SensIT Collaborative Signal Processing Candidate Tracking Benchmarks v0.3

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DARPA CSP Workshop

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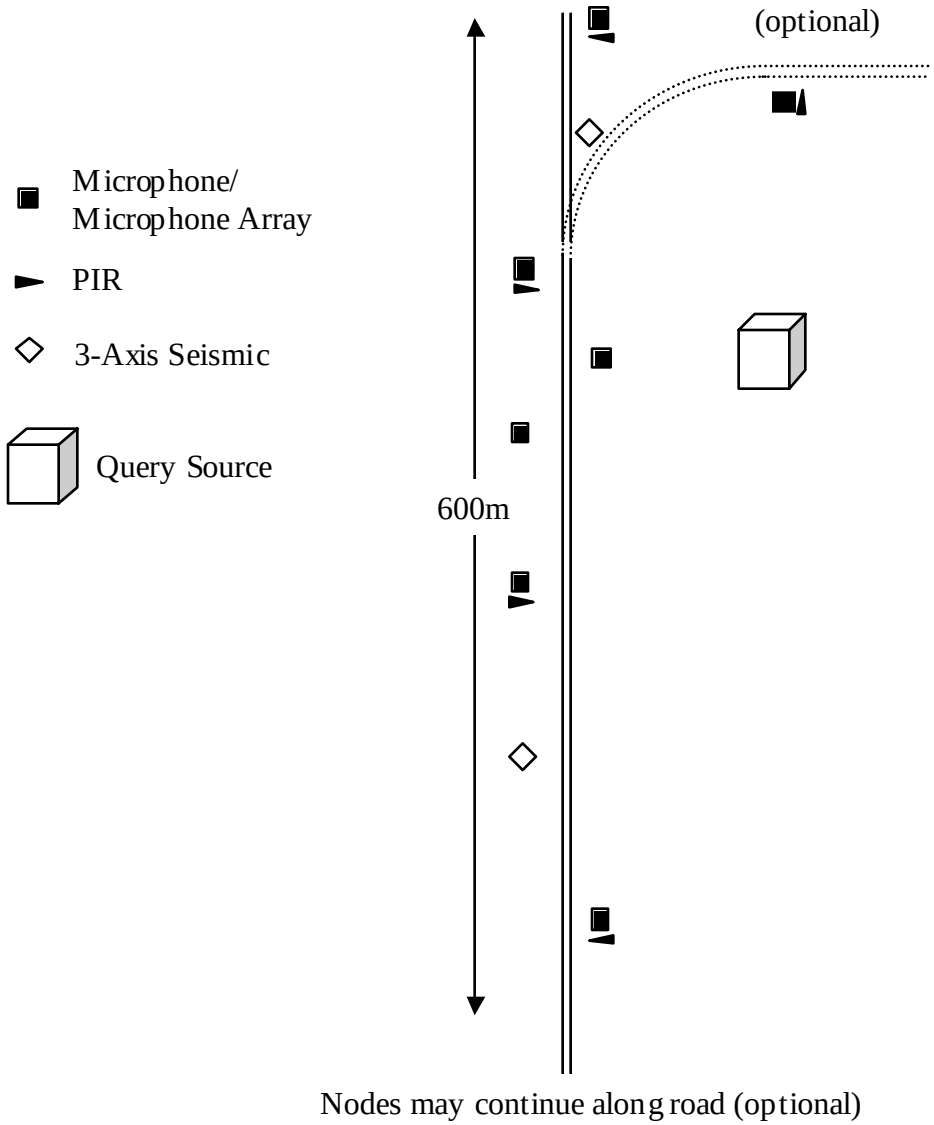
Issues to Consider as we go

- What are the unique challenges of the scenario?
  - Is there a way to make the scenario more "fundamental" and focus on the challenge
- What information needs to be combined from multiple nodes, and how often?
- What are some likely queries?
- How would we benchmark success?
- Can this test be implemented as a real world experiment?

