COMP0130 Robot Vision and Navigation

1A: Introduction to Positioning

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Lecture 1A Objectives

- Introduce the types and methods of positioning
- Explain the structure for Topic 1 of the module

Contents

1. Types and Methods of Positioning

What is Positioning?

Positioning is the determination of the position of a body

Applications include

- Navigation of people, vehicles and robots
- Location-based services
- Machine control
- Vehicle testing
- Tracking and surveillance
- Intelligent transport systems
- Surveying and mapping
- Construction and Structure monitoring
- Dynamic positioning of offshore platforms
- Earth sciences (geodesy, seismology, atmospheric science)

Types of Positioning

Static

The object to be positioned is fixed

Or

Dynamic

The object to be positioned is moving

Real-time

Position solution is required immediately

Or

Post-processed

Position is required hours or days after measurements are made

Self

Position solution is calculated at the object to be positioned

Or

Remote

Position solution is away from the object to be positioned

Positioning in Robotics

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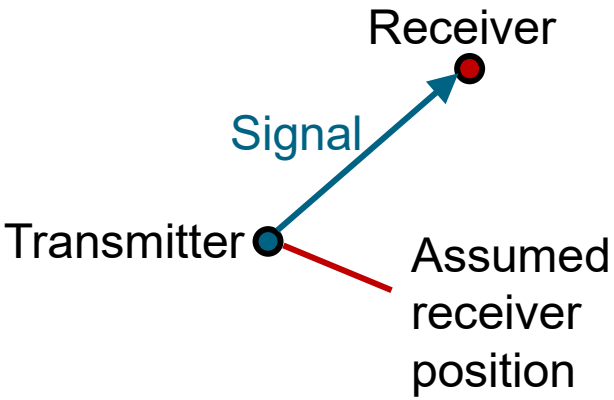
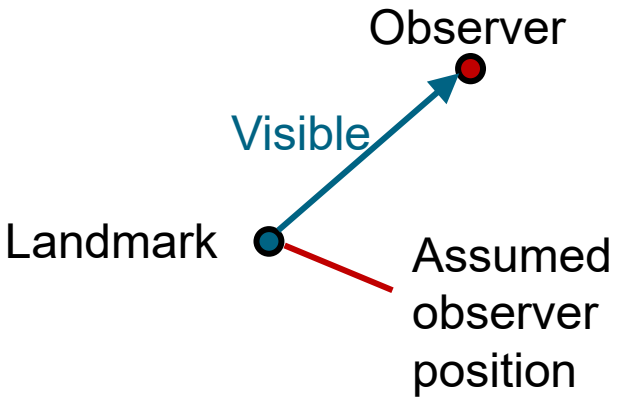
Proximity Positioning: Basic





Radio

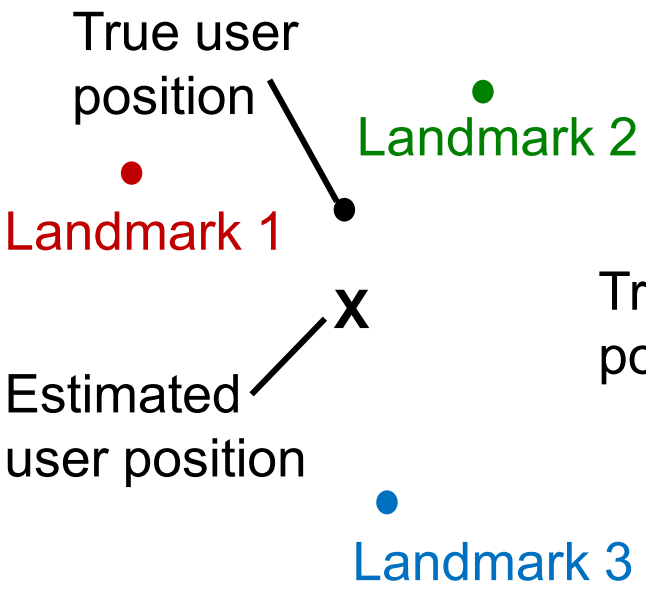
- Mobile user receives base station signal
- User position assumed equal to the base station position
- Best suited to very-short-range
- Example: Phone Cell ID

