Hardware Configuration Design

Module 2, Lesson 2

UNIVERSITY OF TORONTO
FACULTY OF APPLIED SCIENCE & ENGINEERING

In this lesson ...

- Sensor coverage requirements for different scenarios
  - Highway driving
  - Urban driving
- Overall coverage, blind spots

Sensors

appearance input

Camera

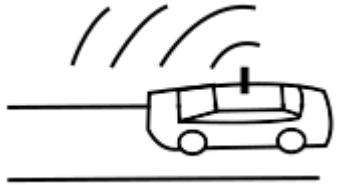
stereo camera: depth information

all-weather 3D input

LIDAR

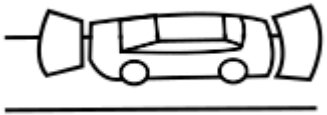
object detection

RADAR



short-range 3D input

Ultrasonics



Ego state estimation

GNSS/IMU

Wheel Odometry

Assumptions

- Aggressive deceleration = $5\ ^{m}/_{s^2}$
- Comfortable deceleration = $2\ ^{m}/_{s^2}$
  - This is the norm, unless otherwise stated

normal

- Stopping distance: $d = \frac{v^2}{2a}$

Where to place sensors?

- Need sensors to support maneuvers within our ODD
- Broadly, we have two driving environments

	Highway	**Urban / Residential**
Traffic Speed	High	Low - Medium
Traffic Volume	High	Medium - High
# of lanes	More	2-4 typically
Other Features	Fewer, gradual curves; merges	Many turns and intersections

Highway Analysis

- Broadly, 3 kinds of maneuvers:
  - Emergency Stop
  - Maintain Speed
  - Lane Change

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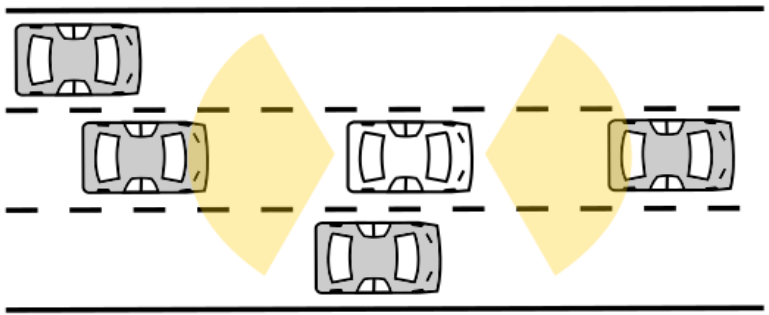
Highway Analysis: Emergency Stop

If there is a blockage ahead, we want to stop in time.



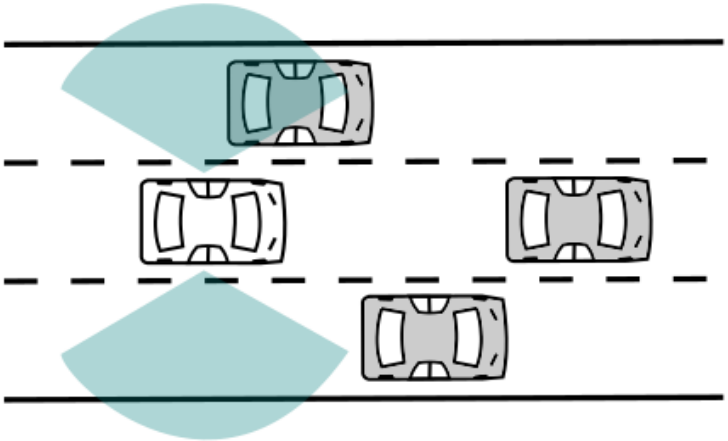
Longitudinal Coverage:

Assume we are speeding at 120 kmph.

Stopping distance could be ~110 metres; *aggressive deceleration*

Highway Analysis: Emergency Stop

To avoid collision, either we stop or change lanes.

