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Design and Implementation of a Knee Rehabilitation Device

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Annotation: Rehabilitation procedures aim to regain normal bodily functions and promote independence in daily living activities while enhancing the limbs' remaining sensorimotor functions. The project consist of a mechanical part that used to move the leg and a control panel used to control the device from time and the strength of the move. The test results shown a good accuracy about 77% according to the tests that made on a healthy male aged 21 years old. For future work it will be add a microcontroller to control the system and add an ankle test rehabilitation.

Keywords: Knee rehabilitation, physiotherapy, motorized rehabilitation device, sensorimotor function, rehabilitation technology, mobility recovery.

CHAPTER 1

General Introduction

1. Introduction

The device features an adjustable speed setting, thus allowing the progression of the patient to be catered for by starting off slow and gradually increasing in speed as the strength and mobility of the limb improves. This will prevent a one-size-fits-all rehabilitation pace being set that often overwhelms patients in the early stages of rehabilitation and is too slow in the later stages.

Traditionally, physiotherapy and rehabilitation methods are tedious and time-consuming processes that many patients struggle to stay motivated for. The purpose of the device proposed in this report is to make rehabilitation a more enjoyable and interesting process for the patient, to increase their adherence to the rehabilitation regime, thus improving the functionality of the limb in the long run. This is achieved through replacing the monotonous and boring exercises with a mechanical system that simulates the action of walking. This will provide the patient with a goal-directed task similar to walking to follow and thus increase their motivation to carry out the rehabilitation exercises.

Looking at the lower leg and foot is very important as it allows us to get from place to place, to lift heavy objects and generally execute patterns of movement that are goal-directed. Due to the importance of the lower limb, it is particularly devastating when one injures the limb, becomes otherwise disabled, or is faced with an amputation. The way in which we treat an injury or amputation has large implications as to how well one will be able to function post-treatment. With the recent wars in Iraq and Afghanistan, the number of leg amputations has sharply increased, and thus so has the demand for improved rehabilitation techniques and devices. This report will look at a novel idea for a lower leg and foot rehabilitation device to be used in the treatment of injury or amputation of th foot and ankle.

Figure 1.1. A typical mobilization and stretch movement for the hip, knee and ankle applied by a therapist.

1.1 Purpose of the Device

The device must be portable to the extent that it can be easily moved to the patient's location, such as a hospital bed, therapy table, or, in some cases, a patient's home. A low-cost, easy-to-use, and maintainable design is also desirable.

The device aims to capture all these types of muscle functions using an actuator to apply a force to move the patient's limb through various patterns resembling the many functional tasks a person may perform with their leg and foot. This device should be capable of being adjusted to accommodate a wide range of patients, from a small child to a large adult, with varying levels of muscle strength. Ideally, there should be a minimum number of mechanical changes between adjustments.

The purpose of the device is to provide a means for patients to rehabilitate their leg and foot muscles as closely as possible to normal human movement. Humans move through alternating patterns of motion at their joints by flexing or extending their muscles (agonist and antagonist) which move the joint. Certain muscles, usually the ones furthest from the torso, function to create a moment (or braking) force to hold a joint steady, allowing other muscles to move a limb. Here again, muscle groups alternate this function at a particular joint. Many movements are involuntary or semi-voluntary, such as when a person walks or climbs stairs, where the limb is guided by an external force such as the terrain it is crossing.

CHAPTER 2

THEORETICAL BACKGROUND

A planar hybrid manipulator system for a foot-plate-based lower limb rehabilitation robot, featuring a passive serial orthosis was presented. The system is modular and can be easily upgraded to a standing-type body weight support mechanism. The rehabilitation strategy is described, and the mechanism's effectiveness is demonstrated using a clinical gait pattern and a real-time prototype. Prototype experiments are conducted to validate the prototype's performance [1].

This review paper summarizes recent developments in robotics, particularly in ankle rehabilitation, using a literature search using scientific and medical databases. The study analyzed studies from the 1950s to present, focusing on various types of rehabilitation robots and their architecture and design features. Despite differences in architectures, only a few have been commercialized. Most rehabilitation robots allow planarflexion-dorsiflexion movements, but most wearable robots do not allow adduction-abduction movement. The design stage also often does not consider the physical appearance or user's perception, limiting the possibility of successful commercialization. The main challenges in robot rehabilitation include the lack of unique protocols for all patient types and the need for additional resources to measure the effectiveness of proposals not yet commercialized. The main design challenges are the incommodities in robot architecture, adaptability to patient needs, and the lack of commercialization and personal use [2].