Environmental Feature

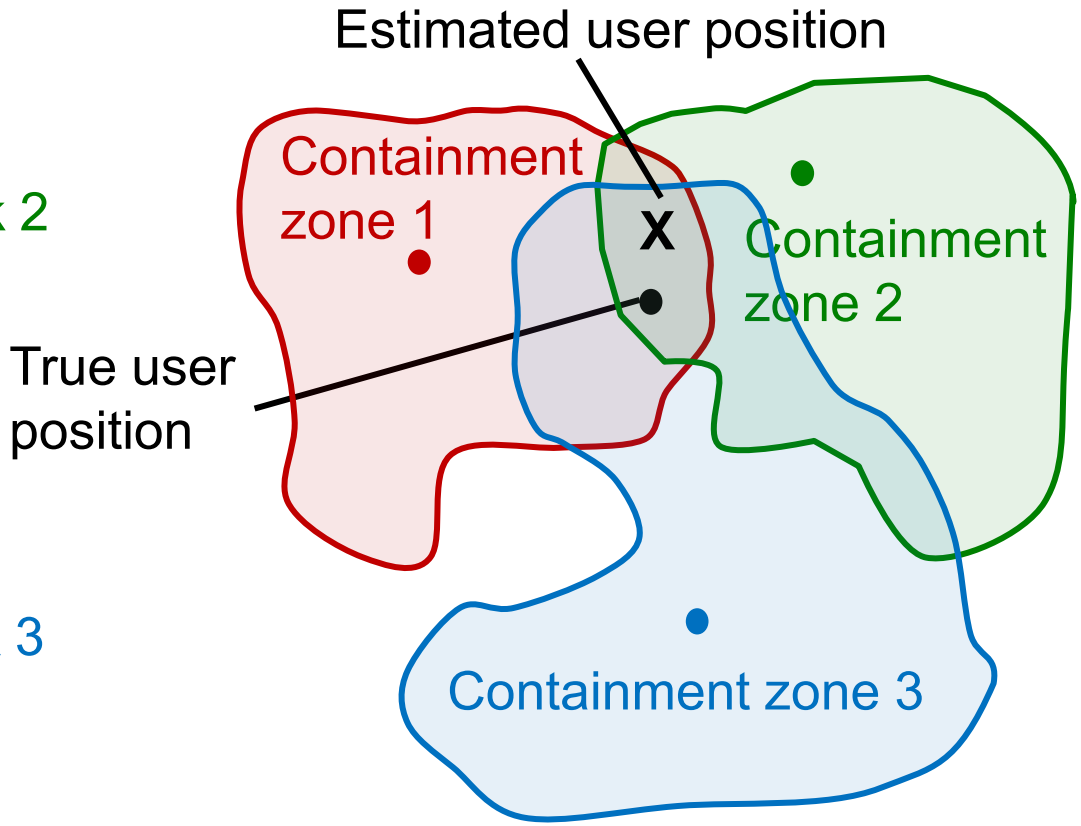
- Mobile observer sees a landmark
- User position assumed equal to the landmark position
- Best suited to very-short-range
- Example: Features on a map