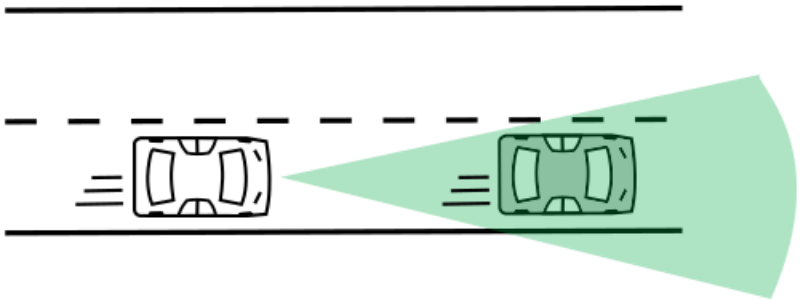


Lateral Coverage:

At least adjacent lanes,
since we may change lanes
to avoid a hard stop.

Highway Analysis: Maintain Speed

Relative speeds are typically less than 30 kmph.

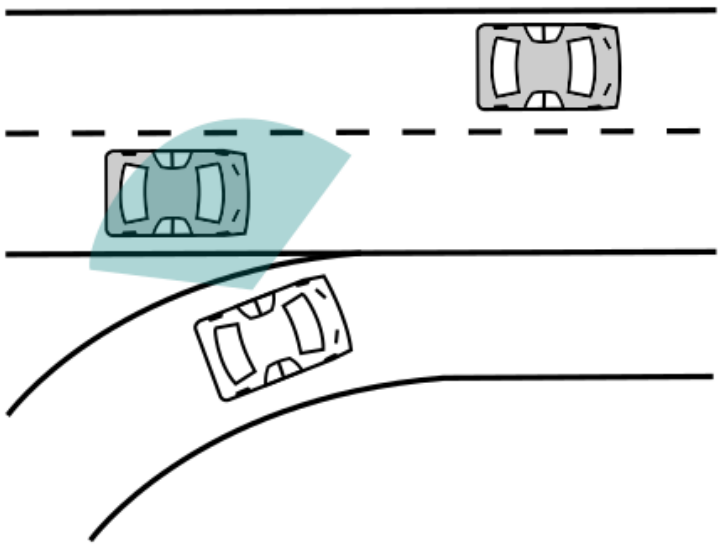


Longitudinal coverage:

At least ~100 metres in front.

Both vehicles are moving, so don't need to look as far as emergency-stop case.

Highway Analysis: Maintain speed with Merge



FOV : 160-180°

40-60m between vehicles

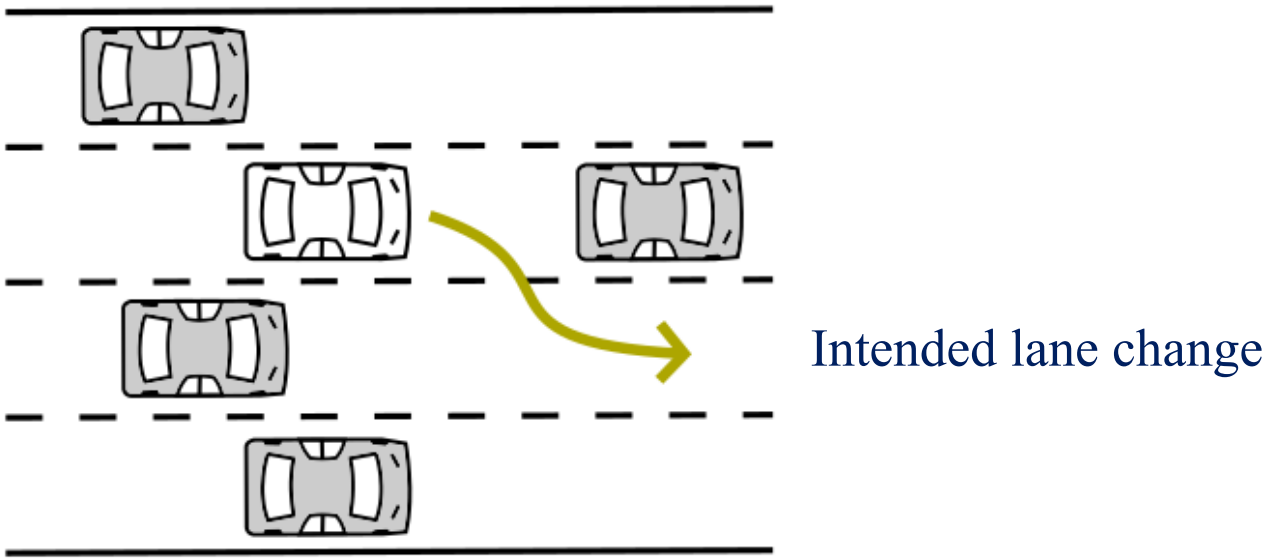
Lateral Coverage:

