Inertial device for medical recovery

The project was developed by Miclescu Victor and Puscasu Alexandru.

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Synthetic subject presentation

Our project purpose is to develop a medical device that can be used in recovery after accidents. It consists in using an accelerometer and gyroscope sensor in order to follow the evolution in movement recovery of a human body part.

Introduction

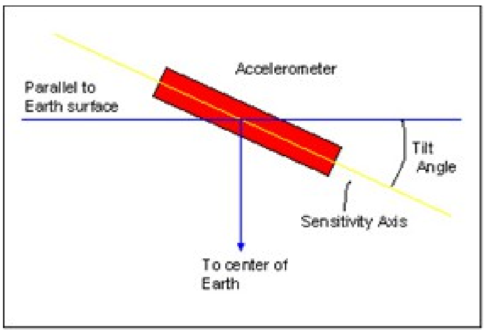
An accelerometer is a sensor for testing the acceleration along a given axis. When a physical body accelerates at a certain direction, it becomes subject to a force equal to:

F=m*a, where:

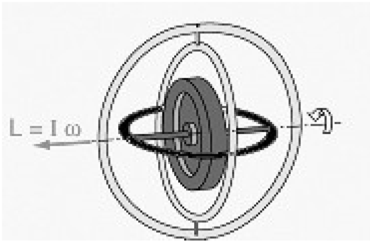
- m is the object mass;
- a is the object acceleration.

The **accelerometer** can detect movement based on double integration of the measured acceleration and addition of the initial position and speed. However, since the Earth exerts a gravity acceleration on all bodies, we can also use the accelerometer to measure tilt.

When the sensitivity axis points directly to the center of the Earth, it measures 1g (assuming no additional hand acceleration in this direction, g= 9.8m/s^2). When the accelerometer sensitivity axis lies parallel to the surface of the Earth, it measures 0 acceleration.



The **gyroscope** sensor measures rotational velocity along the Roll, Pitch and Yaw axes. It depends on the property of rotating mass as illustrated in the following schematic drawing of the classical mechanical gyroscope. This sensor is becoming more common in modern smartphones, and it complement the accelerometer with its ability to measure rotations directly.



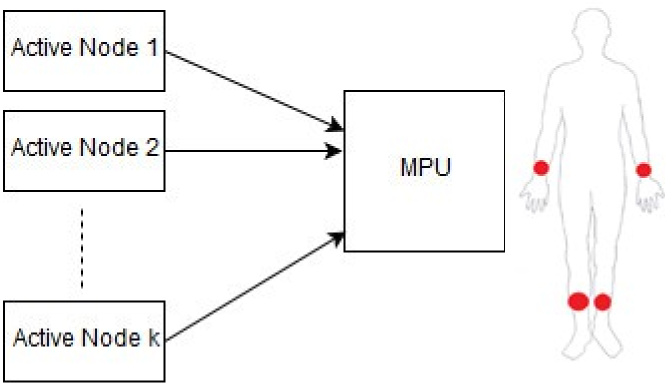
The main part of the project is represented by an ***IMU (Inertial Measurement Unit)*** that has a 3-axis accelerometer and also a 3-axis gyroscope.

It will be used to acquire data in the process of medical recovery. The data that the sensors are acquiring will be sent to a main control unit, where it will be processed. The system will allow to see the form of an exercise in direct comparing to a reference data.

Solution description

The idea of this project is to develop a wearable device that can be used in medical recovery. It can supervise the arm movement and make assessments about the evolution of the recovery.