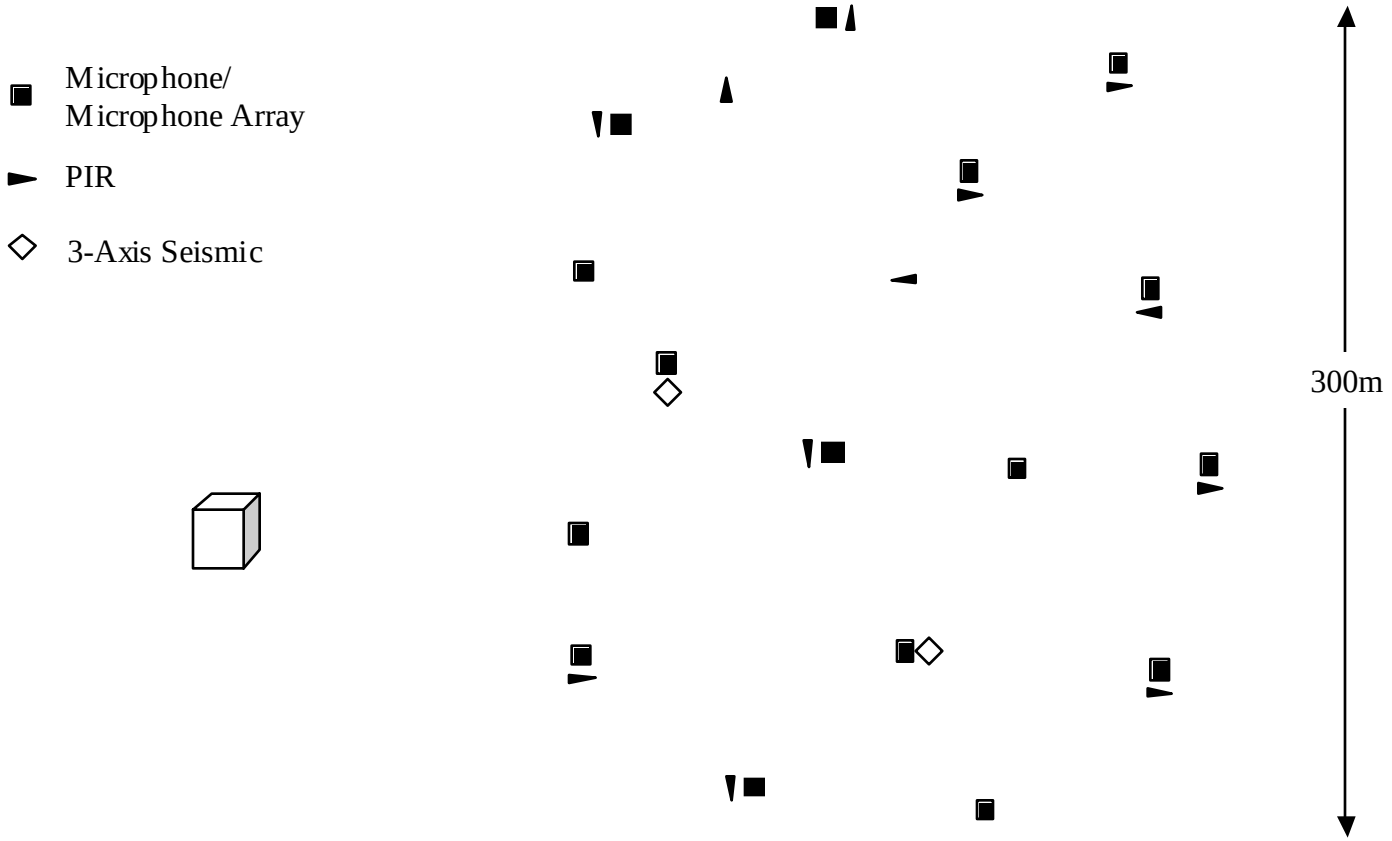
Assumptions

- Single vehicle unless otherwise shown
- Unless otherwise stated, vehicles attempt to maintain constant speed and do not shift gears
- Unless otherwise stated, vehicles start beyond the sensor field and arrive in sequence
- Complications to be handled as we get better:
  - Variation of acoustic signature with aspect
  - Acceleration, braking, and gear shifts
    - Changes the acoustic signals
  - Spatio-temporally varying propagation models
  - Node unreliability

