**MPU9250**

* Provides accelerometer, gyroscope and magnetometer data which is required for processing to obtain reliable x, y and z axis orientation data via the complementary filter.
* Can communicate using SPI architecture which is the main communication that was developed for communication.
* It is compact. Accelerometer, gyroscope and magnetometer on one pcb.
* 1 – 10MHz communication frequency meaning that data can be real-time.
* Ability to configure sensitivity. Default setting too sensitive meaning it is not able to record faster movements.

**HC-05**

* Configurable as slave or master
* UART communication protocol at 115200 bits per second meaning that real time can be achieved with the amount of data I am planning to send.
* Small form factor.

**DE0 Nano FPGA**

* Experienced in using this development board and its software, Quartus.
* Reasonably compact compared to other development boards. It needs be able to fit on my hand.
* FPGAs can achieve true parallelism and so will aid in achieving real-time communication.
* Ability to create custom components.

**STM32L432KC**

* Very small and so can fit onto the arm.
* Many of the capabilities of the larger stm boards are not needed. The only specific capabilities required is SPI and DMA and this board contains both.
* All the heavy calculations that the FPGA cannot perform normally are done using the microcontroller.

**CP2102 UART to USB Bridge**

* Contains USB connector and so can be plugged straight into computer.
* Eliminates the need for using another microcontroller to receive data which would be excessive and is cheaper than a microcontroller, £3 compared to £10.
* Uses UART and so can be directly connected to the HC-05 slave.

**650mAh LIPO Batteries**

* Originally was meant to use a 9V battery but with LIPOs are more compact therefore save space on the arm. Additionally, no external circuitry needs to be used with LIPOs as they work on 3.7V which is the voltage both the stm32l432 and DE0 Nano used for power.
* Two 650mAh batteries provide enough power to power the sensing system for several hours which is adequate. (Insert figure of how much the system can stay powered on before the battery fully discharges)

**MPU9250 Internal Measurement Unit**

Initially a cheaper alternative to the MPU9250 was the MPU6500 however, it did not contain the essential magnetometer which is required to implement the complementary filter for the z-axis. The MPU9250 contains the 3-axis accelerometer, gyroscope and magnetometer which enables the implementation of the complementary filter for x, y and z axes. Furthermore, the MPU9250 contains the ability to configure the sensitivity of the sensors which enables this IMU to register faster rotations.

The MPU9250 can be accessed using the SPI communication protocol between 1 and 20MHz when reading data which provides adequate speed for real-time applications. The SPI protocol that was developed in VHDL in July of 2018, can therefore be utilised to extract the data from this internal measurement unit.

Due to the space constraints on the sensing system, the internal measurement units need to be compact in order to fit on the limited space on the arm. Being approximately 26mm wide and 16mm wide makes this component small enough to be attached to the arm.

**HC-05 Bluetooth Module**

The HC-05 module uses the UART communication protocol which has a maximum baud rate of 115,200 bits per second, or 11,520 (including start and stop bit) bytes per second which. Since the processed IMU data will is sent in through the UART in 13 transactions, the simulation update rate, in theory, should be 295 timer per second which is plentiful for the application. This module also supports full-duplex communication.

The Bluetooth module can be easily configured to have the desired parameters such as the Baud rate or whether the module should be a slave or master through the use of AT commands. This module also has a small form factor which makes it possible to attach to the arm.

**DE0 Nano FPGA**

The FPGA has the ability to truly work in parallel when performing operations and custom components can be developed specifically for communication. This makes the FPGA a good choice when working on real-time communication systems. The DE0 Nano itself has a small form factor compared to other FPGA devices.

**STM32L432KC Microcontroller**

Because the FPG does not readily have the necessary architecture to perform complex calculations to obtain orientation from the raw IMU data values, the data is sent to this microcontroller for processing. There are several factors that influenced the selection process of the SMT32L432KC. The first reason is the form factor. As with all the other components, the microcontroller needs to be compact enough to fit onto the arm without problems. The next two factors are functionality and price. The only requirement from the microcontroller for this application is to be able to communicate using the SPI protocol and be able to compute orientations with adequate speed. Because this microcontroller was small it did not have as many features as the other larger development board, but it contains the SPI feature which was required. Because it less functional and smaller it also costs less.

**CP2102 UART to USB Bridge**

The UART bridge was chosen specifically for the purpose of avoiding the use of another microcontroller just to receive data and send it to the processing simulation as taking this approach would be excessive and costlier than the purchase of a bridge. The CP2102 can be connected to the simulation directly through a computer’s USB port. The HC-05 Bluetooth slave module can be connected to the bridge and the data therefore the received orientation data can be sent to the simulation directly.

**650mAh LIPO Batteries**

The LIPO batteries were chosen over a 9V battery due to their small size, re-chargeability and no need for external circuitry to step down the voltage because both the STM32L432KC and the DE0 Nano FPGA boards can work on 3.7V that the LIPO batteries supply whereas the maximum input voltage for the FPGA is only 5.7V meaning that it would be damaged by the 9V battery.

**Talk about how long the sensing system can run on these batteries.**