Multi-Sensor Data Fusion

Class 3: Sensor Types

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This Week's Agenda

Monday	The Sensor Fusion Problem
Tuesday	Algorithms
Wednesday	Sensor Types
Thursday	Sensor Fusion
Friday	Applications

Course Description

The use of multiple, heterogeneous sensors is often necessary. This is the case in areas such as robot control, autonomous vehicles and military aviation. Different skills are required including electrical engineering, computer science and statistics. These systems can be complex and include many control theory concepts. In this class we will go over the problem, describe the types of algorithms and sensors used and finally will give some examples.

Today's Agenda

- Sensor Types
- Basic Sensors
- Cameras
- Range and Direction Sensors
- GPS/IMU
- Conclusion/Next Class

Sensor Types

- Sensors can be divided into at least two categories
  - Basic Sensors: These types measure and put out a single value (or set of values) at a specified rate or when queried. There is no complexity or substructure to their data.
  - Complex Sensors: These types contain complex information which can be interpreted in many ways.

Basic Sensors

- Examples of basic sensors
  - Magnetometers: typically used for measuring direction.
  - Pressure Sensors
  - Barometric Altimeter: used to measure altitude
  - Temperature Sensors
  - Switch Sensors
  - Inertial Measurement Sensors
    - Accelerometers
    - Rate Sensors
    - Angle Sensors

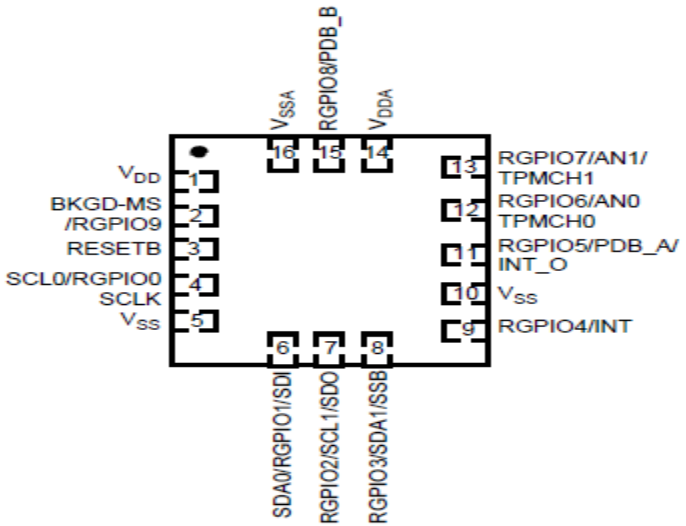
Basic Sensors

- Examples of basic sensors, continued
  - For vehicle systems
    - Odometer
    - Steering angle
    - Brake pressure
  - Industrial
    - Densimeter (density measurement of fluids)
    - Sound Velocity
    - Angular position sensor (measure remotely the angle of a workpiece)

Basic Sensors

- Many modern sensors have built in processing to convert the stress or magnetic field analog values to a digital value that can be used directly. In the past these had to be calculated by the central processing unit using estimation techniques

