Using a Collaborative Network of Distributed Cameras for Object Tracking

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Invision AI

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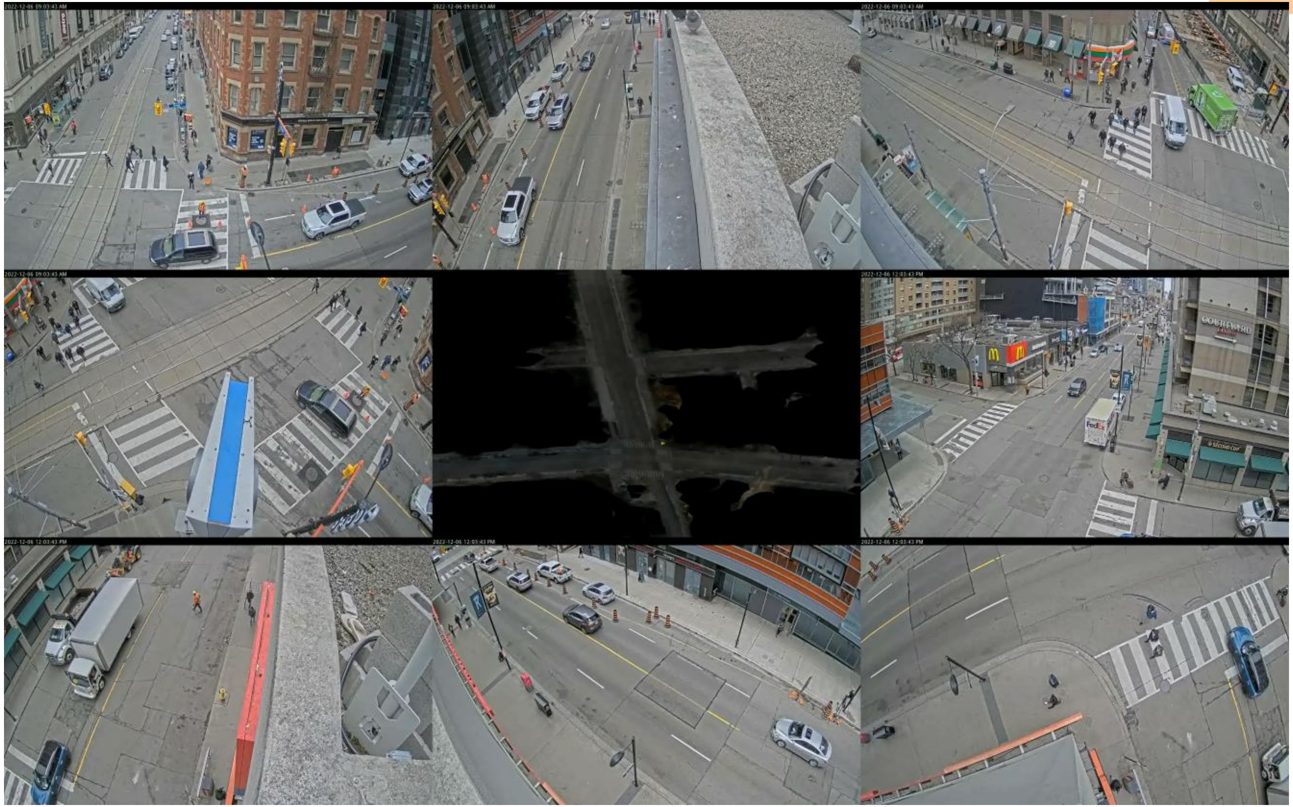
IN·VISION ARTIFICIAL INTELLIGENCE

