# DES535
# Ubiquitous Computing

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Google Classroom Code : pcwnf5t

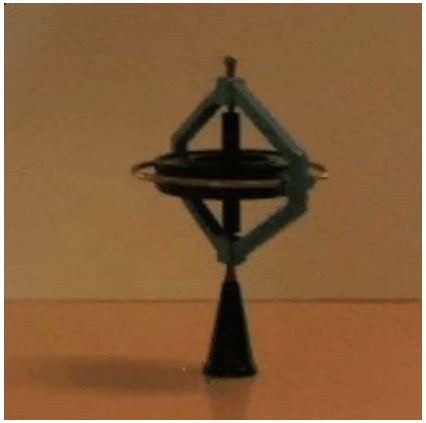
# Motion & Activity Sensing

Module V (Part I)

# Gyroscope

**A gyroscope is a device used for measuring or maintaining orientation and angular velocity**

A **mechanical** gyroscope essentially consists of a spinning mass that rotates around its axis. In particular, when the mass is rotating on its axis, it tends to remain parallel to itself and to oppose any attempt to change its orientation.
If a gyroscope is installed on gimbals that allow the mass to navigate freely in the three directions of space, its spinning axis will remain oriented in the same direction, even if it changes direction.
**Precession** is a change in the orientation of the rotational axis of a rotating body.



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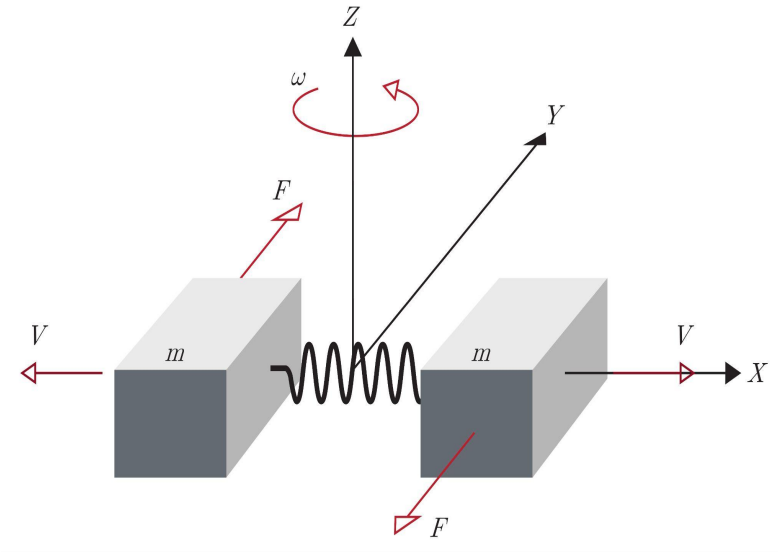
https://www.researchgate.net/figure/Orientation-of-the-head-in-terms-of-pitch-roll-and-yaw-movements-describing-the-three_fig1_279291928

# Gyroscope

A **Micro-Electro-Mechanical Systems (MEMS)** gyroscope measures the angular rate by applying the theory of the Coriolis effect, which refers to the force of inertia that acts on objects in motion in relation to a rotating frame.

- Consider a mass suspended on springs.
- This mass has a driving force on the x-axis causing it to oscillate rapidly in the x-axis.
- While in motion an angular velocity, w , is applied about the z-axis.
- This results in the mass experiencing a force in the y-axis as a result of the Coriolis force, and the resultant displacement is measured by a capacitive-sensing structure.