Linear Array Laydown Example



2D Array Laydown Example



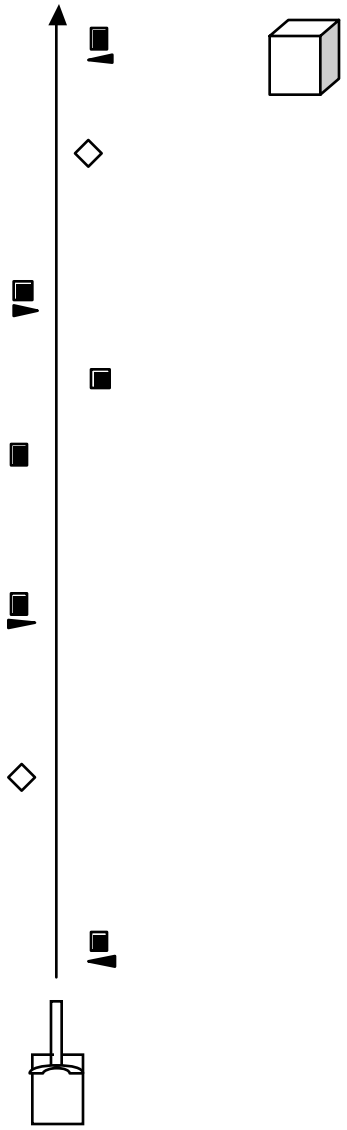
Randomly distributed in [X, Y, θ]

Benchmarking

- Generic Benchmarks
  - Energy Consumption
    - Total, per node (max, avg)
    - f(computation, communication)
  - Detection Accuracy
    - Frequency of false positives, negatives
  - Detection Latency
    - Mean, max vs. query source location
  - Tracking accuracy
    - Mean, max, std.
    - f(desired output frequency)
  - Tracking Latency
    - Mean, max vs. query source location

