPA and WPA2 security protocols as well as standard IEEE 802.11 b/g/n (WiFi) compliance with an on-board antenna, which is used for data encryption to prevent unauthorized access (Mesquita, 2018). It also has powerful on-board processing and storage capability, which allows the integration of various sensors and other devices using its GPIOs with minimal loading during the implementation. The ESP8266 WiFi module is connected directly to the Arduino Uno microcontroller for the data transfer from the sensor used within the Fixtrate system.

C. Vibrating Mechanism

Aside from the notification within the system's mobile application, the Fixtrate user must have a mechanism that alerts them when they are not in the proper posture. The researchers used a vibrating mechanism to manually alert the user about their posture when it passed the set threshold. This **vibrating motor** is a type of DC motor with an eccentric weight on its shaft. The DC control signals are the cause of its rotation within the vibrating motor, which converts to vibrating pulses (Kaaresoja, 2020). This device is dependent on the data gathered from the sensor connected to the main component of the system, which is the Arduino Uno.

3.3.1.3 Software Components

The Fixtrate system's software focuses on the coding and implementation of various system functionality as well as data interpretation and analysis from the sensors and devices connected within the system. It also covers the building of the mobile application for the system, which gives control to the user for adjustments and monitoring of their own posture. The researchers maximize the potential of the Arduino IDE as well as the Blynk IoT application to support the software part of the Fixtrate system.

A. Arduino

To fully implement the supposed functionality needed within the system, such as the processing of data from the sensors and its calibration, and other functionalities needed by the devices attached within the system, the researchers used the **Arduino IDE** for the coding implementation of the Fixtrate system. According to the Arduino Docs website (2022), the Arduino IDE, or Arduino Integrated Development Environment, is software within the Arduino board that serves as a text editor for the code with a message area, a text console, and a toolbar for common functions of the Arduino IDE. This IDE also connects to the board for program uploads and to communicate between the devices connected to the Arduino board. The program needed for the ESP8266 WiFi module is also coded within the Arduino IDE, where the IoT connection functionality takes place. This wifi module is very compatible with Arduino boards and can be connected using serial communication since it contains a serial wifi module.

B. Blynk IoT Application

The Fixtrate system includes a feature that allows the user to control and monitor his or her own posture via a mobile application.

Within the application, the user can monitor their real-time posture data readings as well as adjust the threshold for proper posture of the user. To implement this feature, the researchers use a **Blynk IoT application**, which, according to the Blynk documentation, is responsible for displaying sensor data, storing data, and data visualization. The Blynk application is also designed to implement IoT technology, which requires hardware that can connect to the internet, such as an ESP8266 wifi module. The Blynk application has three major components: the Blynk App, the Blynk Server, and the Blynk Libraries. The application is responsible for the creation of the interface, and the server is responsible for the connection between the application and the hardware components. The libraries, on the other hand, enable the connection between the components by providing a bunch of commands that can be used by the developer (Durani et al., 2018).

