

DESIGN AND FABRICATION OF PAIN THERAPY MANIPULATOR

Submitted in partial fulfilment of the requirements for the award of

Bachelor of Engineering degree in
Mechanical Engineering

By

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BONAFIDE CERTIFICATE

This is to certify that this Project Report is the bonafide work of DARISI KEDHAR SAANDEEP (Reg. No. 40150004) and ADHITYA DHAVALA (Reg. No. 40150005) who carried out the project entitled "**DESIGN AND FABRICATION OF PAIN THERAPY MANIPULATOR**" under our supervision from December 2023 to April 2024.



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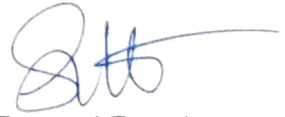
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ABSTRACT

Pain is a major concern for all-aged people, accounting for 80% of healthcare visits. Massage therapy is a safe and effective method for treating pain and improving personal life. However, accessibility, affordability, and the need for assistance from others can limit elderly people's use. This research aims to address this by designing a pain therapist manipulator with a massager unit. The pain therapy manipulator is a ground-breaking initiative that intends to transform pain management by offering accurate, non-invasive treatment choices. The device stresses patient comfort, safety, and usage while using sophisticated technology to improve treatment outcomes. The manipulator employs robotics, haptic feedback systems, and real-time monitoring capabilities to provide accurate therapeutic interventions while also providing healthcare practitioners with useful information about patient reactions and therapy progression. This enables doctors to adjust treatment procedures to individual patients' requirements, thereby improving results and care quality. Despite technological challenges and regulatory requirements, the project has stayed dedicated to quality and innovation. The pain therapy manipulator provides a non-pharmacological alternative to standard pain care, minimizes dependency on opioids, and allows patients to have an active role in their recovery.

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LIST OF ABBREVIATIONS

PLA	Polylactic Acid
3D	Three Dimensional
SW	Solid Works
FV	Front View
TV	Top View
SV	Side View
mm	Millimeter

CHAPTER 1

INTRODUCTION

1.1 INTRODUCTION TO PAIN THERAPY MANIPULATOR

Pain therapy manipulators are robotic devices that combine modern robotics and sensory technologies to control and cure pain by physically manipulating the body. These gadgets offer non-pharmacological pain management solutions to supplement standard treatments. They are outfitted with robotic arms, grippers, or other attachments to execute certain therapeutic procedures. Pain therapist manipulators collaborate with healthcare experts such as physical therapists or rehabilitation specialists and can be programmed to make precise motions, pressures, or massages dependent on the patient's requirements and the therapist's instructions. The therapist may regulate and alter the manipulator's settings to guarantee that the therapy is safe and effective. Pain therapist manipulators provide advantages such as reliable and repeatable therapy treatments, targeting particular parts of the body, and adding sensory feedback systems. Sensory feedback can dynamically modify treatment parameters or offer real-time information, assisting with treatment decisions and maximizing therapeutic outcomes. The use of robotics and automation in pain therapist manipulators enhances efficiency and access to pain management treatments.

In today's society, everyone is focused on their job and responsibilities, but we are not taking care of our bodies, and living an unhealthy lifestyle leads to several common bodily ailments. This impacts and creates aches in significant regions of our bodies, such as the shoulder, knee, leg, back, and neck, which adds to the mental tension. As our physical and mental stress levels grow, so do our illnesses, prompting us to seek mental health counsel and use excessive amounts of medication for minor aches and pains. As we know, the aged people are fighting with the problems in their bodies. To get away from the difficulties, they use medications or require the aid of others to massage them, which leads them to be a dependent person.

Sometimes older individuals are dissatisfied with massages performed by others, which makes them feel uneasy and uncomfortable. The fast-working professionals who are scrambling to save their jobs work more than nine hours every day. This makes them feel exhausted and apprehensive about the remaining time. The aches in their bodies are limitless since they labor for more than a half-day (12 hours) and spend their remaining time unhappy. The pains in their bodies after returning home make them even more miserable.

1.2 TYPES OF PAIN & PROBLEM STATEMENT

1.2.1 Pain

Pain is a universal human experience, serving as a vital warning mechanism to alert us to potential harm or injury. However, pain is not a one-size-fits-all phenomenon. It comes in various forms, each characterized by unique features, causes, and effects on individuals' lives. This essay delves into the diverse landscape of pain, exploring its types, origins, and implications for healthcare and well-being.

1.2.1.1 Acute Pain

Acute pain is a forceful, sharp feeling that alerts the body to possible danger or injury. It is usually temporary and is caused by accidents, surgical operations, or diseases. Acute pain can be stressful and bothersome, causing intense, stabbing, or throbbing feelings. It normally resolves as the body heals. Acute pain can be treated with drugs, rest, physical therapy, or surgery. The purpose of acute pain treatment is to reduce discomfort and speed up the healing process. Acute pain is a natural and necessary response to injury or sickness, and with correct treatment, it may be effectively managed, enabling the body to recover and return to its normal state.

1.2.1.2 Chronic Pain

Chronic pain is a continuous and difficult illness that affects millions of people worldwide, interfering with everyday activities and creating frustration, loneliness, and pessimism. It can be caused by medical illnesses such as fibromyalgia, arthritis,

or neuropathy, as well as previous trauma. The suffering takes many forms, making it a very personal experience for each sufferer. Managing chronic pain frequently necessitates a multidisciplinary strategy that includes medicine, physical therapy, and psychological support. It also has an impact on mental health, resulting in anxiety, sadness, and sleep difficulties.

The battle to get relief might result in a worse quality of life, since people may be unable to participate in activities they formerly liked. Relationships may deteriorate as loved ones try to comprehend and sympathize with the invisible suffering that their family member or friend is experiencing. Challenges include the emotional toll on healthcare systems and the economy, as medical consultations, treatments, and drugs incur significant healthcare expenses. Many people with chronic pain are unable to work or require disability benefits, resulting in lost productivity and financial burden.

1.2.1.3 Cancer Pain

Cancer pain is a difficult and devastating feature of the disease that affects millions throughout the world. It can be caused by tumor strain on nerves, bones, or organs, or as a side effect of therapies such as chemotherapy and radiation. Physical pain is not the sole factor; emotional and psychological distress also play an important role. Managing cancer pain is critical to patients' quality of life, and multidisciplinary teams collaborate to provide comprehensive treatment. Opioids and adjuvant medications are often provided, and palliative care doctors and oncologists work together to personalize therapies. Opioid abuse and insufficient access to palliative care remain significant challenges. Comprehensive, empathetic treatment is critical for relieving suffering and improving the lives of persons impacted by cancer.

1.2.1.4 Nueropathic Pain

Neuropathic pain arises from damage or malfunction of the nervous system itself, leading to abnormal sensations. Two main categories of neuropathic pain include:

- ***Peripheral Neuropathic Pain***: Conditions like diabetic neuropathy or sciatica cause peripheral neuropathic pain, characterized by sensations like

burning, tingling, electric shocks, or shooting pain. These symptoms result from nerve damage or compression.

- **Central Neuropathic Pain:** Damage or dysfunction in the central nervous system, as seen in multiple sclerosis or post-stroke complications, can lead to central neuropathic pain. It often presents as chronic, widespread pain.

1.2.1.5 Headache and Migraine Pain

Headaches and migraines are common and debilitating head pains affecting millions worldwide. Headaches are dull, dull aches caused by factors like tension, sinus congestion, dehydration, or eyestrain, while migraines are more severe and intense, lasting hours or days. Triggers include stress, certain foods, hormonal changes, and sleep disturbances. Treatment options include over-the-counter pain relievers, lifestyle modifications, relaxation techniques, and prescription medications. Understanding these conditions and their triggers is crucial for effective management and relief.

1.2.1.6 Musculoskeletal Pain

Musculoskeletal pain is a prevalent health issue affecting millions worldwide, affecting muscles, bones, tendons, ligaments, and joints. It can be acute or chronic, often linked to conditions like arthritis, fibromyalgia, or osteoporosis. Aging, poor posture, and sedentary lifestyles exacerbate the pain. It can lead to decreased mobility, productivity, and psychological distress. Effective management involves physical therapy, medications, lifestyle modifications, and assistive devices.

1.2.1.7 Problem Statement

Based on a survey conducted by elderly people and working professionals they suffer from a lack of body pain, so to get away from the pain they need the help of others for massaging as they feel dependent on others, or they will consult physiotherapy for normal body pains and taking medicines. Purchasing former products is manually controlled and some are expensive to purchase so they refuse to purchase these products.

1.3 MOTIVE OF THE PRODUCT

So, the main purpose of this product is to give effective comfort in massaging with their usage of time, as it works with their automatic controls so they can increase and decrease the required pressure of the device and to bring the product with the best affordable price of purchase further all may be able to use it. Thus, a novel pain therapist robot is proposed to overcome the problems mentioned above, it provides proper pain relief and gives safe and secure massage with adjacent force. It gives a massage either a sitting position or a sleeping position. This pain therapist robot is moved from one place to another place using the four wheels fixed at each corner with a rotatory motor added on each wheel.

1.4 FORMER PRODUCTS

Former massage therapy products such as electric massagers, kneading massagers, roller massagers, vibrator chairs, swing rollers, shoulder relief devices, and vibrator massagers. These items still have value for people looking for affordable self-care options, even if they were originally used for muscle relief and relaxation. These previously owned devices provide affordable solutions for anyone on a budget or looking for certain functionalities, even though newer ones may have more advanced features. These repurposed massage therapy tools address a range of requirements and desires, from reducing stress to increasing circulation. They are still good options for people who value their health within their limits, whether they are bought online, at thrift stores, or through classified ads.

- ❖ Swing roller
- ❖ Shoulder relief
- ❖ Vibrator massager
- ❖ Roller massager
- ❖ Vibrator chair
- ❖ Electric massager
- ❖ Kneading massager

1.4. 1 Swing Rollers

Swing rollers, which are commonly used in treatment, can indirectly assist control pain by giving sensory input, increasing coordination, and encouraging relaxation. These movements, which include swinging forward, backward, and rotating, can assist regulate the neurological system and alleviate pain perception.

They also increase balance and body awareness, which indirectly helps to manage pain by lowering strain. Swinging can improve a person's perception of body position in space, giving them more control over their actions and perhaps lowering discomfort caused by uncomfortable postures or movements.

Swinging's rhythmic action can also help to relax muscles, which can help with pain relief. However, before utilizing swing rollers for pain treatment, you should visit a healthcare practitioner, especially if you have any underlying medical concerns.



Fig:1.1: Swing Rollers

1.4.2 Vibrator Massagers

Vibrator massagers are a non-invasive and drug-free method of pain management. They produce pulsing vibrations that permeate soft tissues, encouraging improved blood flow, muscular relaxation, and the pain gate theory. These vibrations increase blood circulation, sending oxygen and nutrients to the affected area, hastening healing and lowering muscular tension. The idea proposes that vibrations stimulate nerve fibers, preventing pain signals from reaching the brain and offering brief pain relief.

Vibrating massagers come in a variety of styles, including portable massagers, percussive massagers, and hand massagers, each tailored to a certain requirement. Vibration treatment can help improve blood flow and relax tight muscles, manage chronic pain, and relieve tension headaches. However, it is crucial to note that vibration massagers are not a cure and should not be replaced. To summarize, vibrator massagers can be an excellent pain management tool, but it is critical to see a doctor about any underlying medical concerns to ensure safe and effective pain treatment.



Fig:1.2: Vibrator Massagers

1.4.3 Roller Massagers

Roller massagers are a popular self-care item for pain management that apply pressure to specific muscles and connective tissues. This pressure improves circulation, bringing in new oxygen and nutrients to help heal and decrease inflammation. It also helps to release trigger points, which can cause discomfort, by applying pressure to relieve muscular tension and restore appropriate function.

Roller massagers provide more than just pain treatment; they also increase flexibility, recuperation time, and performance. They can help athletes, weekend warriors, and those who work at desks and suffer from muscular tightness. Roller massagers come in a variety of styles, from smooth foam rollers to knobbly ones meant for deeper tissue action. It is preferable to begin with a milder roller and graduate to a firmer one as your tolerance grows. By introducing roller massagers into your regimen, you may manage muscular discomfort, increase flexibility, and improve your general well-being.



Fig:1.3: Roller Massagers

1.4.4 Vibrator Chair

There are two sorts of massage chairs: classic and robotic. Traditional massage chairs allow therapists to readily reach a recipient's head, shoulders, and back, whereas robotic massage chairs employ electronic vibrators and motors to deliver a massage. Nobuo Fujimoto of Osaka, Japan, invented the first massage chair in 1954. Chair massage is conducted in ergonomically built portable chairs, with emphasis on the head, neck, shoulders, back, arms, and hands. It is frequently used in contexts such as commercial offices, employee appreciation events, trade exhibits, and conferences.

Robotic massage chairs employ internal electronic motors and gears to massage the person sitting in them, with controllers that allow you to change the kind, location, or strength of the massage. The first electric massage chair was created in Japan before to WWII. Massage chairs resemble recliners and come in a variety of styles and brands, including office-style chairs powered by internal batteries or a separate massaging pad. The Family Fujiryoki firm created the first robotic massage chairs in 1954. Today, Japan is the leading consumer of massage chairs, with polls indicating that more than 20 % of household processes. Massage chairs provide profound relaxation.