Proximity Positioning: Advanced

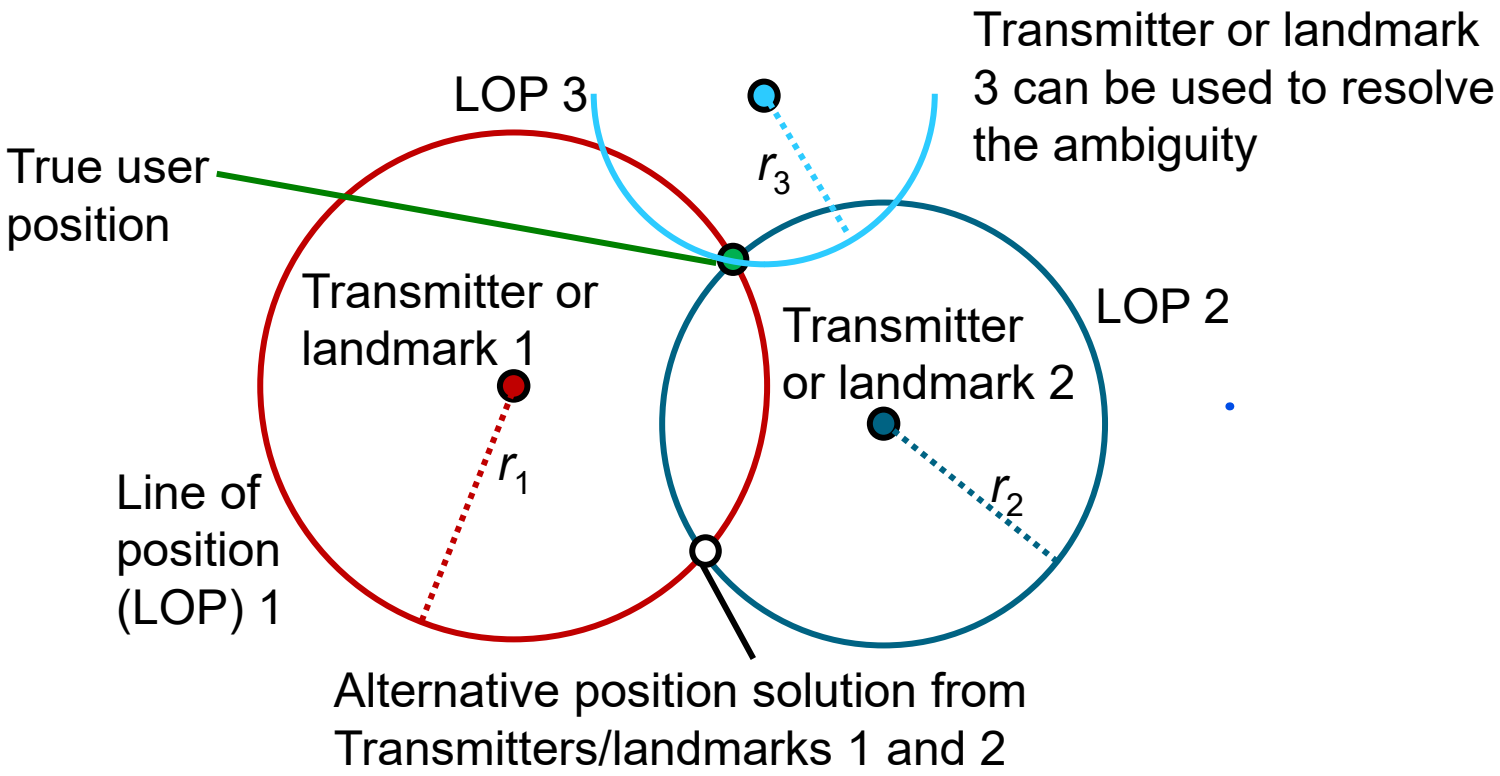
Averaging basic proximity fixes



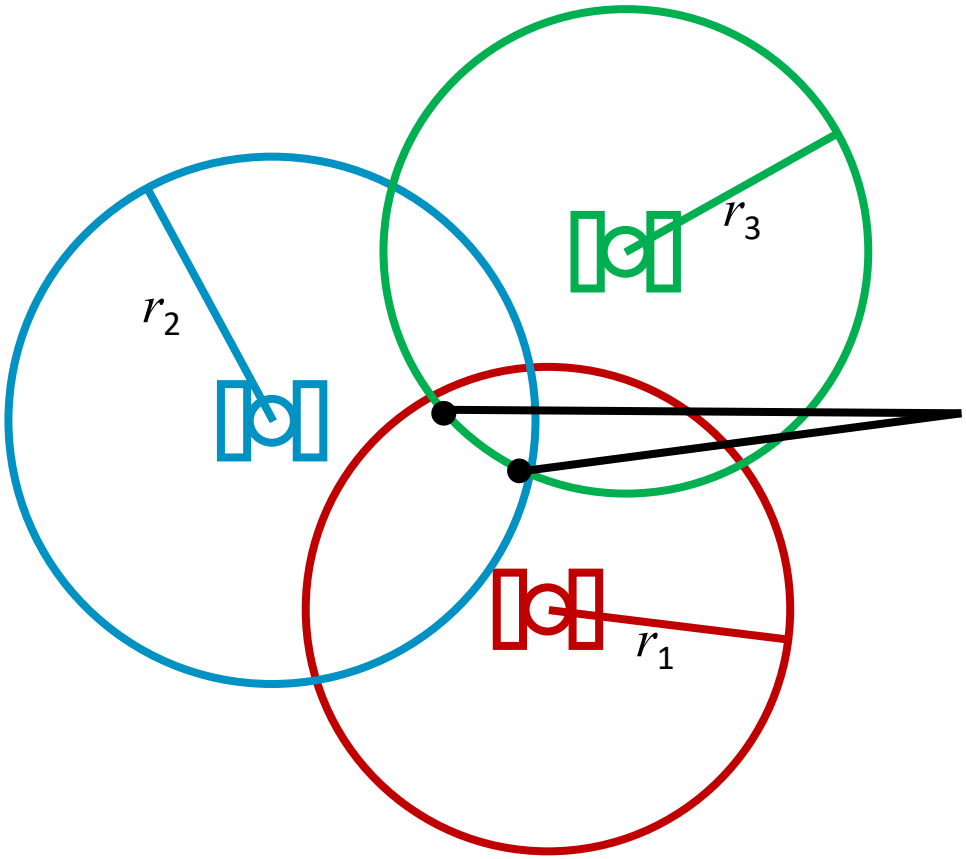
Containment intersection method



Ranging in Two Dimensions

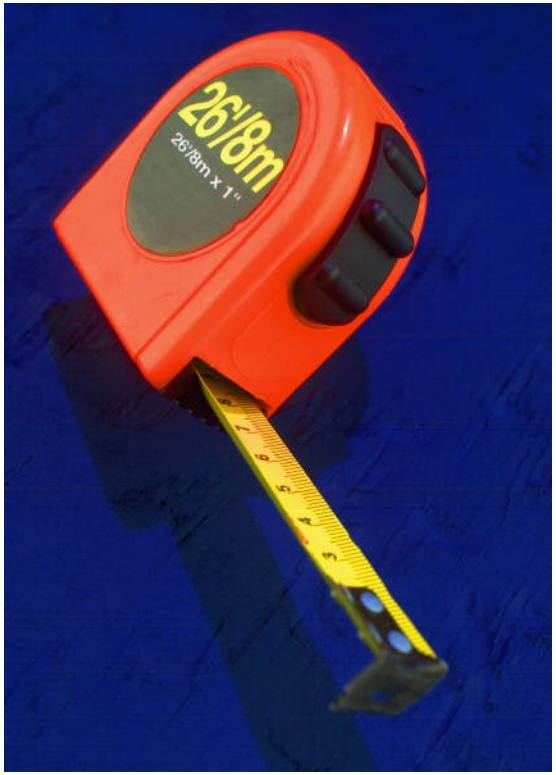


Ranging in Three Dimensions

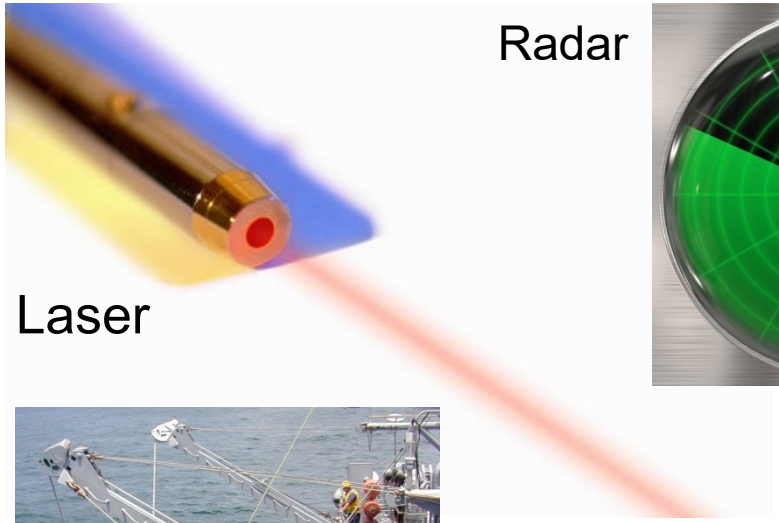


Ranging Measurement (1)

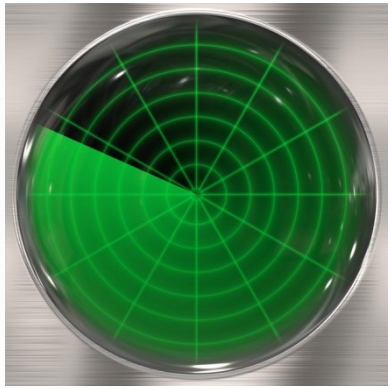
1.Physical Measurement