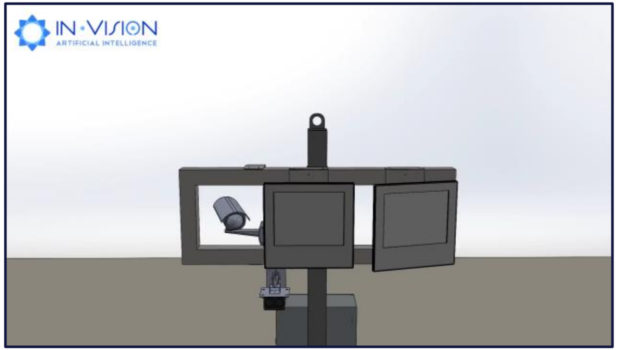
Younge & College: 8 Cameras Outdoors



About Invision AI

Vehicle Occupancy Detection

High-performance Road-side only

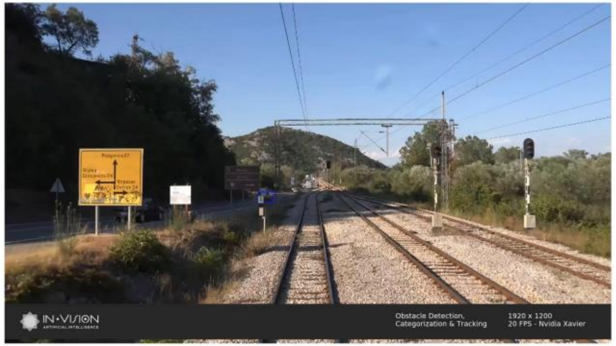


Transurban

AYALON HIGHWAYS

Autonomous Rail

Obstacle Detection

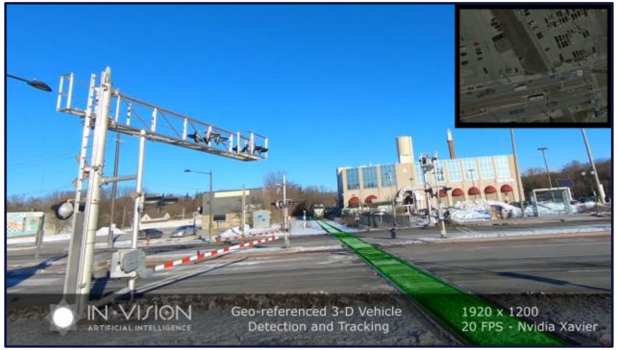


THALES

METROLINX

Intersection Monitoring

Hazard Detection



Montréal

York Region

Desired Properties of the System

We want our Collaborative Network of Distributed Cameras for Object Tracking to have the following properties:

- Scalability with respect to the number of tracked objects
- Scalability with respect to tracking area
- Reasonable installation constraints (power and network requirements)
- Privacy preserving

Part 1: Mapping and Calibration

Terrain Model and Calibration (Cont'd)

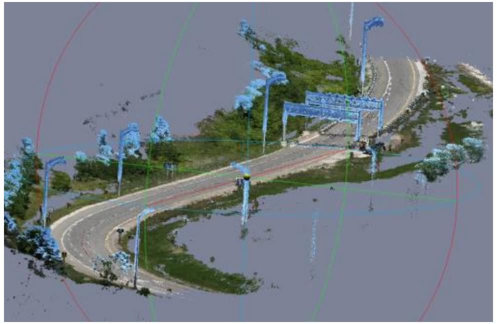
Problems:

1. We need a map.
2. We need to calibrate with respect to the map.

There are two different approaches of how to obtain maps and camera calibrations (camera positions and internal parameters); using structure from motion (SfM) and image matching, or finding already available maps and manually calibrate the cameras.

