

Smart Sensors for ITS

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What information is needed?

- Sensors to detect vehicles
 - type, speed, presence, count, etc.
- Sensors to detect pedestrians (safety)
- Environmental sensors
 - black ice, rain, flood, etc.
- Sensors to detect other parameters of use in smart infrastructure
 - e.g., bridge load, vehicle weight, height, etc.



Sensor types (& a little history)

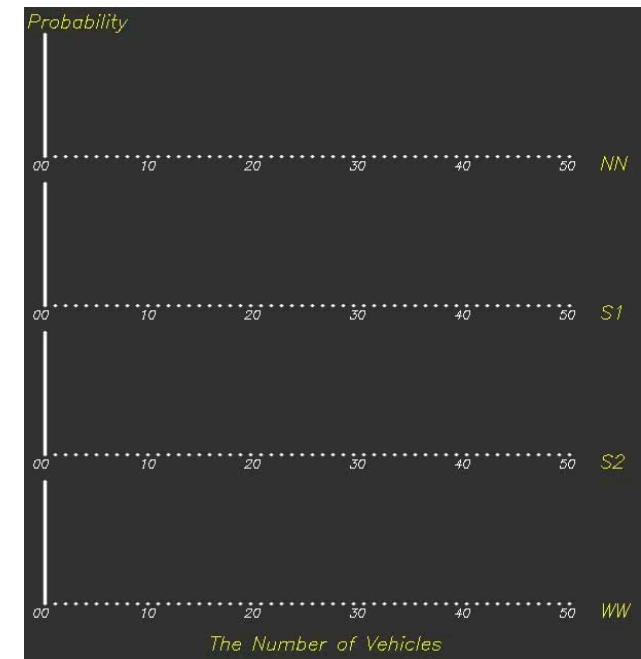
- Horn actuated (1928)
- Metal plate pressure sensor (1928)
- Wheel noise sensor (1931)
- Pneumatic tube
- Inductive loop
 - Gold standard and the most prevalent today (but basically dumb)
- Magnetometer
- Acoustic array
- Infrared (active and passive)
- Radar (CW, pulse, UWB)
- Ultrasonic
- Video analytics for traffic (& pedestrians)
- Vehicles as sensors (Ubiquitous Sensing)
 - Probes & DSRC (CALM)

Making basic loops smarter

- Use loops
 - Queue length & end-of-queue (pat. pend.)
 - Relationship between queue length, inflow, outflow, vehicle length and speed.
 - Use probabilistic methods to update queue length
 - Inflow, outflow and vehicle length are estimates

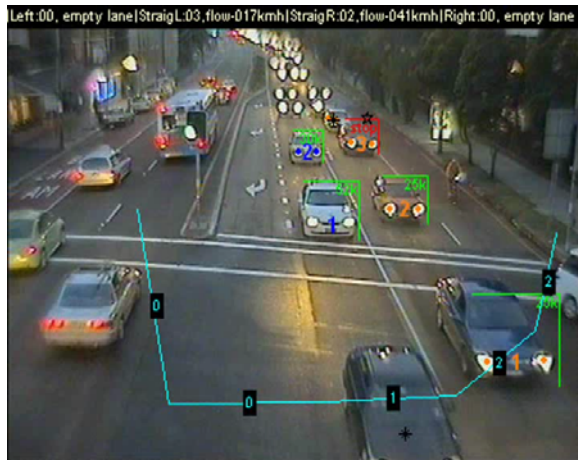


$$p(q_{t+1} | o_{1:t+1}) \propto p(q_{t+1} | o_{1:t}) p(o_{t+1} | q_{t+1}) \\ = p(o_{t+1} | q_{t+1}) \sum_{q_t} p(q_{t+1} | q_t) p(q_t | o_{1:t})$$



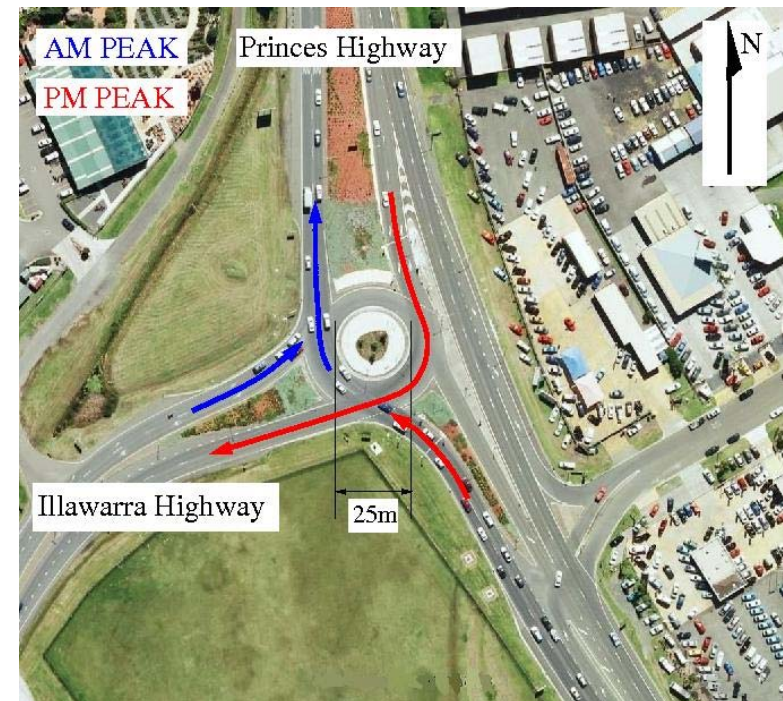
Video Sensors

- Much richer data stream (speed, type, etc)
- Robustness is a problem (weather, lighting, etc)
- Can use thermal but cost is high
- Pedestrians as well!



Applying Advanced Sensing

- Roundabouts work well with moderate, balanced flows
- Unbalanced flows lead to excessive queuing
- Geometry causes flow dependent queuing
- Standard solution is metering
 - Upstream detector presence on control arm
 - Signals on conflicted arm
- Queue estimation improves performance
- Applied at Albion Park
- Smart loops & eight video cameras
- 7% reduction in delay



The future of sensing in ITS

- Holy-grail: a pole mounted sensor system
 - Cost effective loop replacement
 - Robust (environment)
 - Rich data output
- No single sensor is good enough
- Solution: Data fusion
 - Combine multiple physical sensors
 - Hot research topic
- Until we all have CALM (DSRC, etc.)
 - And really accurate positioning



Ubiquitous Sensing enables Collaborative Mobility