3.3.2 Flowchart

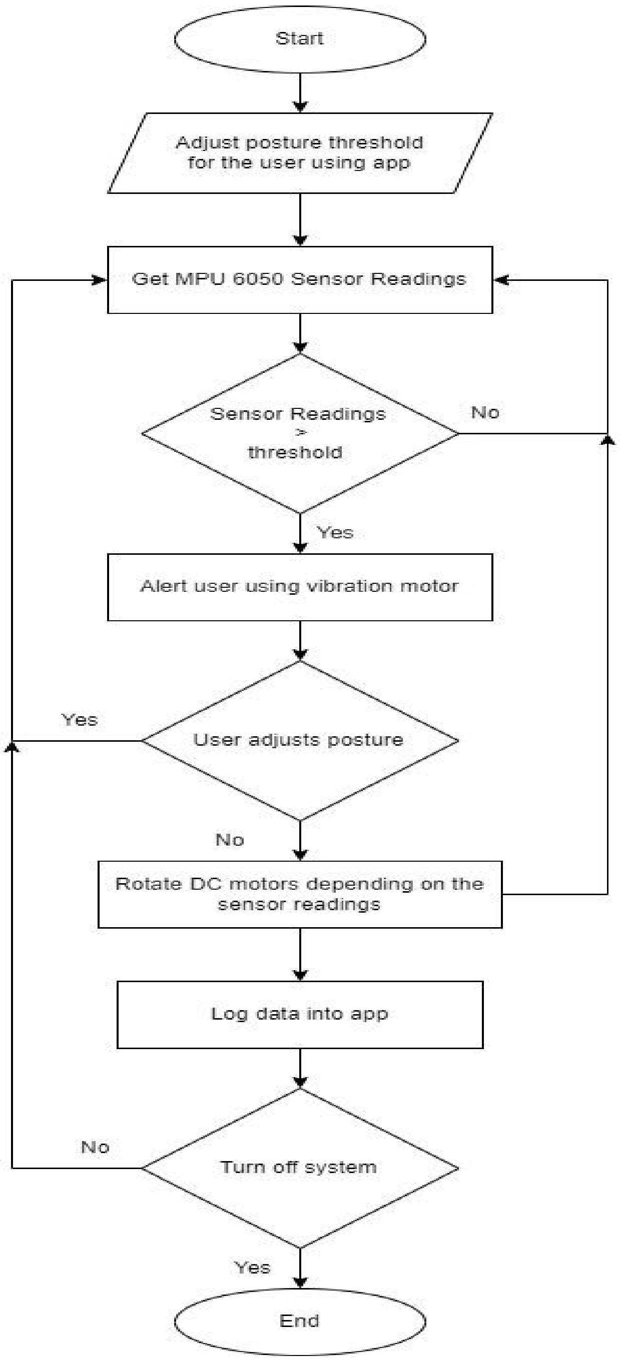

Figure 3.2.2 General flowchart of the system

Figure 3.2.2 presents the general flowchart or the entire process on what is going to happen on the implementation of the system. Firstly, we have to initialize the posture threshold depending on the user's normal posture level. This will be done on our mobile application which is a part of the system's design. Next, we have to take inputs from the MPU-6050 sensor readings. The readings will include the orientation of the user's back posture in respect to the X, Y, and Z axis. After the collection of data from the sensor, we will then compare its value from the threshold level initialized at the beginning. If the sensor reading is greater than from the threshold value, then it would send a signal to the vibration motor to vibrate, alerting the user to fix their posture. Otherwise, it would continue to collect sensor readings until improper value is detected. If the user still did not adjust and correct their posture even after notification, it would initiate the DC motors to rotate accordingly to fix it back to the acceptable threshold . Next, it would log the data readings in our mobile application for monitoring purposes. Lastly, the user can decide whether to terminate the entire process.

3.3.3. Schematic Diagram

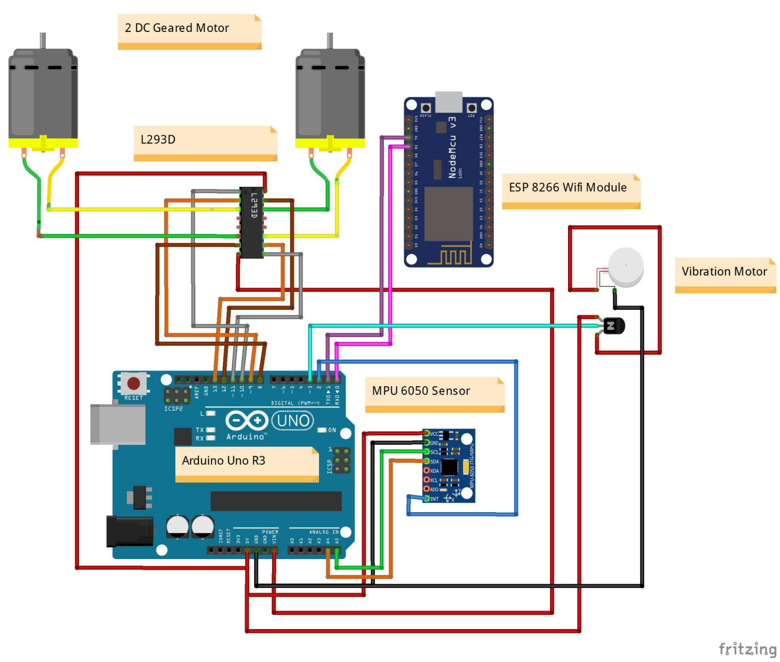

Figure 3.3.3 Schematic Diagram

Figure 3.3.3 shows the schematic diagram that our system is going to utilize. Here, several components are incorporated to make our posture detection and correction system possible. For our microcontroller, we are going to use Arduino Uno R3 because of its availability and the researcher's familiarization of this component. The Arduino Uno is also easy to use as multiple processes just like our system can be achieved. On the other hand, NodeMCU ESP8266 Wifi Module is also present on our system. It is mainly used for the development of end-point IoT (Internet of things) application since the approved proposal included the use of a mobile application to monitor and adjust the posture of the user. The wifi module is connected onto the Arduino's communication pins that will receive and transmit data from the sensor and the controls. Another important component on our system is the MPU-6050 or three-axis accelerometer and three-axis gyroscope sensor. This sensor is used in our system since this outputs the X, Y, and Z axis values which are very crucial in determining the user's posture. This module is a compact and affordable option than using separate accelerometer and gyroscope sensors. For the correction mechanism of the system, we are going to implement the use of two DC geared motors and make a DIY (do-it-yourself) brace that automatically corrects the upper body posture of the user.