Fig:1.4: Vibration/ Massage Chair

1.4.5 Electric Massager

Electric massagers are devices that provide a massage experience at home by vibrating, kneading, or using a mix of techniques. They provide several advantages, including muscular relaxation, stress alleviation, pain management, and better circulation. Handheld massagers are versatile for spot treatments on areas such as the neck, shoulders, back, and legs, percussion massagers use a powerful tapping motion to penetrate deep into muscle tissue, foot massagers, shiatsu massagers, and massage chairs.

When selecting an electric massager, consider the region you want to massage, the desired massage strength, portability, and noise level. If you have any underlying health issues, see your doctor. With several choices available, there is bound to be a massager that meets your requirements and tastes. To summarize, electric massagers are a simple and efficient approach to reduce muscular tension, promote relaxation, and manage pain. With so many variations available, you're likely to find a massager that meets your requirements and tastes.



Fig:1.5: Electric Massager

1.4.6 Kneading Massager

Kneading massagers are electric devices that massage particular parts of the body, such as the neck, back, foot, or full body. They relieve pain, reduce tension, increase circulation, and promote better sleep. They are portable and may be utilized at home, business, or on the go. To select the best massager, examine the target region, intensity levels, heat treatment function, and portability. Kneading massagers can be an effective tool for muscular relaxation, stress reduction, and overall well-being. You may experience the benefits of a massage whenever you want by selecting the proper model and operating it carefully.



Fig:1.6: Kneading Massager

1.5 MOTOR

A servo motor is a rotational actuator that allows precise control over angular motion. It is utilized in a variety of applications, including robotics, automation, aerospace, and manufacturing. Its essential components are a DC motor, a position feedback sensor, a control circuit, and a gearbox. The control circuit takes electrical data from an external controller and determines the motor's intended position or angle. It then compares the current position to the desired position, altering the motor's speed and direction of rotation to reduce inaccuracy. This closed-loop

control system provides excellent accuracy and reproducibility.

The gearbox of a servo motor converts the motor's high-speed, low-torque output into a lower-speed, higher-torque output, allowing the motor to apply adequate force and maintain its position even under load. Servo motors have various benefits, including accurate motion control, high torque capabilities, and a wide range of speed control options. They're tiny, lightweight, and energy-efficient.

Servo motors are widely utilized in robotics for joint actuation, CNC machines, 3D printers, camera gimbals, self-driving cars, and industrial automation. To operate a servo motor, a servo controller or driver creates control signals that normally adhere to a defined protocol such as Pulse Width Modulation. The controller may order the motor to move to a certain place by adjusting the pulse widths.

CHAPTER 2

LITERATURE SURVEY

(Bussi res et al., 2016) Assistive devices in pain therapy are tools and technologies that help patients with various medical conditions manage or alleviate pain. They improve the quality of life for acute or chronic pain patients and are frequently recommended by healthcare professionals. Canes, crutches, braces, and orthopaedics are necessary assistive devices for people suffering from musculoskeletal pain, injuries, or conditions such as osteoarthritis. Transcutaneous electrical nerve stimulation (TENS) machines stimulate specific body parts to reduce pain and promote relaxation. Wearable technology and mobile apps have become more common in pain therapy, allowing patients to track their pain and practice mindfulness techniques. AESOP, for example, has the potential to change medical procedures, but its clinical benefits are still unknown. SAR (socially assistive robotics) is a promising approach to reducing pain during medical procedures, improving cognitive abilities, reducing loneliness and depression, and improving function after stroke.

(Gromala et al., 2015) Chronic pain is a complicated condition that is frequently treated with pharmacological analgesics. Virtual reality (VR) technologies, such as the "Virtual Meditative Walk" system, which uses biofeedback sensors and an immersive virtual setting to teach mindfulness-based stress reduction (MBSR), have been successful in treating severe pain. The Georgia Institute of Technology's Meditation Chamber uses VR to reduce stress levels as well. Mechanical circulatory assist devices (LVADs) are increasingly being used to treat severe heart failure, but healthcare professionals must understand their physiology, potential complications, diagnostic procedures, and treatment decision-making. Robots are increasingly being used to manage pain, with dementia patients being more likely to use them for both procedural and chronic pain. Kurt Semm's invention of laparoscopic surgery is regarded as the gold standard for minimizing discomfort, anxiety, and recovery time. Future research, however, must prioritize patient safety and medical ethics. Robotic surgery is a cutting-edge surgical technique that employs computer-controlled instruments with advanced sensing and display capabilities.

(Bao et al., 2019) Since the development of the first robotic exoskeleton to determine the current state of the field, we conducted a bibliographic analysis. The analysis evaluated publications in the field of robotics. Biggest contribution to the field of robotic exoskeletons. Research on an average number of publications. Number of citations and h-index per publication. 20 scientific journals measured by the number of publications.

(Bouteraa et al., 2020) The purpose of this research is to design and develop a new robotic device for upper limb rehabilitation. The focus is on a new symmetrical robot that can be used for rehabilitation of the right and left upper limbs. The purpose is to automatically provide electrical stimulation based on the condition of the muscle being rehabilitated. However, the proposed approach uses electrical stimulation for recovery, relaxation, and pain relief. Automatically activates the corresponding stimulation mode based on the detected EMG signal. Stimulation activation: manual preset mode and EMG control mode. The developed robotic device is symmetrical and reconfigurable. A stimulator connected to the robot to improve the quality of the rehabilitation process. Stimulating the physical rehabilitation process allows effective rehabilitation sessions for neuromuscular upper extremity recovery. The software interface allows physical therapists to set exercise movement parameters, define stimulation modes and record patients. Signal extraction –Functional electrical stimulation and robotic motor rehabilitation are the main techniques used. The main purpose of incorporating robots into the rehabilitation process is to compensate for the resulting loss of functionality.

Soft robotics is a branch of robotics that focuses on the development of robots and robot components made of flexible and deformable materials. Unlike traditional rigid robots, soft robots are designed to mimic the mechanical properties and flexibility of living organisms such as animals and plants. This approach allows robots to interact with the environment in unique ways and perform tasks that are difficult for traditional robots (Albu-Schaffer et al., 2008).

Soft robots are typically made of materials such as silicone, rubber, and elastomers and can bend, deform, and adapt to their environments. This flexibility is useful for

tasks such as grasping irregularly shaped objects and navigating complex environments (Chua et al., 2019).

Soft robotics can be used in wide range of applications, including healthcare, search and rescue, exploration, and human-robot interaction (Institute of Electrical and Electronics Engineers, n.d.). Soft robotics presents unique challenges in control, sensing, and materials, and the development of robust and reliable soft robots relies on advances in these areas to make them suitable for a variety of applications (Rus & Tolley, 2015). Soft robotics is a rapidly growing field with the potential to revolutionize the industry and improve human-robot interaction by giving robots the flexibility and adaptability to perform a wide range of tasks efficiently and safely (Yim et al., 2022).

(Sunny et al., 2016) Prosthetics and orthotics are specialized fields of healthcare that focus on providing solutions for individuals with limb impairments or musculoskeletal conditions. (Crowe et al., 2019) Prosthetics involves the design, manufacture, and adjustment of artificial limbs (prostheses) to replace missing or missing body parts (usually arms or legs). These devices are intended to restore mobility, function, and aesthetics to people who have suffered amputations or congenital limb defects. Prosthetists work closely with patients to create customized prosthetics that meet the patient's specific needs and preferences. Modern prosthetics are made from advanced materials such as carbon fibre and often include sophisticated mechanisms to mimic natural joint movements.

(Spaulding et al., 2020) Orthotics is a medical field that deals with the development, manufacture, and use of orthotics. These are external devices that support, correct, and adjust different parts of the body, especially the musculoskeletal system. Orthopaedic devices include braces, splints, and shoe inserts. Prosthetists work with patients to assess their condition and develop customized orthopaedic solutions to correct problems such as limb deformities, joint instability, and spinal disorders. These devices can help improve posture, reduce pain, and increase mobility while providing structural support.

(Magnusson et al., 2019) Both prosthetics and orthotics aim to improve the quality of life for people with physical disabilities by providing customized solutions that support mobility, functionality, and comfort. Advances in materials and technology continue to drive innovation in these areas, resulting in increasingly effective and personalized devices for patients.(ROSICKY et al., 2016)

In addition, multidisciplinary collaboration with prosthetists, orthotics, physical therapists, and other medical professionals ensures comprehensive care for people requiring prosthetics orthotics, and orthopaedic procedures.

(Wang, 2017)To ensure safe, accurate, and aligned operation, robotics in pain therapy rely on advanced control systems and software. Control algorithms enable robot movement precision and accuracy, while kinematic control determines the position and orientation of end-effectors.(Sathish & Dhanabalan, 2018) The system can adjust force, speed, and position based on real-time feedback from sensors such as force sensors and motion capture devices. To adapt therapy parameters based on patient data, machine learning algorithms can be integrated.

(Rajan & Saffiotti, 2017)Artificial intelligence-powered systems can optimize treatment plans, predict patient responses, and personalize therapy. To protect patients, software systems must include fail-safes and emergency stop mechanisms.

(Trost et al., 2019) Intuitive user interfaces help healthcare professionals communicate with the robotic device, and patients can interact with the software to provide pain feedback (Software Defined Healthcare Networks, n.d.). Robotics in pain therapy assistive devices is rapidly evolving, driven by miniaturization, machine learning, and AI. These advancements will make devices more portable and versatile, as well as improve real-time treatment adaptation. Collaboration among robotics engineers, medical professionals, and software developers will spur innovation and ensure that devices meet the needs of patients.

(Kragic et al., 2018) The incorporation of robotic pain therapy devices into telehealth platforms will increase access to specialized care, particularly for patients who live

in remote or underserved areas. Collaborative robots (cobots) will become more common, increasing the overall quality of care. By providing precision, personalization, and remote monitoring, robotics, and assistive devices are revolutionizing pain therapy. (Kragic et al., 2018a) The integration of advanced control systems and software ensures that the system operates safely and effectively. As technology advances and challenges are addressed, the future of robotics in pain therapy appears promising, with the potential to improve the lives of countless people suffering from chronic pain.

(Helm et al., 2020) Robots are progressively being equipped with machine learning (ML) and artificial intelligence (AI) algorithms, revolutionizing their capabilities and allowing them to do difficult jobs on their own. Robots can now learn from data, adapt to shifting settings, and make wise judgments thanks to these algorithms. (Alzubi et al., 2018) Robots can recognize and comprehend their environment thanks to ML algorithms. Through the use of image and sensor data, they can recognize things, people, and barriers, which is essential for interaction and navigation.

(Brougham & Haar, 2018) Robots can plan the best routes and move about on their own thanks to AI systems. They can make modifications in real-time to avoid hazards and get to their destinations without incident. (Sarker, 2021) ML algorithms can make robots more socially aware, allowing them to understand human gestures, emotions, and intentions, making them safer and easier to use. By analysing sensor data, AI algorithms predict when robotic systems need maintenance, reducing downtime and operational costs.

(Bharadiya & Bharadiya, 2023) Integrating ML and AI algorithms into robots not only improves their capabilities but also makes them more adaptable to a wide range of applications, from manufacturing and medicine to agriculture and space exploration. These algorithms are constantly evolving, promising a future in which robots become smarter, more versatile, and integrated into our daily lives.

(Hoc, 2000) Human-machine interaction (HMI) is the term used to describe how people and machines communicate and interact, usually using different

technologies and user interfaces. It is essential to how people engage with and manage tools, gadgets, Vehicles, and computer programs. To give users flexible and natural methods to engage with machines, modern HMI frequently mixes many modes of interface, including touch, voice, and gesture detection. This improves usability and accessibility. Effective HMI systems give users feedback to validate their actions or warn them of mistakes. Feedback may be tactile, visual, or audible (2019 IEEE Conference on Information and Communication Technology., n.d.). Artificial intelligence-driven HMIs utilize machine learning and natural language processing to better interpret user input and offer more individualized replies. The demands, capabilities, and preferences of the user should be given priority in HMI design. To produce interfaces that fulfil user expectations, human-centered design approaches include user research, prototyping, and usability testing.

(Faas et al., 2021) It is essential to ensure that HMIs are usable by those with impairments. This entails creating user interfaces that may be customized to suit different requirements, such as screen readers for the blind or voice commands for people with restricted mobility. Particularly in applications containing sensitive information, like banking or healthcare, securing user data and ensuring secure interactions are crucial components of HMI design. (Guzman & Lewis, 2020) HMI may try to make socially interactive or emotionally engaging experiences. For instance, chatbots or social robots may be created to build relationships with people. HMIs are continuously improved and optimized based on user input and advancing technology. To stay up with evolving customer expectations and technology breakthroughs, regular upgrades and changes are necessary.

(Nakanishi et al., 2020) Technologies like teleoperation and remote assistance allow people to interface and operate equipment and gadgets remotely. These ideas have important applications in a variety of fields, including manufacturing, healthcare, and space exploration.

(Majstorovic et al., 2022) Robots that can be operated remotely are frequently utilized in hazardous material handling, remote surgery, and bomb disposal. Robotic arms that can be operated remotely by surgeons make it possible to operate on patients in a variety of areas while minimizing invasiveness. (Zhang, 2020)

Advanced sensors, cameras, and other data-capturing tools are frequently used in teleoperation to give operators a real-time perspective of the remote environment. For making decisions and exercising precise control, this knowledge is essential.

(Yang et al., 2020) The goal of remote help is to use technology to support and direct people or workers in the field. Live video communication is frequently used for remote help, which enables specialists to observe what users or field employees are going through and offer assistance in real-time.

