

KneeTwister

laxity and angle measurement

abstract

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KneeTwister, laxity and angle measurement

This abstract is taken from the report *KneeTwister, laxity & angle measurement* written at June 1, 2005. The report is written under supervision of dr. ir. P. Holmes and ing. F. Cook. It represents the results of device developed and implemented at the Unit of joint reconstruction, RJAH Orthopaedic Hospital, Oswestry, United Kingdom.

The KneeTwister is a device which will be used to measure the laxity in the knee joint. It also measures the angle between the upper and lower leg during an internal and external rotation.

Problem situation

The knee is one of the most complex and traumatized joints of the human body. Surgeons need to know the amount of damage before surgery and the improvements the patient makes after the surgery. The task of the KneeTwister is to provide a reproducible score in the form of the amount of laxity.

Problem definition

The main demands for the KneeTwister are:

- Measure the momentary angle between two reference points in space.
- Measure the force applied to the leg.
- Calculate the laxity from these measured values.

Assignment

Develop an electronic device which fits the following needs:

- Measures the range of rotation between the upper and lower leg.

- Can be operated by one staff member, is simple to operate.
- Standardizes the measurement by relating the outcome to the applied force.
- Is small, mobile and battery powered.
- Displays the outcome on a LCD display.

Objectives

The main objective of this assignment is to design a working prototype that is equipped with all functions that the surgeons have requested. Users must be able to easily operate the device by using a simple user interface. The dimensions of the device have to be small enough to take it along with them.

Method of approach

To measure the angle between the upper and lower leg accelerometers are used. Accelerometers can be used to calculate the angle between the accelerometer and the gravitational force. By measuring the angle to ground of 2 accelerometers the relative angle can be calculated. The amount of force applied to the leg is measured by pressing a metal bar. A Hall-sensor is exposed to a magnetic field and the strength of this magnetic field is proportional to the pressure on the metal bar. The sensor will give a voltage which is proportional to the applied force.

The signals of the accelerometers are relatively small and disturbed by noise. First these signals are filtered to separate the noise from the actual signals. After this the signals are amplified to voltage levels usable for the microcontroller. To save components and power consumption every signal uses the same amplification circuit. For the individual signals the characteristics of the amplification are set differently to obtain the optimum signal levels. The design of the hardware of the KneeTwister has some limitations like a battery power supply and the demand for a portable device. Because of these limitations the design became more complicated and some different solutions have been found and some compromises have been made. The end result is a fully functional hardware prototype. Small changes that are made have been implemented in a new printed circuit board design.

The software consists of three parts: the communication with the hardware, the main program and the calculations. To communicate with the hardware some drivers have been written. The main program presents the required information to the user and takes care of measuring and storing this information. The calculations are made by some functions and a custom-designed mathematical library.

Conclusions and recommendations

At the moment of writing this report the device is not yet fully functional. The hardware is finished and the software is almost entirely operative. At this

moment there is a problem calculating the angles. It is a question of time to solve this minor problem and finish the software.

To improve the functionality of the KneeTwister the following actions can be taken:

- Two-way communication with a computer can be implemented to ease the calibration process. This only requires extra components and extra functionality in the software. The hardware and the basic software are designed with these functionalities in mind.
- The pcb is designed to be as small as possible. The pcb is not designed to fit in a box. The position of some components might be changed in order to fit the hardware in a small box.
- An option to change some settings can be implemented to be able to change certain software settings without reprogramming the microcontroller.
- A proper user interface must be developed and implemented.