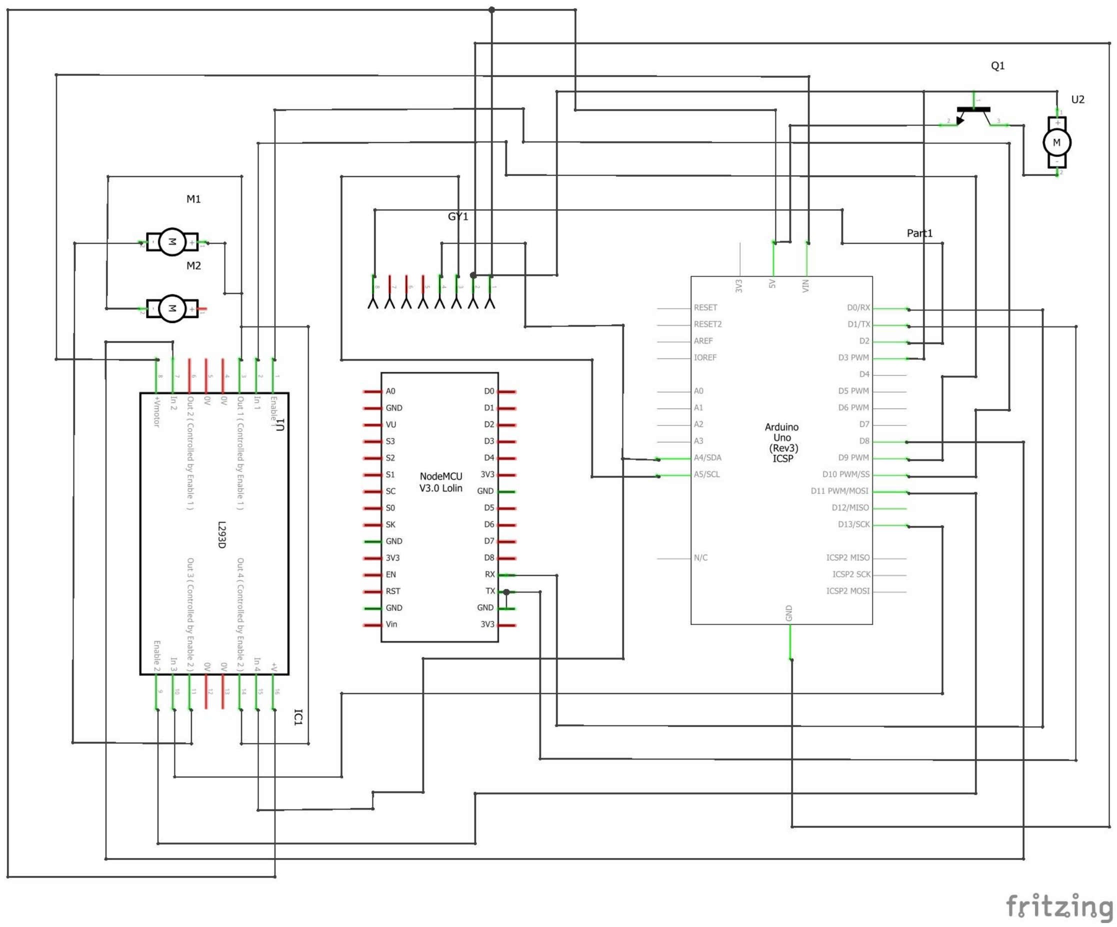

Figure 3.3.3.2 Wiring diagram

Figure 3.3.3.2 exhibits the wiring diagram well as the pin configurations of the modules, microcontroller, and IC components of the system. Major connections of the prototype include the use of digital pins of the Arduino microcontroller onto the L293D or 16-pin Motor Driver IC. Since the system will be utilizing two DC motors, the use of this integrated chip is important as it is designed to control two motors simultaneously. As for the connections of the MPU-6050 sensor, we are going to use the analog inputs of the Arduino and the SCL and SDA pins of the sensor. The SCL pin is for the clock pulse used in I2C communication while the SDA pin is for the data transfer. Other connections include the integration of the vibration motor which was also connected using the Arduino's digital pin.

Statistical Analysis

The researchers will utilize one-tailed t-test as the statistical method to determine significant changes in the normal body posture of the participants before and after using *Fixtrate* (*Statement of the Problem 2*). The test is used to prove the effectiveness of the device by verifying that the sample falls under the critical area on only one side of the curve instead of being bidirectional (Kenton, 2022). Because the study is only concerned with the posture improvements of the users and not with other possible results, this type of testing is suitable to drive the appropriate conclusions for the given problem.

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