CG4002: Computer Engineering Capstone Project

Hardware Sensors

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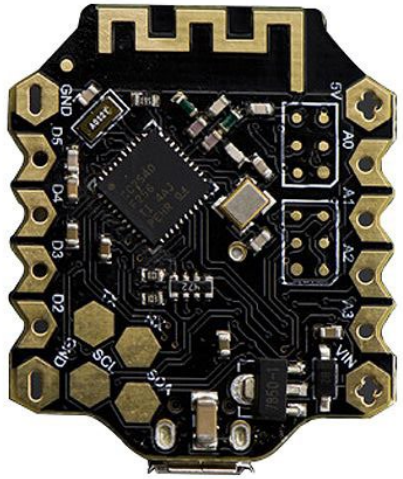
Hardware Sensors Requirements

- Design the Laser Tag Gun and Target Suit
- Power System Design
- Detect Laser Tag Game Actions!!!!!
- Design your own Final Move



Beetle BLE

- The Beetle BLE (Former name as Bluno Beetle) is an Arduino Uno based board with Bluetooth 4.0 (BLE)
- ATmega328@16MHz
- Bluetooth Low Energy (BT 4.0)
- Micro USB port
- Super Compact Size
- Support Bluetooth HID and ibeacon
- Support Wireless Programming
- Digital Pin x4, Analog Pin x4, PWM Output x2, UART interface x1, I2C interface x1,Micro USB interface x1, Power port x2
- Weight ： 10g

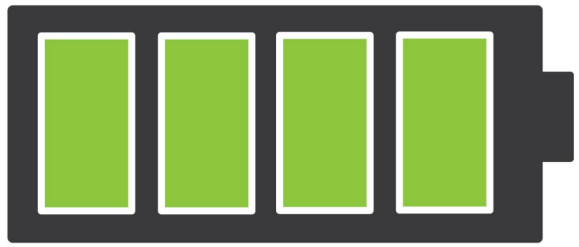
Source:https://www.dfrobot.com/index.php?route=product/product&product_id=1259&search=beetle&description=true&category_id=48&gclid=Cj0KCQiAsbrxBRDpARIsAAnnz_MokTwqL2LxM-OZI0JlZv2S_zNbUMkXhpnIkH734XtveQnhZ3dNI1MaAu-UEALw_wcB

Laser Tag Gun and Target Requirements

- A Laser tag gun (Transmitter) that can shoot at an opponent
- An accompanying target suit that can detect shots
- Working range of 3m
- Line of Sight
- Good to have!! – Visual and audio feedback when a target is hit and when the player loses all health points

Sensors – Laser Tag Gun and Target

- Infra-red Transmitter and Detector
  - Traditionally user in laser tag
  - Needs line of sight to function
  - Range can be improved by programming the transmitting IR and isolating the corresponding frequency at the detector (Think TV Remote!)
  - Simpler to implement
- Software Visualiser Camera as the detector
  - Need to share resources with the software visualizer
  - What would you choose to transmit the shooting?
- Other possible transmitter-sensors
  - Ultrasonic Sensors??
  - UWB Sensor??



Power System Design

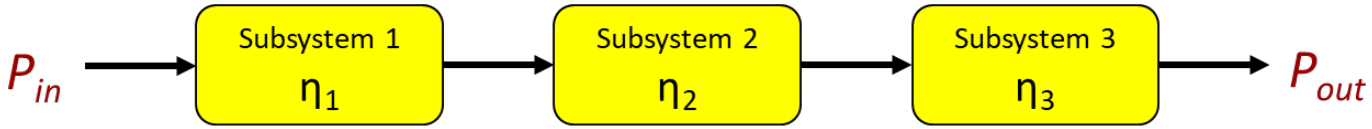
- Why Power System Design???

VS

- How Big a Battery do you need?