(Nakanishi et al., 2020) With advancements in communication networks, sensor technology, and augmented reality, both teleoperation and remote support technologies have seen tremendous development. They allow for safer, more effective, and more affordable operations in a variety of industries, which ultimately boosts output and lowers risks in difficult or distant situations.

(Kumar & Elavarasi, 2016) Pain is a universal human experience that has a significant impact on the overall quality of life. Effective pain management is critical in healthcare, and robotics is a game changer in this field. It provides novel pain management solutions that go beyond traditional methods.

(Cifuentes et al., 2020) This review investigates the applications of robotics in pain therapy, with a focus on its role in improving pain assessment accuracy and objectivity. Robotics is transforming the way we diagnose, treat, and manage pain, thereby improving the overall quality of life.

(Thai et al., 2020) Robots with advanced sensors can measure physiological responses to determine pain levels, providing more accurate assessments than subjective self-reports. This data assists clinicians in tailoring treatment plans to specific areas.

(Peters et al., 2018) Robotic surgical systems are becoming increasingly popular in the treatment of pain, particularly in spine and nerve-related conditions. Robotic-assisted spinal surgery improves implant placement accuracy while reducing post-operative pain and complications.

(Peters et al., 2018) Robots are also used in neuromodulation techniques such as spinal cord stimulation and deep brain stimulation, which can reduce chronic pain by modifying neural activity. Robots are revolutionizing pain management by providing immersive environments for distraction and relaxation during painful procedures. They are also important in pain research, helping to develop new treatments and therapies. Robots are used to conduct high-throughput screening of potential pain medications, which speeds up drug discovery. They use human movement and biomechanics simulations to better understand pain mechanics and develop targeted interventions.

(Hylands-White et al., 2017) Conventional therapies cannot manage chronic pain, which carries on after healing or without tissue damage. Instead, patients must be given the means to effectively manage their pain. Analgesics, interventions, stimulations, and irritants are all part of treatment plans that also address psychosocial issues. Pain clinics provide a biopsychosocial approach, empowering patients to manage their pain and lead fulfilling lives.

(Schwan et al., 2019) Nonsteroidal anti-inflammatory drugs (NSAIDs) are antipyretic and anti-inflammatory drugs that prevent the COX pathway from metabolizing arachidonic acid, thereby inhibiting prostaglandin synthesis. While more recent NSAIDs selectively inhibit COX-2, they are less toxic than older NSAIDs like aspirin and naproxen, which are nonselective. Effective for chronic pain that is mild to moderate. (Sowah et al., 2018) Non-specific low back pain (LBP), which affects quality of life, workability, and productivity, is a serious public health issue. It affects 60–70% of industrialized nations and is responsible for 37% of all LBP worldwide. LBP restricts daily activities, which increases absenteeism from work and places a financial burden on healthcare systems and economies. It carries socioeconomic costs, such as the fact that it is the leading cause of disability among young adults in the UK and accounts for 149 million lost working days annually.

(Rawal, 2016) Back pain, which affects people of all ages and socioeconomic backgrounds, can seriously negatively impact daily activities and general well-being. The use of assistive technology is growing in popularity as a non-invasive, economical treatment for this condition. Lumbar support cushions, which are

frequently found in office chairs, car seats, and standalone cushions, are made to reduce pain and discomfort in the lower back. They are designed to keep the spine's natural curve, ease the strain on the lumbar discs, and enhance posture. These accessories bridge the space between the lower back and the chair, encouraging a healthy sitting posture and reducing pressure on the lumbar spine. Many can be modified to meet the unique needs of users.

(Guo et al., 2016) By preserving a neutral spinal posture, lumbar support devices can lessen lower back pain, especially during extended periods of sitting. However, depending on specific factors, their efficacy may vary. The comfort and effectiveness of these devices could be improved in the future by improvements in materials and ergonomics, as well as integration with smart technology like sensors and feedback mechanisms, which would offer individualized support and posture feedback.

(Bertrand et al., 2021) Posture-correcting tools, like wearable braces and smartphone apps, assist users in maintaining proper spinal and shoulder alignment, which decreases back pain. When a user deviates from the ideal posture, these devices gently press or give feedback to the user's body. Smartphone apps use the accelerometer to detect slouching and send reminders to correct posture, while wearable braces pull the shoulders back.

(Bullock et al., n.d.) Joint pain, stiffness, and decreased mobility are all symptoms of arthritis, an international disease. Despite the lack of treatment, assistive technology has been created to help arthritis sufferers manage their symptoms and enhance their quality of life. Simple tools and cutting-edge mobility aids like powered wheelchairs are among these gadgets. They improve well-being overall, increase independence, and lessen pain. Due to joint pain and stiffness, arthritis frequently has an impact on mobility. Canes and walkers are examples of assistive devices that support an active way of life. Canes provide support and stability while walking, easing joint stress. Walkers, which come in a variety of designs like standard, rolling, and knee walkers, offer strong support and stability and are therefore perfect for people with severe arthritis.

(Amaral et al., 2018) Crutches are designed to shift weight away from painful joints and can be adjusted to fit different heights, which is especially important for people with lower extremity arthritis. Wheelchairs provide advanced arthritis patients with independence and mobility, with manual and powered options available. Splints and braces, which are available for various joints such as the wrists, knees, and fingers, are essential for managing pain and preventing further damage.

(Rodriguez et al., 2021) Individuals with arthritis should use compression gloves, knee supports, and ankle and foot orthotics to relieve pain and swelling in their hands. Knee braces and supports provide stability and comfort, whereas AFOs provide ankle and foot support and alignment. Adaptive tools and devices are designed to assist people with arthritis in maintaining their independence and performing daily tasks more easily. Larger-handled jar openers and kitchen utensils with specialized grips make cooking and meal preparation easier. Dressing sticks and sock aids make it easier for people with limited mobility or dexterity to put on and take off clothing. Assistive devices and apps that can help manage arthritis and maintain independence have been developed as a result of technological advancements.

(Rawal, 2016) Postoperative pain rehabilitation is an important aspect of post-surgery patient care, involving a variety of strategies and interventions to manage and alleviate pain. Effective management not only improves patient comfort but also speeds up recovery time. Assessment, pharmacological interventions, non-pharmacological approaches, and the role of a multidisciplinary team in optimizing patient outcomes are all important components. A thorough assessment is performed to tailor treatment plans to the patient's specific needs during postoperative pain rehabilitation. Clinicians can measure pain intensity, location, and impact on daily life using a variety of tools, including visual analog scales and the Brief Pain Inventory. Because pain perception differs between individuals, a holistic assessment approach takes patient-reported outcomes and subjective experiences into account. Previous pain experiences, psychological state, and cultural background can all have an impact on pain perception.

CHAPTER 3

AIM AND SCOPE

3.1 AIM OF THE PROJECT

The project "Design and Fabrication of Pain Therapy Manipulator" aims to develop a sophisticated robotic system capable of providing targeted and tailored pain relief to individuals with chronic pain problems. Chronic pain is a debilitating medical disease that affects millions of individuals throughout the world, and standard pain treatment approaches typically fail to give lasting relief. This project aims to address this essential healthcare issue by developing, producing, and deploying a customized manipulator that uses cutting-edge technology to provide pain medication precisely and efficiently.

3.2 OBJECTIVES

- To solve the people's pains anxiety feelings and tiredness for normal body pains.
- To save their money by spending their savings on medicines and transport charges to consult doctors always for normal pains.
- The survey taken from the people about the former products found some minor problems that do not satisfy them to use it always.
- As the former products have disadvantages with their use, some products are handheld devices that may be used only by ourselves, expensive products available in the market cannot be used by all, and discomfort in using cheap massaging devices.

3.3 SCOPE OF THE PROJECT

- From Assumption Mapping we found the problem statement, that till now what are the problems people facing. How they are suffering from pain and why they are not comfortable with former products.
- Then survey was taken from both elderly and working professionals with our problem assumption question we knew well about their problems.
- With the efficient needs of the elderly people and working professionals we have gone through a better design to give the best pain relief mechanism.

CHAPTER 4

MATERIALS AND METHODOLOGY

4.1 MATERIALS

4.1.1 Frame

A frame acts as a major component in end effector of a pain therapist robot which carries load of other components and act as support to components. The frame is designed in solid works with accurate dimensions. The physical appearance of frame looks like U U-shaped size in upper side of the frame and a rectangular shaped size in lower side of the frame. The Frame Carries the 2 rods, rack, pinion and the servo motor. The Rod is mounted at the top of the frame which is supported by the rack. In the bottom of the frame the servo motor is fixed, and it's connected to the pinion. The servo motor does the function of rotation further using the rack and pinion the movement of the axis in the rod is done. The frame does the major function because the full load and motor vibration are carried by the frame while performing the operations.

The dimensions of the frame:

- The total length of the frame 280mm
- The breadth of the frame (from left to right) = 120mm
- The thickness of the frame varies from top to bottom
- The cylindrical rod is fixed at the bottom of the frame to connect with the robotic arm.
- The length of the rod =300mm.
- The lower rectangular shaped in frame supports the servo motor

- The length of the lower rectangular shape = 150mm
- The breadth of the lower rectangular shape = 120mm
- There are two rectangular-shaped holes in the middle of the U-shaped frame.

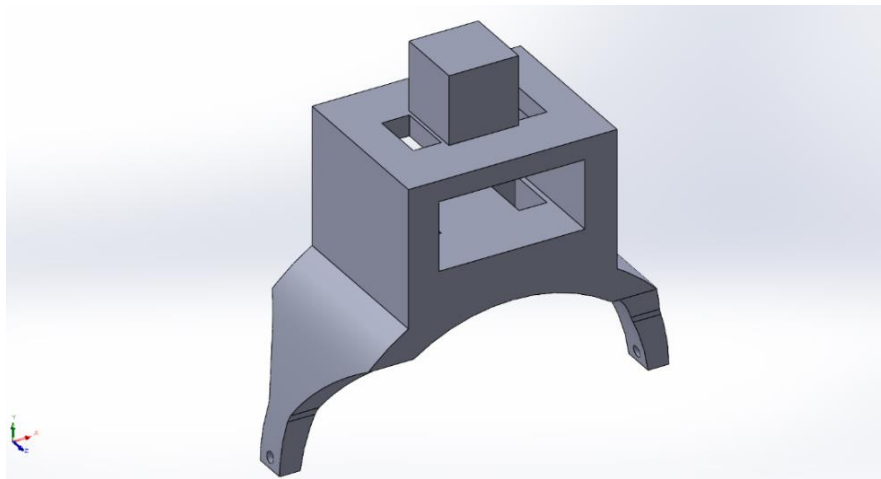


Fig: 4.1: Frame

4.1.2 Rod

The other component of a pain therapist robot is the connecting rod, which is connected to the bottom of the frame. The connecting rod is connected from the left side of the frame to the right side of the frame. The connecting rod is fixed in the device. The physical appearance of the connecting rod is in a cylindrical shape. The connecting rod carries the Acupressure balls which are in contact with the user's body. The rod has the function to carry the Acupressure balls and to move forward and backward direction according to the movement of the device.

The dimensions of the connecting rod:

- The total length of the rod = 300mm
- Number of rods used = 1Nos
- The diameter of the rod = 7mm



Fig: 4.2: Rod

4.1.3 Rack and Pinion

Rack and pinion play major mechanisms in this pain therapist robot. The pinion is connected to the servo motor and the rack is connected to the rod with the help of a holder and gripper. When the servo motor receives the signal from the FSR sensor it begins to rotate with the pinion as the rotational motion is converted into the linear motion due to the strong connection between rack and pinion. This results in the circular motion in pinion and the rack gives the linear movement. This linear movement of the rack helps in the up-and-down movement of the connecting rod.

The dimensions of the pinion gear

- The diameter of pinion = 24.30 mm
- Total number of teeth in pinion = 25 teeth
- Pitch circle = 4 mm
- The diameter of the inner hole = 5 mm
- The width of the pinion gear = 10 mm

The dimension of the rack

- The total length of the rack = 185mm
- Total number of teeth in rack = 39 teeth
- The width of the rack = 10mm

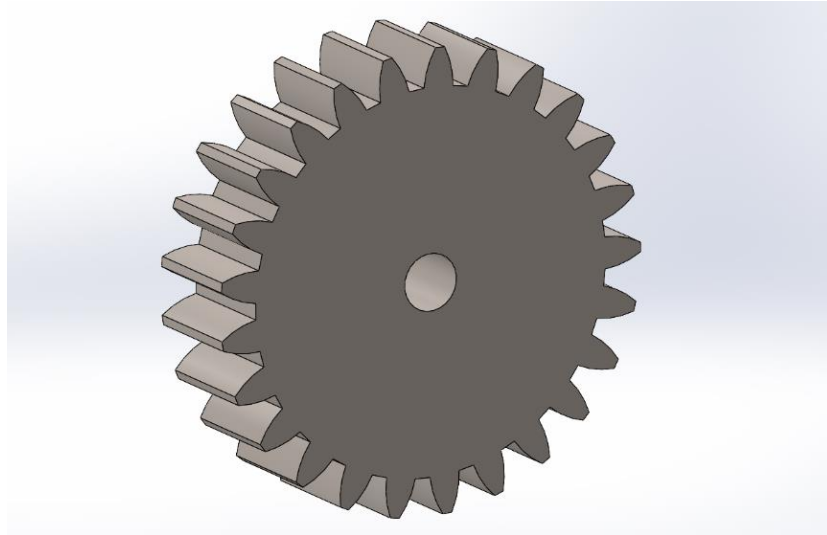


Fig: 4.3: Pinion

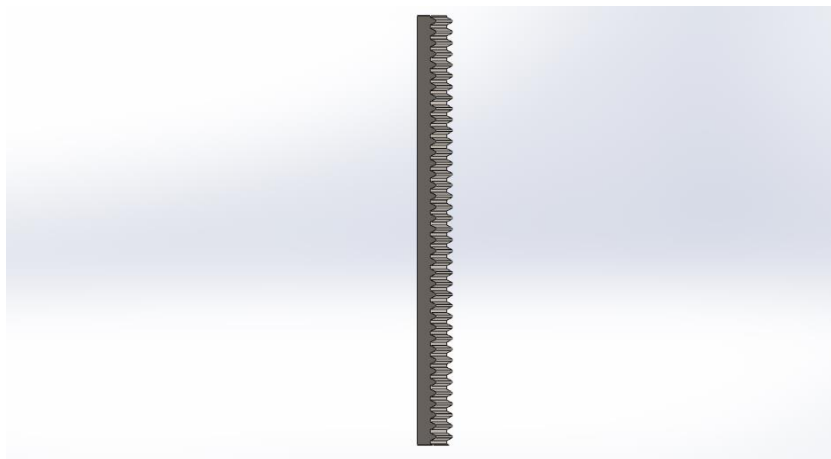


Fig: 4.4: Rack

4.1.4 Servo Motor

In this pain therapy Manipulator, we are using a servo motor to rotate the pinion with specified torque and a specified angle of rotation. Servo motor not only helps in rotation it also helps to push the object forward and backward. Here we are using the servoMG996R model to run the pinion. The servo motor is controlled electrically through Arduino Nano programmed in Arduino software with a specified angle and torque. The servo motor consists of three connecting wires red, brown, and orange.

