Introduction
The objective of this project is to create a series of sensors that will measure motion of the human body during rehabilitation and clinical evaluation. The application of this device is for the measurement of head tilt in patients with Cervical Dystonia being treated at the University of Rochester Neurology Outpatient Department and the measurement of knee flexion in stroke patients at the Nazareth College Physical Therapy Clinic.

Testing
The sensors were tested for accuracy, precision and the effects of possible outside magnetic forces. A test rig was adapted from a previous MSD team and modified to measure tilt in the X and Y directions and rotation in the Z direction simultaneously. Some parts of the test rig needed to be replaced with non-ferrous material to avoid interference with the magnetometer in the sensor. The enclosures were also tested for adjustability, comfort and strength.

Test Results
The graph was created by rotating the head tilt system 30° in the pitch, roll and yaw directions independently.

Both devices were accurate within the customers’ needs and also met their requirements for size and weight. Accuracy was also tested using the Mechanical Spine Platform created by previous MSD team P10007 at the Nazareth Physical Therapy Clinic.

Enclosures
The head device is comprised of adjustable elastic straps going around the head and across the top. One sensor sits on the top of the head in the center and a second sensor is attached to the chest of the patient. The three angles of head tilt are found with respect to the sensor on the chest.

The knee device is comprised of two adjustable elastic straps, one placed above the knee and the other below. A sensor is attached to each strap and the angle between them is found.

Needs & Objectives
It is necessary for the device to measure both static abnormalities (degrees of head tilt) and dynamic abnormalities (frequency of tremors). The ideal angles for the device to be able to measure are +/- 80 degrees of tilt in the lateral and anterior/posterior directions and +/- 100 degrees of rotation. The device needs to be precise, but a 5-10° error would be acceptable. By interfacing with the base unit, the device can give quantitative results and feedback during a clinic visit.

Sensor Selection
For the device, two Razor 9 Degrees of Freedom IMUs were used. Each Razor consists of single-axis gyroscope, a dual-axis gyroscope, a triple-axis accelerometer and a triple-axis magnetometer, which gives nine degrees of inertial measurement. The outputs of the sensors are processed by an on-board ATmega328. A serial to USB converter is used to convert the serial outputs to USB which is connected to the base unit.

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