Universität Hamburg
DER FORSCHUNG | DER LEHRE | DER BILDUNG

# Data-glove based on IMU Sensors - Prototyp Version 2

Can Bagdas

Universität Hamburg · Fachbereich Informatik

18.01.2022

# Agenda

- Introduction
  - Motivation
  - Goals
- State of the Art
  - Sensortypes
  - Similar Datagloves
- Systemdesign
  - Sensors
  - Microprocessor
  - Connection
  - Architecture
- Demo
- Conclusion

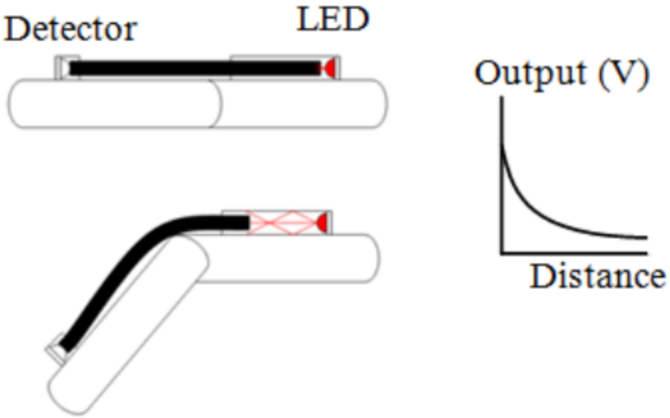
# Motivation

- Medical Area[3]
  - Motor rehabilitation
  - Learning on in a virtual reality instead in real life
- Sign Language[3]
  - Reading finger movements
- Gaming
  - Metaverse

# Goals

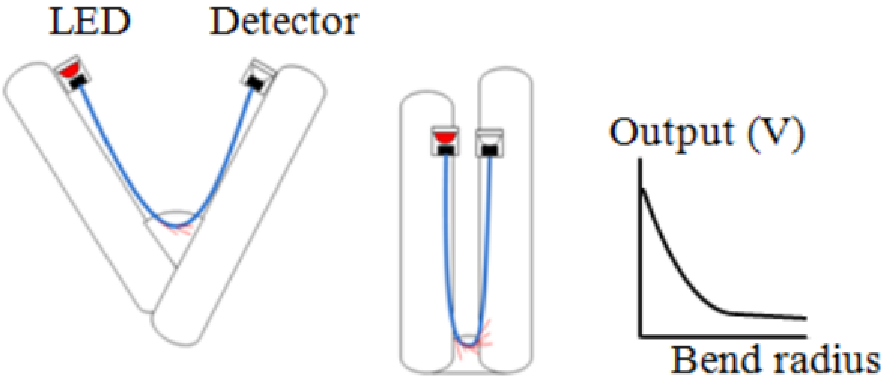
- **Main Goal:** Prototyp of a IMU-based Dataglove
  - with the **MPU-6050** and **MPU-9250**
  - with the **BMI160** and **MPU-9250**
- Stable communication

- Flexion Sensor[2]
  - **Principle:** Surface stretching
  - Usage of a fibre to detect coupling
  - Detector and LED connected with a fibre
  - Finger Flexing - Coupling loss increase


Detector
LED
Output (V)
Distance

## State of the Art - Sensortypes

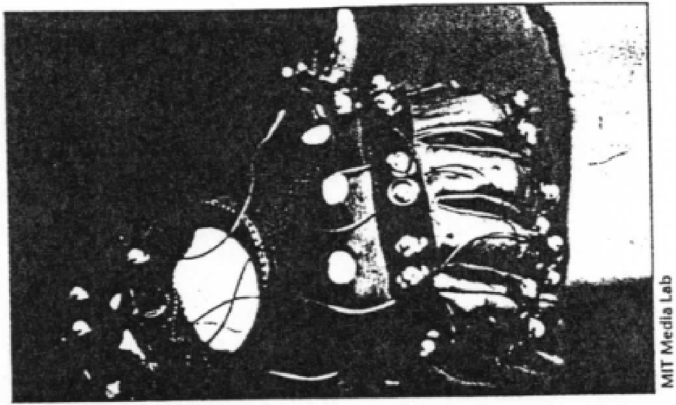
- Flexion Sensor[2]
  - **Principle:** Surface stretching
  - Usage of a fibre to detect coupling
  - Detector and LED connected with a fibre
  - Finger Flexing - Coupling loss increase
  - Abduction - Voltage increases