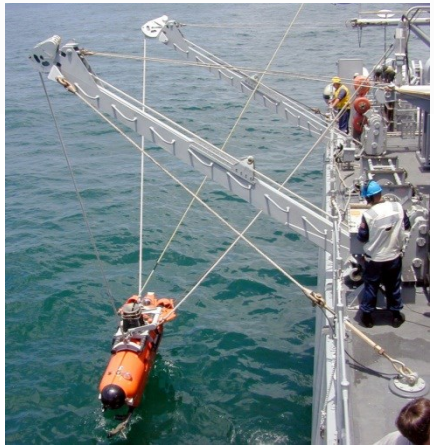


2. Bounce a signal off the target and time it



Radar





Sonar

Ball

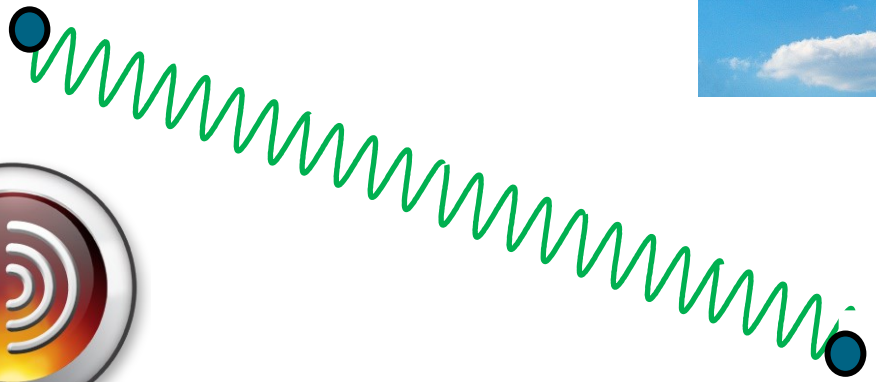
1. Types and Methods of Positioning

Ranging Measurement (2)

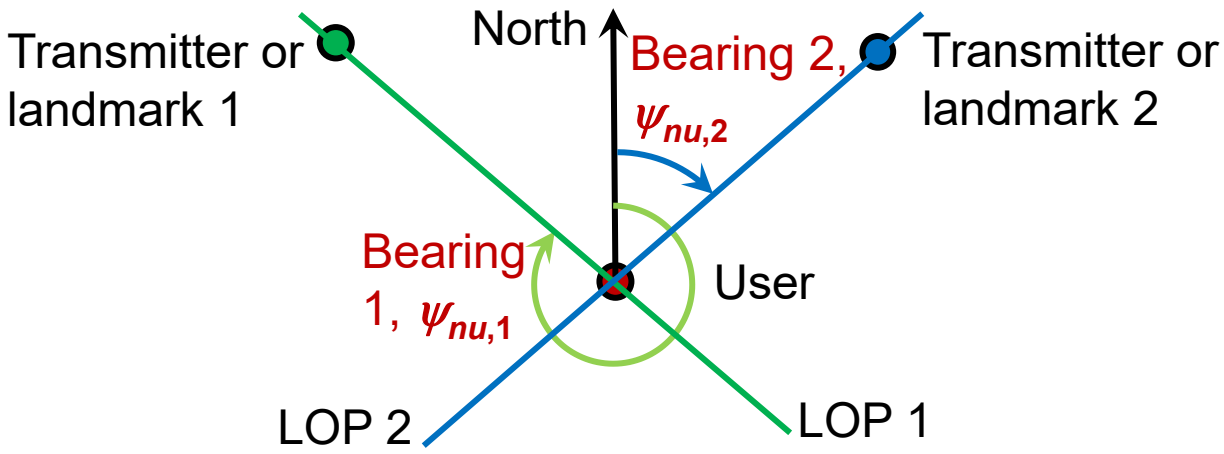
3. Transmit a signal
    a. From a known position to an unknown position
    b. From an unknown position to a known position
    c. Between two unknown positions
    d. In both directions

