# Development of a Novel Distributed Wearable Sensor Platform

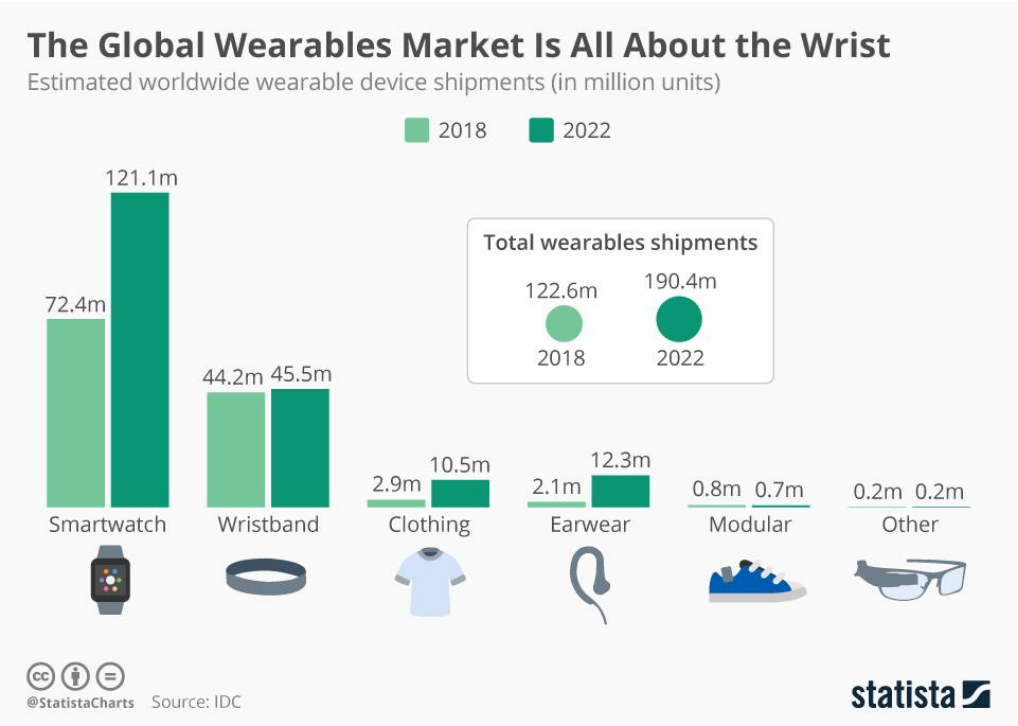
Tarek Nasser El Harake

Carleton UNIVERSITY

# Wearables

Are devices full of sensors that take the shape of normal clothing items

- Miniaturization of sensor technologies and increases in computational power
- Explosion in wearable technologies
- Development of devices for new applications
- Need for sensor exploration tools