- Task-specific Benchmarks

1: Track Single Target



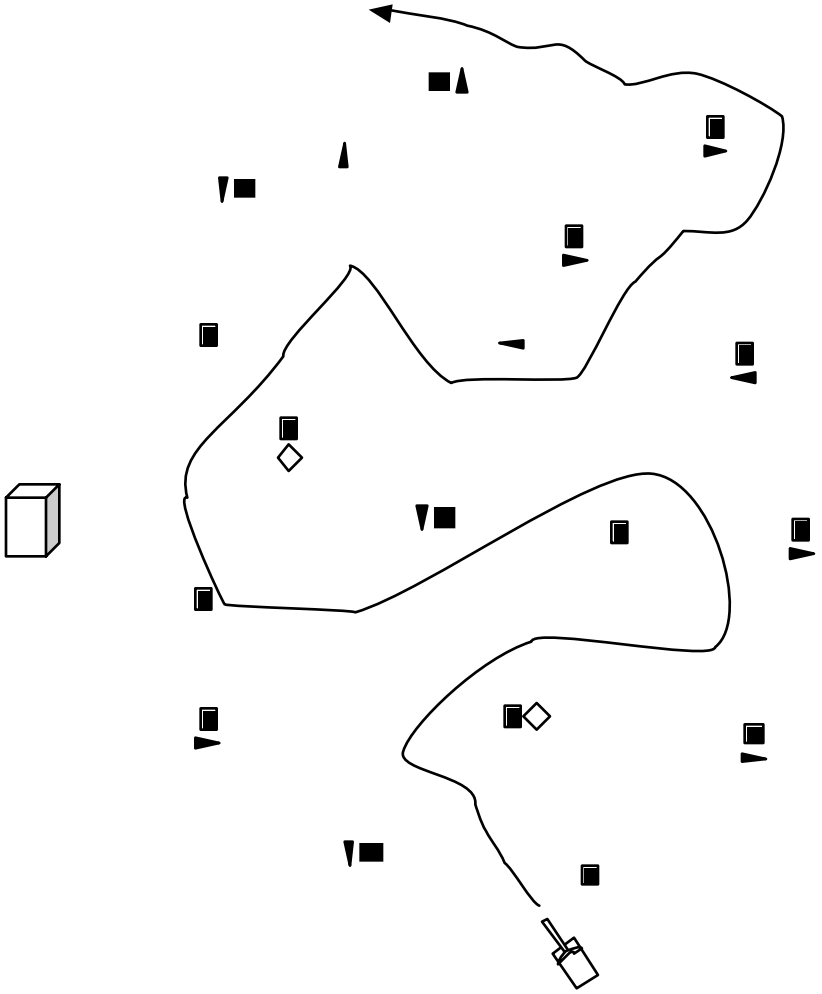
Task

- Estimate target position vs. time

Challenges

- Localize target
- Maintain accurate estimate in large gaps between sensors
- Fuse data from multiple sensor types

2: Track Single Maneuvering Target



Task

•Estimate target position vs. time

Challenges

•No road, hence no prior knowledge of vehicle trajectory

•Constant direction dynamics models no longer adequate

•Many sensors making simultaneous observations

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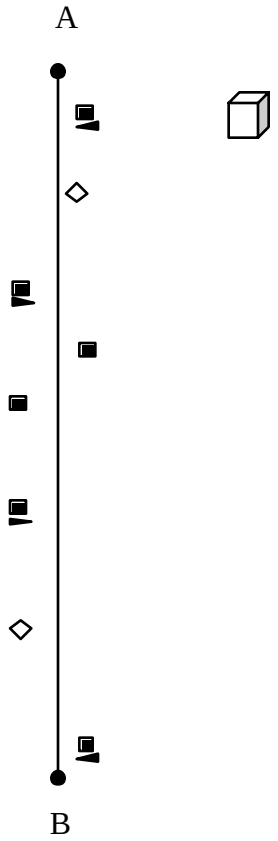
3: Track Accelerating/Decelerating Target



Task

- Estimate target position vs. time

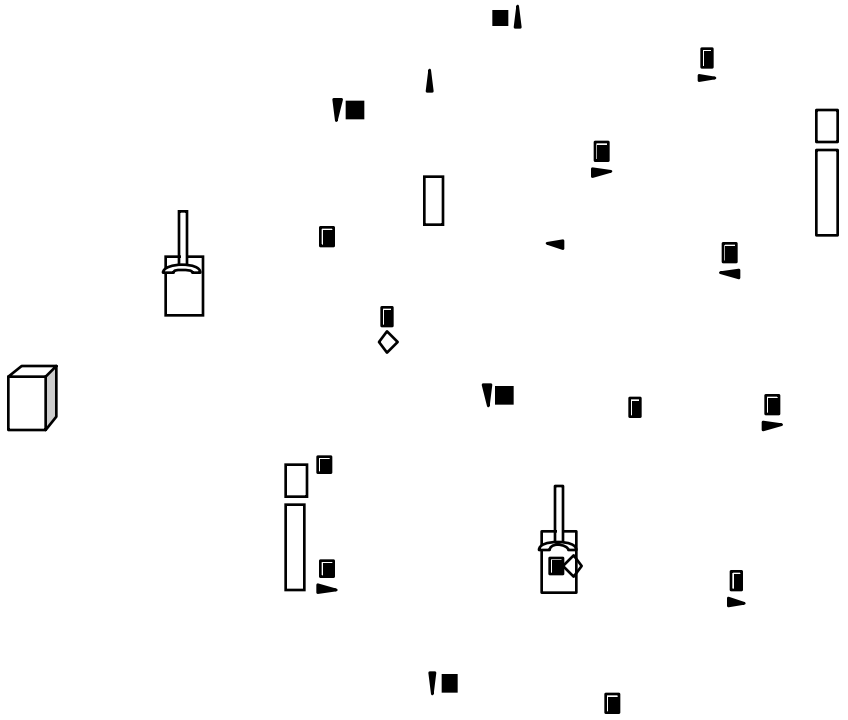
Challenges

- Vehicle signature time-varying
- Constant velocity dynamics models no longer adequate
- Gear shift requires maintaining internal discrete state (curr. gear)