The red is the positive terminal, the brown is the negative terminal, and it is grounded.



Fig: 4.5: Servo Motor

4.1.5 Arduino Nano

The Arduino Nano is used to control the servo motor rotation angle according to the force applied to the FSR sensor. When the force is exerted on the FSR sensor it sends signals to the servo motor via Arduino Nano and then the motor starts rotation in the clockwise direction up to the required interval of time. when the force exerted is removed on the FSR sensor then the servo motor rotates in an anti-clockwise direction to bring the rack and pinion to the original Position. There are three connecting pins from the servo motor which is connected to Arduino Uno. The red wire pin (positive) is connected to the 5v pin in Arduino, the brown colour wire (negative) is connected to the ground, and the yellow wire pin (signal) is connected to the pin9 in Arduino. Using the c programming the Arduino is controlled to do its function. The main function of the Arduino is to control the servo motor which is connected to pinion. The Arduino Code used in the device is mentioned in the appendix.

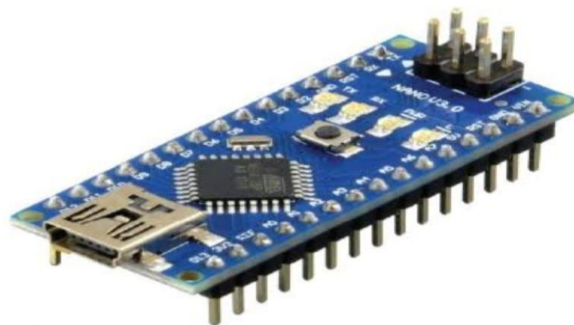


Fig: 4.6: Arduino Nano

4.1.6 Acu Pressure Ball

The Acupressure balls are fixed in the frame rod and it does the major role of compressing with the required force. This rubber ball plays a vital role in the pain relief for the users. The function of the rubber balls is to have contact with the user's body to press with the required force and also rotate itself 360 degrees.

Dimensions of the Rubber Ball:

- The Diameter of the rubber ball is 32 mm.
- The Inner hole diameter is 8mm

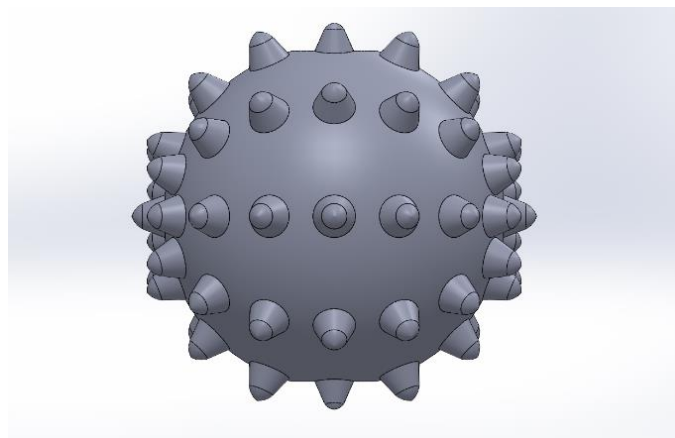


Fig: 4.7: Acu Pressure Ball

4.1.7 Holder

The holder is attached to the rack and pinion in the device. The holder holds the pinion and connects it with the connecting rod via gripper. The holder consists of 4 C- shaped structures which helps in the movement of gripper freely. The FSR sensor is attached to the holder.

- The height of the holder = 50mm
- The length of holder = 24 mm
- The width of holder = 20mm

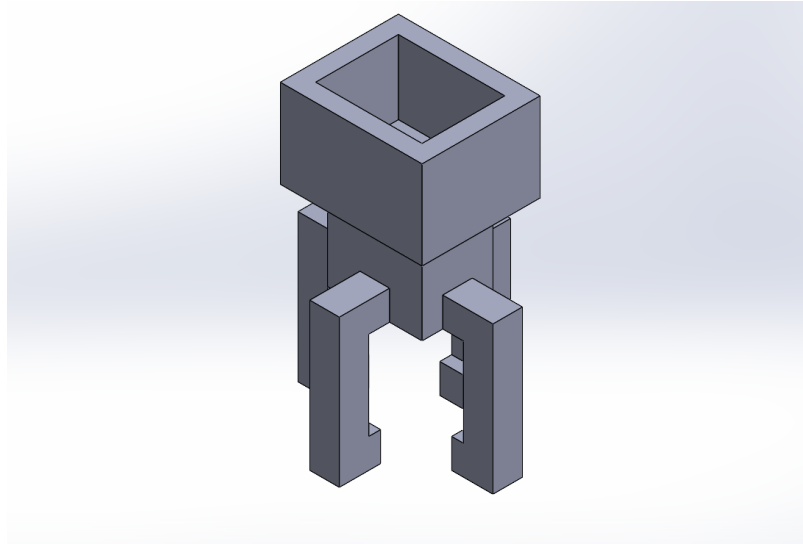


Fig: 4.8: Holder

4.1.8 Gripper

The gripper is attached to the connecting rod and gets locked in the holder. The gripper is locked in the holder and it moves freely in linear motion in the holder.

- The length of gripper = 21mm
- The width of gripper = 17mm
- The height of gripper = 35 mm
- The diameter of the gripper = 8mm

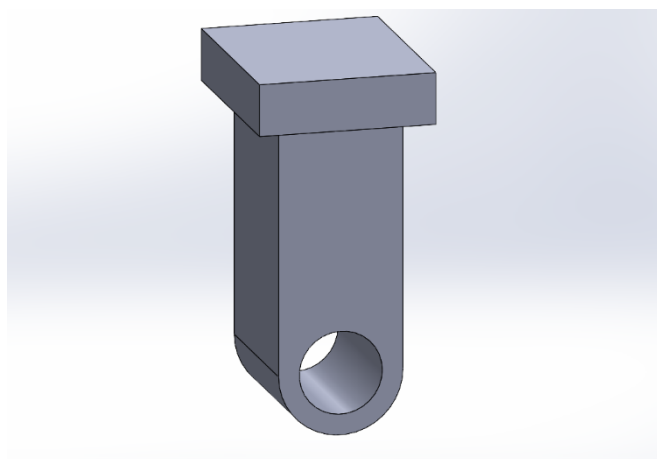


Fig: 4.9: Gripper

4.2 METHODOLOGY

The project will follow the following steps:

1. **Research and Literature Review:** Conduct an extensive review of existing pain therapy techniques, devices, and scientific literature to identify the most effective therapeutic modalities and design considerations.
2. **Conceptual Design:** Develop preliminary design concepts for the pain therapy manipulator based on the research findings and the identified requirements. Consider factors such as ergonomics, portability, and ease of use.
3. **Detailed Design and Engineering:** Refine the chosen design concept and create detailed engineering plans, including CAD models and technical drawings. Consider factors such as materials, manufacturing processes, and cost-effectiveness.
4. **Prototype Development:** Build a functional prototype of the pain therapy manipulator based on the finalized design. Conduct rigorous testing and evaluation to ensure its performance, safety, and usability.
5. **Iterative Refinement:** Collect feedback from healthcare professionals and potential end-users to identify areas for improvement. Refine the design and functionality based on the feedback received.
6. **Final Product Development:** Based on the feedback and refinements, develop the final version of the pain therapy manipulator. Ensure it meets all the design objectives and safety standards.

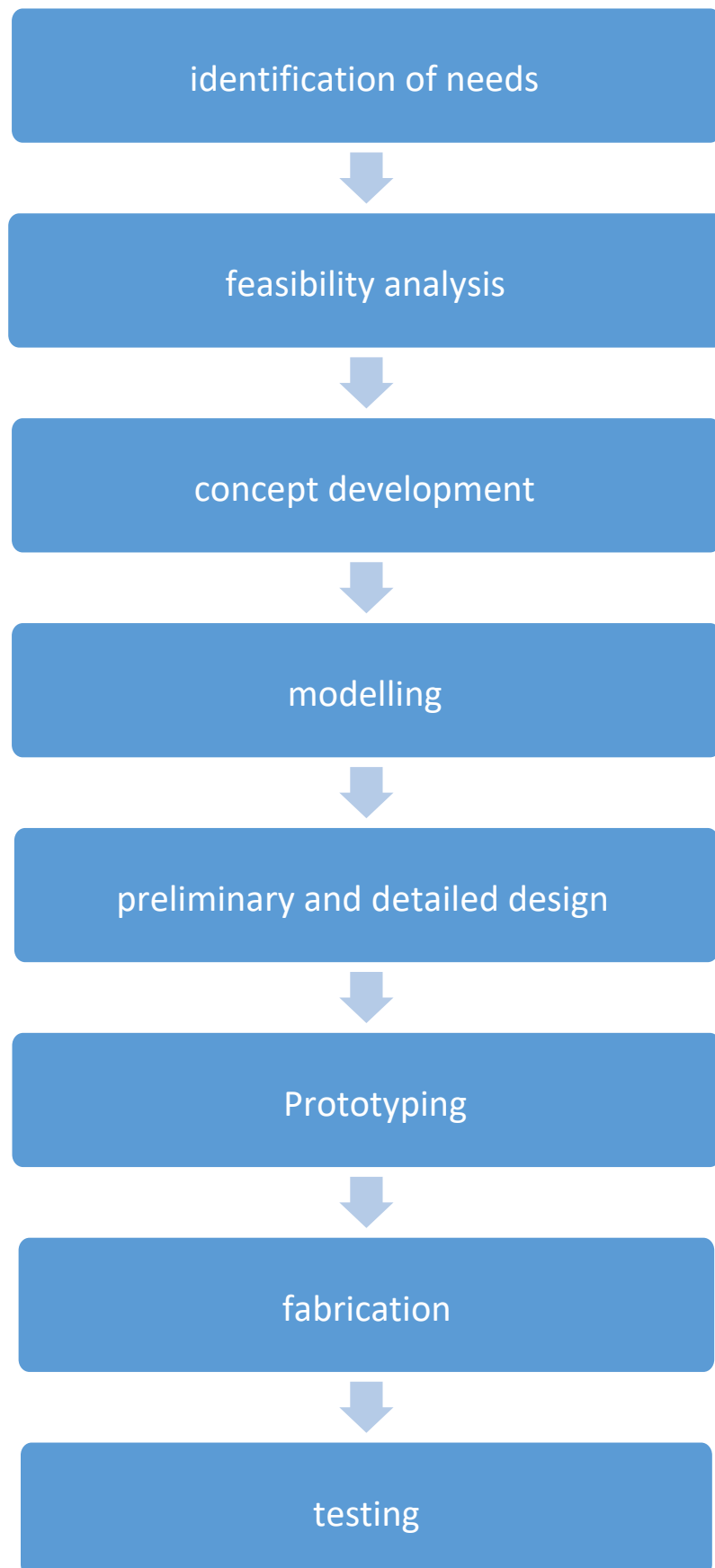


Fig: 4.10: Flow Chart

4.2.1 Identification of Need

The survey was taken from several people like elderly and working professionals, as they follow different lifestyles in focusing their work and duties. They are not taking care of their own body, this causes severe pain in their bodies further increasing body pain and mental stress. Finding a way to cure this kind of pain massager is needed but without the help of others it's difficult to solve, former products in the market are manually controlled devices.