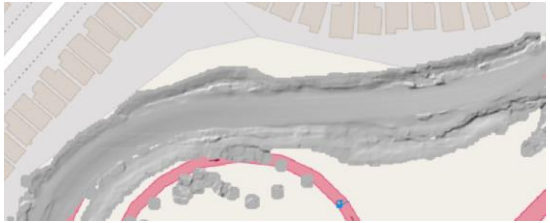
Top-View and Elevation Model From Video

Acquisition

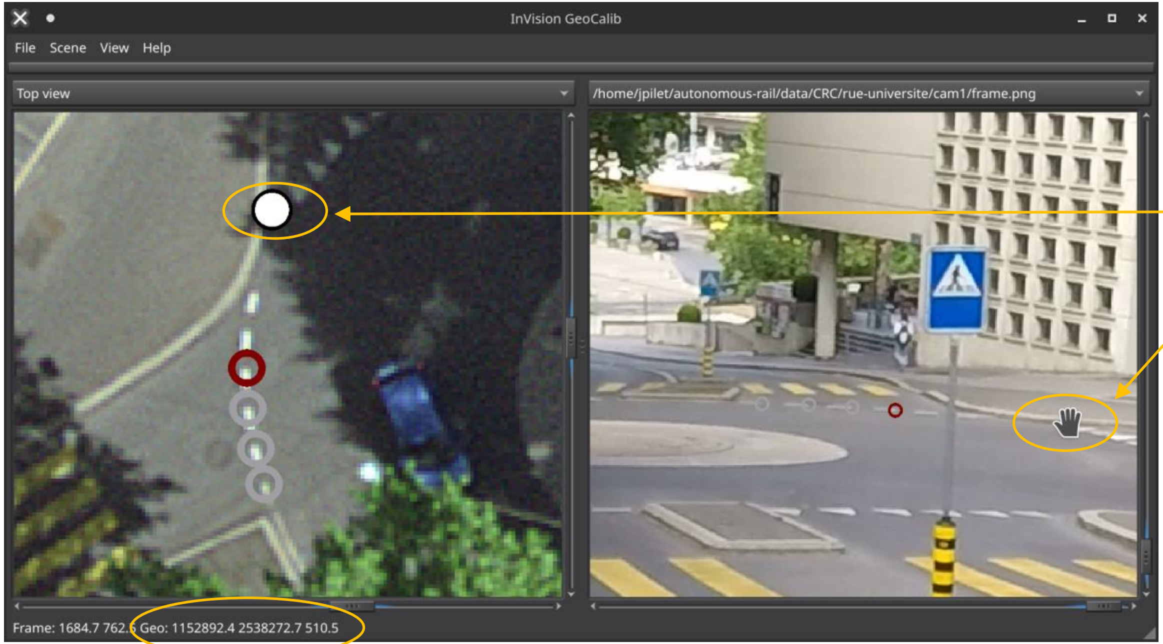


Structure from motion point cloud (COLMAP, OpenSfm, OpenMVS)

Top view + digital elevation model (DEM)



Calibration From Top-View + DEM



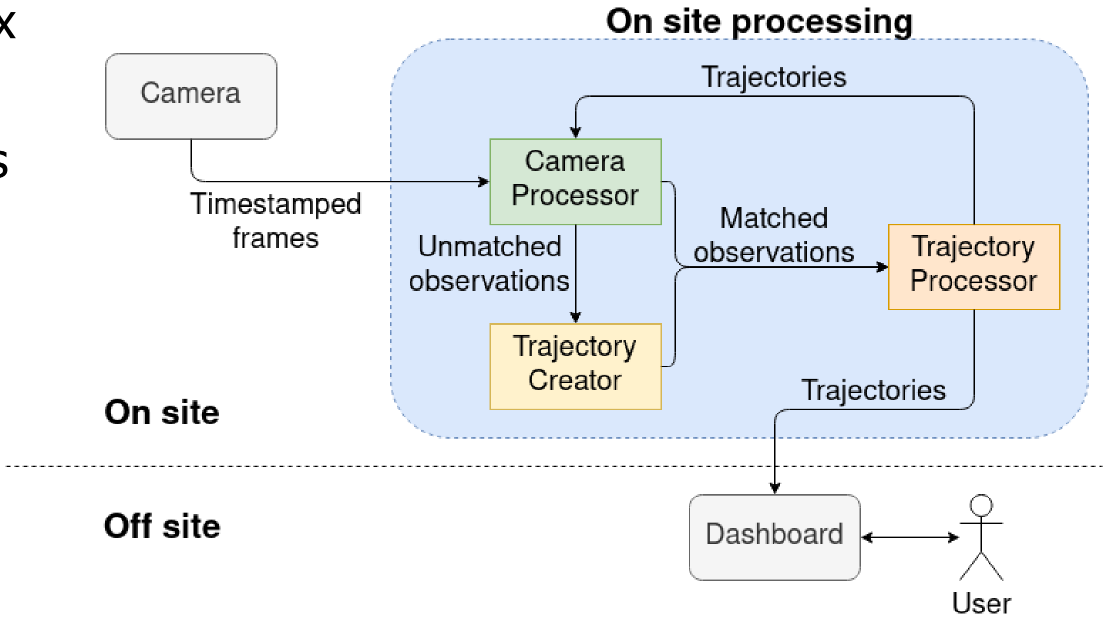
Calibration data links image coordinates with map coordinates.

Swiss coordinate system. Top-view + DEM publicly available.