Vehicle begins stationary and idling at point "A"
Accelerates, maintains constant velocity
Decelerates and stops and point "B"

Extra credit: Handle gear shifts

4: Count Stationary (idling) Targets



Task

- Count number of targets
- Locate targets

Challenges

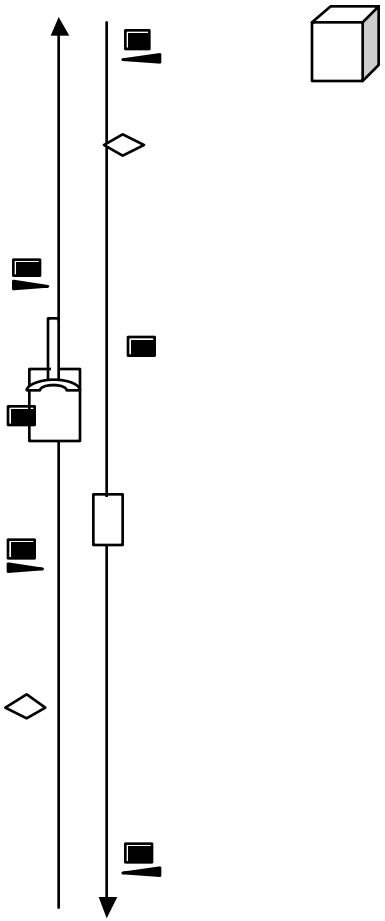
- Multiple vehicles
- Unknown number of vehicles
- Cannot depend on peak-finding (CPA) of acoustic signal