Range is determined from the difference in times of transmission and arrival

Signals can be
- Radio
- Acoustic
- Optical/ infra red

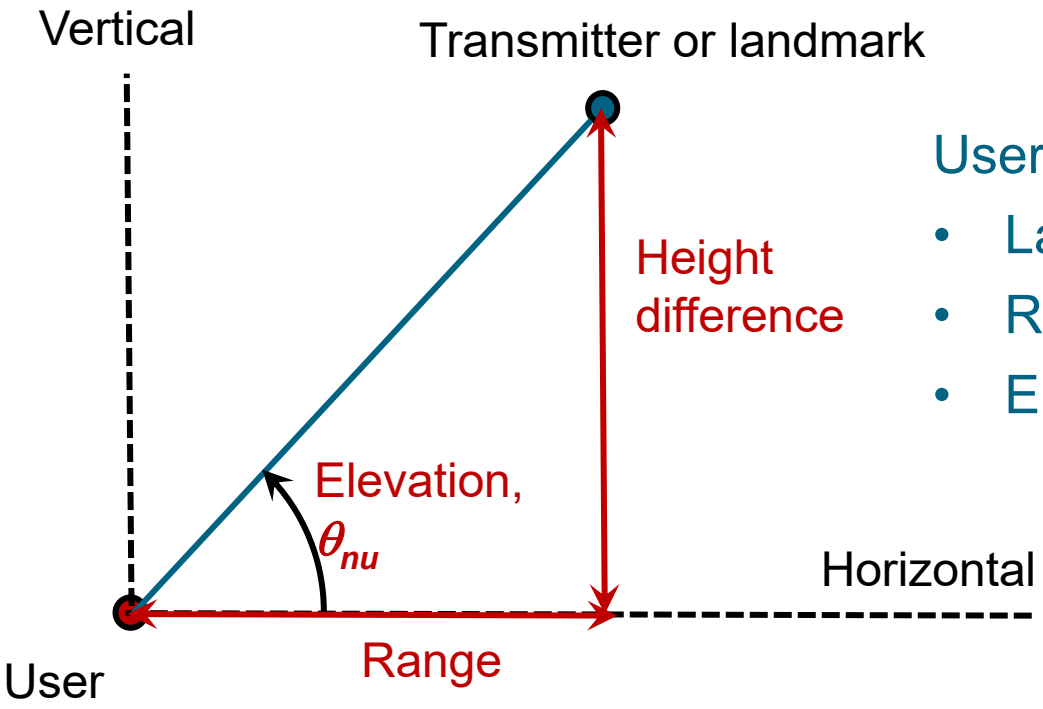


Angular Positioning in Two Dimensions



- Also known as triangulation
- Position determined from directions of line of sight
- Obtained from bearings with respect to north
- If north is unknown relative bearings (and an additional landmark) may be used

Angular Positioning in the Third Dimension



User height may be obtained from

- Landmark height
- Range to landmark
- Elevation angle

1. Types and Methods of Positioning

Angle Measurement

Camera

Radio direction finding

Theodolite

Pattern Matching (1)

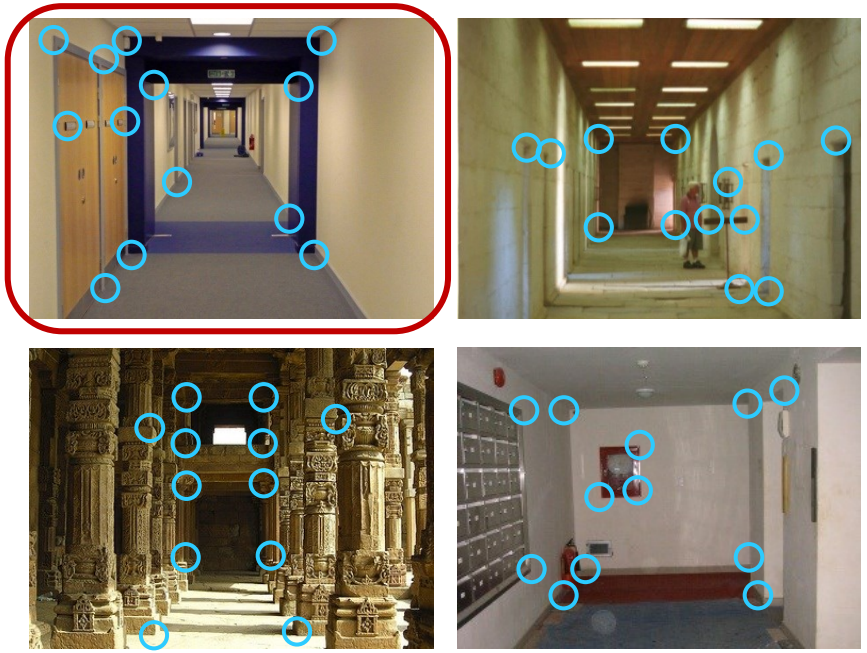
- Measures some features of the environment
- Compare them with a database
- The best match gives the position

