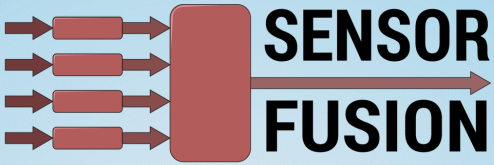


# Lab Work: Orientation Estimation using Smartphone Sensors

Sensor Fusion

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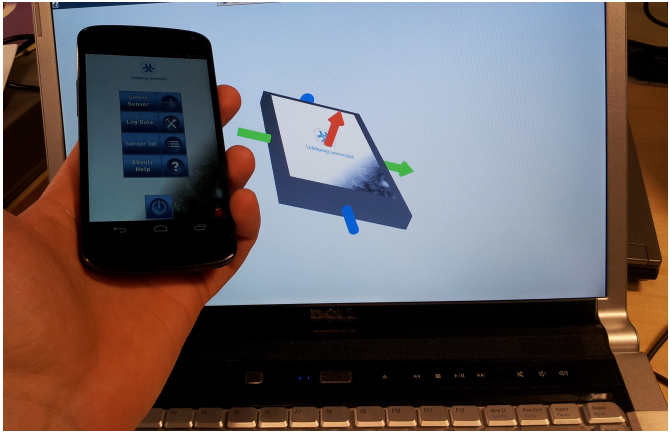
# Problem Formulation

**Given:**

- Inertial measurement from smartphone.
- Build-in smartphone orientation estimate.

**Goal:**

- Determine orientation of the smartphone in real time.
- Be able to handle outliers.



# Tasks

1. Connect the phone with your lab computer.
2. Get to know your data.
3. Add the EKF time update step.
4. Add the EKF accelerometer measurement update step.
5. Add accelerometer outlier rejection.
6. Add the EKF magnetometer measurement update step.
7. Add magnetometer outlier rejection.
8. Test your filter without gyroscope measurements.

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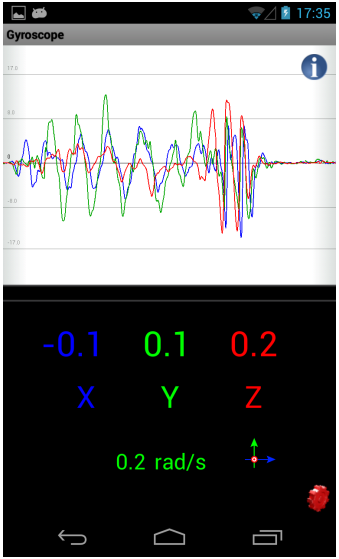
**Examination**

Present a working solution of the orientation estimation problem addressing the aspects highlighted in the lab instructions.

# The Measurements




Using measurements available on most phones, and any other gadgets.

- *Inertial measurement unit* (IMU):
  - Accelerometer:
    *Gravity points down*
  - *Gyroscope:*
    *Relative orientation change*
  - *Magnetometer (not inertial):*
    *A compass points north*

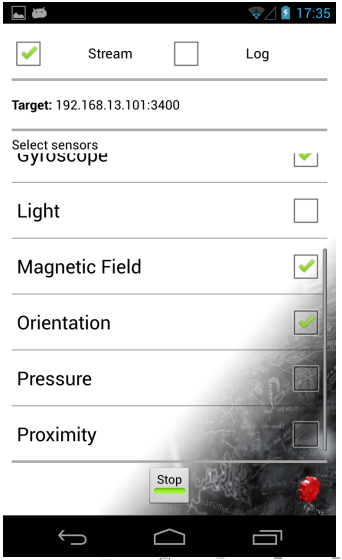
# Important Components

- Experience *quaternions* as an orientation representation.
- Design and implement an *extended Kalman filter* (EKF).
- Understand outliers and mitigate them.

```
%% Filter loop
% Repeat while data is available and q hasn't been pressed
while server.status() && ~ownView.quit
  data = server.getNext(5);

  gyr = data(1, 5:7)';
  if ~any(isnan(gyr)) % Gyro measurements are available.
    % Do something
  end

  acc = data(1, 2:4)';
  if ~any(isnan(acc)) % Acc measurements are available.
    % Do something
  end

  mag = data(1, 8:10)';
  if ~any(isnan(mag)) % Mag measurements are available.
    % Do something
  end

  orientation = data(1, 18:21)'; % Google's orientation.

  % Visualize result
  setOrientation(ownView, x(1:4));
  setOrientation(googleView, orientation);
end
```

# Getting Started

1. Install the Sensor Fusion app.
2. Connect your smartphone and computer to the same network
3. Start MATLAB, determine and set the correct target IP in the Sensor Fusion app.
4. Start the collection in MATLAB.
5. Start streaming data from the app.
6. The MATLAB script should have access to measurements in real time.



# Troubleshooting: Phone cannot connect to MATLAB

## Symptom

The phone does not connect to the Matlab function.

- The app indicates "I/O error".
- MATLAB says "Unsuccessful connecting to client!".

## Reasons

The phone cannot connect to the server/MATLAB function.

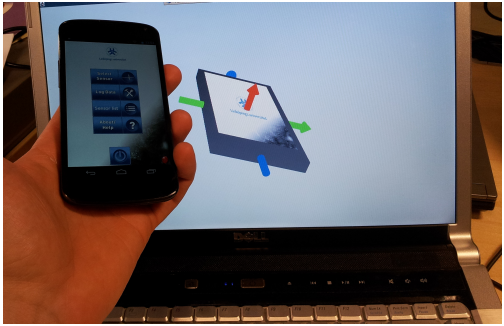
- Start MATLAB script **before** start streaming in the app.
- The wrong target IP is set in the app.

  *It should match the IP listed when you start the MATLAB script.*
- Connect the phone and computer to the same network,

  *Technically the phone must be able to address computer directly.*
- Allow incoming connections to the computer from port 3400.

  *The port can be changed, to one open in the firewall, in the app, but then the script must be updated too.*

# Closing Remarks



- **Goal:** Estimate the orientation of a smartphone.
- **Main objectives:**
  - Experience working with real data, and handle imperfections and disturbances.
  - Gain understanding of inertial (and magnetic) measurements, and their complementary properties for the problem.
  - Use quaternions to represent orientation.
  - Design and code an extended Kalman filter (EKF)
- **Examination:** Present a working solution.
- **Time requirement:** approx. 16 h