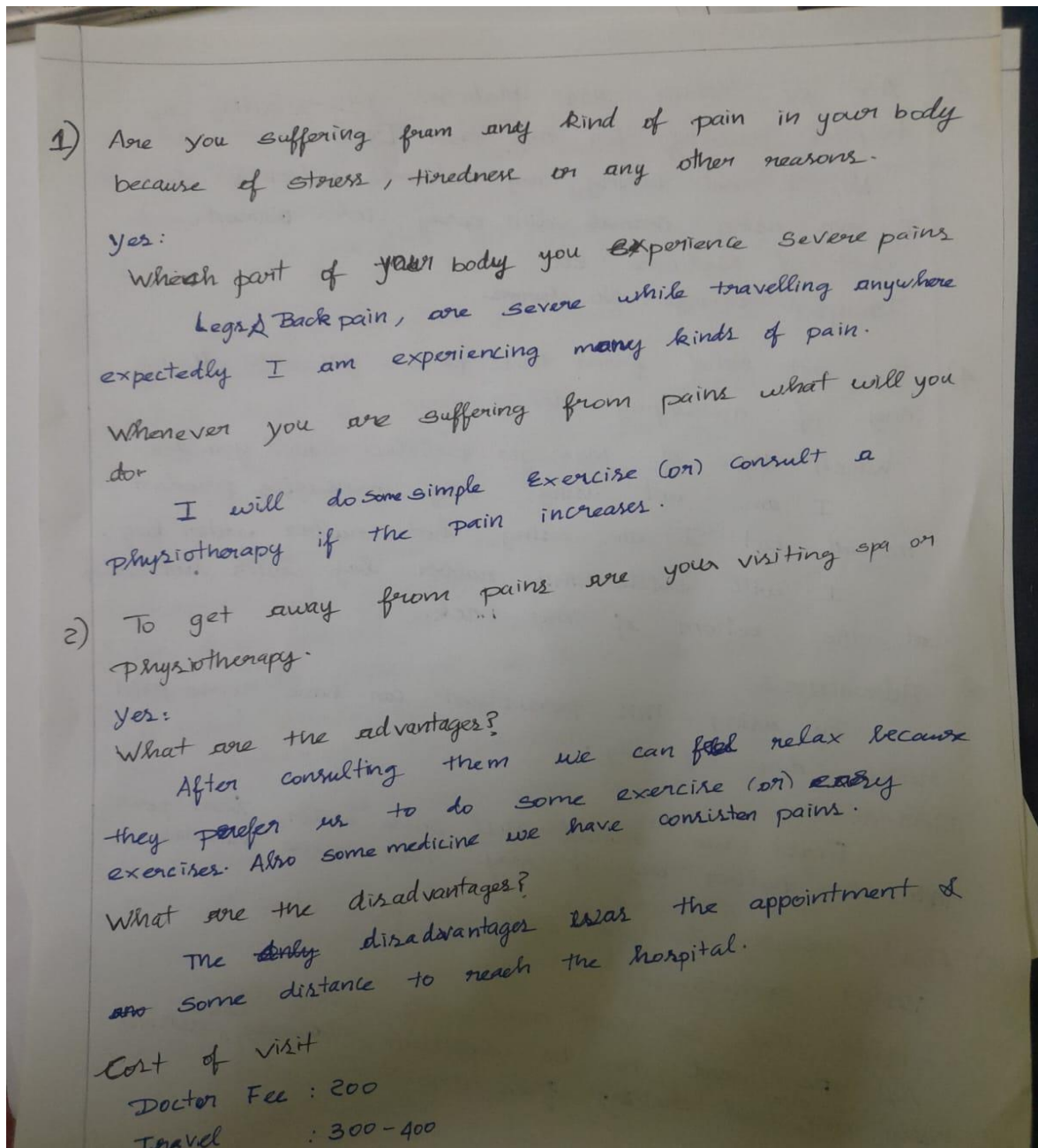


Fig: 4.11: Survey Page 1

- 3) Are you taking any Medicine or visiting the hospital regularly for this pain. [yes]
 No, I not taking any internal medicines but I am using normal volini spray, iodox ointment.
 Cost of Medicine : 200
 Transport charge : No charges.
- 4) To get relief from this pains, you are using any of massaging devices:
 Which type of Massager product will you use:
 I am not using any massaging product instead but I am using hot rubber water bag.
 I will settle this rubber bag with hot water at the bottom of my back.
- 5) Advantages:
 By using this persistent can have some pain relief day by day.
 Disadvantages:
 First we should Boil some water, then pour into the rubber bag it may take some minutes.
- 5) For Massaging do you ask help from other:
 Yes : Sometimes.
- 1) what will be your mood while asking help:
 As we need to be dependent, because ^{while} asking help we ^{also} need their free time.

Fig: 4.12: Survey Page 2

What will be their mood:

They will do a good massaging but if they have some important work they ~~may~~ will ~~regret~~ refuse to do (or) do for a little bit time.

⑥ Do you feel comfort by their Massage?

Yes: sometimes.

Which kind of Massage do you prefer for your pain.

* By holding (or) pressing ~~out~~ legs.

* By pressing Back & shoulders.

⑦ We have decided to construct a device "pain therapist Robot" with our innovative idea & skills we have planned to ~~construct~~ this device with as a ~~frame~~ ^{using} ~~material~~ ^{product} with a affordable budget.

i) What should be the need of our device for your massaging & your expectations.

The device must press (or) hold ~~any~~ the back & shoulder with the adjustable pressure. And it should work with our limited time usage.

⑧ Why you need the Automatic Adjustable massager?

As I have sometimes a little pain & some times have severe pains in my body how can your robot know.

So it should work with the adjustable pressure with our manually control.

Fig: 4.13: Survey Page 3

4.2.2 Feasibility Analysis

ASSUMPTION MAPPING

As we gone through assumption mapping with four categories

- Known – important
- Unknown –important
- Known – unimportant
- Unknown –unimportant

To Create the model according to the need of the user, the assumption mapping method is used to define the known problems, unknown problems and former prototype problems and what are the benefits that are present in the former products. By this method we can able to understand the problem and new build a design.



Fig: 4.14: Assumption Mapping

4.2.3 Alternative Designs

The below images represent the former designs of the pain therapist robot. More than eight designs were created using the SolidWorks software. Then those designs are created as simple prototypes, further some problems are defined in the product. The rod is unable to bend flexibly and it reaches its fracture point very fast. So we have solved the problems that are defined and finally made a final Model with all the modifications done.