Part 2: Tracking Algorithm

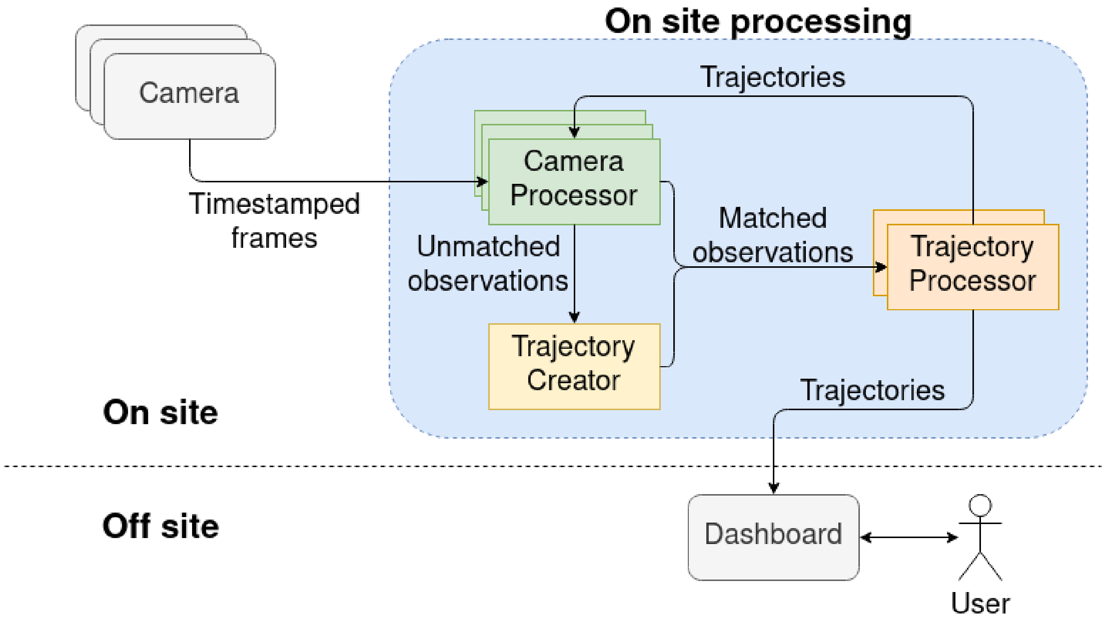
System Overview

- Each processing node is a Unix process.
- Arrows represent inter process communication; can cross machine boundaries.
- Only metadata leaves the deployment site. Image data only travels between camera and camera processor.