Usually current lane

Adjacent lanes would be preferred for merging vehicle detection.

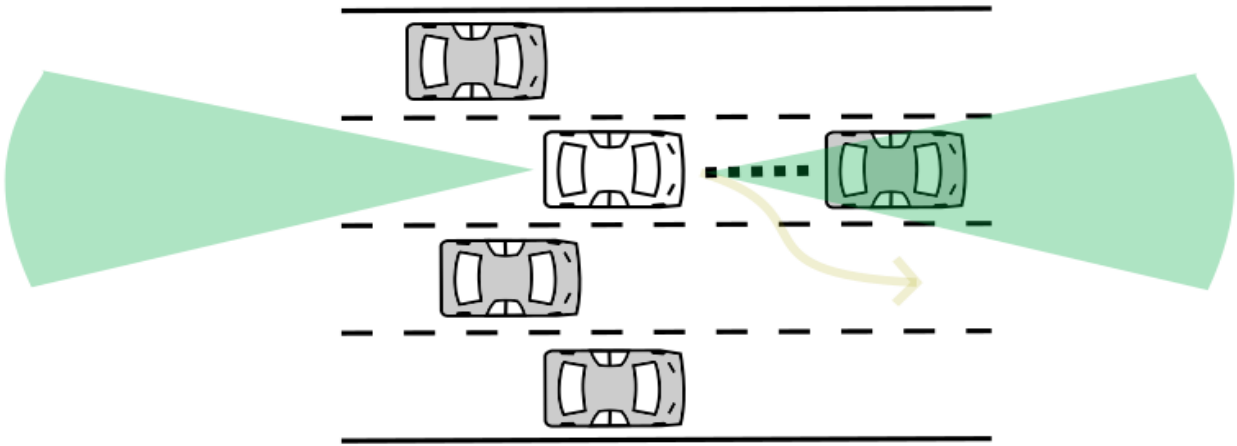
Highway Analysis: Lane Change

Consider this possible lane change scenario:



Highway Analysis: Lane Change

Longitudinal coverage: Need to look forward to maintain a safe distance.

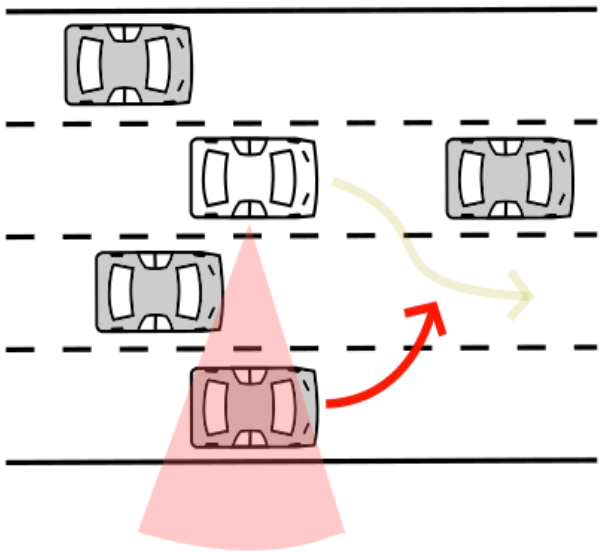


Need to look behind to see what rear vehicles are doing.