*Projected increases in wearable markets by Statista*

# Consumer Devices

Off the shelf devices, usually targeted towards health and fitness


**From Factor**: Small

**Complexity**: Intuitive and easy to use

**Cost**: Low

**Monolithic**: Single point of measurement

**Sensor Selection**: Limited

**Data Access**: Limited

**Features**: Limited



*The Polar chest strap, Apple Watch, and FWD Powershot 2*

# Research Devices

Advanced instrumentation systems, targeted towards researchers

**Form Factor**: Often large and bulky

**Complexity**: Complex and hard to operate

**Cost**: High

**Monolithic**: Often a single large unit

**Sensor Selection**: High

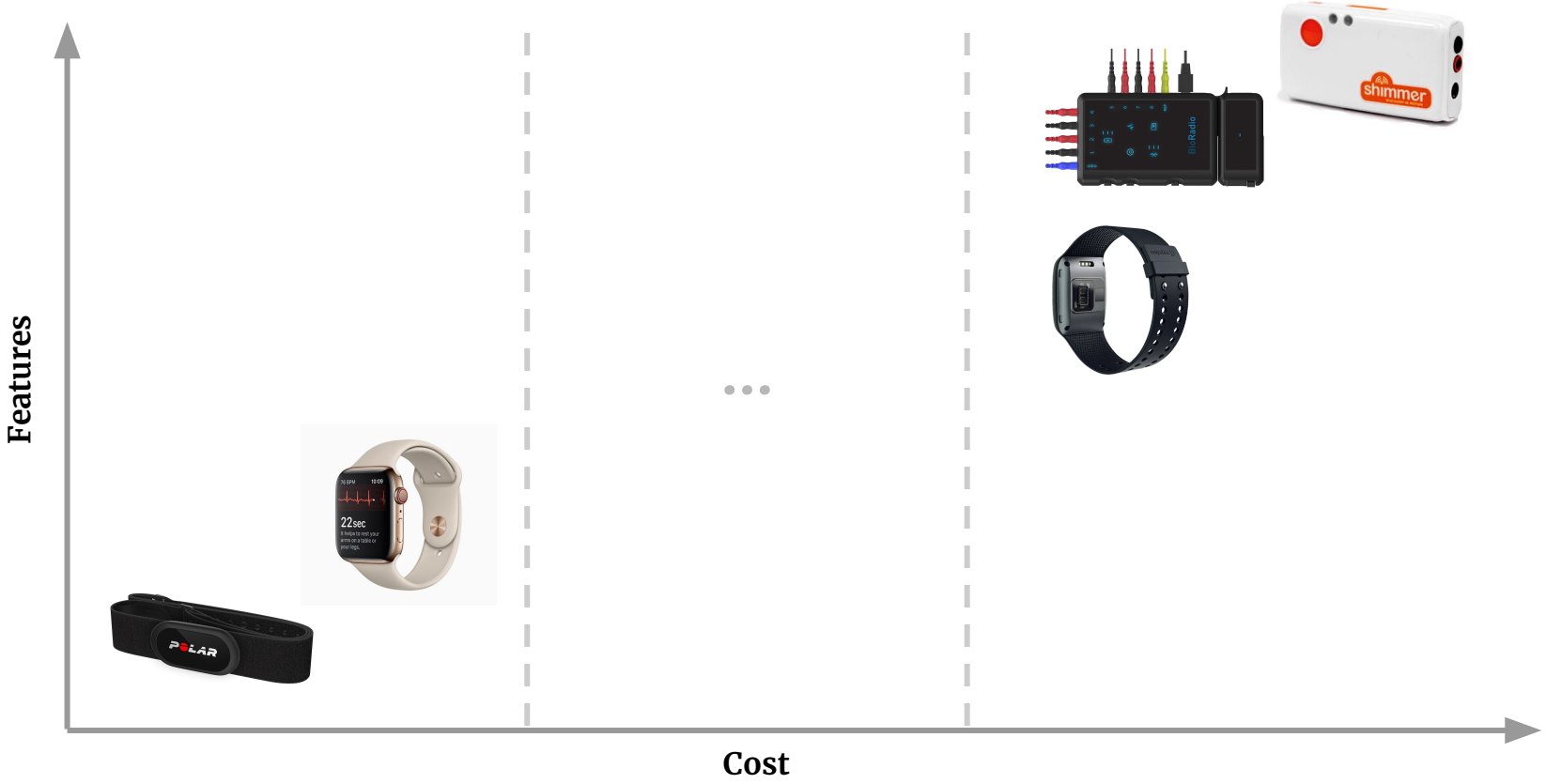
**Data Access**: Access to unfiltered raw data