The system has a reference data of a correct move of the right and left arm. When the subject starts the exercise, the system acquires the data and send it to the main unit where it is processed. The results are traced on a screen, represented in comparison with the reference. There can exist one or more active nodes that collect data and send it to the main processing unit (MPU) as shown in the figure:

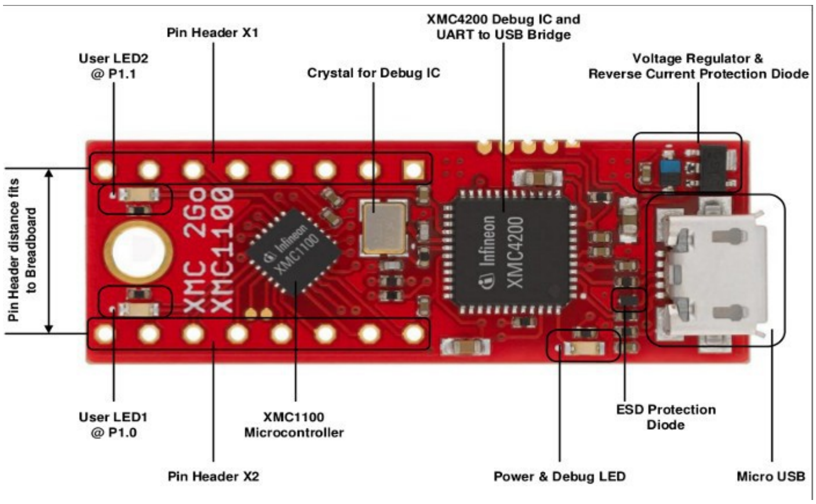


Data acquisition is made using ***Pololu MiniIMU-9 v5*** sensor. In fact it is a IMU with 3-axis accelerometer, gyroscope and magnetometer.

For our project we used only the data from accelerometer and the gyroscope – LSM6DS333. It is a low power device, with different operational modes, configurable through the registers that it has implemented. It can be used in applications like pedometer, step counter/detector, free-fall detection, motion functions, IoT and connected devices.

An I2C interface permits the access of all nine independent measurements (rotation, acceleration and magnetic). The acquired data is then sent to the active node processing unit, in this case represented by a XMC2Go platform.

The XMC2Go is a microcontroller equipped with the ARM M0 microprocessor. The main advantage of the XMC2Go is that it’s a real tiny device with all the externals needed for small projects.



The active node will send data to the MPU using a wireless communication such as Bluetooth or Wi-Fi connection.

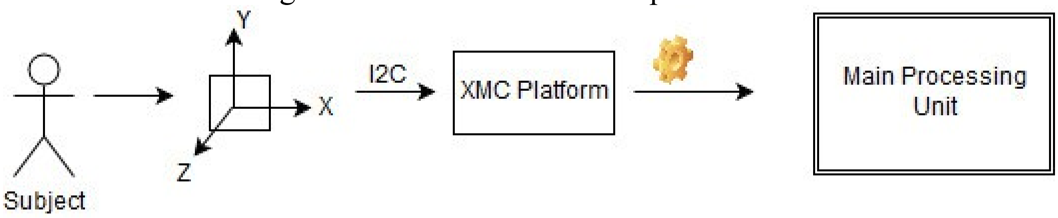
The Main Processing Unit is represented by a Raspberry Pi an amazing platform. It helps us to compare the graphics for one arm or one foot which suffered an accident, graphics for same member in different phases of recovery and compare them with a reference (a healthy member) to see improvements of a treatment.

MPU receives the data packages from the active node and accumulates it into a buffer. Acquisition rate is 10 samples /second, fact which confer us a sufficient period to process our buffer without interferences from UART. Samples for references are store in a text file and samples what are coming from acquisition are store in a local buffer. After 30 seconds (300 samples) , the patient can do a gesture few times and analyze them.

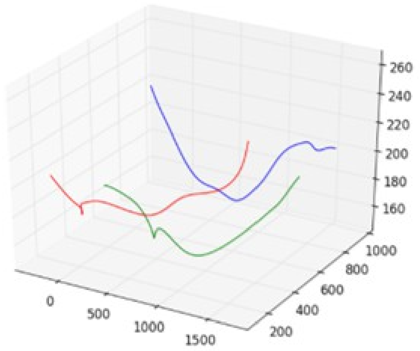
The data package has the form:

Acceleration | Gyro values: a_x a_y a_z | g_x g_y g_z

The interfacing between a active node components is described in the following figur***e:***



For plotting our graphics we decide to use from python a library which permit us to have a comparison between a reference and our data.



Results presentation