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How modern technology to measure the knee joint mobility might help children with Cerebral Palsy (CP)

CP is a disorder of movement that affects co-ordination caused by lack of muscle control by the brain. CP patients have knee joint disorder such as stiff-knee gait and flexion and extension deformities. There is a lack of research on measuring the knee joint angle for a longer period on children with CP using modern technology. This could help physicians or physiotherapists to provide better rehabilitation treatments accordingly to every child's needs. Using IMU (Inertial measurement unit) might be a solution for this.

Developing a prototype using IMUs to do 24 hours measurement of knee joint mobility

Inertial measurement unit is a self-contained system that uses gyroscope, accelerometers and magnetometer to measure linear and angular motions. An IMU provide 2 to 9 DOF (Degrees of Freedom) that refers to the number of different ways an object can move throughout the 3D space. Accelerometer measures motion in X, Y and Z axes, magnetometer calculates the direction the sensor is facing with the respect to magnetic north, and gyroscope measure the rotation of the sensor in space in terms of roll, pitch and yaw.

Two IMUs of model BNO055 and BNO080 from Bosch uses fused algorithms from gyro, magnetometer and accelerometer and provides data such as absolute orientation in Euler vectors or quaternions, that are a system of numbers in 4-D. The 4 scalar numbers from quaternions reorient vectors in a single rotation, without changes in length. They are easy to obtain since the sensors have build in functions and are free from a phenomenon called gimbal lock (two axes describe the same rotation locking the axis), something that is common in Euler vectors and provides inaccurate data.

One IMU was placed on a human subject's thigh, and the other on the shank. The knee joint angle was measured from the absolute value of the quaternions from both IMUs. Implementation was done on Arduino nano. The angles had a maximum error of 1-2°, which was amazing! BNO055 gave accurate results if the sensors were free from magnetic disturbances, tilts or heavy vibrations. Measurements over a longer period provided some heavy drifting errors on BNO055 sensor, something that was a little annoying, however; another successor, BNO080, provided more accurate result due to it's several operational modes but also provided minor drifting errors over time. Please check out the Youtube video to find out more!

Youtube video for this thesis: https://www.youtube.com/watch?v=vZMe6denCBs&t=14s

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