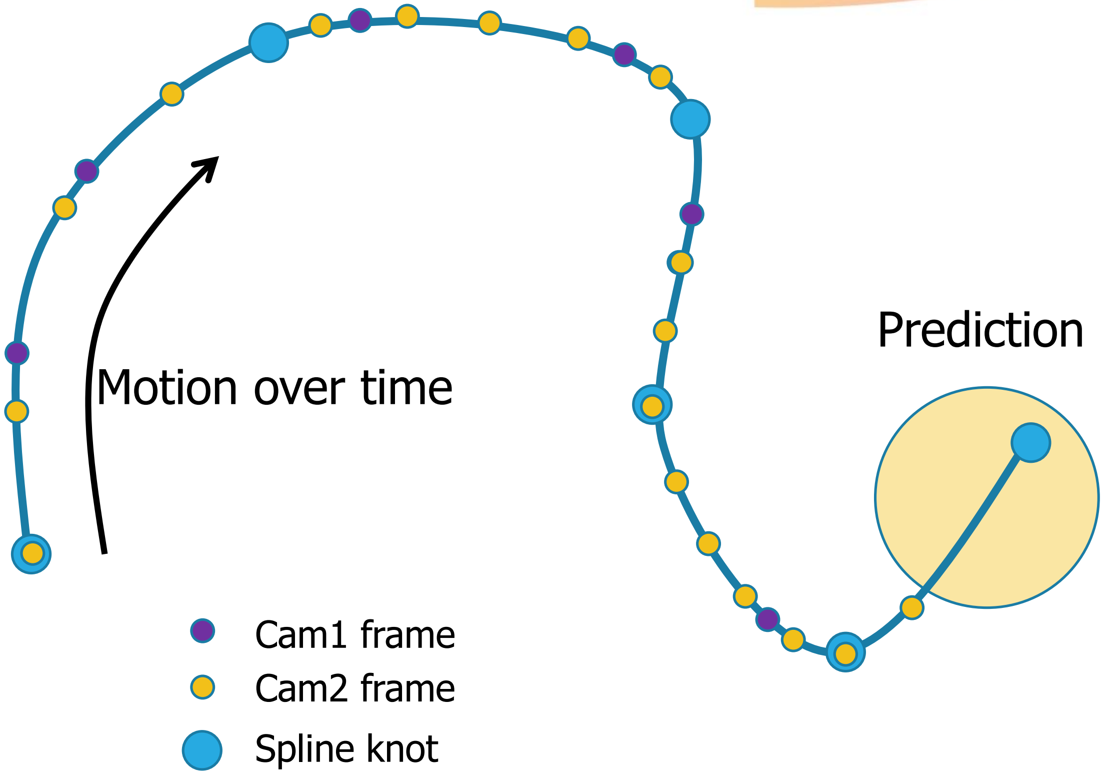
System Overview: How to Scale

- More processing power is obtained by adding more processing nodes.
  - Can be on a new machine.
- Multiple nodes of the same type gives us redundancy; if a processor node breaks (hardware or software), its load can be redistributed, and the system continues to work.



Trajectory Representation

- Trajectory estimated as a spline.
- 1 knot every second.
- Pose (orientation and size) consistency across a track imposed through an on-line non-linear optimization process.
- Able to deal with varying rates of incoming data.
- Predicts motion in the future.



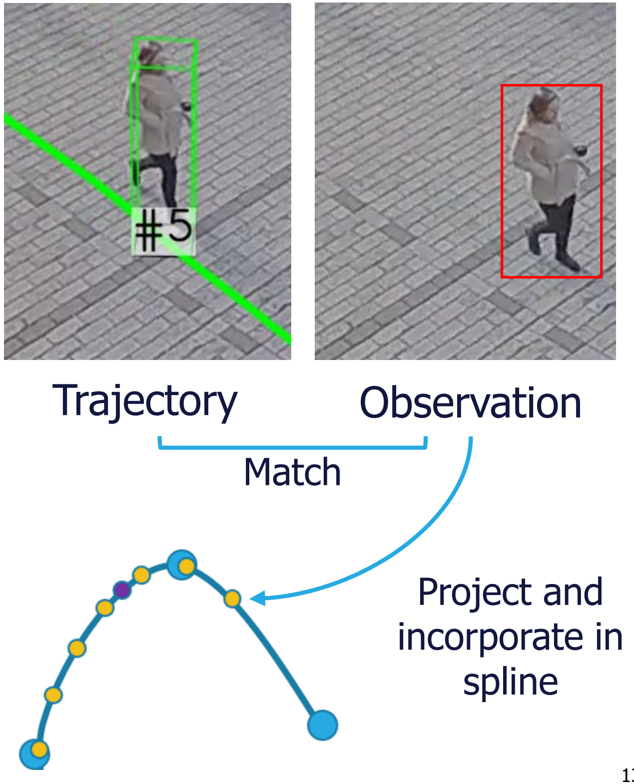
From Observation to Trajectory

Camera processor:

- Produce 2D observations (Neural Net object detector) and associate with trajectories.
- Send association to trajectory processor.