This paper proposes a wearable parallel mechanism for ankle rehabilitation, reducing the burden on therapists and patients. Kinematic analysis is used to develop performance indices, including reachable workspace index, motion isotropy index, force transfer index, and maximum torque index. The mechanical structure includes a basic machine-drive system and a multi-model position/force data collection system. The performance evaluation shows the wearable parallel robot has sufficient motion isotropy, high force transfer performance, and large maximum torque performance within a large workspace, making it suitable for ankle rehabilitation [3].

A foot/ankle monitoring system which consists of a Controlled Ankle Motion (CAM) boot, a microcontroller, sensors, and a web application was proposed. The microcontroller with the sensors on the CAM boot monitors and analyzes exerted weight, humidity, acceleration, and angular velocity of a patient’s injured foot or ankle during the recovery phase. The sensor values are sent wirelessly to a database and visualized on a web application. The proposed system will benefit doctors and patients in rehabilitation. The patients can gain a better understanding of how to follow through with the treatments and the doctors can monitor patient movements even after having left the hospital [4].

CHAPTER THREE

METHODOLOGY

3.1. Introduction

This chapter describes the design methodology followed during the design and development of the rehabilitation system. The chapter describes the parameters that were considered and each

subsystem that resulted in the final design.

3.1. List of Component:

1- Mechanical part

2- Motor

3- Control panel

2.1.1 Hardware Component:

- Mechanical part: this part consists of a iron bar that used to move the support cushion as shown in figure 2.1.

Figure (2.1) Mechanical part

- Motor: The motor used to move the mechanical part forward and backward to make a good rehabilitation the motor shown in figure 2.2.

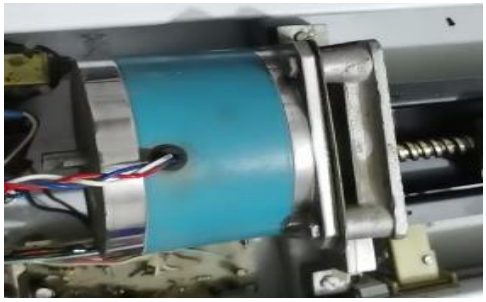

Figure 2.2. The motor

- Control panel: the control panel used to control the strength of the movement and the time as shown in figure 2.3.

Figure 2.3. Control panel

CHAPTER FOUR

RESULTS

4.1. Introduction:

In this project, we used simple, low-cost components to create an easily usable device that analyzing the effectiveness, safety, and usability of a leg rehabilitation device typically involves evaluating various factors such as clinical outcomes, user satisfaction, and technical performance. Here's how analytical results might be approached for each of these aspects:

Clinical Trials: Analyzing data from clinical trials can provide insights into the device's effectiveness in improving patient outcomes, such as mobility, strength, and functional abilities. Also, outcome Measures: Assessing quantitative measures before and after using the device, such as range of motion, muscle strength, gait analysis, and quality of life scores. Furthermore, the usability: which is user feedback: Analyzing feedback from users, including patients, therapists, or caregivers, regarding the device's ease of use, comfort, intuitiveness, and overall satisfaction.

4.2. Working principle:

The device system will work using a motor that will move the leg and return it many times.

Table 4.1. The accuracy

Parameters	Test 1
Total number of experiment	100
TP	76
FP	5
TN	14
FN	5
Precision (%)	77
Recall (%)	77
Accuracy = $\mathbf{2 \times \frac{recall * precision}{recall + precision} \times 100\ \%}$	77

CHAPTER FIVE

CONCLUTION

5.1. Conclusion

Rehabilitation procedures aim to regain normal bodily functions and promote independence in daily living activities while enhancing the limbs' remaining sensorimotor functions. The project consist of a mechanical part that used to move the leg and a control panel used to control the device from time and the strength of the move. The test results shown a good accuracy about 77% according to the tests that made on a healthy male aged 21 years old. For future work it will be add a microcontroller to control the system and add an ankle test rehabilitation.

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