Task-Specific Benchmarks

- Accuracy of count

vs. dynamic range of acoustic outputs from ensemble of vehicles

5: Two-way traffic



Task

- Track target positions
- Estimate target crossing time

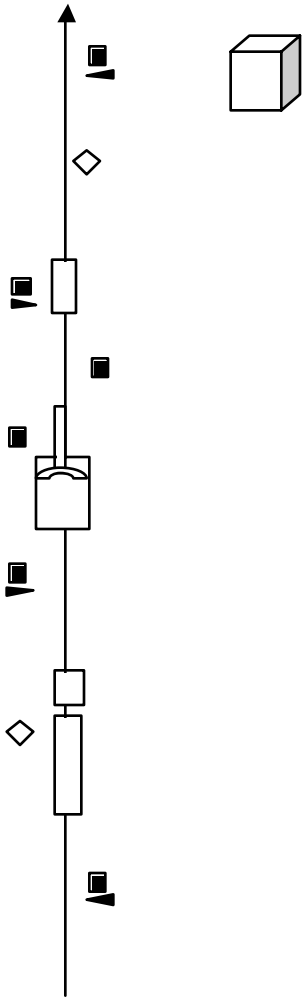
Challenges

- Vehicles in close proximity, need to use dynamics to keep identities separate

Task-Specific Benchmarks

- Accuracy of crossing time estimate

6: Convoy on a Road



Vary inter-vehicle spacing to vary problem difficulty

Task

- Count number of vehicles of each type
- Determine order of vehicles

Challenges

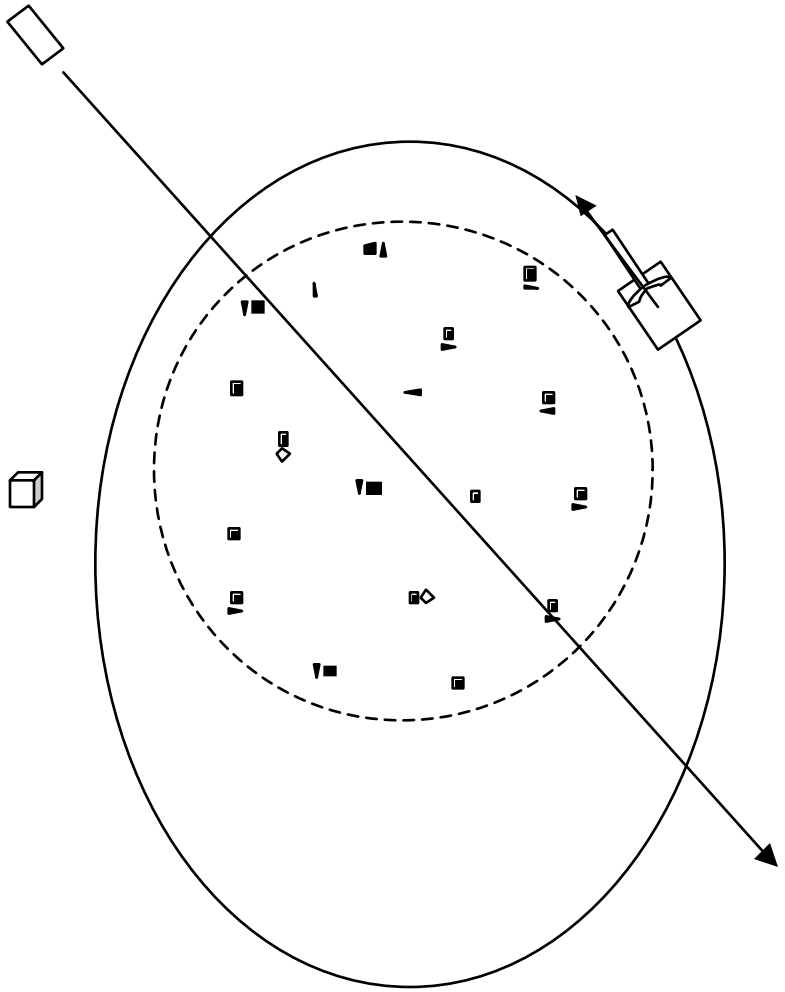
- Multiple vehicles
- Classification and state information must follow vehicle along full length of road

Task-Specific Benchmarks

- Accuracy of count & order

vs. vehicle spacing & convoy velocity

7: Perimeter Violation Sensing



Task

- Alert on violation of perimeter
- Ignore activity outside of perimeter (distractors)
- Identify violator type and track location

Challenges

- Filter out distractor
- Respond quickly while minimizing quiescent activity

Task-Specific Benchmarks

- Detection delay
- Power usage during periods of no violation
- Frequency of false positives

all vs. distractor/violator source amplitude ratio

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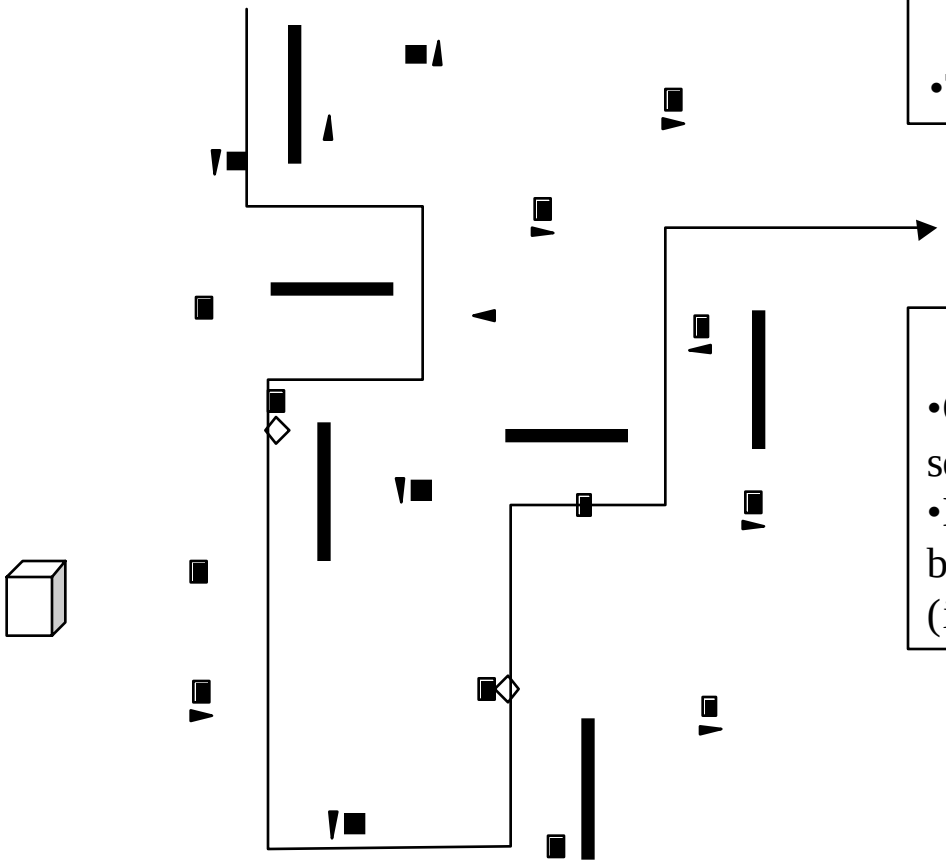
8: Tracking in an Obstacle Field