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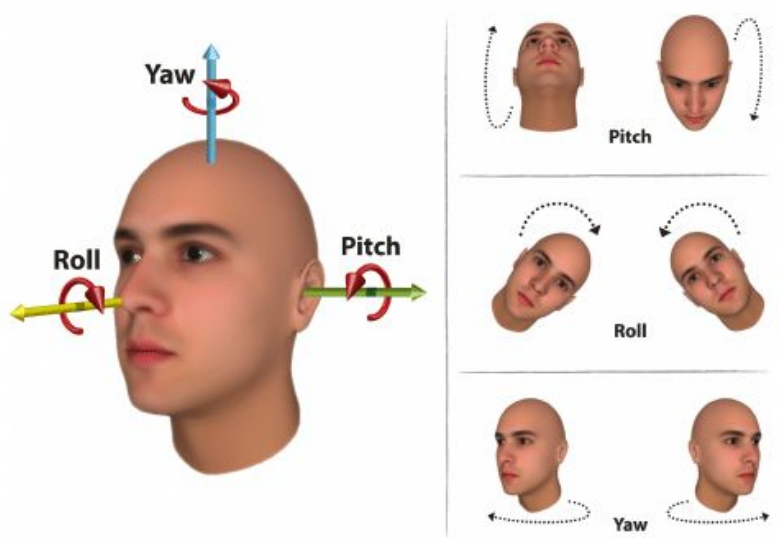
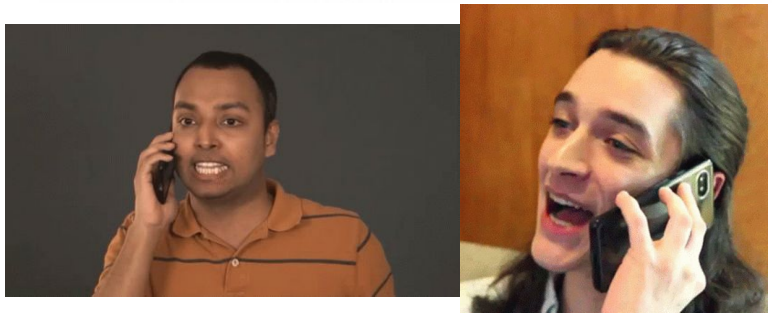
# Gyroscope

- Rotation around the front-to-back axis is called roll.
- Rotation around the side-to-side axis is called pitch.
- Rotation around the vertical axis is called yaw




Can you think of an application that detects speakers emotion from the Gyroscope reading of their smartphone?



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# Human Activity Recognition

## Activity Category

| Category | Specific Activities |
|---|---|
| Locomotion | Walking, running, jogging, lying, standing, sitting, going upstairs/downstairs, and so on |
| Transport mode | Cycling, riding a bus, driving, traveling with a vehicle, and so on |
| Phone usage | Texting, making a call, using an app, browsing the web, checking the email, and so on |
| Entertainment | Playing soccer, playing basketball, attending a party, gaming, and so on |
| Health-related activity | Falls, respiration, rehabilitation activities, smoking, and so on |
| Daily activity | Sleeping, using computer, shopping, eating, attending a meeting, having a conversion, going to work, and so on |
| Gesture | Body gestures, arm gestures, hand gestures, head gestures, body languages, sign languages, and so on |
| Emotion | Angry, disgust, fear, happy, sad, surprise, neutral, and so on |
| Security | Presence, attacking, abnormal activities, and so on |

https://dl.acm.org/doi/pdf/10.1145/3472290

# Human Activity Recognition

## Main Characteristics of Human Activity Recognition Systems

1. Execution

- Offline

The system records the sensor data first. The recognition is performed afterwards. Typically used for non-interactive applications such as health monitoring. Example : A system that pervasively tracks user's accelerometer and gyroscope data and analyses their total "active time" for each day. The analysis is done at 12 am everyday.

- Online

The system acquires sensor data and processes it in real time. Typically used for activity-based computing and interactive applications in human-computer interaction. Example : A system analyses the IMU data to count the number of steps and notifies the user upon reaching 5000 steps.

https://dl.acm.org/doi/pdf/10.1145/2499621

# Human Activity Recognition

## Main Characteristics of Human Activity Recognition Systems

2. Generalisation

- User independent
  The system is optimised for working with a large number of users. Example: A smart office desk that uses a threshold to check users' EDA for detecting stress.

- User specific
  The system is tailored to a specific user. Performance is usually higher than in the user-independent case, but does not generalise as well to other users.

  Can you think of an example?

https://dl.acm.org/doi/pdf/10.1145/2499621

# Human Activity Recognition

## Main Characteristics of Human Activity Recognition Systems

3. Recognition

- Continuous
  The system automatically “spots” the occurrence of activities or gestures in the streaming sensor data. Example : A system that identifies “blink” from the continuous ultrasound signals, reflected from the eye region.

- Isolated (Segmented)
  The system assumes that the sensor data stream is segmented at the start and end of a gesture by an oracle. Example : A system that separates a “blink” from “drowsiness” by analysing the ultrasound signals reflected from the eye region in a 2 secs window.

https://dl.acm.org/doi/pdf/10.1145/2499621

# Human Activity Recognition

## Main Characteristics of Human Activity Recognition Systems

4. Activities

- Periodic

  Activities or gestures exhibiting periodicity, such as walking, running, rowing, biking, etc. Sliding window segmentation and frequency-domain features are generally used for classification.