LED
Detector
Output (V)
Bend radius

# State of the Art - Sensortypes

- Flexion Sensor[2]
  - **Principle:** Surface flexing and abduction
  - Usage of a fibre to detect coupling
  - Detector and LED connected with a fibre
  - Finger Flexing - Coupling loss increase
  - Abduction - Voltage increases
- Camera based Tracking[1][3]
  - **Principle:** Visual motion tracking
  - A Glove stubbed with LEDs
  - e.g. MIT LED glove

# State of the Art - Sensortypes



- Inertial Measurement Unit - IMU[4]
  - **Principle:** Measuring velocity, orientation and gravitational force
  - Inertial Acceleration and Angular rotation
  - Micro Electron Mechanical System - MEMS Sensor
  - Two sensor types
    - Accelerometer
    - Gyroscope
    - 6DoF
  - Three sensor types
    - additionally with magnetometer
    - 9DoF
    - Good for dynamic orientation calculation

## Pros and Cons

- Flexion Sensor
  - Accuracy depending on the quality and placement
  - Different handsizes can give inconsisten data
  - Good calibration can take hours(can be stored)

- Camera based Tracking
  - Motion blur and occlusion error
  - Fast calibration
    1. Camera position
    2. Bone Length
  - Frequency includes image processing and data matching

- IMU
  - High Accuracy
  - Affordable (if not placed on every joint)
  - High sample rate 200Hz order of magnitude
  - 3DoF orientation and for some finger more than enough[7]

# Manus Prime II

[https://www.manus-meta.com/legacy-products/prime-ii, 2022]

- Manus Prime II[6]
- 10x 2DoF Flexible sensors
- 6x 9DoF IMUs
- Sample rate at 90Hz
- 5 hours (swappable)
- 45 seconds calibration


https://www.manus-meta.com/legacy-products/prime-ii

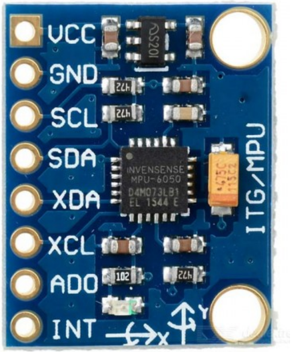
[https://bebopsensors.com/, 2022]

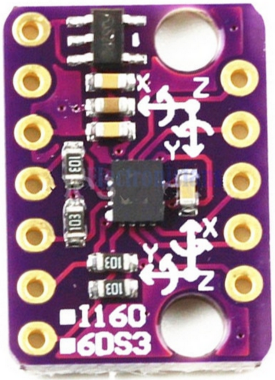
- BeBop[5]
- 10 smart fabric bend sensors
- 6x 9DoF IMUs
- Sample rate at 160Hz
- 2 hours battery(swappable)
- 5 seconds calibration


https://bebopsensors.com

MPU-6050

- 16-bit digital triaxial Gyroscope/Accelerometer
- temperature measurement
- low power consumption
- only I2C support
- 400kHz
- 2x1.5x0.1 cm

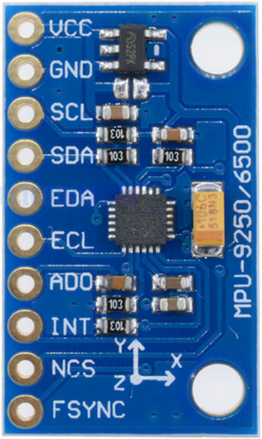





BMI160

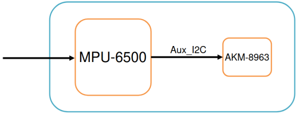
- 16-bit digital triaxial Gyroscope/Accelerometer
- Really small
- low power consumption
- SPI/I2C support
- Extended I2C mode allows a frequency up to 1MHz
- Low power - High precision
- 1.8x1.4x0.1 cm

# Systemdesign - Sensors - MPU-9250




## MPU-9250

- Similar like the two before
- 6-axis IMU MPU-6500
- Magnetometer AK-8963
- I2C-400KHz
- SPI-1MHz

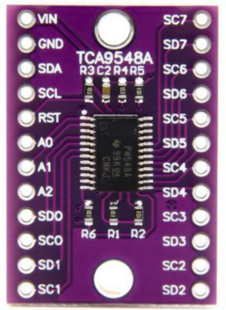


Esp32

- CPU clock frequency from 80MHz to 240MHz
- WiFi Module - 2.4GHz   2.5GHz
- Integrated SPI flash of 4MB
- I2C, SPI interface
- many more features

# Multiplexer - TCA9548A

```
//TCA Selector

void tcaselect(uint8_t i) {
    Wire.beginTransmission(TCAADDR);
    Wire.write(1 << i);
    Wire.endTransmission();
}
```