16-pin LGA
3 mm x 3 mm x 1 mm
Case 2094-01



Pin connections

Cameras

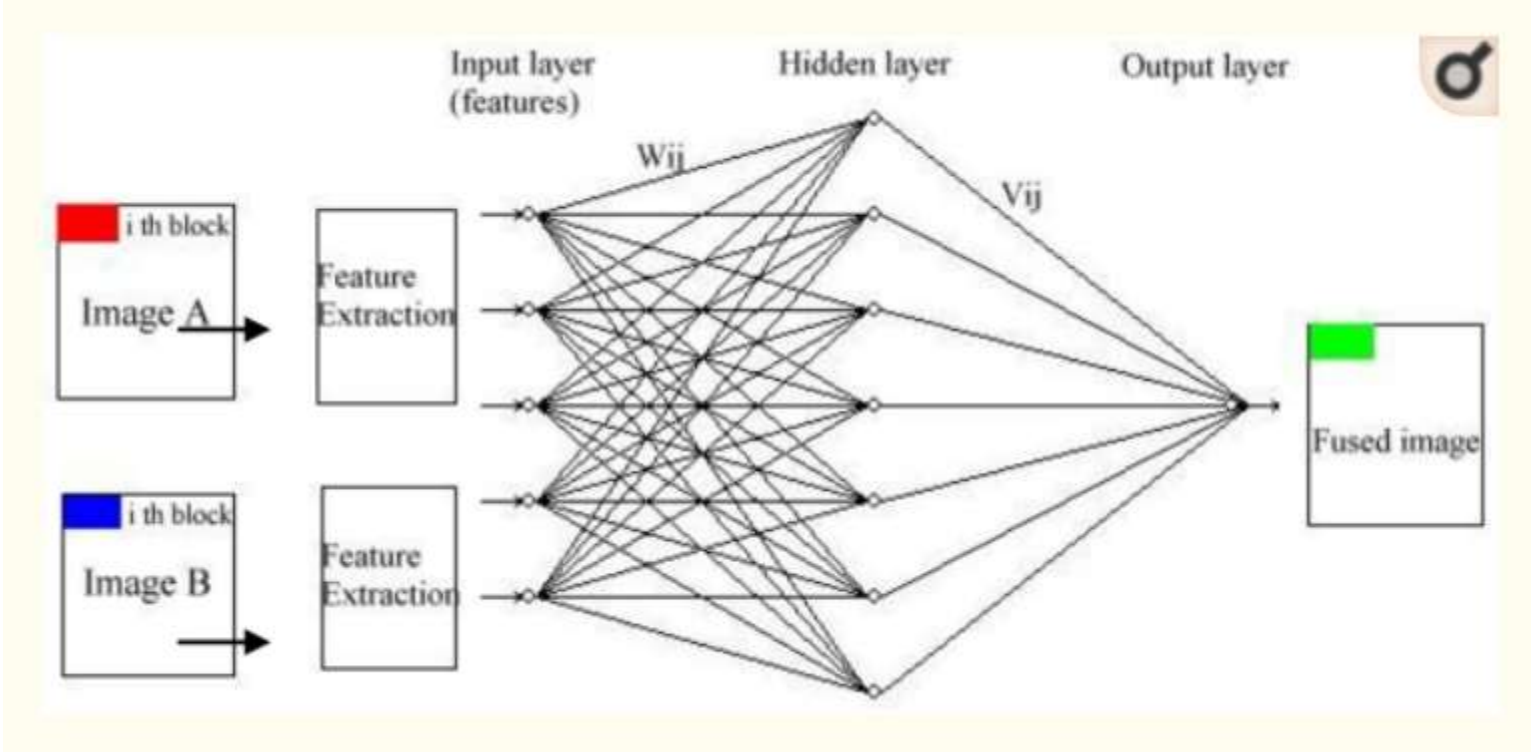
- Cameras, or computer vision systems, come in many different forms and often form a critical function in various automation systems. These range from autonomous vehicles to robots to inspection systems.
- Different wavelengths of light can be used for different purposes
  - Visible
  - Infrared
  - Ultraviolet