4.2.3.1. Design-1

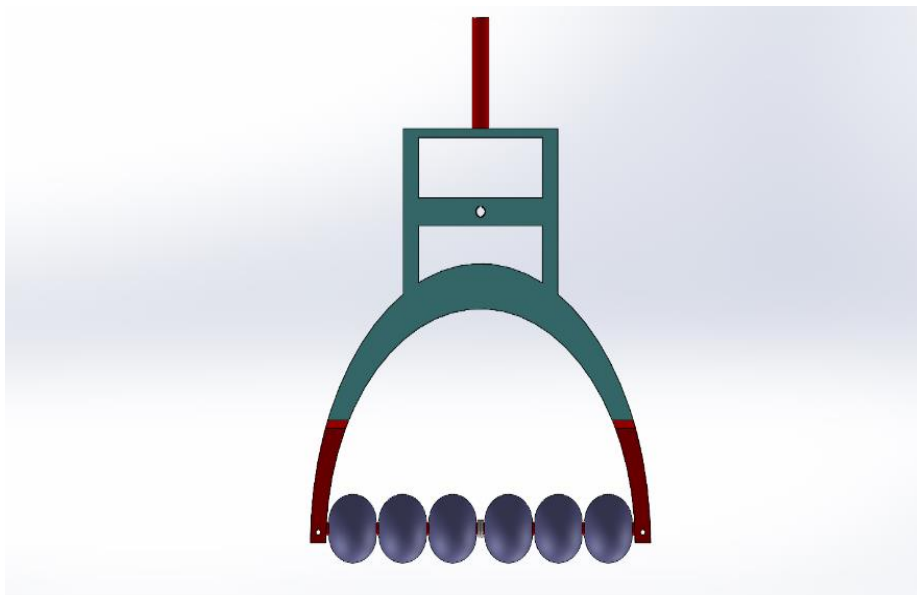


Fig: 4.15: Alternative Design-1 Front View

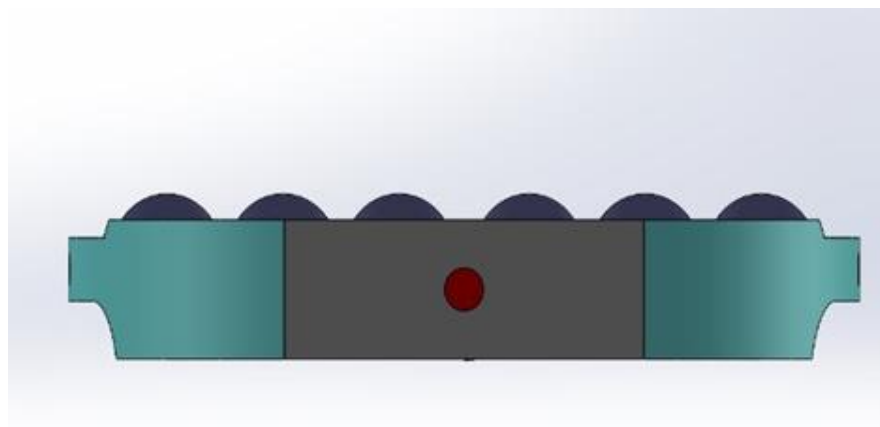


Fig: 4.16: Alternative Design-1 Top View

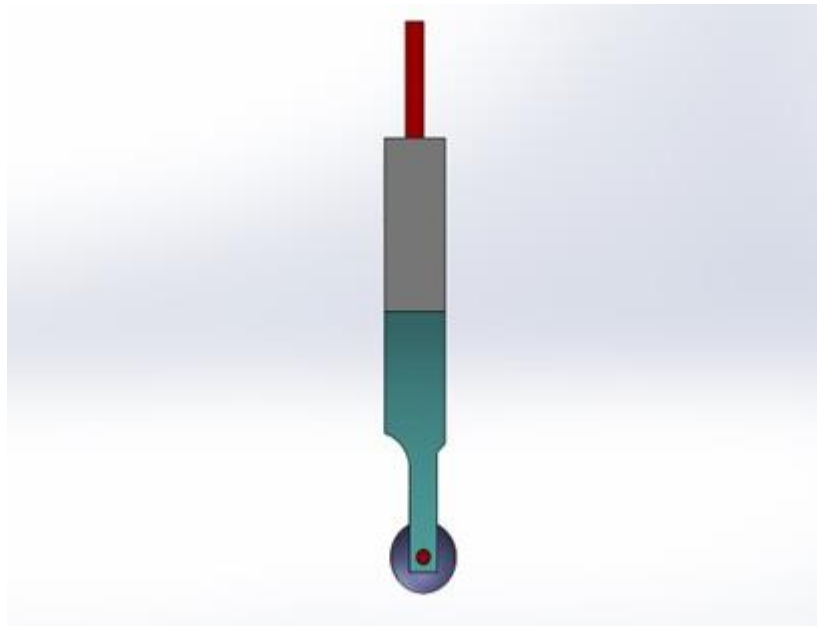


Fig: 4.17: Alternative Design-1 Side View

4.2.3.2 Design-2: -

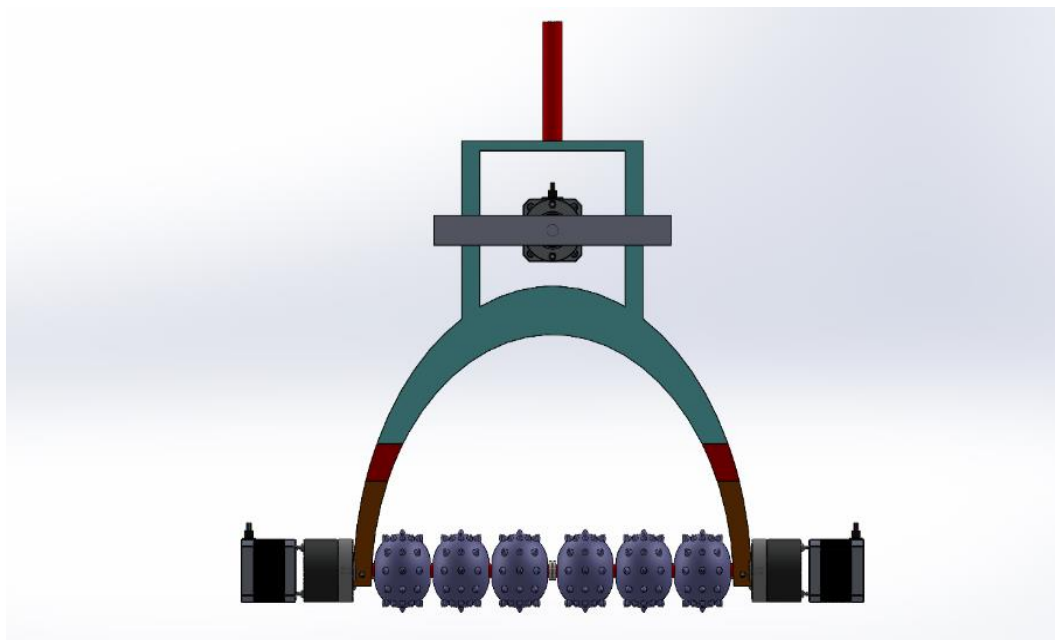


Fig: 4.18: Alternative Design-2 Front View

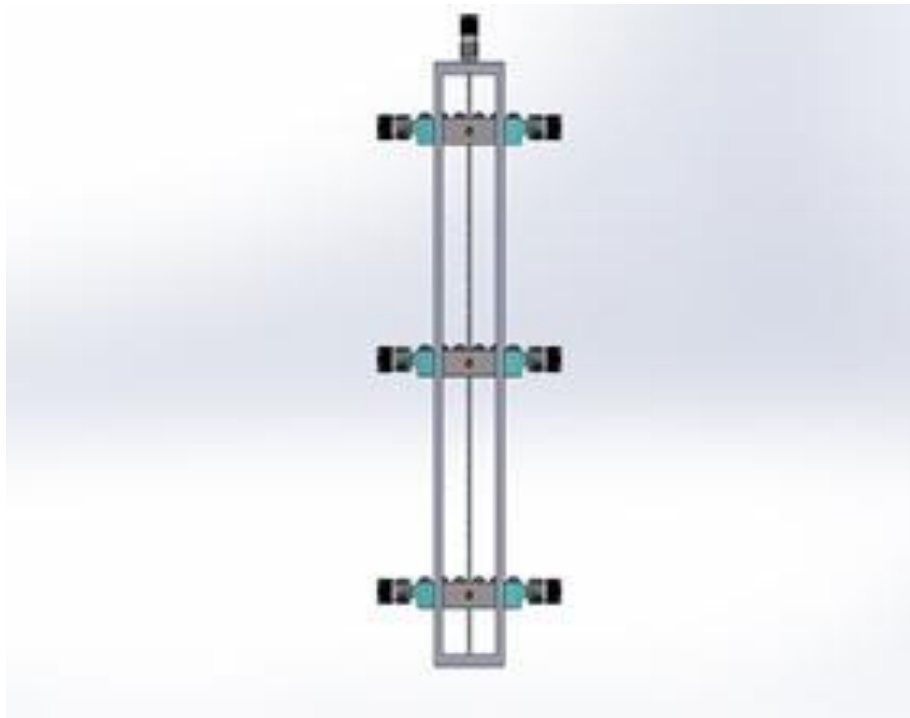


Fig: 4.19: Alternative Design-2 Top View

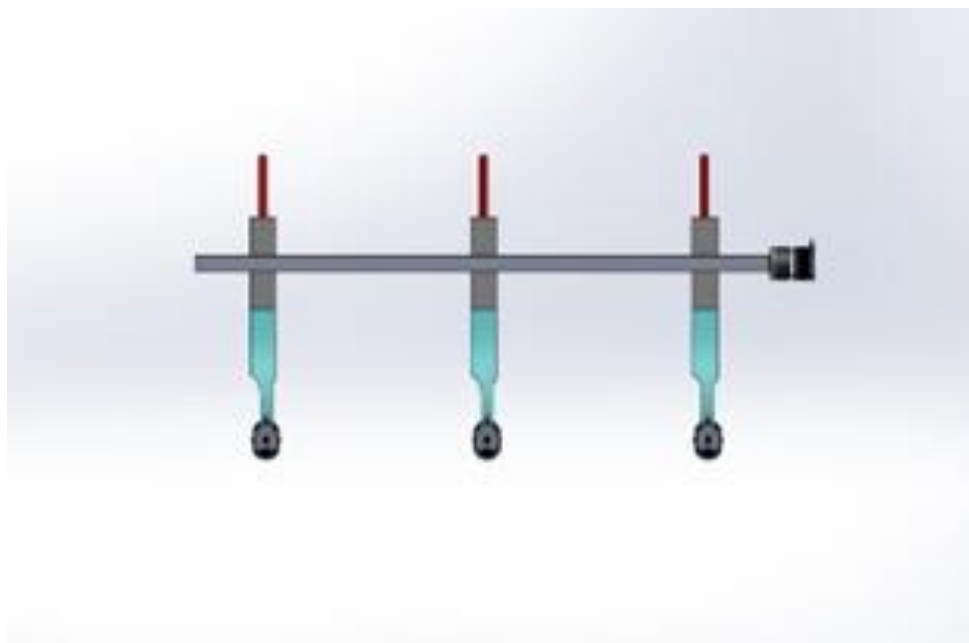


Fig: 4.20: Alternative Design-2 Side View

4.2.3.3 Design-3: -

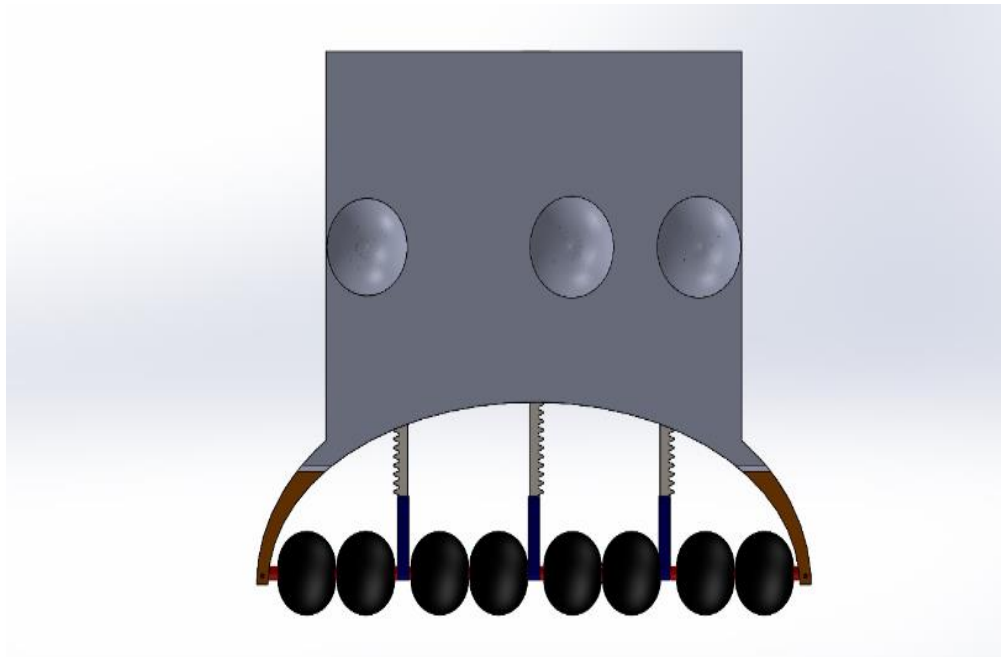


Fig: 4.21: Alternative Design-3 Front View

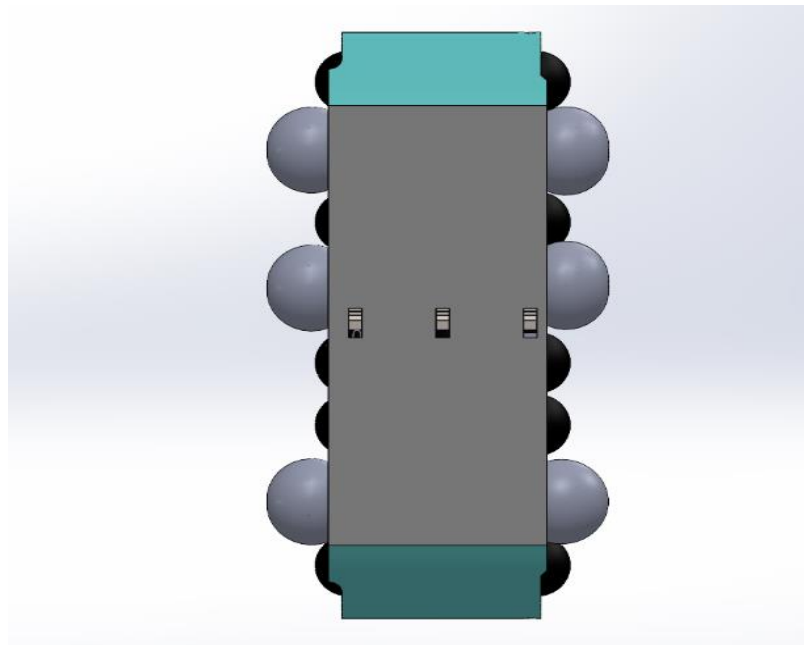


Fig: 4.22: Alternative Design-3 Top View

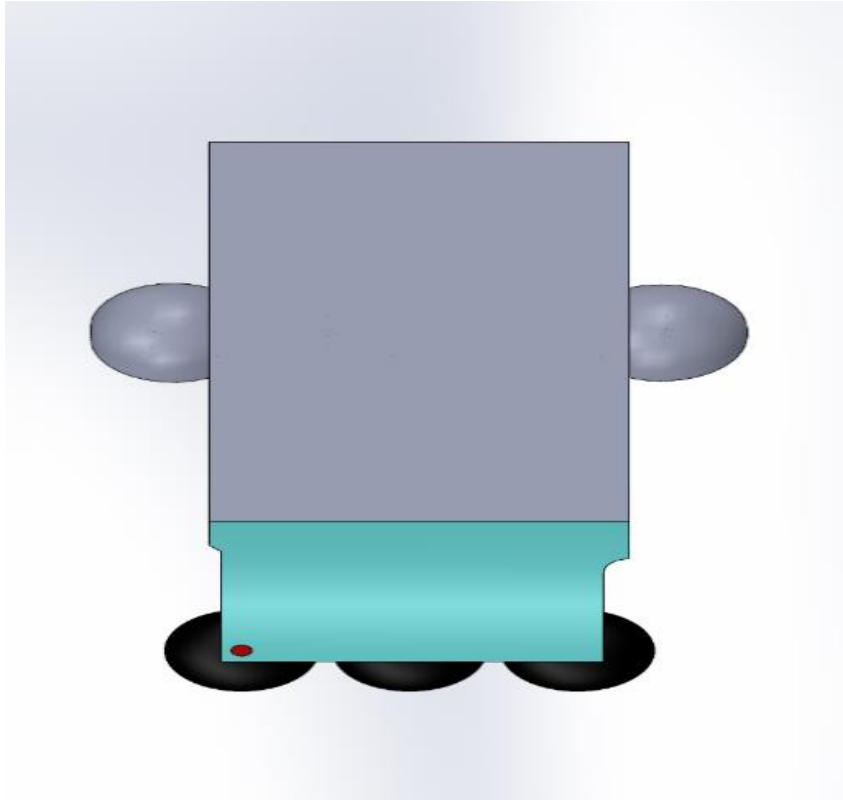


Fig: 4.23: Alternative Design-3 Side View

4.2.4 Finalized Design

The Final design of the Pain Therapy Manipulator is done by the innovation of the part design components. The former design is improved a lot to solve the various problems. The final design is created with the required dimensions and the simulation is performed in the SolidWorks software.

For the final design of the pain therapy manipulator, three to four designs were sketched out on paper with approximate dimensions. One design that felt comfortable and compact was chosen, and some more functions were added to it. The concept has now been accurately modeled in SolidWorks with two FSR sensors, two servo motors, acupressure balls, a rack, a pinion, and an Arduino Nano Board.