Highway Analysis: Lane Change

Laterally, we need to look not just in the adjacent lanes, but probably further.

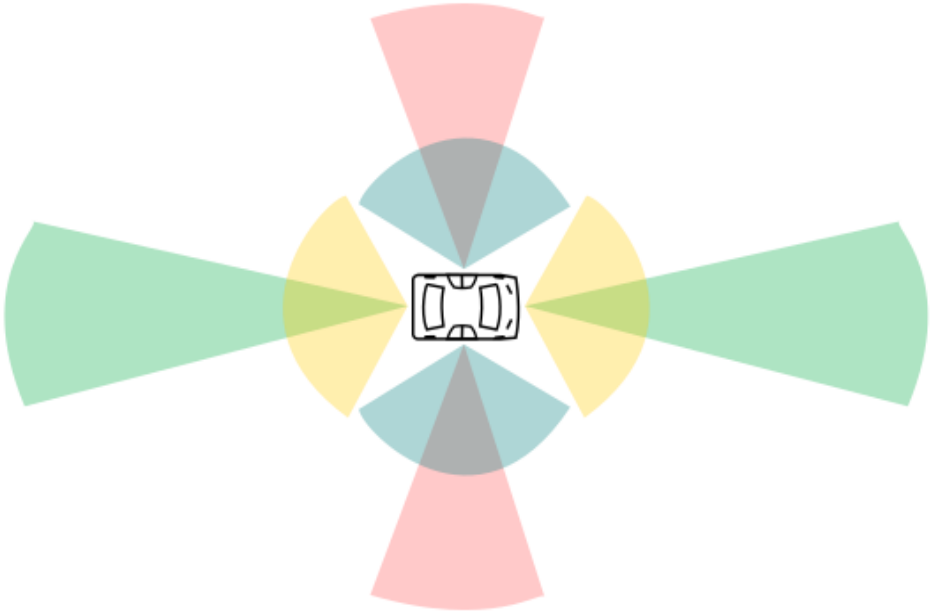
Lateral coverage:
Need wider sensing



what if?

Highway Analysis: Overall Coverage

- Emergency Stop
- Emergency Stop, Maintain Speed
- Maintain Speed, Lane Change
- Lane Change



Urban Analysis

Broadly, 6 kinds of maneuvers:

- Emergency Stop
- Maintain Speed
- Lane Change

- Overtaking
- Turning, crossing at intersections
- Passing roundabouts

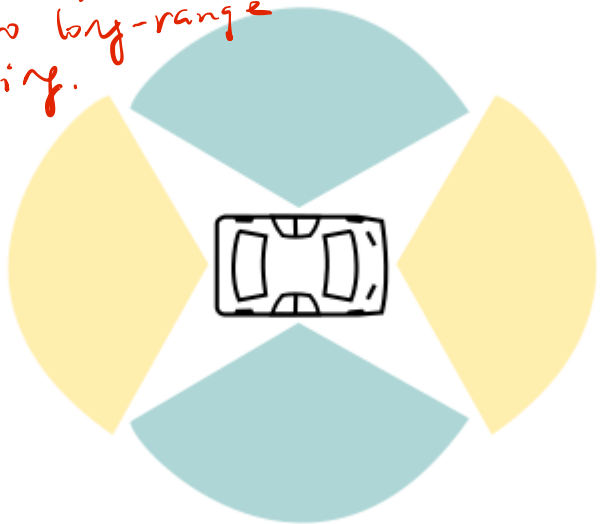
Urban Analysis

Broadly, 6 kinds of maneuvers:

- Emergency Stop
- Maintain Speed
- Lane Change

Similar to highway analysis!

Not as quick so no long-range sensing.