Example 1: Image features

Captured image

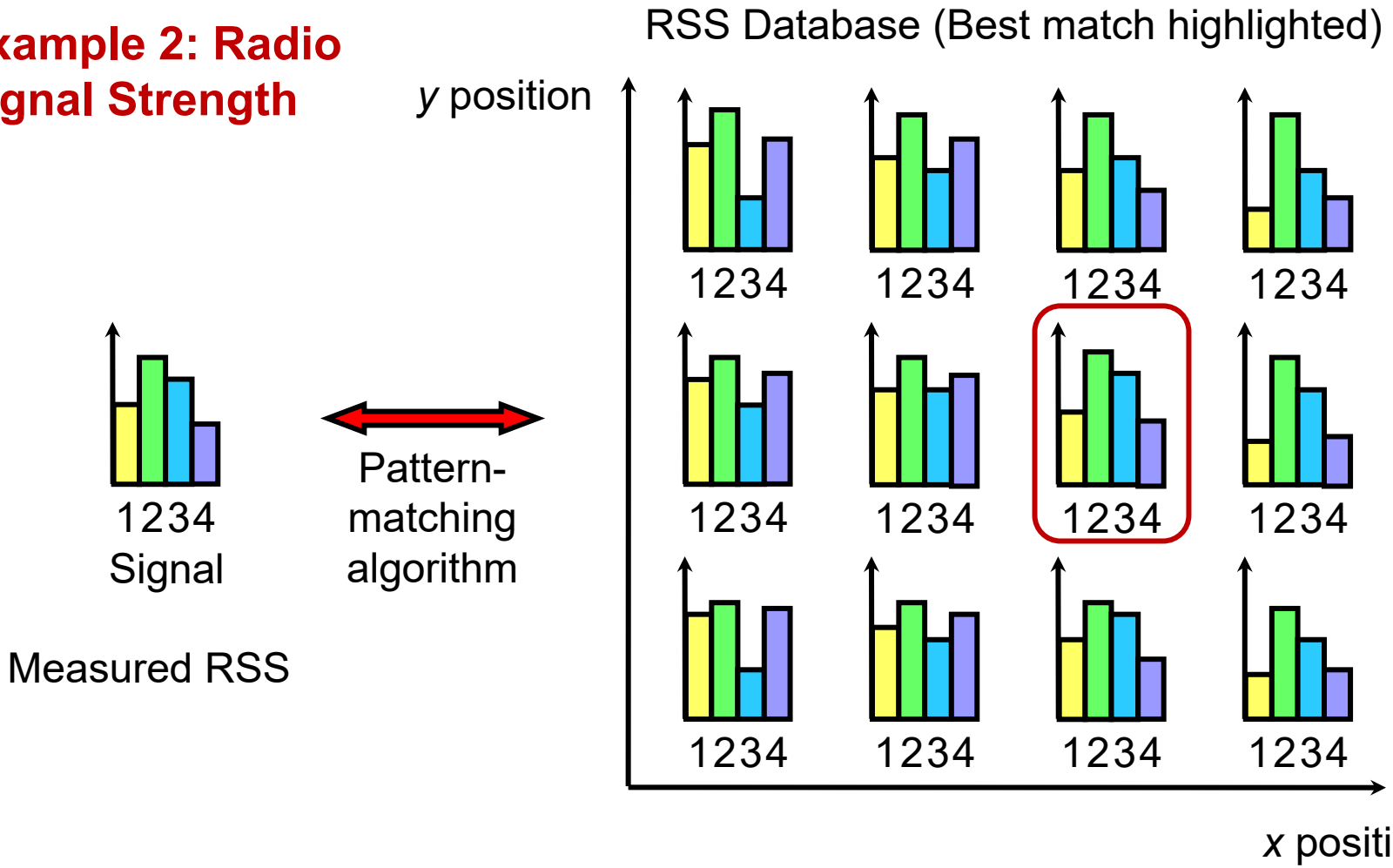
Pattern-matching algorithm

Image database

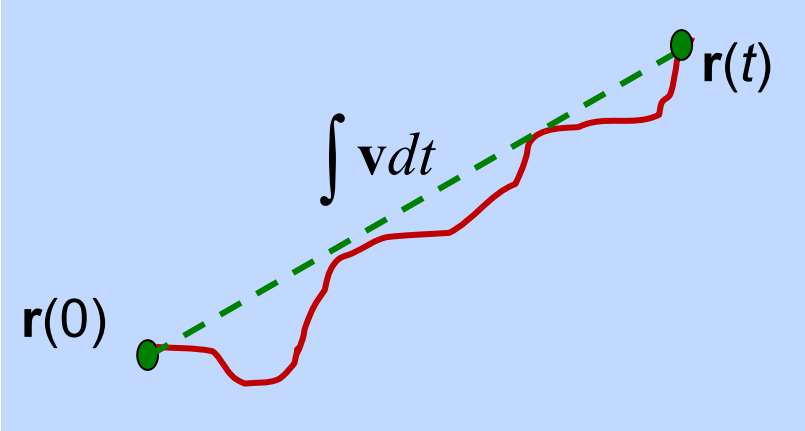


Pattern Matching (2)

Example 2: Radio Signal Strength



Dead Reckoning



- Measures change in position
- Measurements made in sensor body frame
- Need attitude to determine direction of motion with respect to the Earth