Task

•Track vehicle position

Challenges

•Obstacles cause individual sensors to lose lock on the target

•Different sensing modalities are blocked differently by obstacles (i.e. seismic vs. acoustic)

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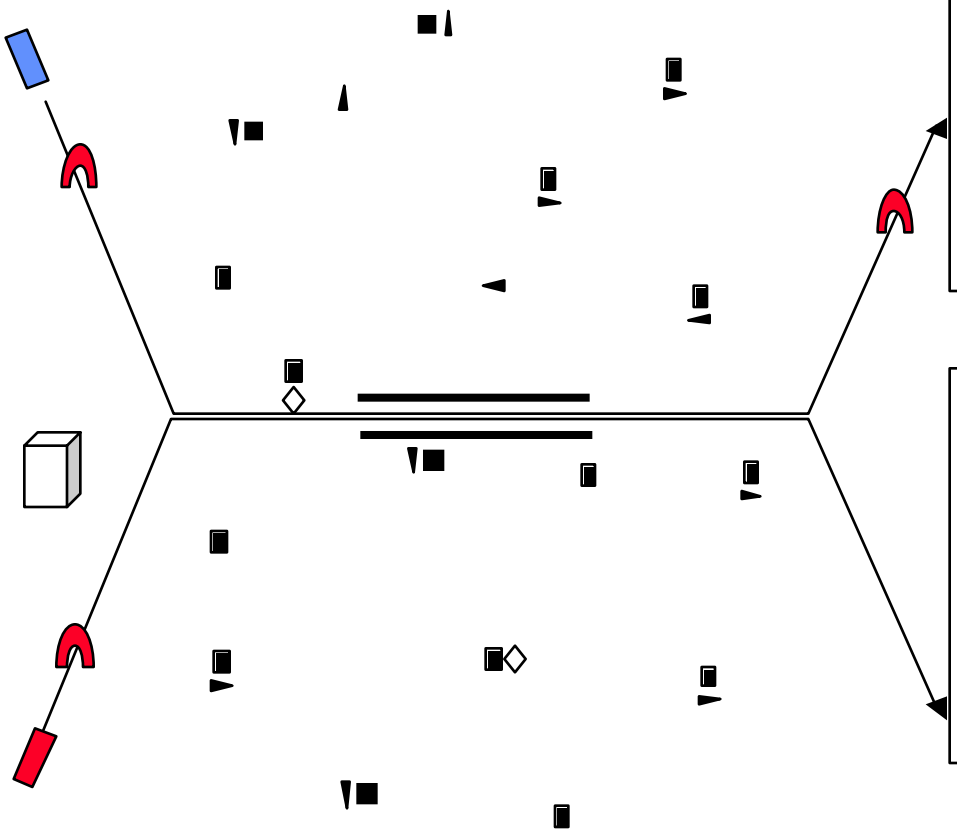
9: Road Junction Merge/Split on Localized One-Time Sensor



Targets can only be distinguished from each other by magnetometers (shown), which give one-time "red/blue" output when the vehicle passes over them.