Cameras

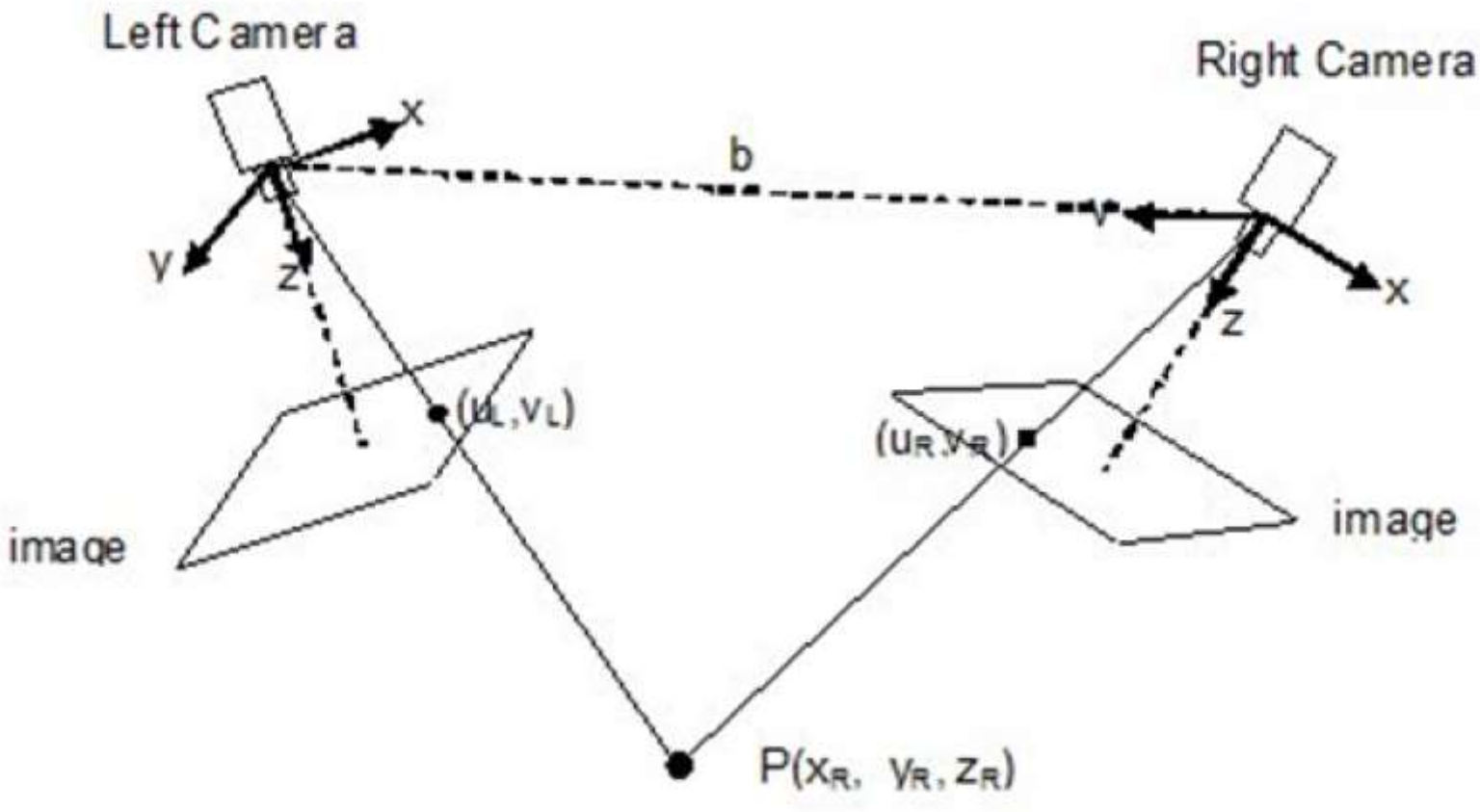
- In vehicle and robot applications these are often the best sensors to allow a view of the environment
- The are also the most complex to process
  - Typical processing steps include edge processing, object identification, relationship identification
  - Spectral information may be used to identify specific types of objects
  - Depth information is often critical to planning movement
  - Processing is typically on a frame by frame basis with estimation techniques used to track trajectories