**Features**: Advanced features and analytics tools




*The Empatica E4, BioRadio, and Shimmer3*

# Current Landscape



# Goals

An ideal system would aim to bridge the gap between the two extremes

**Form Factor**: Very small and wearable

**Complexity**: Intuitive and easy to use

**Cost**: Low

**Distributed**: Multiple units creating a body area network

**Sensor Selection**: High

**Data Access**: Access to unfiltered raw data

**Features**: Advanced features and analytics tools



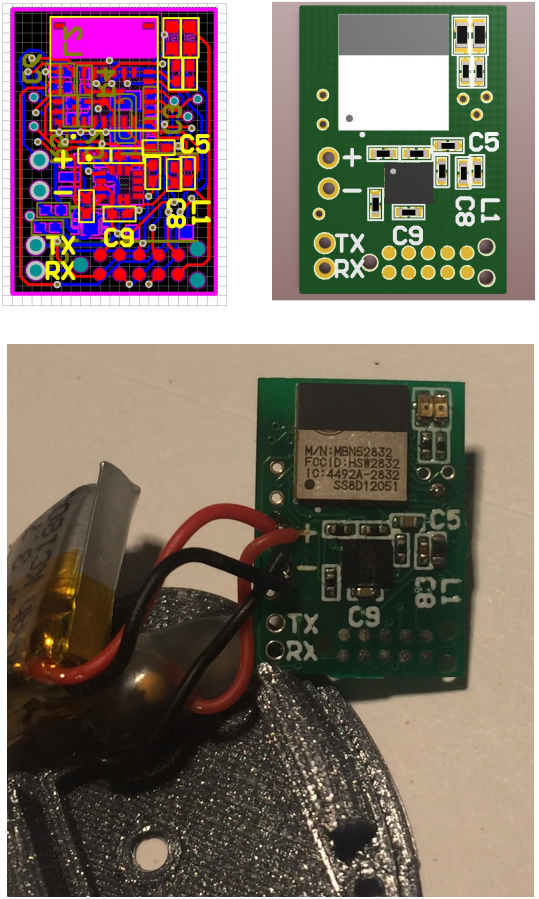
*The Apple Watch and BioRadio*

# Overview


USB
Bluetooth
Analog Node
IMU Nodes
Hub
Output Node
PC Application

# Hardware

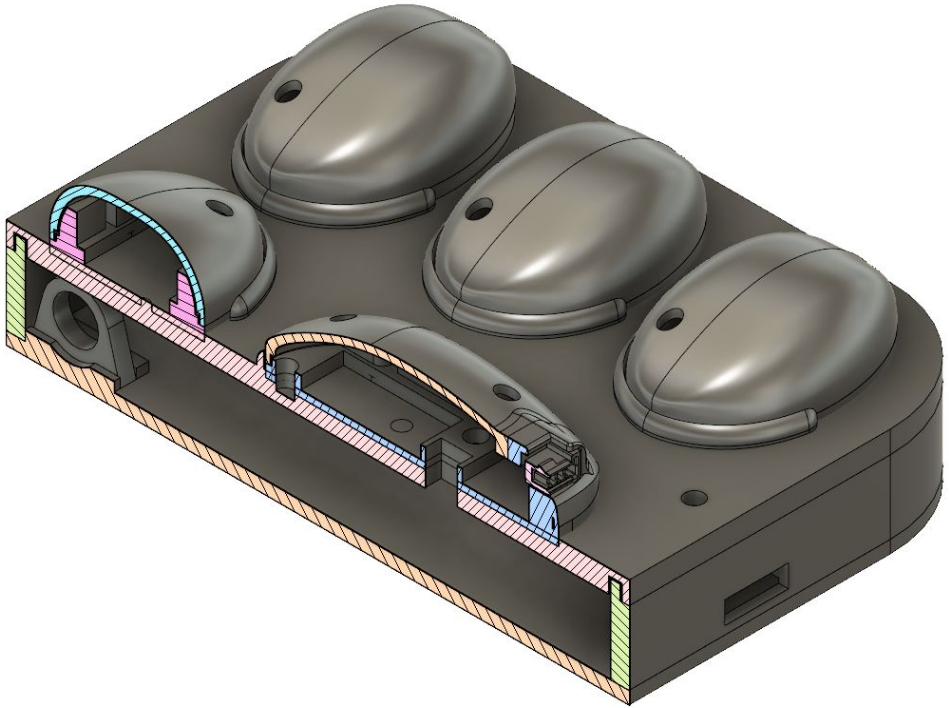
- Very small 13 x 18mm PCB footprint
- On board motion sensor
- Connector-less programming interface
- Green and red LED status indicator
- Analog node variant with two 12 bit ADC
- Output node variant with two digital output