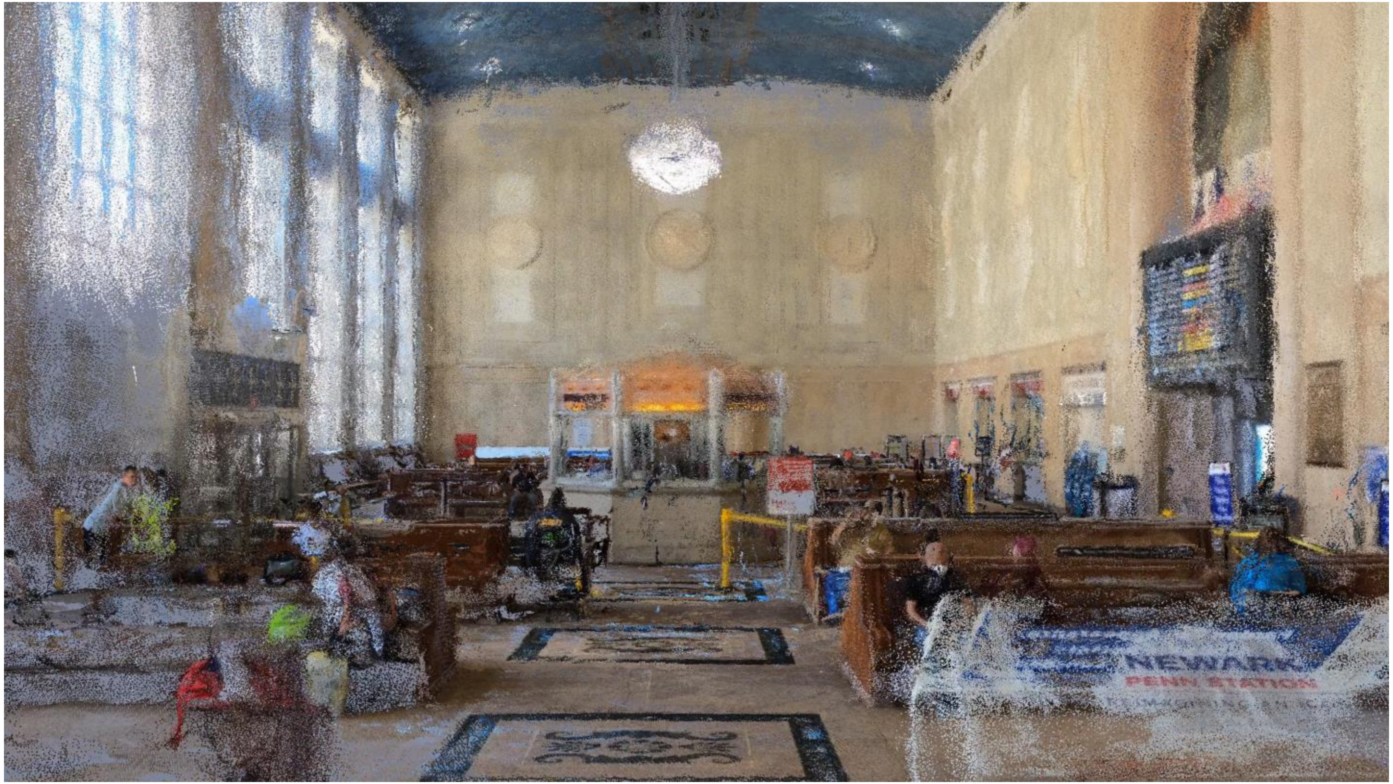
Trajectory processor:

- Project observations (from all views) to common map coordinate system.
- Fusion of all observations + motion model.
- Send updated trajectory back to camera processors.



Part 3: Demos

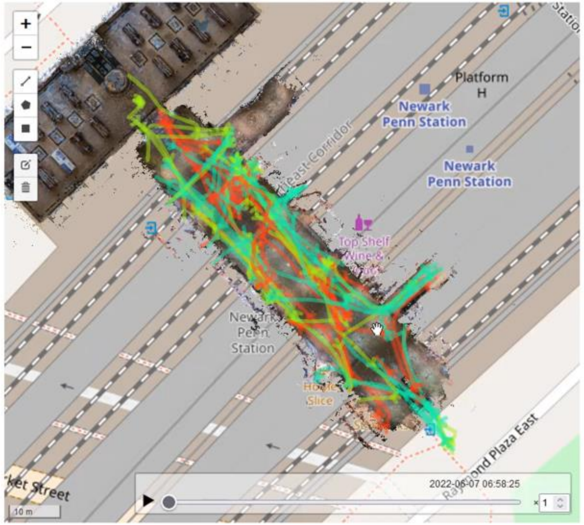
Demo, 8 Cameras Indoors



Demo, 8 Cameras (Dashboard)

IN·VISION ARTIFICIAL INTELLIGENCE | Statistics | Heatmap | Trajectories | Counting Geometries | Alerts Preview | Help

Map Region (All)



Start	End	Object type	Face Mask	F.M. Confidence	Sort: ▲ Sta
2022-06-07 07:00:00 - 2022-06-09 20:00:0(					Search
2022-06-07 06:58:25	2022-06-07 07:00:28	Person	Has Mask	0.97	Export
2022-06-07 06:58:54	2022-06-07 07:00:04	Person	No Mask	0.86	
2022-06-07 06:59:11	2022-06-07 07:00:16	Person	Has Mask	0.70	
2022-06-07 06:59:23	2022-06-07 07:01:33	Person	No Mask	0.90	
2022-06-07 06:59:33	2022-06-07 07:00:01	Person	Unknown	1.00	
2022-06-07 06:59:41	2022-06-07 07:00:17	Person	Has Mask	0.68	
2022-06-07 06:59:41	2022-06-07 07:00:14	Person	No Mask	0.98	
2022-06-07 06:59:42	2022-06-07 07:00:02	Person	Has Mask	0.70	
2022-06-07 06:59:					

