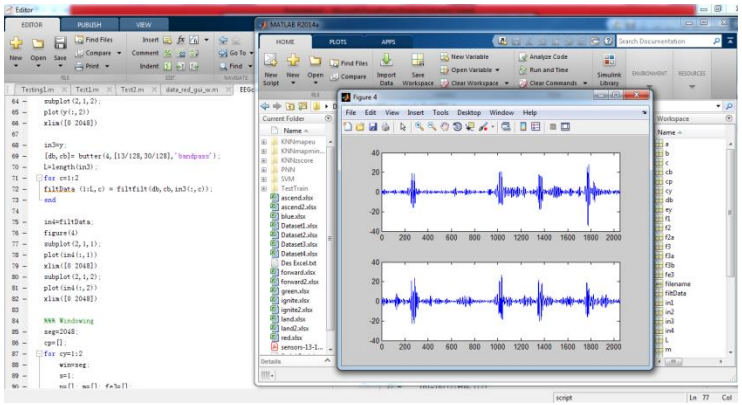
# Real-Time Signal Processing System

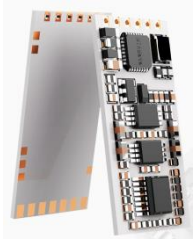
# How it works?

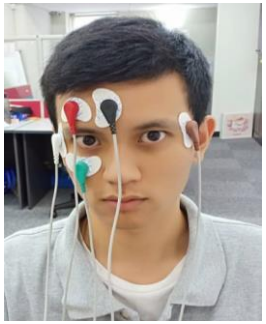


Connect Mindata and Acquire Signal

Signal Processing Algorithm

Hardware Interface (Drone)