*Stages of hardware development of the node*

# Mechanical

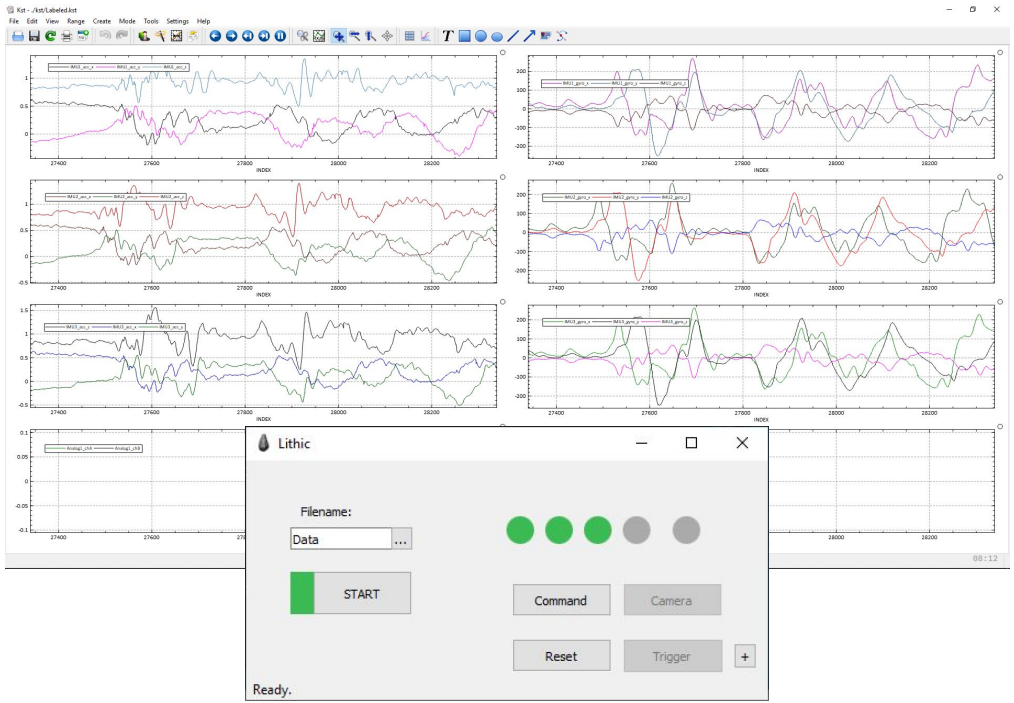
- 3D printed enclosure
- Minimal form factor
- Magnetic docking station
- Versatile anchor points
- Modular connection modules



*Node and Hub enclosures designed in the Fusion360 CAD software*

# Software

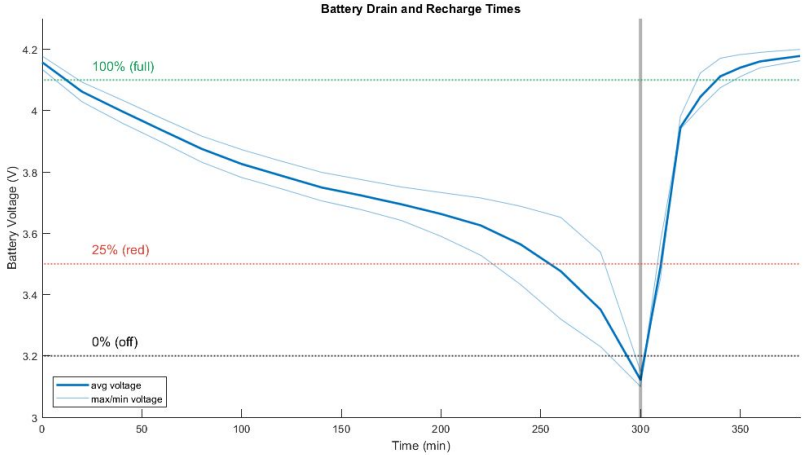
- Simple, easy to use GUI
- Real-time visualization
- Low latency, high throughput
- Bidirectional Bluetooth comm.
- Multi-camera synchronization
- Custom output node sequences
- Cloud integration