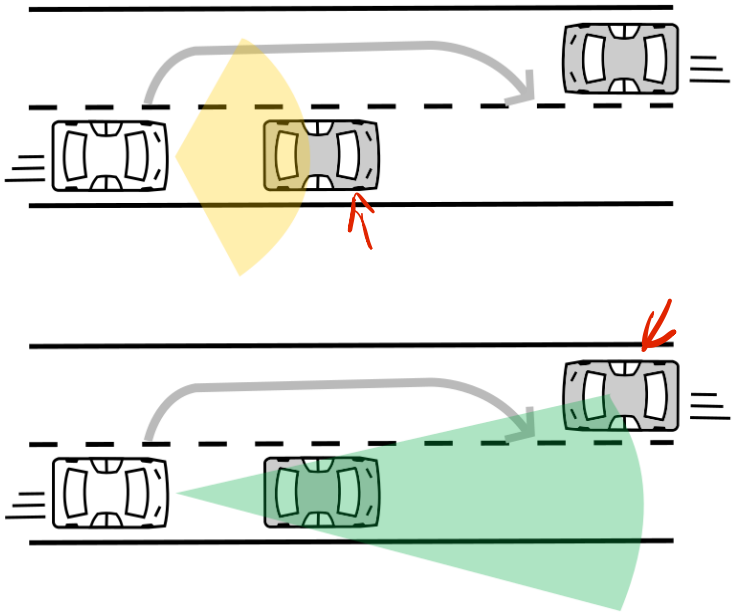


- Overtaking
- Turning, crossing at intersections
- Passing roundabouts

Urban Analysis: Overtaking

Longitudinal coverage:

If overtaking a parked or moving vehicle, need to detec oncoming traffic beyond point of return to own lane.

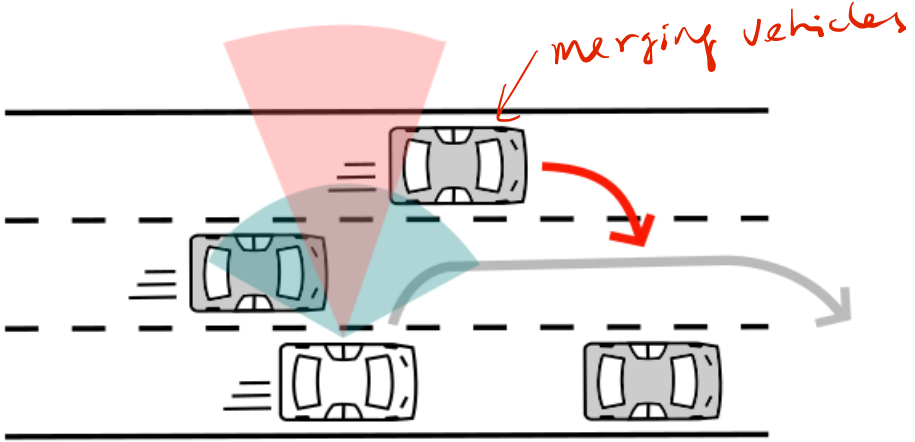


Urban Analysis: Overtaking

Lateral coverage:

Always need to observe adjacent lanes.

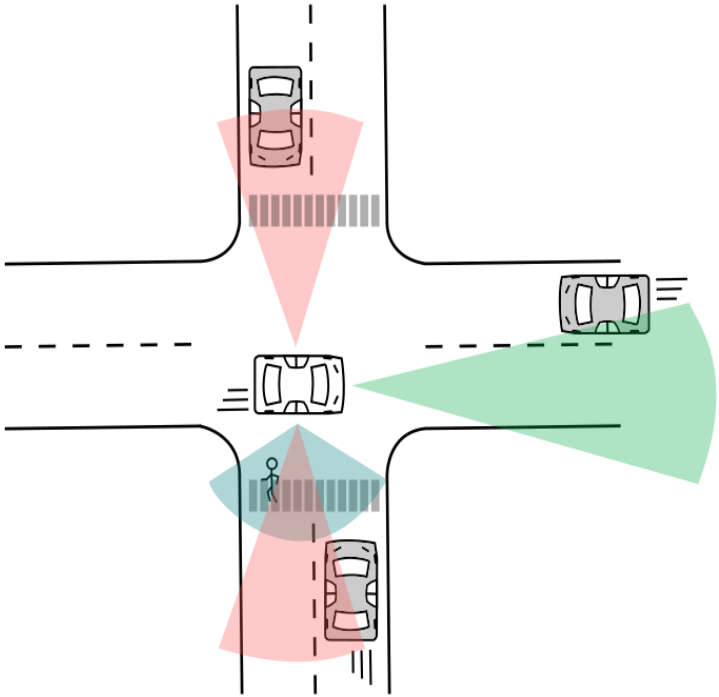
Need to observe additional lanes if other vehicles can move into adjacent lanes.