- Sporadic

  The activity or gesture occurs sporadically, interspersed with other activities or gestures. Segmentation plays a key role to isolate the subset of data containing the gesture. Example?

- Static

  The system deals with the detection of static postures or static pointing gestures.

https://dl.acm.org/doi/pdf/10.1145/2499621

# Human Activity Recognition

## Main Characteristics of Human Activity Recognition Systems

5. System model

- Stateless
  The recognition system does not model the state of the world. Activities are recognised by spotting specific sensor signals. This is currently the dominant approach when dealing with the recognition of activity primitives (e.g. reach, grasp).
- Stateful
  The system uses a model of the environment, such as the user's context or an environment map with location of objects. This enhances activity recognition performance, at the expense of more design-time knowledge and a more complex recognition system.

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# Human Activity Recognition

## Intraclass Variability

Such variability occurs because the same activity may be performed differently by different individuals. Intraclass variability can also occur if an activity is performed by the same individual.

## Interclass Similarity

An inverse challenge is given by classes that are fundamentally different but that show very similar characteristics in the sensor data

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# Human Activity Recognition

## Types of sensors for HAR

- Ambient Sensors

Ambient sensors require to be installed at fixed locations to recognize activities, which usually contain a server (e.g., WiFi access point) and a client (e.g., WiFi receiver).
Examples: GPS, **WiFi**, Cellular, RFID etc.

- Wearable Sensors

Wearable sensors are the sensors that are easy to carry and are usually built in smart devices.
Examples: Accelerometer, Gyroscope, Magnetometer, Barometer, Camera, Light, Acoustic Sensor, Biosensors.

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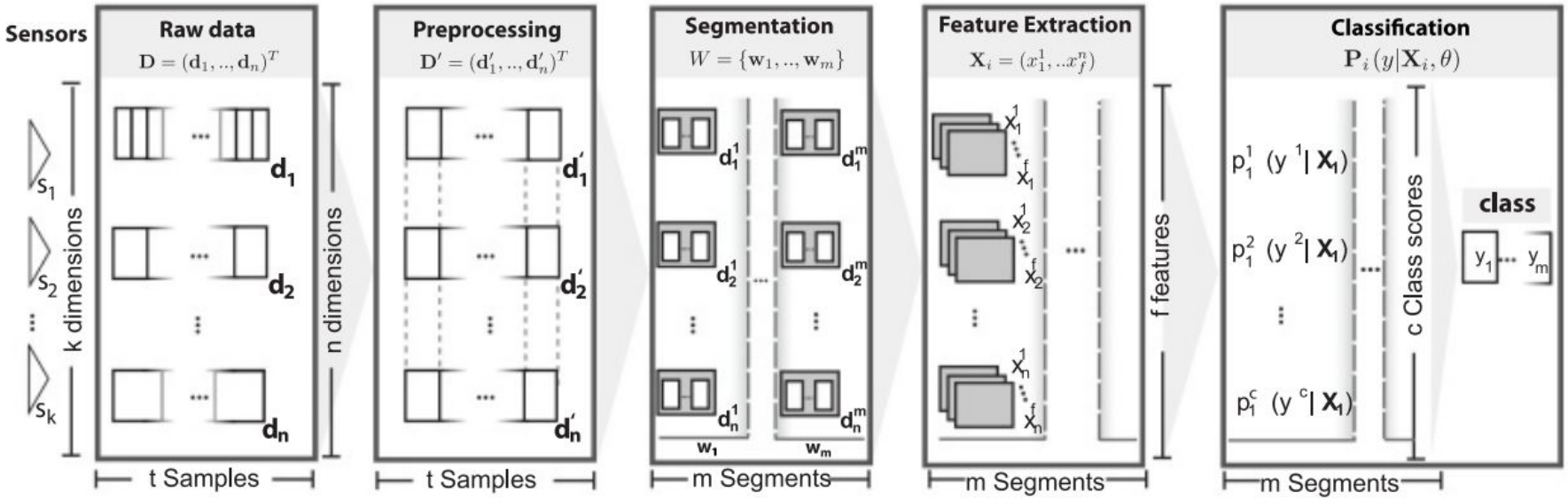
# Human Activity Recognition

## Activity Recognition Chain (ARC)




An ARC comprises stages for data acquisition, signal preprocessing and segmentation, feature extraction and selection, training, and classification. Raw signals (D) are first processed (D ) and split into m segments (Wi) from which feature vectors (Xi) are extracted. Given features (Xi), a model with parameters θ scores c activity classes Yi = {y1,..., yc} with a confidence vector pi.



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