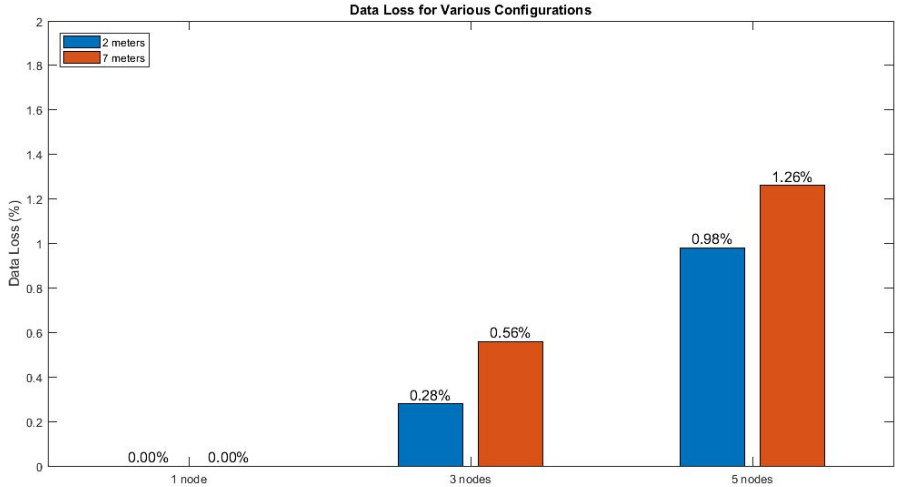



*The Application's Main Menu and Visualizer*

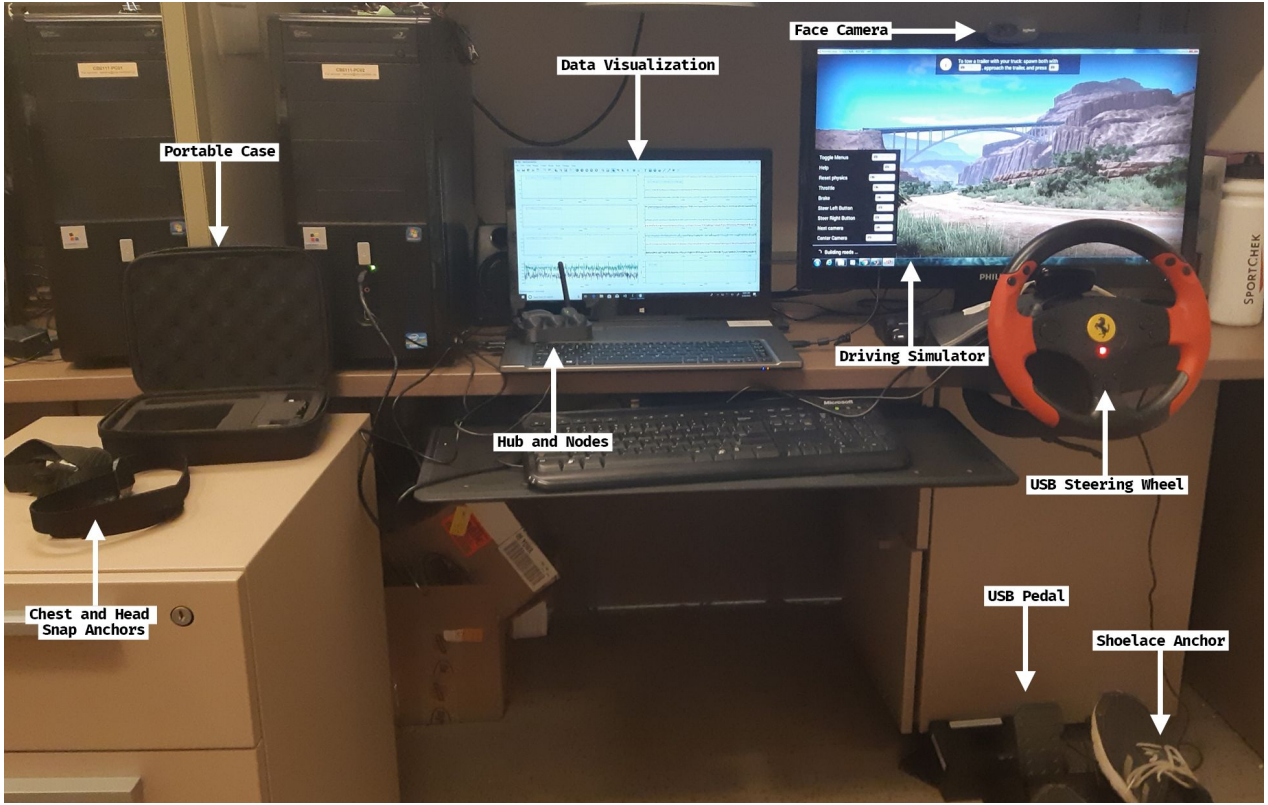
# Validation

- Application Validation
- Battery Life
- Physical Robustness
- Magnetic Connector
- Range
- Synchronization
- Data Loss