Cameras

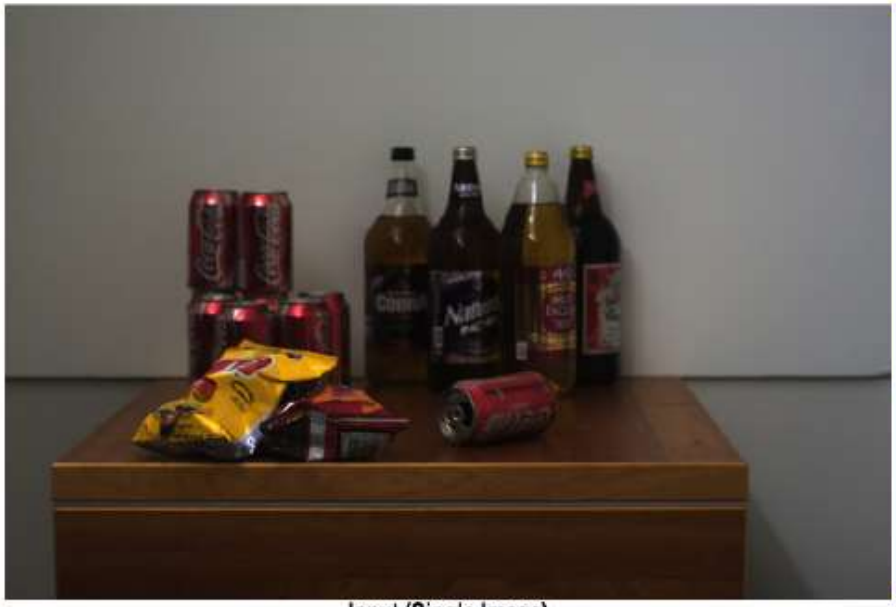
- Processing techniques often involve Artificial Neural Networks (ANN)



Cameras



Cameras



Input (Single Image)