Key benefit

- No external transmitters or landmarks needed

Key drawback

- Position error grows with time

Examples

- Car odometer
- Doppler radar
- Inertial navigation

Contents

2. Introduction to Topic 1

Positioning and Navigation Technologies

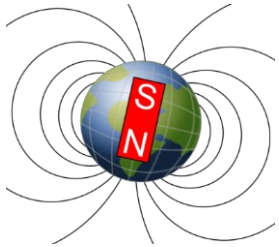
Global Navigation Satellite Systems (GNSS)

GPS, GLONASS, Galileo, Beidou




Wheel-Speed Odometry


Magnetic Heading

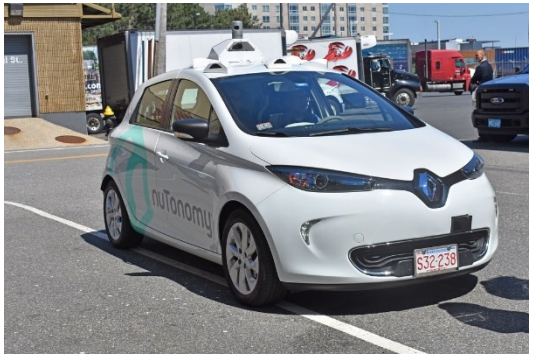
Inertial Navigation

2. Introduction to Topic 1

Robotics Applications

GNSS works best **outdoors**. Adding the other sensors improves resilience

Autonomous cars



Precision agriculture

Construction

Source: Wikipedia

Bomb disposal

Source: Wikipedia

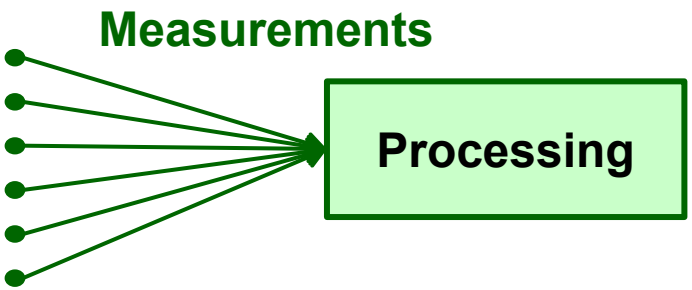
Lawnmowing

Can anyone think of other outdoor robotics applications?

Estimation Techniques

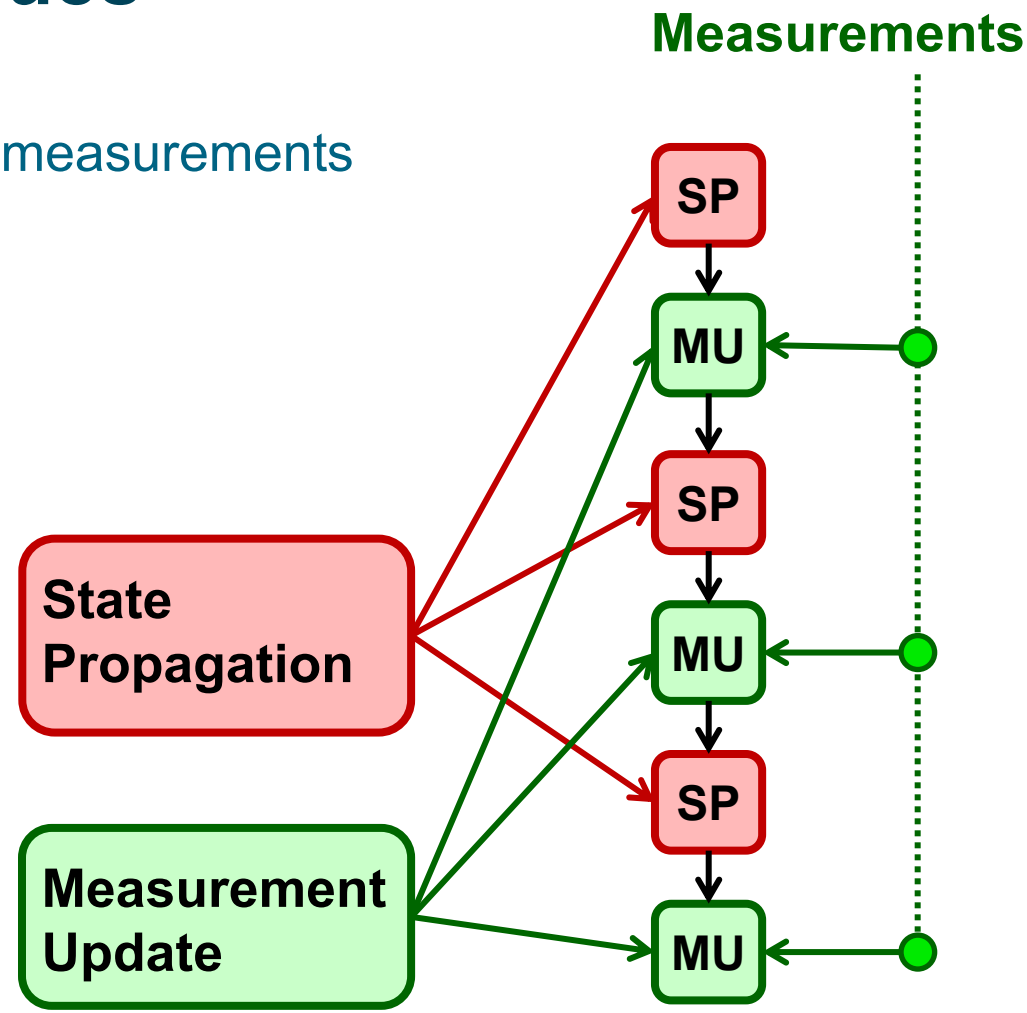
Least-Squares Estimation

Used to estimate position from measurements made simultaneously



Extended Kalman Filter

Used to estimate position and velocity from measurements over multiple time epochs *and* integrate multiple sensors