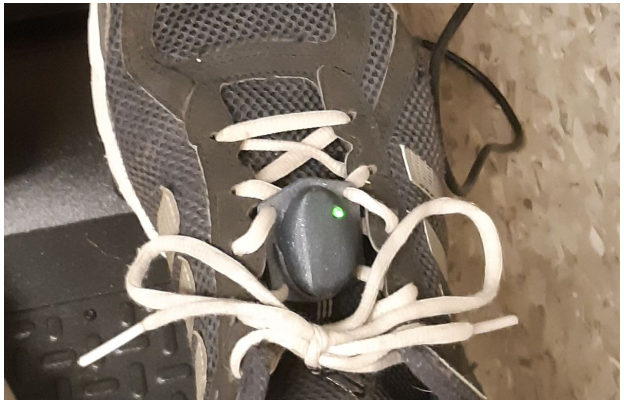


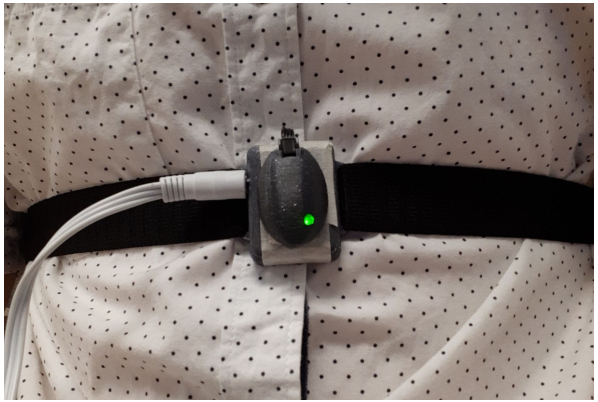



# Experimental Setup



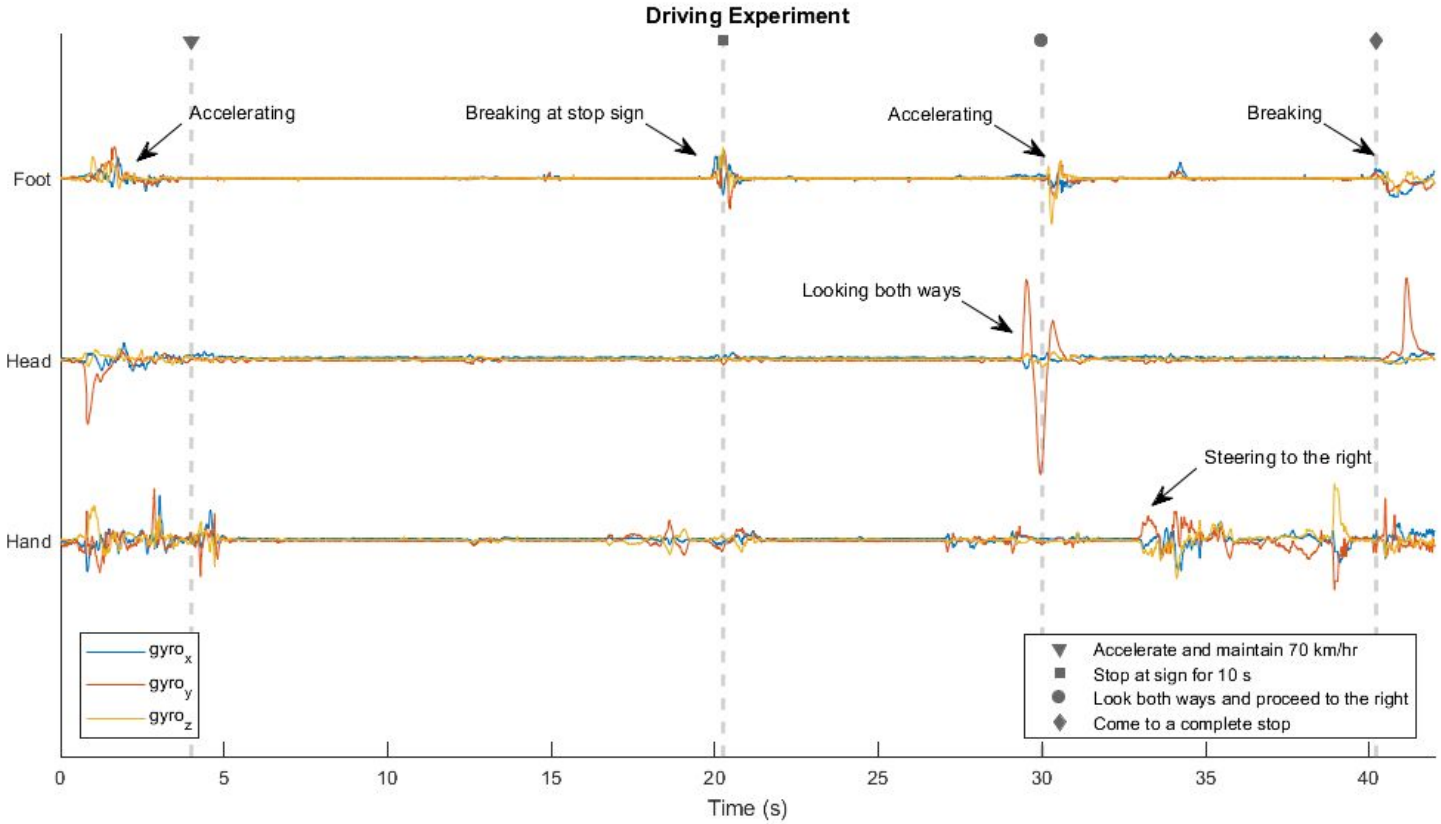
# Node Positions





*Three nodes attached to various body parts using the anchor points*

# Experiment: Analysis



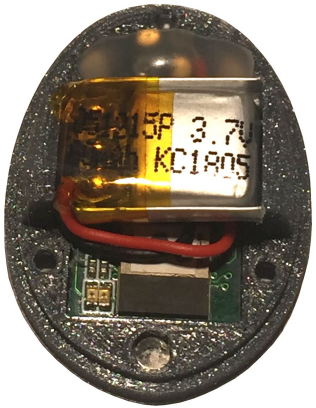
# Achievements

- Distributed
- Modular
- Extendable
- Small and lightweight
- Easy to setup and modify on the spot
- Raw sensor data
- Low latency, real-time communication
- Simple and intuitive

