Automatic Regulation and Monitoring of CPM Machine

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ABSTRACT

The aim of this project is empowered by adding independency to the individuals during Continuous Passive Motion. In this project, a Continuous Passive Motion (CPM) Machine is designed that will enable the patient to move their leg continuously. This project is for measuring the muscle oxygen of the patient who is using CPM and to control the motion. The oxygen level is measured by using the Near-Infrared spectroscopic principle and is attached as a device to the patient and it continuously monitors the oxygen level. This is performed after surgeries like total knee replacement and anterior circulate ligament reconstruction. Patient who has undergone these surgeries must be treated with CPM machine. But the machine could not identify the tearing of the muscles during the procedure and this could lead to post-surgical trauma. To prevent these damages to the muscles NIRS is attached to this mechanism. It detects the oxy-hemoglobin level in the tissues and stops the machine when the muscle oxygen reaches the threshold value (90 mmHg). The potentiometer is used to vary the oxygen level manually since the oxygen level below the threshold cannot be measured practically. The machine continuously works when the oxygen level is above the threshold. Moreover, ESP8266 module is used to monitor the oxygen level continuously and the data is stored in the cloud for future references.

INTRODUCTION

Passive motion is movement generated by an outside source and does not require the activation of muscles. Repetitive passive motion for rehabilitation can be done be either a physical therapist or a continuous passive motion (CPM) machine. The CPM machine flexes and extends the patient's knee for a specified time, range, and velocity. Physical therapists instruct patients to adjust the range and the velocity of the CPM to values that do not cause pain. A CPM machine treatment methodology can standardize the machine parameters to ensure an effective and efficient post-operative physical therapy. The type of surgery, severity of the injury, and activity level can affect the duration of the post-operative physical therapy. While exercising, muscles work harder which creates an increased demand for oxygen. As a result, breathing becomes heavier and heart rate increased in order to pull more oxygen into the blood stream.

LITERATURE REVIEW

1. T. Kuźmierowski (2017) in this paper defines the design assumptions for the construction of an original demonstration of a CPM device, based on which a solid virtual model will be created in a CAD software environment.
2. Somkiat Tangjitsitcharoen (2018)After knee replacement surgery, rehabilitation is needed to recover to normal levels of mobility. A continuous passive motion (CPM) machine is usually introduced at this stage to aid rehabilitation.
3. Ngoc-Bich Le(2013)authors' afford is to solve three basic problems remaining in current Knee Continuous Passive Motion (CPM) machine, that is designing to reduce production costs in accordance with the conditions of adaptive design to help minimize relative sliding between leg, thigh.
4. In this study, a new, light, and portable CPM machine with an appropriate interface, is designed and manufactured. The knee joint can be rotated from the range of 150 to 1200 with a pace of 0.1 degree/sec to 1 degree/sec by this machine. One of the most important advantages of this new machine is its own user-friendly interface.
5. NIRS monitoring is commonly used to measure cerebral oxygenation (rSO2). In this review, we will show that tissue hypoxia occurs frequently in the perioperative setting, particularly in cardiac surgery.

EXPERIMENTAL PROCEDURE CONTINUOUS PASSIVE MOTION MACHINE

Passive motion is movement generated by an outside source and does not require the activation of muscles. Repetitive passive motion for rehabilitation can be done be either a physical therapist or a continuous passive motion (CPM) machine. Physical therapists commonly prescribe patients to use a CPM machine at home for the weeks following surgery. The CPM machine flexes and extends the patient's knee for a specified time, range, and velocity. Physical therapists instruct patients to adjust the range and the velocity of the CPM to values that do not cause pain. Efficient rehabilitation requires that the patient adjusts the input parameters on a daily basis based on pain tolerance. However, these variables currently have no standard for the CPM machine treatment.

Therefore, there is a need to determine an effective physical therapy treatment methodology using a CPM machine. A CPM machine treatment methodology can standardize the machine parameters to ensure an effective and efficient post-operative physical therapy. A physical therapy treatment methodology can have several dependent factors The type of surgery, severity of the injury, and activity level can affect the duration of the post-operative physical therapy. The patient characteristics (e.g. gender, size, and weight) can also be contributing factors in determining the range of motion or velocity of CPM. The duration of the treatment, the range of motion, and the knee flexion velocity are the parameters that can change in order to optimize the physical therapy treatment.

CONSTRUCTION

The CPM device has two 4-bar linkages similar to that of the commercially available devices. A linear slider driven by a stepper motor controls the motion of the slider-rocker linkage. The motion of the double-rocker linkage controls the angle of knee flexion. The device is capable of 120 degrees of rotation at angular velocities from 30 to 750 degrees per minute. The device is made almost entirely of 6061-T6 aluminium.

The linear slider came equipped with a 24V stepper motor. The device has closed-loop control with a constant power supply. The output current of the power supply can adjust the speed of the device. In order to change rotational direction of the linear slider (i.e., flexion/extension), the direction of current can be reversed by switching the leads on the power supply.

The CPM Machine is derived by the stepper motor in a controlled motion. The NIR Sensor is connected to the patients in the toe, which is connected to the Arduino board. The L293driver module is connected to the Arduino with the stepper motor which is connected to the CPM machine. The threshold is set before attaching the sensor to the patients and when the NIR Sensor senses the muscle o2 level in the patient while exercising, if the patient analysed below the threshold level the CPM Machine automatically stops else the machine runs continuously. Potentiometer is used for the voltage divider and control the speed of the stepper motor.

RESULT AND DISCUSSION

The CPM Machine is designed by using the aluminium shaft materials. The stepper motor is connected to the CPM Machine and control of the stepper motor is by using the L293 Driver module. The movement of the legie., forward and backward by changing the directions of the stepper motor in clockwise and anticlockwise direction. With the help of NIR Sensor, the muscle oxygen level is continuously measured. The threshold value is fixed by arduino program. These results are viewed in the monitor by using ESP8266 module.
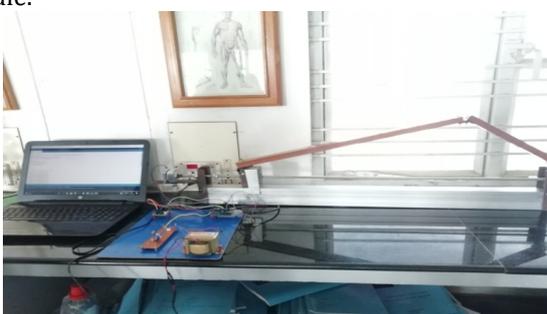
CONCLUSION

Many basic fundamental researches and development challenges remain in linear actuator development, NIR Sensor development, control and to assemble in a disciplined manner. This project has focussed on the NIR Sensor based automatic control of the CPM Machine when the muscle oxygen level gets decreased during the continuous movement (exercises) the NIR Sensor senses the level and if it is below the threshold value(90mm/Hg) the machine automatically stops else the machine runs continuously. The stepper motor is used to drive the CPM Machine which is connected to the Arduino board. The L293Driver module is used to protect the back EMF from the motor. Thus the analysis of the patients are addressed in the command windows, can be seen in our mobile via internet.

FUTURE WORK

The musical system can be placed for the children in the CPM machine while exercising so the child will be more enthusiastic in doing it without any hesitation. It may be made wearable device for our convenience. It can be worn while exercising also in future.

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