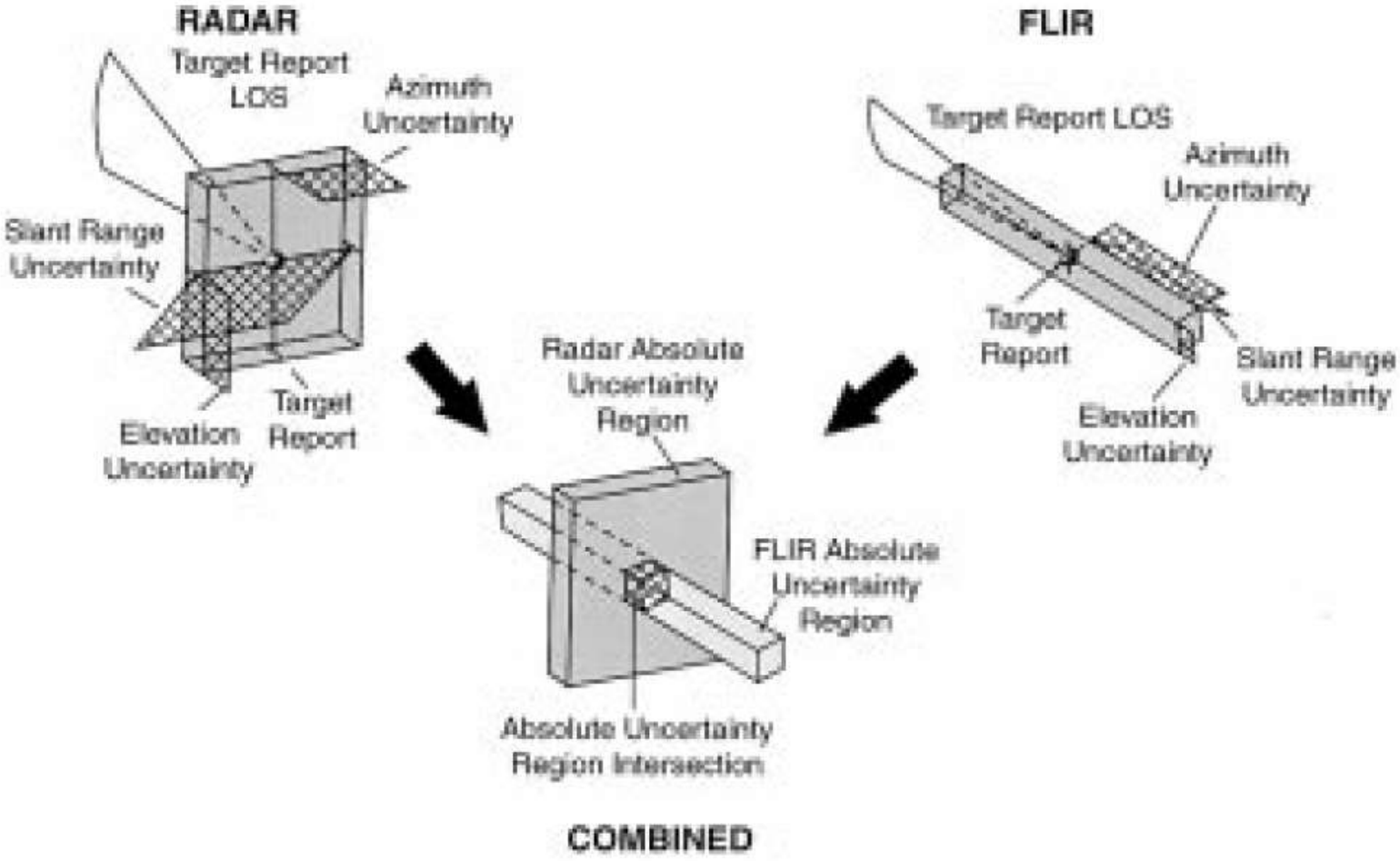
Estimated Depth

Range and Direction Sensors

- There are several types of range and direction sensors we can use
  - Radar
  - Lidar
  - FLIR (Forward Looking Infrared)
- Processing for each may include the types of algorithms we discussed previously for the overall sensor fusion process
  - Layered architecture

Range and Direction Sensors

- Combining Radar and FLIR sensors reduces uncertainty



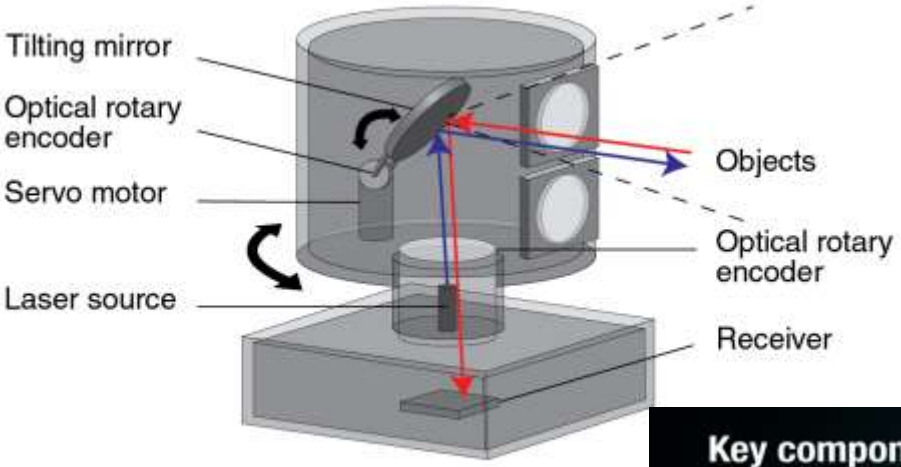
Range and Direction Sensors

- Lidar is a sensor used to detect objects in the environment. It is similar to radar
  - Lidar stands for Light Detection and Ranging
  - Originally developed for remote sensing and mapping
  - Being used increasingly as price and size decrease
- Several different types
  - Spinning scanning
  - Solid-state scanning
  - Time of flight
  - Flash
  - Coherent