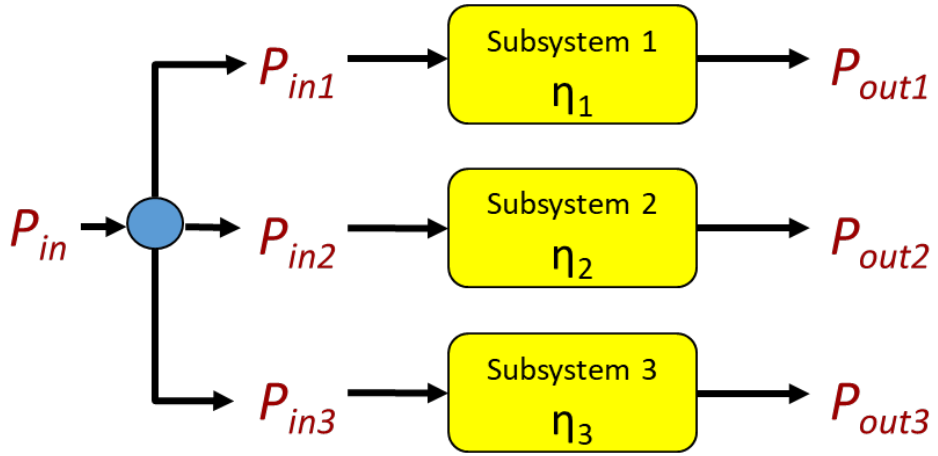
Power Budget and Battery Design

- Subsystems in Series $P_{in} = \frac{P_{out}}{\eta_1 . \eta_2 . \eta_3}$



- Subsystems in Parallel

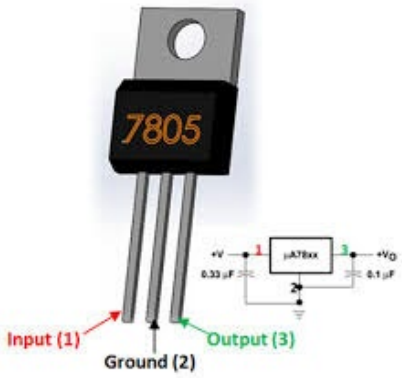
$$P_{in} = P_{in1} + P_{in2} + P_{in3}$$



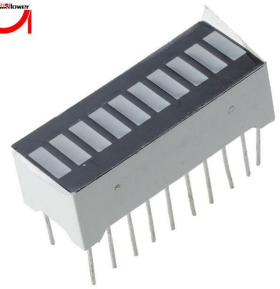
- Subsystems in Series and Parallel

PS: Sample battery design video also has been uploaded

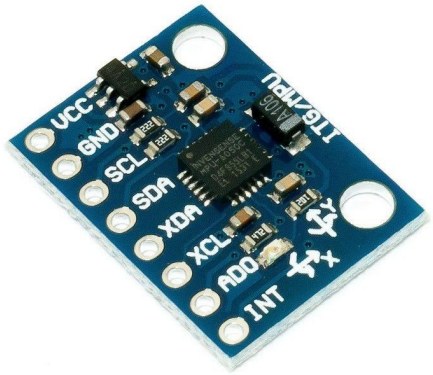
Beetle Power Options



- Button Cell Battery
  - Small, Portable, Lightweight
  - High running cost, does not last long
- AA Battery
  - Relatively small, can be integrated to the body sensor system, rechargeable
  - Unregulated voltage, requires voltage regulator or DC-DC convertor



Interfacing Info



- General Purpose Input/Output (GPIO)
  - configure a pin as output / input and write/read digital data to the pin
  - Simple devices such as ultrasound, IR, 2-line LCD display, Buzzers, LEDs
- Inter-integrated circuit (I2C)
  - 2 wire, synchronous, serial, master-slave, half-duplex, in-band addressing using 7-bit addresses (+read/write bit), short-distance [Arduino Library : Wire]
  - Slower devices such as accelerometer, gyro, compass etc

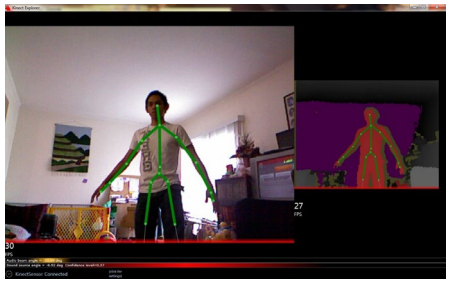
Interfacing Info

- Universal asynchronous receiver/ transmitter (UART, also called serial)
  - 2 non-shared wires, asynchronous, serial, full-duplex, longer distance (using a physical layer) [Arduino Library : Serial]
  - Between computers / microcontrollers, RFID modules, GSM modules
- Take note of the voltage levels of each device and component (3.3V / 5V/12V etc)
  - Do you require level shifting between 3.3V sensors and 5V Beetles?
- Take note of the max. current supplied by each pin of the device
- Read the datasheet carefully for such info