2. Introduction to Topic 1

Topic Structure

Week 1: GNSS and Least-Squares

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Week 2: GNSS and the Kalman Filter

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Week 3: Integrated Navigation

Tuesday to Friday
Watch the week's recorded Lectures (3h in week 1; 2h in weeks 2 & 3)

↓

Friday
Attend the Seminar & ask questions

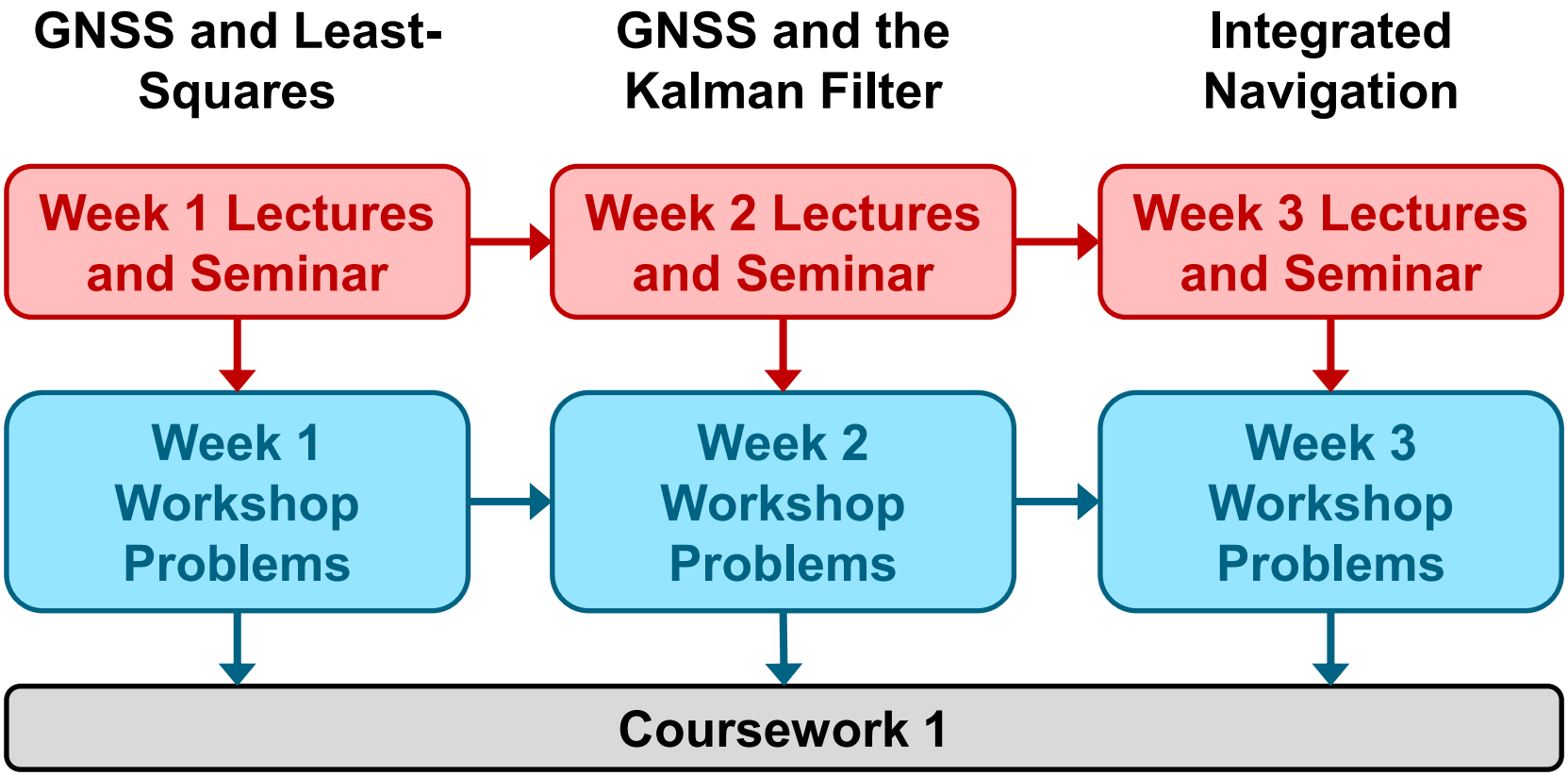
↓

Friday to Monday
Look at the workshop problems and start work

↓

Monday
Attend the workshop where we will help you with the problems

Topic Dependencies



Further Reading

Groves, P. D., *Principles of GNSS, Inertial, and Multisensor Integrated Navigation Systems*, Artech House, 2nd edition, 2013

- Link on Moodle