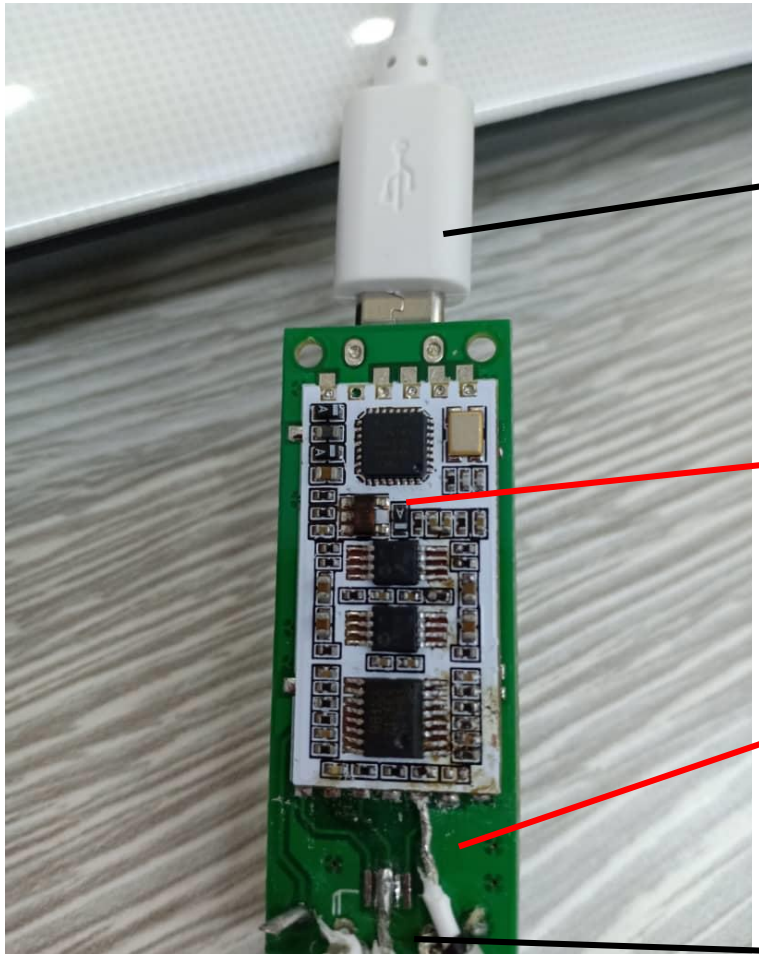
# Connect Mindata and Acquire Signal

**Step 1:** Design the data collection device (soldering required)

1. Connect mindata chip with universal asynchronous receiver/transmitter (UART) module.

2. Connect the device with electrodes.

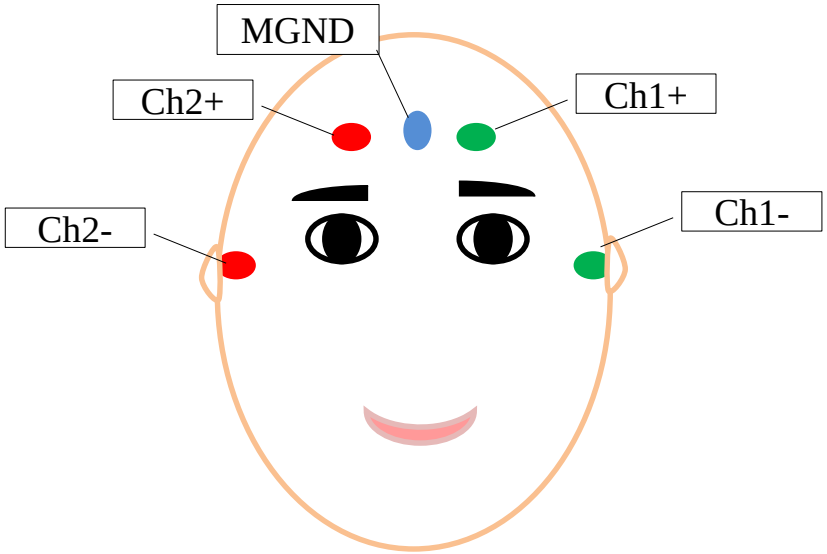
# Sample Data Collection Device



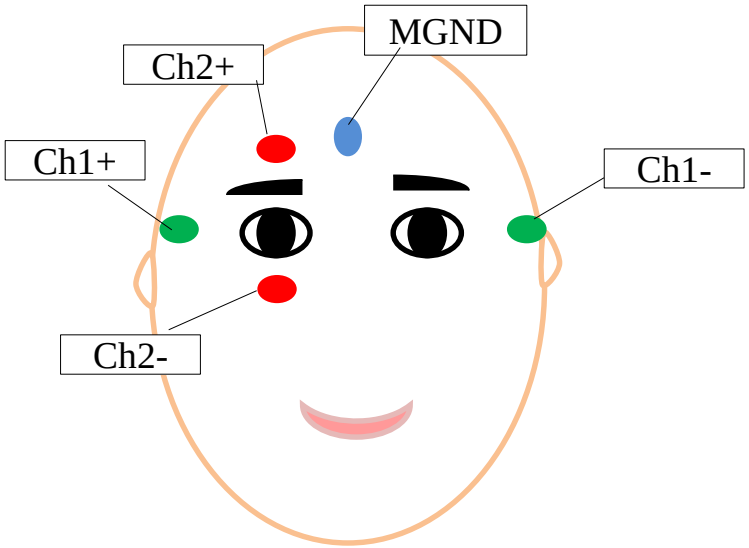

Mindata Chip with UART

# Connect Mindata and Acquire Signal

**Step 2:** Connect electrodes with proper placement (10-20 system)




Sample EEG placement (FP1 and FP2)




Sample eye blink EMG / EoG placement (right eye)

# Connect Mindata and Acquire Signal

**Step 3:** Connect to serial port / processor to receive data

e.g. in MATLAB:

1. Declare com port, s=serial(‘com3’);
2. Data buffering
3. Binary data to signed integer
4. Data stacking (sample frequency = 256 Hz)

# Signal Processing Algorithm

**Step 4:** Design signal processing algorithm (methods use and parameters setting)

1. Detrend the signal by subtracting overall mean.
2. Filtering, e.g.
   - ✓ EEG – band pass 8-50 Hz, Butterworth $4^{th}$ - $6^{th}$ order
   - ✓ EMG – high pass filter 50 Hz, Butterworth $4^{th}$ order
   - ✓ EoG – band pass 0.1-30 Hz, Butterworth $4^{th}$ order
   - ✓ Notch filter with 50 Hz cut-off frequency can be used to remove the power line interference
3. Feature extraction (e.g. mean, energy, entropy).
4. Decision making (threshold value / classification e.g. KNN, SVM and etc.)

# Hardware Interface

**Step 5:** Send decision to drone to carry out action

e.g. in MATLAB:

```
s=serial('com5');    % declare serial port
fopen (s);           % open serial port
fprintf (s,'%c','Fly'); % print text to serial port
fclose (s);          % close serial port
```

# Off-line Signal Processing

Purposes:

1. Design signal processing algorithm (signal analysis, decide parameters and features).
2. Create database for classification (training and testing).