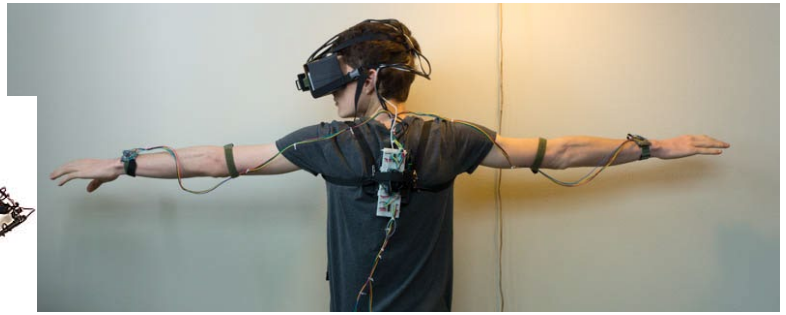
Human Movement Estimation

- What is Human Movement Estimation?

- How do we do it?
  - Optical Systems
  - Non-Optical Systems

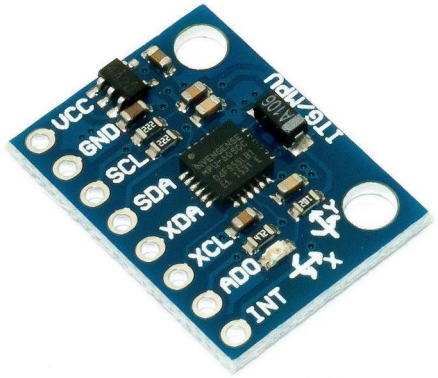


Human Movement Estimation

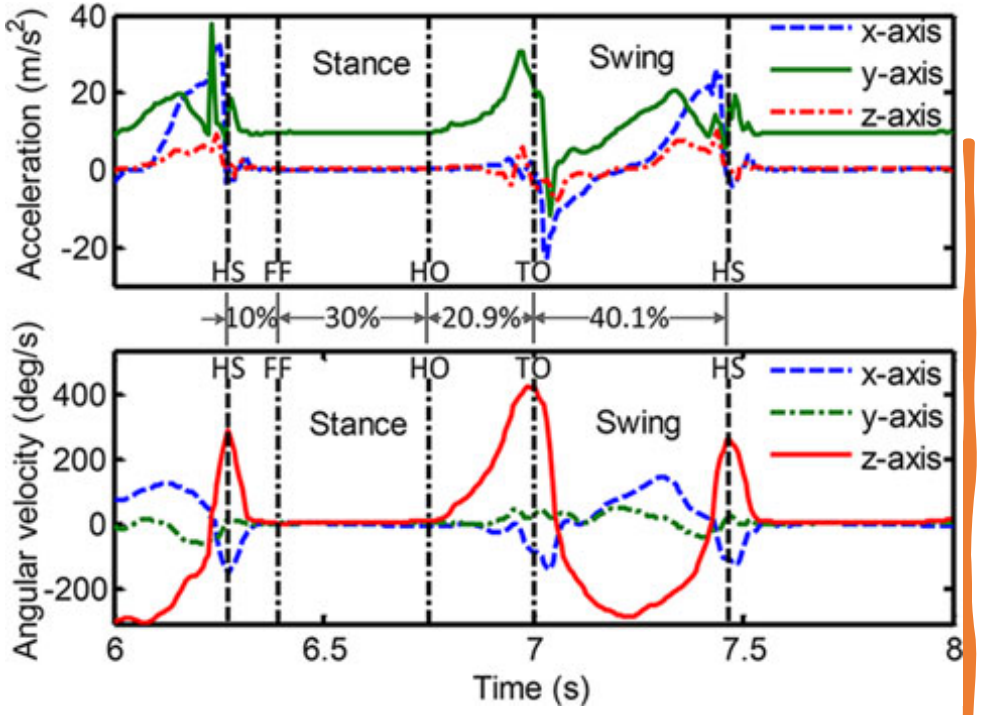


- Data captured from image sensors to triangulate the 3D position of a subject between two or more cameras calibrated to provide overlapping projections
  - Marker Based System
  - Marker-less System
- Inertial Systems
  - miniature inertial sensors
  - biomechanical models
  - sensor fusion algorithms
  - $1,000 to $80,000 USD
- Mechanical motion
  - exoskeleton motion capture systems
  - $25,000 to $75,000 USD