Task

- Track targets
- Maintain target identities
- Re-establish identity of both targets when right-hand magnetometer is crossed

Challenges

- Need to conserve number and type of targets as they pass through tunnel.
- Need to reason about targets – Seeing blue at top right mag. guarantees red at bottom.

Task-Specific Benchmarks

- Time to propagate data from RHS magnetometer to red car in the lower RHS

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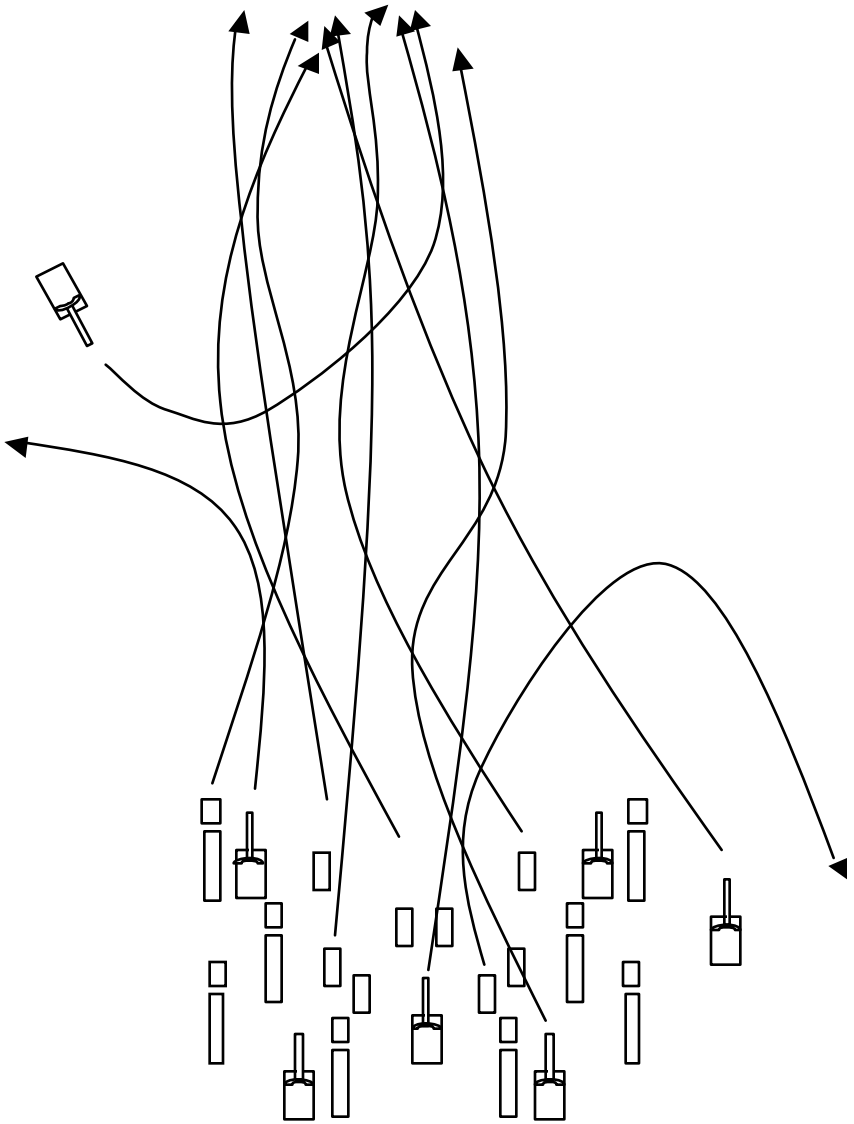
10. Cluster Behavior



Task

- Track cluster centroid
- Keep count of vehicles in cluster adjusting as some leave and join

Challenges

- Large number of targets
- Coalescing many similar targets, limiting exponential hypothesis blowup
- Measuring global properties of cluster (centroid, count) rather than properties of single target

Task-Specific Benchmarks

- Maximum number of targets which can be handled simultaneously
- Centroid accuracy