Urban Analysis: Intersections

Observe beyond intersection for approaching vehicles, pedestrian crossings, clear exit lanes.

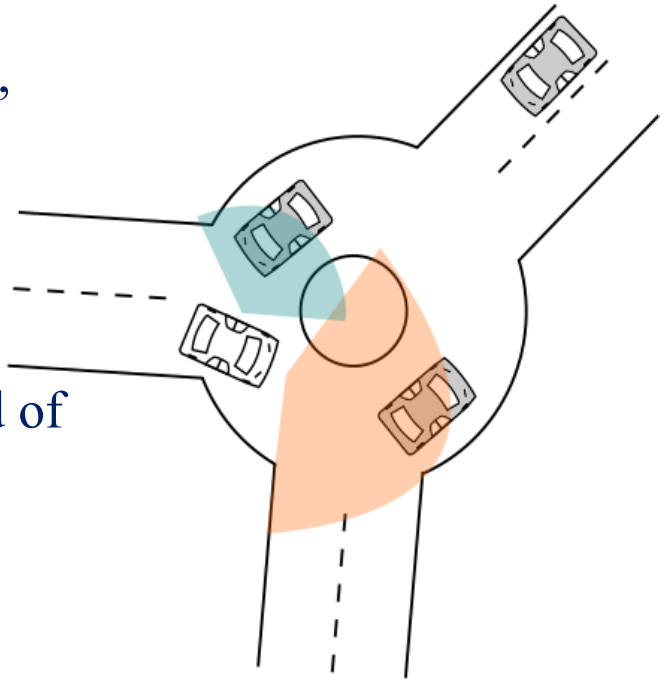
Requires near omni-directional sensing for arbitrary intersection angles



Urban Analysis: Roundabouts

Lateral coverage:
Vehicles are slower than usual, limited range requirement.

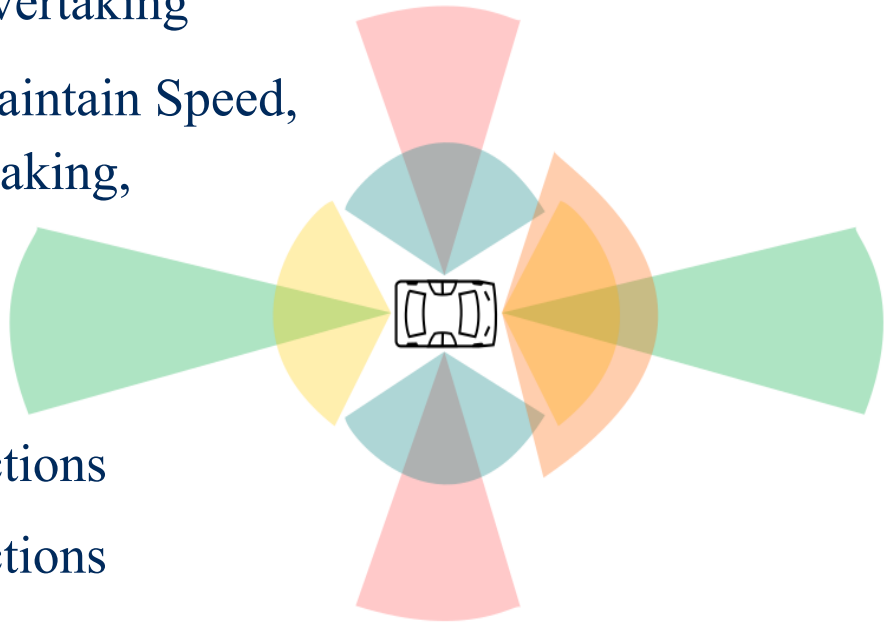
Longitudinal coverage:
Due to the shape of the roundabout, need a wider field of view.