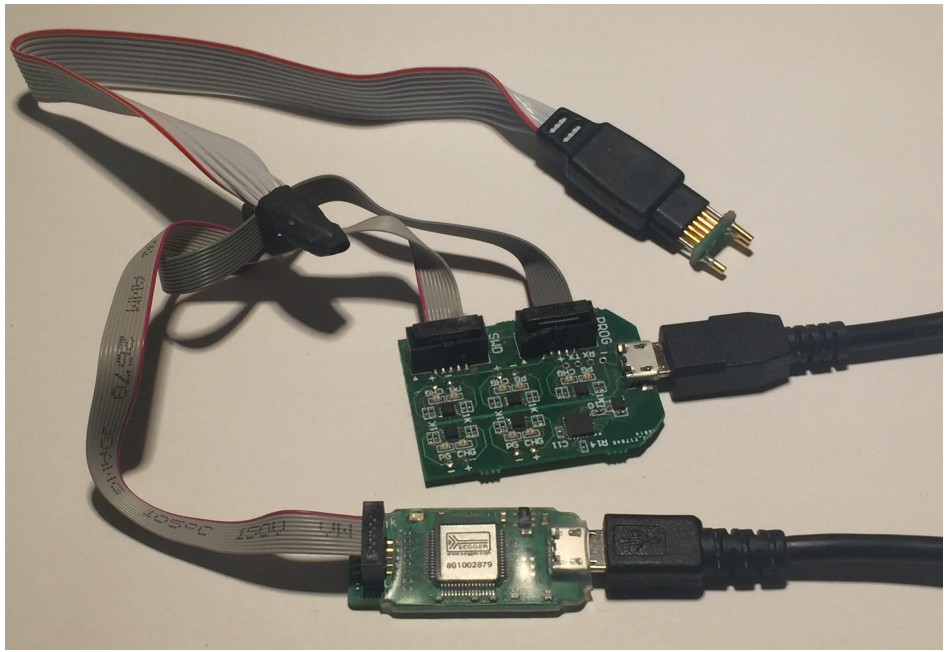
*Complete system in its carrying case*

# Challenges

- Bluetooth
- Range
- Battery




*The inside of a node*

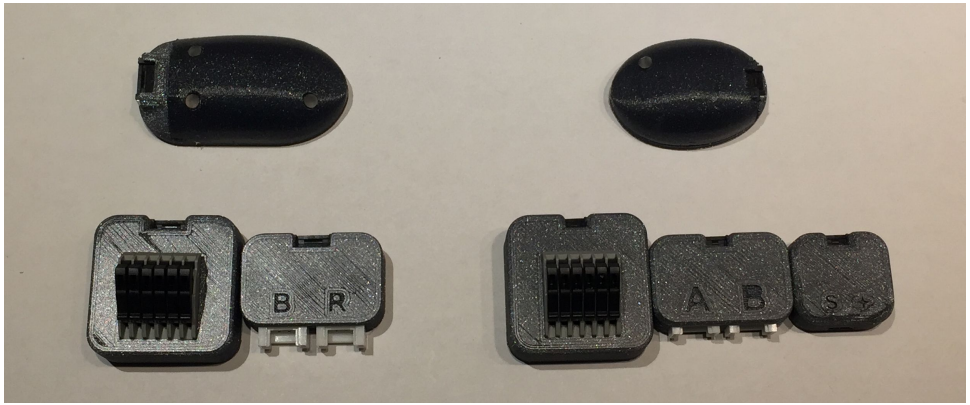



*Custom board used to program the nodes*

# Future Work

- Better Radio Protocol
- Increased Runtime
- Increased Range
- Additional Sensor Modules
- Conclusion

*The magnetic connection interface*




*The various connection modules for external devices*