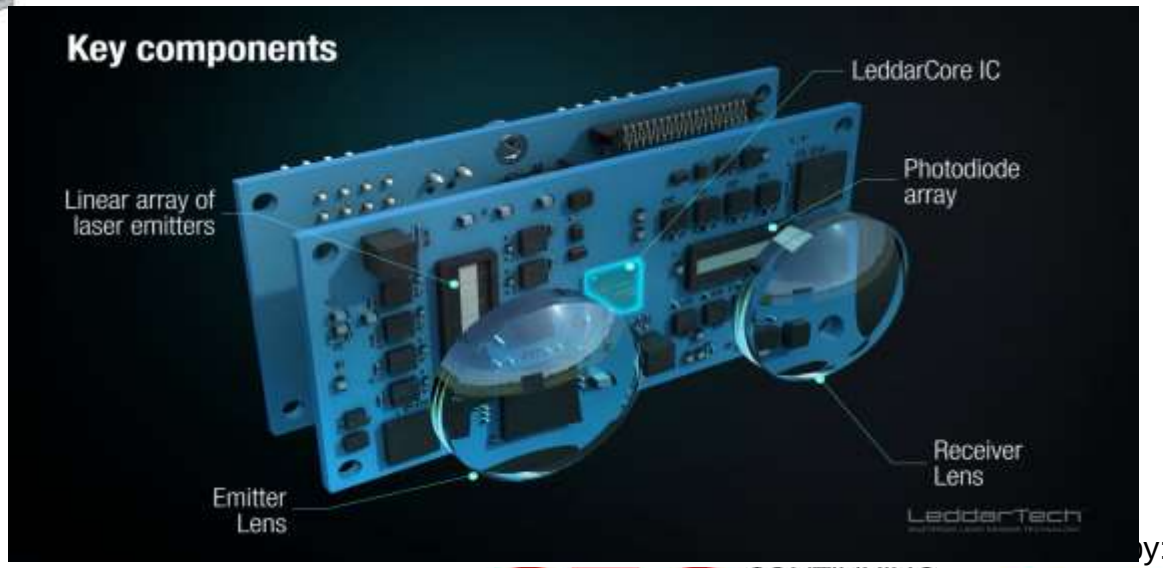
Range and Direction Sensors

- Lidar systems generally use time-of-flight of the light signal from the laser to the target to the detector
  - Some systems use a burst of light and a more complex detector (more common for mapping)
- Various methods, such as spinning mirrors or solid-state detectors are used
- There are generally many lasers incorporated into the system (up to 128)

Range and Direction Sensors



Internals of both a spinning scanner Lidar and a solid-state Lidar system



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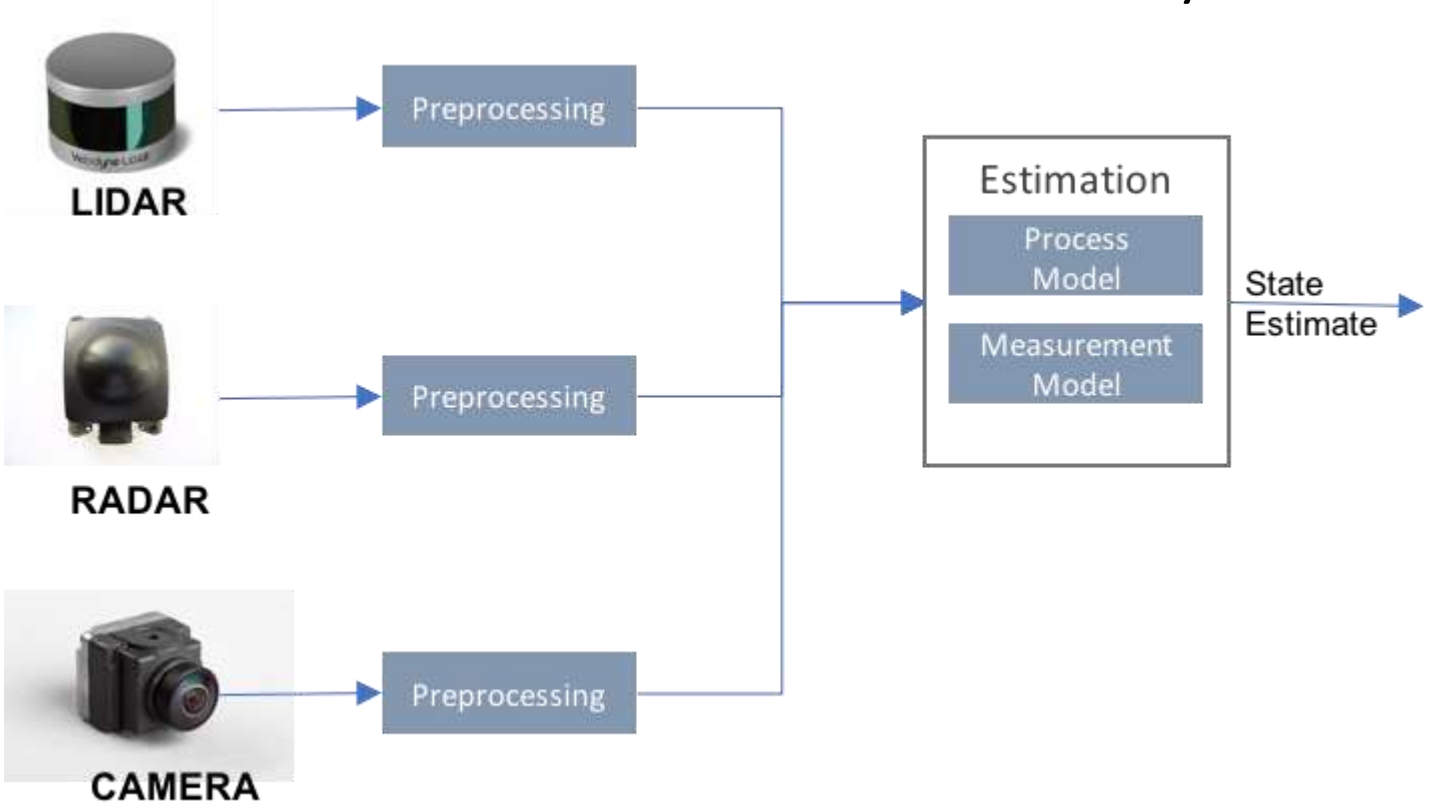
Range and Direction Sensors