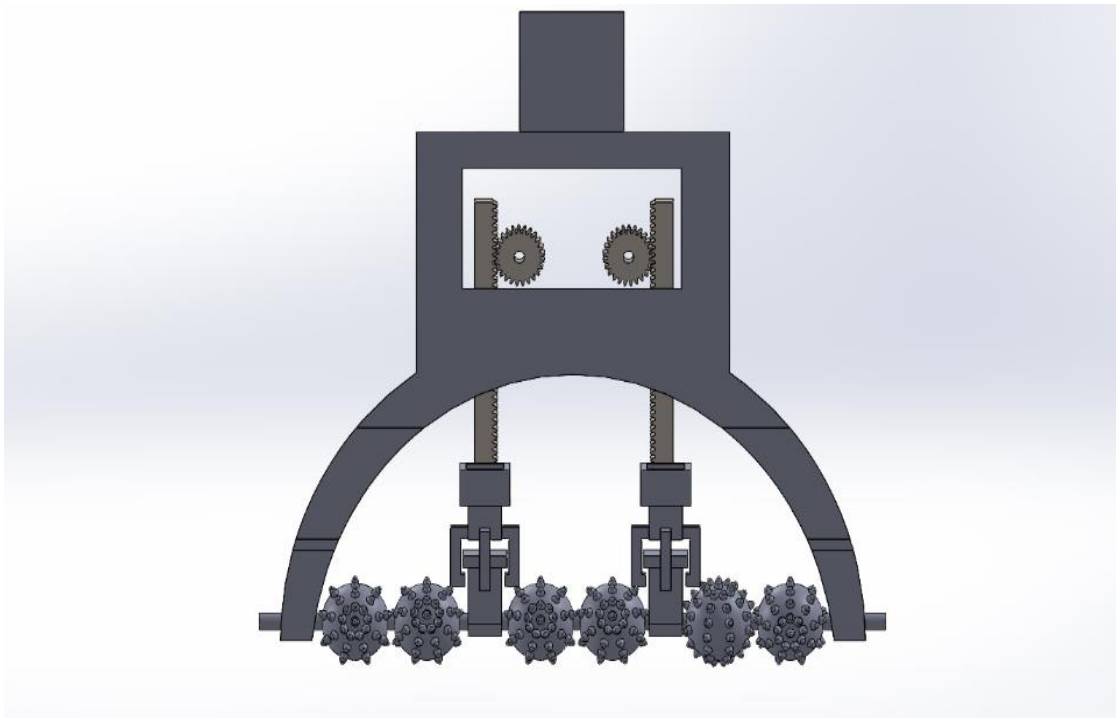


Fig: 4.24: Finalized Design

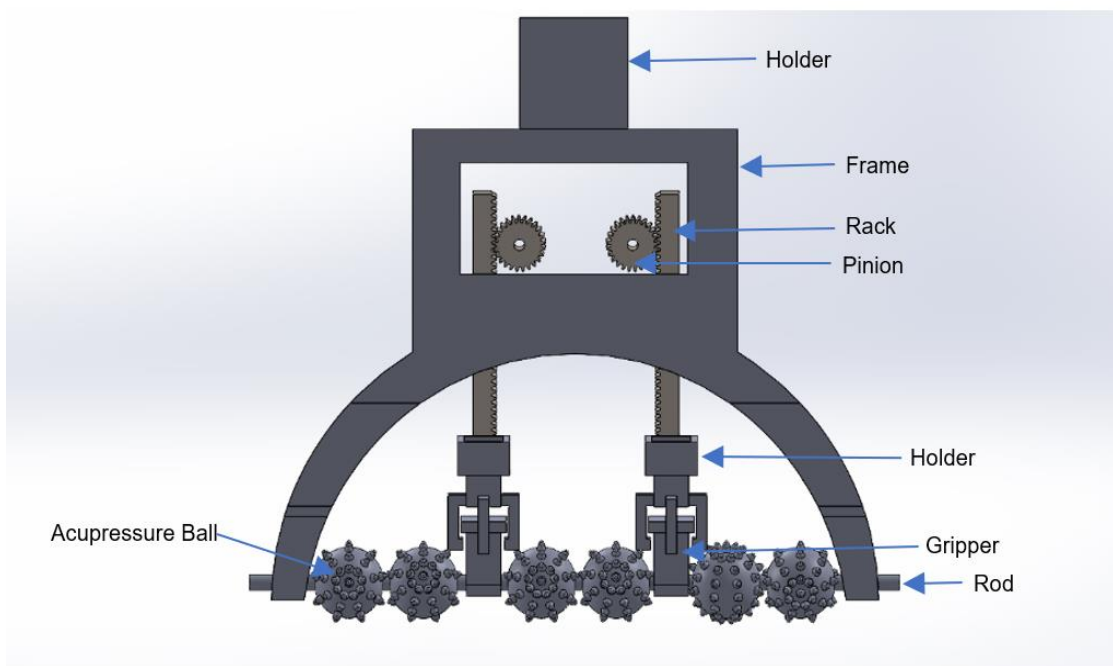


Fig: 4.25: Design Components

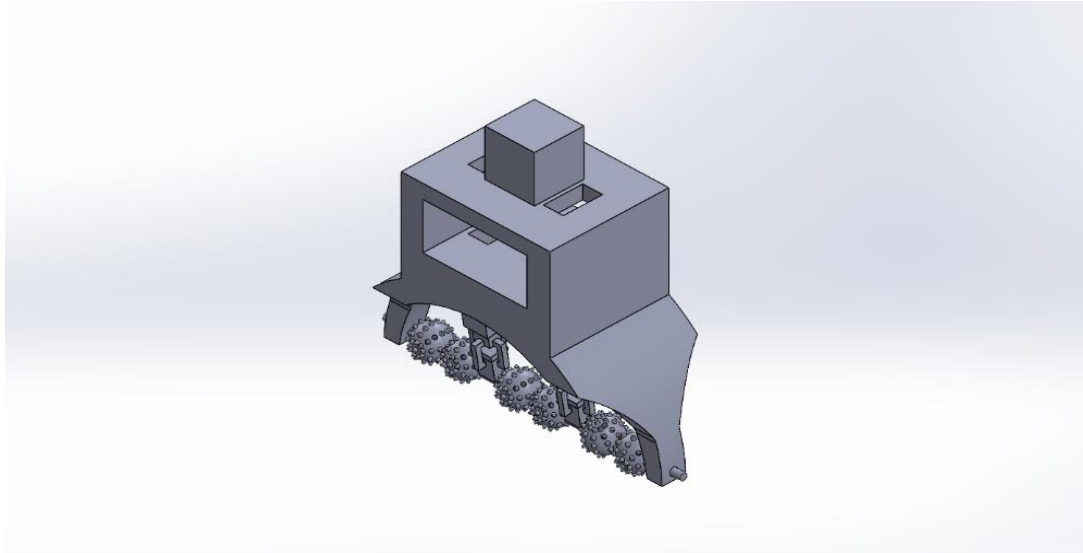
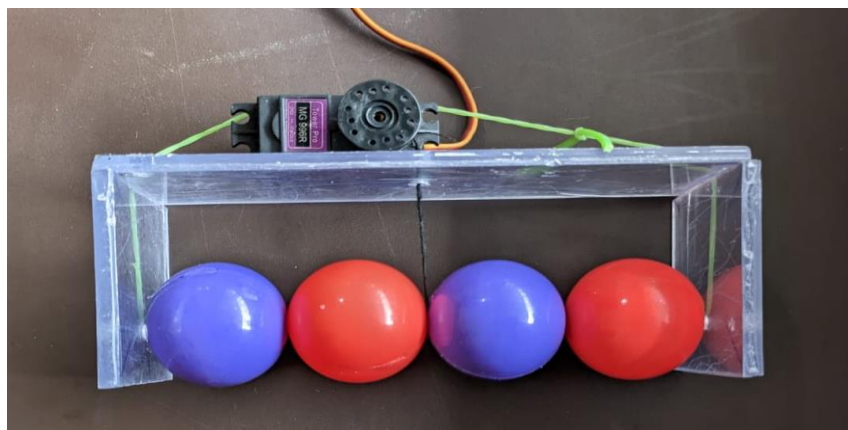


Fig: 4.26: Isometric view of Design

4.2.5 Fabrication:

The Sample prototype is made to test and find out the best elastic/elongating materials for holding the ACU pressure balls in the model. In the initial stage, we made the sample prototype using acrylic sheets, rubber bands hollow plastic balls. The elongation properties of rubber bands give a good result but, in the end, they failed to withstand the weight of the prototype and they started to break while in the test phase.



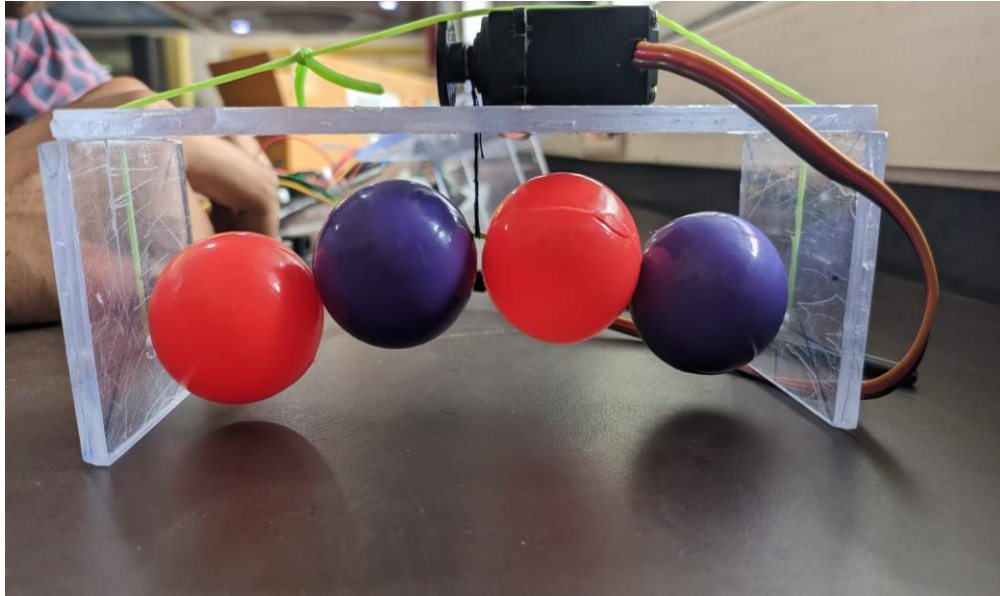


Fig: 4.27: Sample Prototype

After testing elongating various materials and various ways we made the Final Prototype with a Normal clothes hanging elongated thread which is made up of rubber and can withstand high pressure and heavy weight. The final design Prototype is made of assembling different components. Some are purchased directly and some are 3D printed. Here are the images of the components that are used in the prototype.

4.2.5.1 Servomotor



Fig: 4.28: Servomotor

4.2.5.2 Rack and Pinion



Fig: 4.29: Rack and Pinion

4.2.5.3 FSR Sensor

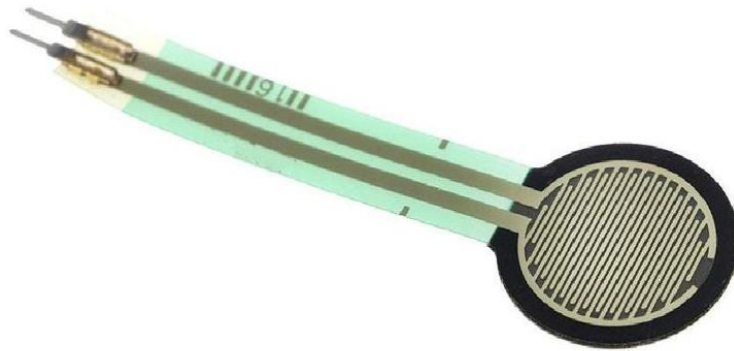


Fig: 4.30: FSR Sensor

4.2.5.4 Gripper (3D Printed Part)

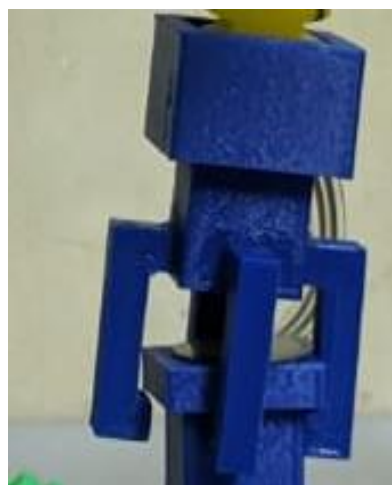


Fig: 4.31: Gripper

4.2.5.5 Holder (3D Printed Part)



Fig: 4.32: Holder

4.2.5.6 Arduino Nano

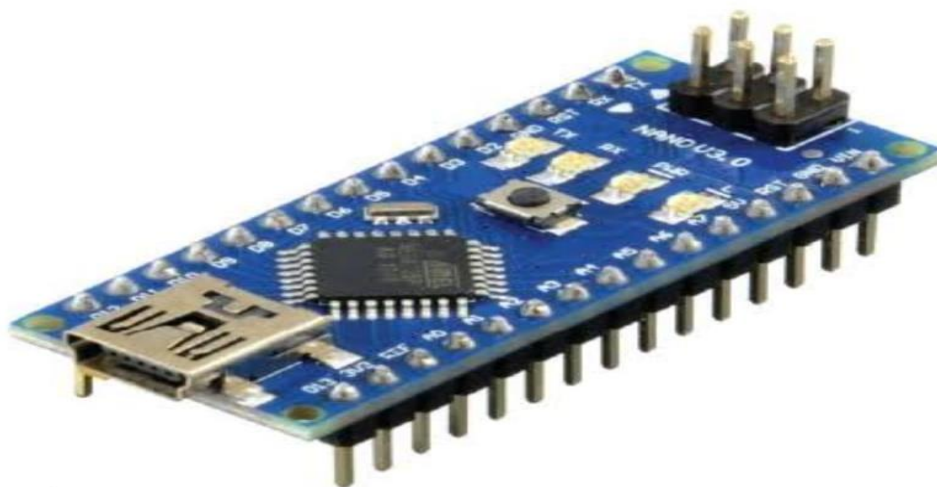


Fig: 4.33: Arduino Nano

4.2.5.7 Acupressure Balls



Fig: 4.34: Acupressure Balls

4.2.5.8 LED Display

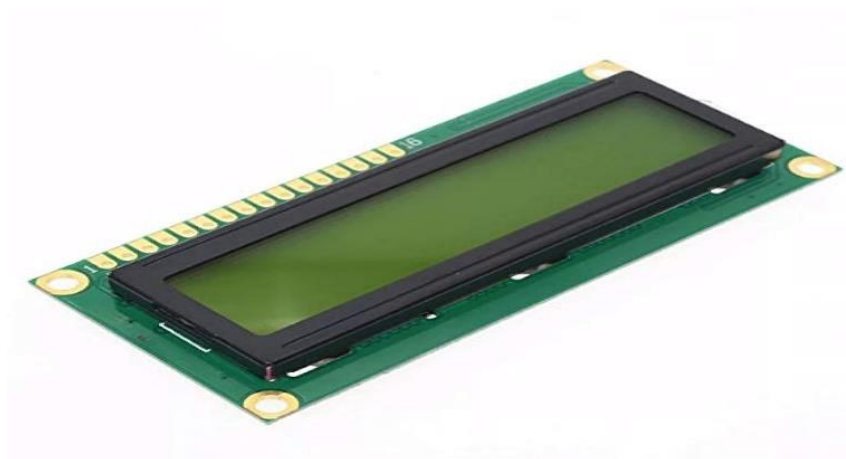


Fig: 4.35: LED Display

4.2.5.9 Battery



Fig: 4.36: Battery

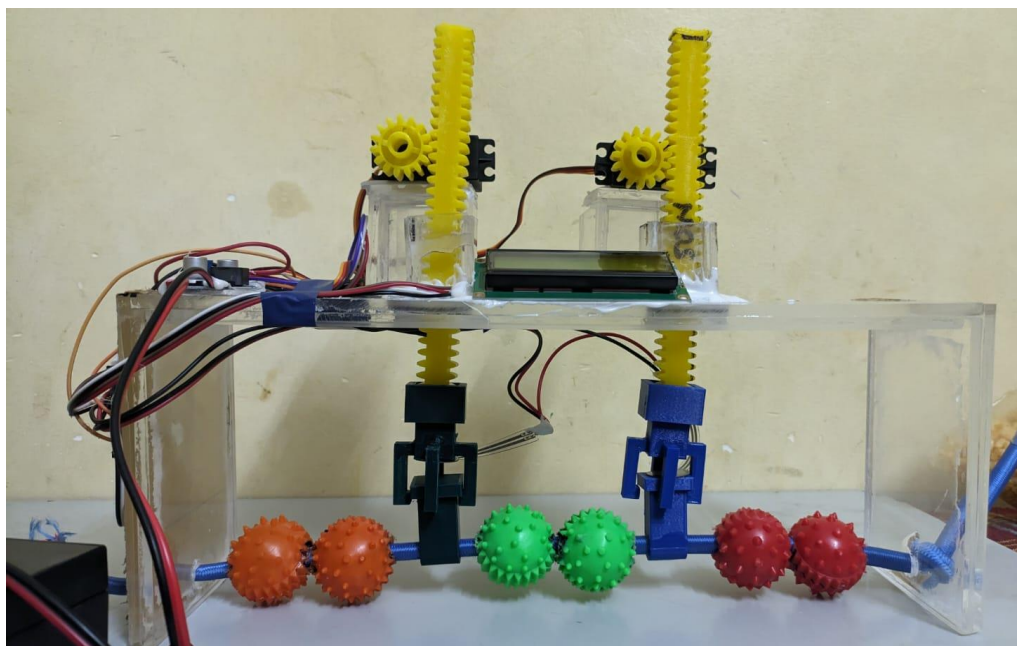


Fig: 4.37: Functioning Prototype Integrated with Arduino

The design is created, and the prototype is fabricated. This is the image of the Working Prototype assembled with all the components. The device is connected to the battery for the power supply. The LED display is connected to show the value of applied pressure on the FSR sensor.