Laser Tag Game Actions



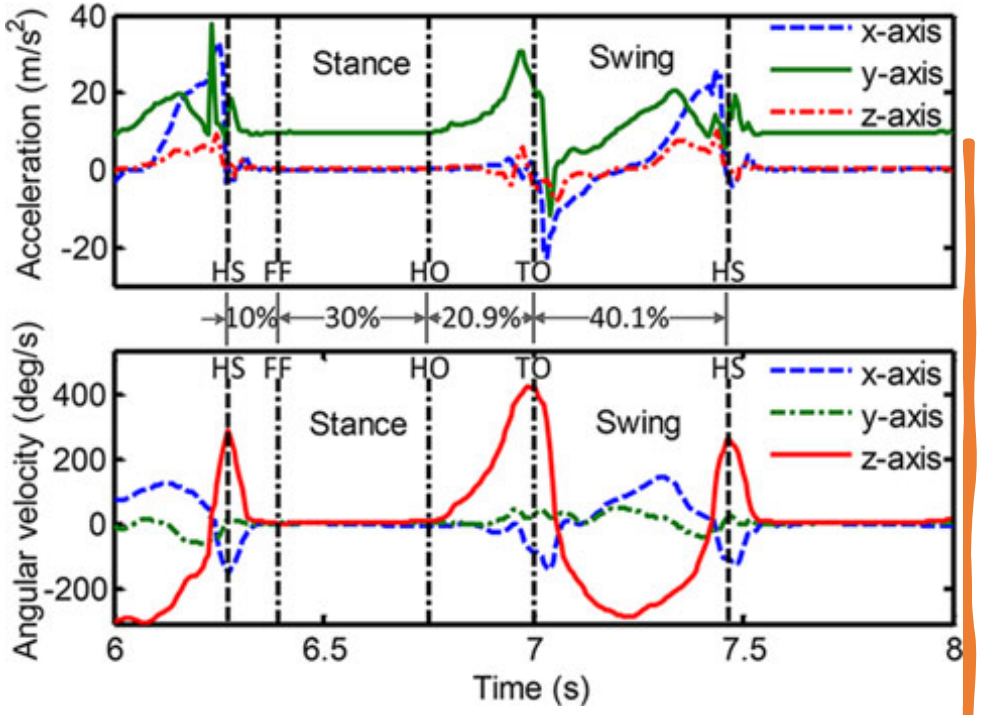
- What type of actions need to be measured?
  - Grenade
  - Shield
  - Reload
  - Final Game Move
- What type of systems/ sensors can we use?
  - Cameras
  - Flex Sensors
  - Inertial Sensors



Sensor Measurement Protocol

- Sampling – IMU Signal Processing
  - Filtering: Remove noise from the signal
  - Conversion of raw data to appropriate format (e.g. Hex value to m/s^2 for acceleration)
- Feature Extraction
  - Example Sampling Frequency: 5-50 Hz
  - Analysis Window: 250ms – 1000ms
  - 500 ms contains 25 samples per sensor
  - Use of sliding window?

Image from Wang, ZHELONG & Zhao, Hong-Yu & Qiu, Sen & Gao, Qin. (2015). Stance-Phase Detection for ZUPT-Aided Foot-Mounted Pedestrian Navigation System. IEEE/ASME Transactions on Mechatronics. 20. 1-1. 10.1109/TMECH.2015.2430357.



Sensor Measurement Protocol

- Benefits of Feature Extraction on the Beetle
  - Communication protocol is simpler
    - 1 second window: 6 sensors/IMU * 2 IMUs per user* 50 samples/1 second = 600 samples
    - Extracting features: e.g. 6 features per sensor* 6 sensors/IMU* 2 IMUs per user = 72 features
  - Utilization of the Beetle resources
  - Decentralized Debugging of sensors and each body unit is easier and convenient

Image from Wang, ZHELONG & Zhao, Hong-Yu & Qiu, Sen & Gao, Qin. (2015). Stance-Phase Detection for ZUPT-Aided Foot-Mounted Pedestrian Navigation System. IEEE/ASME Transactions on Mechatronics. 20. 1-1. 10.1109/TMECH.2015.2430357.

Documentation

- A proper documentation is very useful in debugging
- Document everything in a wiki / knowledge bank (eg: NUS wiki, GIT, Microsoft Teams)
  - Include the links. Always have wiki open whenever you google
  - Save all the datasheets, libraries you used (you need to specify the library source in your code clearly)
- Will help you in final documentation. It will also serve as a learning journal
- “Oh, I had seen it somewhere, can’t recall where” issues can be minimized

Thank You

PS: Check the Hardware Sensors under Week 6 (Individual Full Subsystem Test) for expected deliverables