Urban Analysis: Overall Coverage

Emergency Stop, Overtaking

Emergency Stop, Maintain Speed, Lane Change, Overtaking, Intersections, Roundabouts

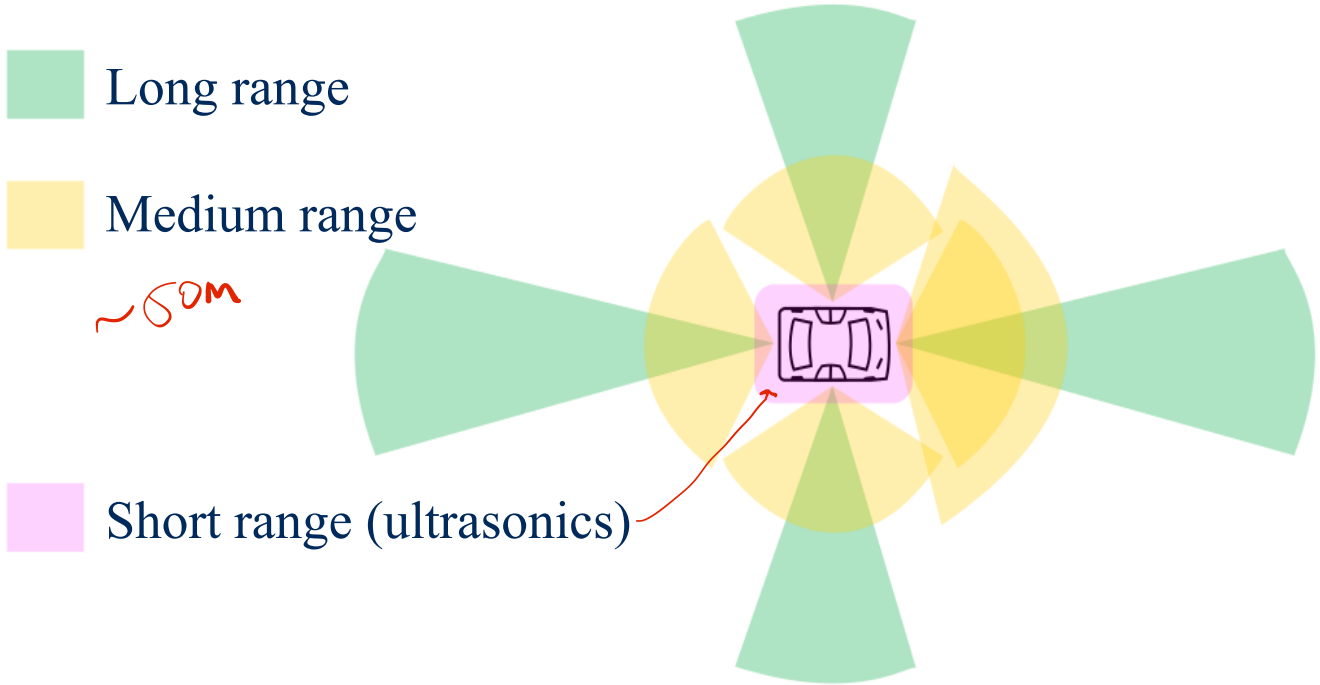


Overtaking, Intersections

Overtaking, Intersections

Roundabouts

Overall Coverage & Sensors Analysis



Summary

- Sensor coverage analysis - longitudinal and lateral coverage
  - highway driving
  - urban driving
- costs, blind spots