CHAPTER 5

CONCLUSION

The pain treatment manipulator is a revolutionary medical tool that provides non-invasive, efficient, and patient-friendly pain management options. It combines mechanical engineering, biological sciences, and human-centered design to provide precise and effective pain treatment. The project's goal was to develop a versatile and adaptive device capable of treating a wide spectrum of patients and pain disorders. Advanced technology like robots, haptic feedback systems, and real-time monitoring improve the precision and efficacy of pain relief therapies, giving healthcare providers significant information about patient reactions and treatment outcomes.

This multidisciplinary collaboration of professionals in engineering, medicine, and rehabilitation sciences has improved our understanding of pain processes and treatment options. The pain treatment manipulator has the potential to transform pain management by providing hope to millions of people suffering from acute and chronic pain. It minimizes dependency on opioids and enables patients to play an active part in their recovery.

The final model for a robotic arm was created using issue statement identification, assumption mapping, and real-world examples. Surveys were done with older persons and working professionals to better understand their concerns and develop answers. The objective was to design a low-cost, weightless, and pleasant robotic arm that could be used as a massage tool. The study concentrated on the robotic arm's end effector, designing a variety of designs to overcome any difficulties. The design was processed using 3D printed Pla material and then fastened to the arm's end effector. The program was designed to work according to user specifications, guaranteeing that the prototype could be utilized as an effective massage device for the elderly. The design and model were created to provide comfort.

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APPENDIX - 1

AURDINO CODE FOR AURDINO NANO BOARD

```
#include <Wire.h>
#include <LiquidCrystal_I2C.h>

// Set the LCD address to 0x27 for a 16 chars and 2 line display
LiquidCrystal_I2C lcd(0x27, 16, 2);

//////////

const int RunningAverageCount1 = 64;
float RunningAverageBuffer1[RunningAverageCount1], RunningAverageVolt1;
int NextRunningAverage1, i1;

const int RunningAverageCount2 = 64;
float RunningAverageBuffer2[RunningAverageCount2], RunningAverageVolt2;
int NextRunningAverage2, i2;

//////////

#include <Servo.h>

Servo myservo1, myservo2;

int val1, val2;

//////////

int msOp5 = 0;

char update_flag = 0;

int force1, force2;
```

```

unsigned char pos1, pos2;

void setup()
{
  Serial.begin(9600);

  myservo1.attach(9);
  myservo2.attach(10);

  //////////

  // initialize the LCD
  lcd.begin();

  // Turn on the backlight and print a message.
  lcd.backlight();

  //////////

  cli();//stop interrupts

  //set timer0 interrupt at 2kHz
  TCCR0A = 0;// set entire TCCR2A register to 0
  TCCR0B = 0;// same for TCCR2B
  TCNT0 = 0;//initialize counter value to 0
  // set compare match register for 2khz increments
  OCR0A = 124;// = (16*10^6) / (2000*64) - 1 (must be <256)
  // turn on CTC mode
  TCCR0A |= (1 << WGM01);
  // Set CS01 and CS00 bits for 64 prescaler
  TCCR0B |= (1 << CS01) | (1 << CS00);
  // enable timer compare interrupt
  TIMSK0 |= (1 << OCIE0A);

```

```

/*
//set timer1 interrupt at 1Hz
TCCR1A = 0;// set entire TCCR1A register to 0
TCCR1B = 0;// same for TCCR1B
TCNT1 = 0;//initialize counter value to 0
// set compare match register for 1hz increments
OCR1A = 15624;// = (16*10^6) / (1*1024) - 1 (must be <65536)
// turn on CTC mode
TCCR1B |= (1 << WGM12);
// Set CS12 and CS10 bits for 1024 prescaler
TCCR1B |= (1 << CS12) | (1 << CS10);
// enable timer compare interrupt
TIMSK1 |= (1 << OCIE1A);

//set timer2 interrupt at 8kHz
TCCR2A = 0;// set entire TCCR2A register to 0
TCCR2B = 0;// same for TCCR2B
TCNT2 = 0;//initialize counter value to 0
// set compare match register for 8khz increments
OCR2A = 249;// = (16*10^6) / (8000*8) - 1 (must be <256)
// turn on CTC mode
TCCR2A |= (1 << WGM21);
// Set CS21 bit for 8 prescaler
TCCR2B |= (1 << CS21);
// enable timer compare interrupt
TIMSK2 |= (1 << OCIE2A);
*/
sei();//allow interrupts
}

ISR(TIMER0_COMPA_vect)
{
  ++ms0p5;

```

```

if(msOp5 > 200)
{
    update_flag = 1;

    msOp5 = 0;
}
}

void loop()
{
    RunningAverageBuffer1[NextRunningAverage1++] = analogRead(A2);
    if(NextRunningAverage1 >= RunningAverageCount1)NextRunningAverage1 = 0;
    RunningAverageVolt1 = 0;
    for(i1=0; i1< RunningAverageCount1; ++i1)RunningAverageVolt1 +=
RunningAverageBuffer1[i1];
    RunningAverageVolt1 /= RunningAverageCount1;

    RunningAverageBuffer2[NextRunningAverage2++] = analogRead(A3);
    if(NextRunningAverage2 >= RunningAverageCount2)NextRunningAverage2 = 0;
    RunningAverageVolt2 = 0;
    for(i2=0; i2< RunningAverageCount2; ++i2)RunningAverageVolt2 +=
RunningAverageBuffer2[i2];
    RunningAverageVolt2 /= RunningAverageCount2;

    if(update_flag == 1)
    {
        val1 = (int)RunningAverageVolt1;
        val2 = (int)RunningAverageVolt2;

        force1 = map(val1, 0, 900, 0, 9999);
        force2 = map(val2, 0, 900, 0, 9999);

        pos1 = map(val1, 0, 300, 0, 180); if(pos1 > 180)pos1 = 180;
        pos2 = map (val2, 0, 300, 0, 180); if (pos2 > 180) pos2 = 180;

```

```

myservo1.write(pos1);
myservo2.write(pos2);

lcd.setCursor(0, 0);
lcd.print("Force1: ");
    if (force1 < 10) lcd.Print(" ");
    else if (force1 < 100) lcd.Print("");
    else if (force1 < 1000) lcd.Print(" ");
    lcd.Print(force1);
    lcd.print(" g ");
    lcd.setCursor(0, 1);
    lcd.print("Force2: ");
    if (force2 < 10) lcd.print(" ");
    else if (force2 < 100) lcd.print("");
    else if (force2 < 1000) lcd.print(" ");
    lcd.print(force2);
    lcd.print(" g ");

    update_flag = 0;
}
Delay(10);
}

```

APPENDIX – 2
CERTIFICATE OF RESEARCH PAPER



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ROBOTICS IN ASSISTIVE DEVICES FOR PAIN THERAPY – A REVIEW

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ABSTRACT

Chronic pain is a major global healthcare challenge, affecting millions of people and lowering their quality of life. Traditional methods, such as medications and physical therapy, have demonstrated some efficacy, but there is growing interest in using robotics and assistive devices to revolutionize pain therapy. This review article looks at the current state of robotics in pain therapy assistive devices, focusing on emerging trends, challenges, and potential future directions.

KEYWORDS: - Robotics, Pain, Pain Therapy, Assistive Devices, Medical Robotics, Robotics in Healthcare

INTRODUCTION: -

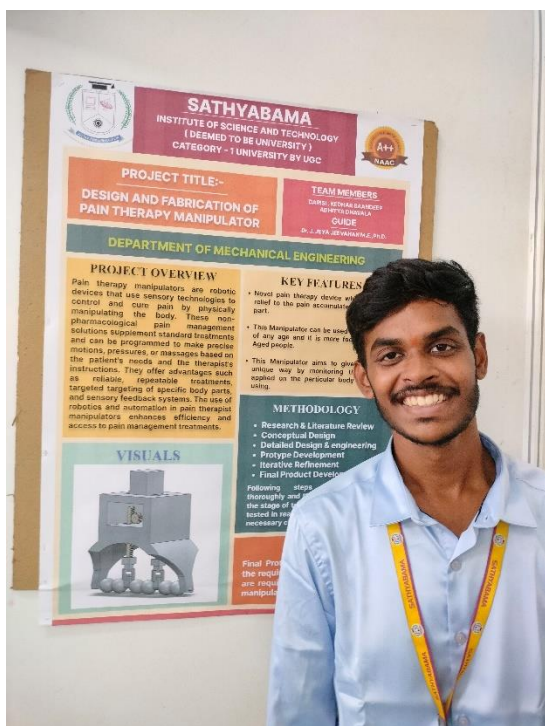
Pain in older adults is a complicated issue with many different causes. Individuals' bodies change physiologically as they age, which contributes to the development of pain. Osteoarthritis, neuropathy, and fibromyalgia are all common causes (Reid et al., 2015). Fractures can be caused by age-related conditions such as osteoporosis, which are significant sources of pain in the elderly. Pain is also caused by chronic illnesses such as cancer and heart disease (Redfield et al., 2018). Medications used to treat these conditions may have side effects that cause pain. Depression and anxiety, for example, can exacerbate pain in older adults, while social isolation and loneliness can influence pain perception (Dale & Stacey, 2016). Because of communication difficulties and misconceptions about pain being a natural part of aging, pain in the elderly may go unreported and untreated. Comprehensive assessments and individualized care must be used by healthcare providers (Dale & Stacey, 2016).

Assistive devices are tools, technologies, or equipment that help people with disabilities improve their independence and quality of life (Sidhu et al., 2020). They come in a variety of shapes and sizes, serve a variety of functions, and are classified based on their intended function (Saborowski & Kollak, 2015). Wheelchairs, walkers, canes, speech-generating devices, hearing aids, cochlear implants, assistive listening devices, screen readers, magnifiers, Braille displays, adaptive utensils, dressing aids, teachers, cognitive impairments, memory issues, smart home systems, computer software, apps are examples of assistive technology (Meshram et al., 2019). These devices assist individuals with mobility impairments in moving around independently, assisting with speech and communication difficulties, amplifying sound or providing clearer audio, assisting with visual impairments, assisting with daily tasks, and promoting inclusivity (Karadagur Ananda Reddy et al., 2017). Technological advancements continue to broaden the range and effectiveness of these devices, creating new opportunities for independence (Leo et al., 2017).

The robotic pain therapy device is a game-changing advancement in medical technology that provides a personalized, real-time approach to pain management (Geenen et al., 2018). It adapts and evolves its therapy based on the patient's specific needs using advanced artificial intelligence and robotics technology (Hashimoto et al., 2020). The device continuously assesses pain levels and adjusts therapy using sensors, machine learning algorithms, and biofeedback mechanisms (Artificial Intelligence, Machine Learning and Reasoning in Health Informatics—Case Studies, n.d.). It differs from other pain relief methods due to its non-invasive nature, which includes gentle massage, targeted pressure point stimulation, and thermal therapy. Because the device is highly portable, patients can receive therapy whenever and wherever they need it (O'Connell et al., 2018). It is controlled by a simple mobile app, allowing patients to tailor their pain management experience. This device has the potential to significantly improve people's quality of life (Lee et al., 2018).

APPENDIX – 3

TECHNOVATION PHOTO



APPENDIX – 4

PATENT INFORMATION

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Sr No.	CBR No.	Reference Number /Application Type	Application Number	Title/Remarks	Amount Paid
1	17389	ORDINARY APPLICATION	202441018453	A NOVEL PAIN THERAPIST ROBOTIC END EFFECTOR FOR APPLYING MASSAGING TO DIFFERENT PARTS OF OUR BODY	1750
2		E-2/1365/2024-CHE	202441018453	Form2	0
3	17389	E-12/2988/2024-CHE	202441018453	Form9	2750
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APPENDIX - 5
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