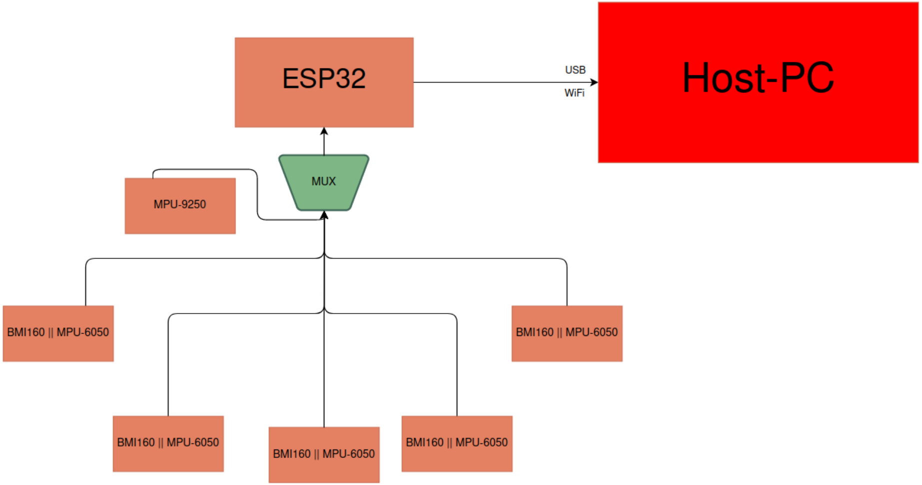

- Allows sensors to communicate with a microprocessor with only limited busses
- Easy to use
- Up to 8 devices

# Connection

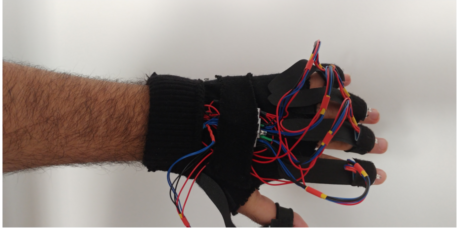
```
void setup(){
    Wire.begin();
    Wire.setClock(4000000UL);
    Serial.begin(115200);
    while (!Serial);
    delay(1000);
    udp.setupWiFi(ssid, pwd, ipAddress, udpPort);
}

void UDPCONNECTION::sendBuffer(uint8_t length){
  if(getStatusWifi()){
    wifiUdp.beginPacket(ipAddress, ipPort);
    wifiUdp.printf(buffer, length);
    wifiUdp.endPacket();

  }else{
    Serial.write(buffer);
    Serial.println("");
  }
}
```

- Usage of UDP/Serial
- Connecting to WEP/WPA2
- Easy to use

# Architecture



# Demo



# Conclusion

- **Main Goal** was to create two Prototyps of IMU-based Datagloves
  - Raw data output
  - Stable communication

# Conclusion

- **Main Goal** was to create two Prototyps of IMU-based Datagloves
  - Raw data output
  - Stable communication
- Difficulty to design the glove
- Magnetometer inconsistent

# Conclusion

- **Main Goal** was to create two Prototyps of IMU-based Datagloves
  - Raw data output
  - Stable communication
- Difficulty to design the glove
- Magnetometer inconsistent
- Future
  - Calibration
  - Adding camera based tracking with the LEDs

# Reference


[1] D.J. Sturman und David Zeltzer. "A survey of glove-based input". In: *Computer Graphics and Applications, IEEE* 14 (Feb. 1994), S. 30–39. DOI: 10.1109/38.250916.

[2] Lucas Majeau u. a. "Dataglove for consumer applications". In: (Jan. 2011).

[3] Laura Dipietro, A.M. Sabatini und Paolo Dario. "A Survey of Glove-Based Systems and Their Applications". In: *Systems, Man, and Cybernetics, Part C: Applications and Reviews, IEEE Transactions on* 38 (Aug. 2008), S. 461–482. DOI: 10.1109/TSMCC.2008.923862.

[4] Norhafizan Ahmad u. a. "Reviews on Various Inertial Measurement Unit (IMU) Sensor Applications". In: *International Journal of Signal Processing Systems* 1 (Jan. 2013), S. 256–262. DOI: 10.12720/ijsps.1.2.256-262.

[7] Wokke S. "Calibrating the Manus VR Glove improving calibration for the Manus VR flex sensor glove using ground truths". Magisterarb. Eindhoven University of Technology, 2017.

# Reference

[5] *BeBoP*. 2021. URL: https://bebopsensors.com/bebop-sensors-announces-worlds-first-haptic-glove-designed-exclusively-for-oculus-quest-forte-data-glove-with-oculus-quest-controller/.

[6] *Manus Prime 2*. 2019. URL: https://www.manus-meta.com/legacy-products/prime-ii.