# Off-line Signal Processing

## Data Collection

1. Understand the nature characteristics of biosignals.
2. Design data collection protocol according to the biosignals.

# Tips For Protocol Design

EEG

- Scheme 1: stimulus induction (external: visual, sound, music// internal: spelling and imagination).
- Scheme 2: attention detection (relax to focus).

EMG eye blinks:

- 2 eye blinks, 3 eye blinks, static eye closed and static stare.

EoG eye ball movement:

- Up, down, right, left, up-right, up-left, down-right and down-left.

# Tips For Pilot Training

1. Limits body movement.
2. Limits eyes blinking for EoG and EEG.
3. Follow the protocol.
4. Be consistent.

# Tips For Choosing Features

EEG: frequency domain features, frequency ratios

EMG eye blink: time domain features, peak detection

EoG: time domain features, maximum peak amplitude, minimum amplitude, area under curve (AUC)

# Tips For Decision Making Algorithm

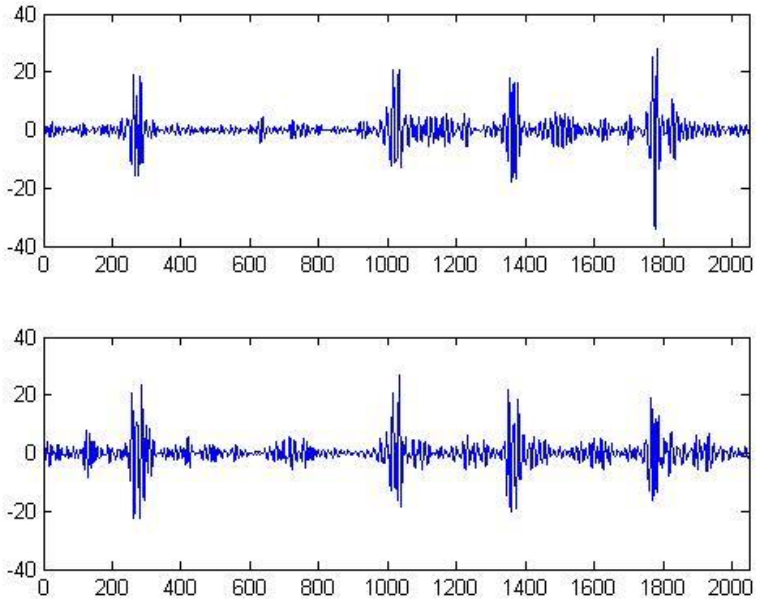
Threshold method:

- if threshold>1, then ‘fly’; else ‘land’
- Database may be required to analyze the threshold value during off-line.

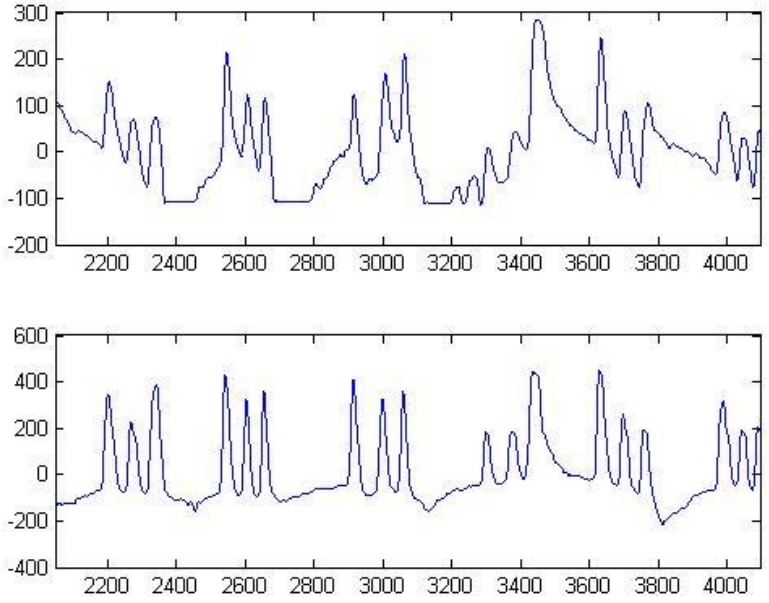
Classification:

- Database may be required during real-time
- Can be pre-trained
- K-nearest neighbour (KNN), support vector machine (SVM), neural network (NN), decision tree (DT)

# Sample Signal (Filtered)




EEG signal




EMG eye blinks