- These sensors are often combined with vision systems



Note that each has its own preprocessing step

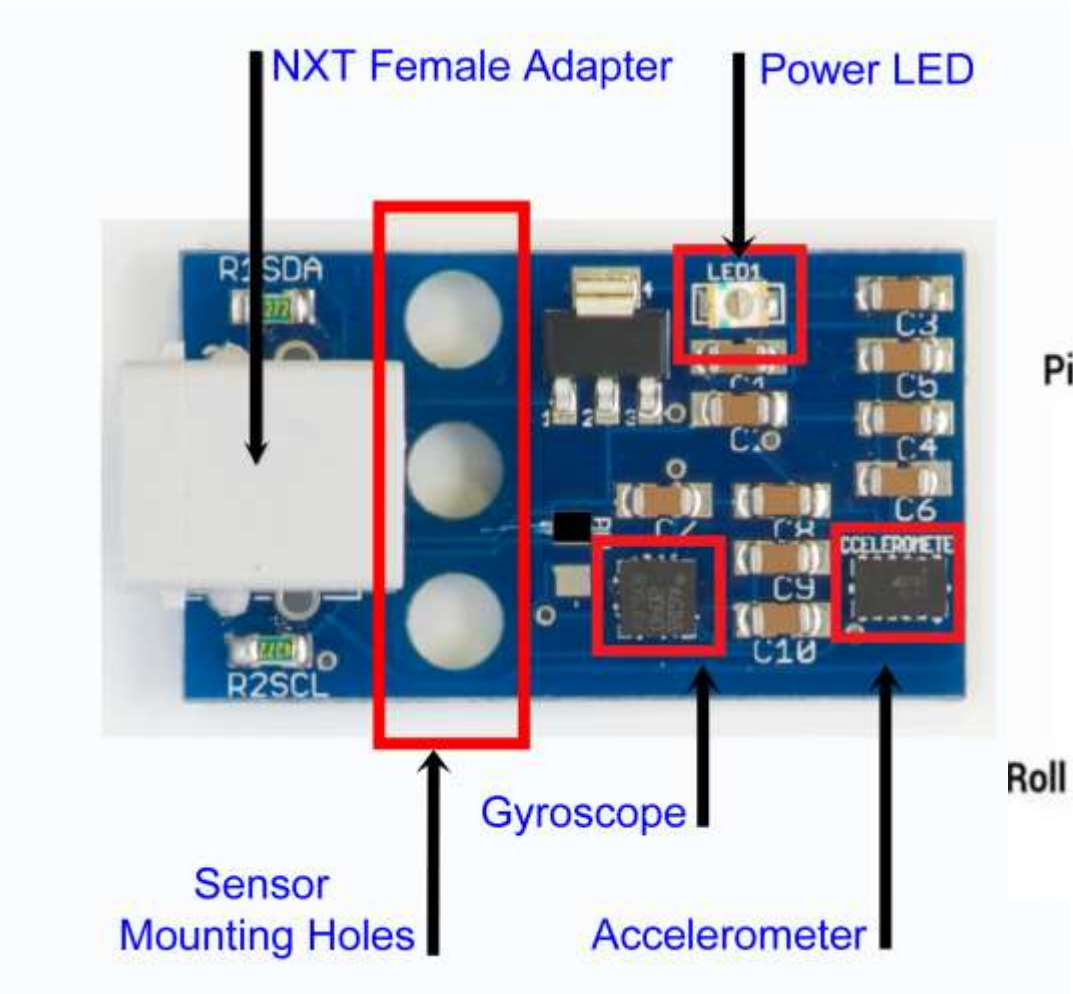
GPS/IMU

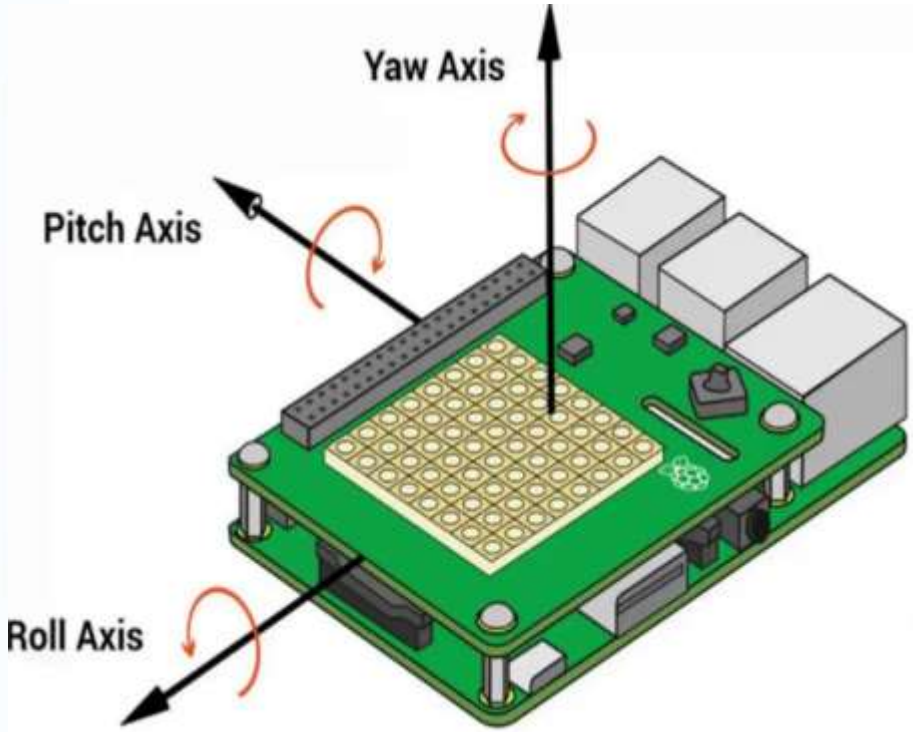
- GPS, or Global Positioning System, uses a constellation of satellites to provide absolute position
  - Accuracy is good, but not absolute
  - Integrated with other sensors, it can help increase the accuracy of position information

GPS/IMU

- IMU, or Inertial Measurement Unit, measures specific force, angular rate and orientation
  - Uses gyroscopes, accelerometers and magnetometers to give linear velocity, angular rate and attitude
  - Systems are now very compact, with the components implemented as integrated circuits
  - Used in dead reckoning, or with position information from systems such as GPS can give absolute location and direction

GPS/IMU


NXT Female Adapter
Power LED
LED1
C3
C5
C4
C6
C9
C10
Gyroscope
Sensor
Mounting Holes
Accelerometer


Yaw Axis
Pitch Axis
Roll Axis

Conclusion/Next Class

- We have looked at the two classes of sensors
- We have reviewed the details of some common sensors used in MSDF applications
- Tomorrow we will pull together the components and develop a general approach to the problem