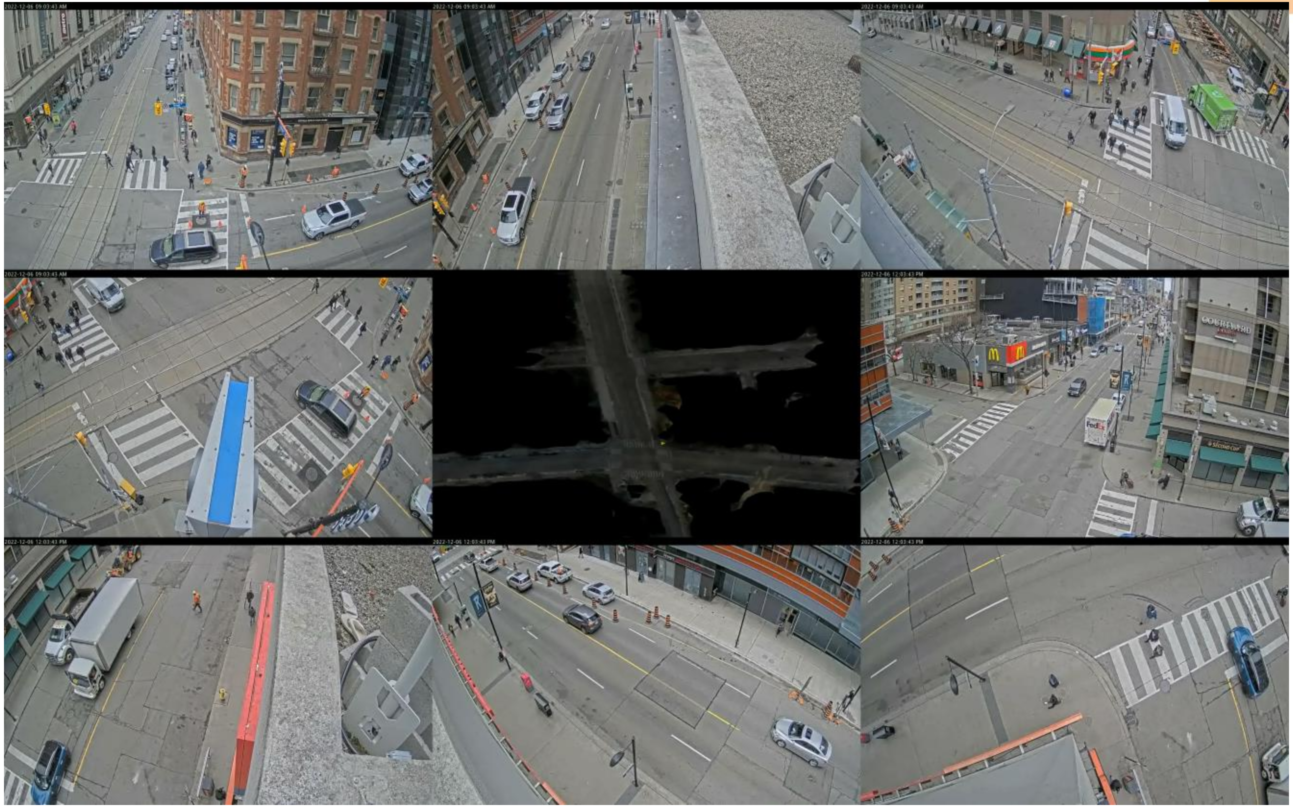
1 2 3 4 5 6 7 8 ... 1000 ... Next »

Remaining Challenges and Conclusion

Questions and Challenges

- Installation constraints means it is not always possible to use a wired network:
  - Could we do networking with radio + mesh network?
- The system needs a lot of compute; how to get a low energy, affordable NN inference system?
  - Anything else than NVidia Jetson products?
- Calibration of the system is time consuming. Are there better solutions out there for automatic calibration?

Conclusion



References and resources

Software and libraries

COLMAP
https://colmap.github.io/

OpenSfM
https://opensfm.org/

PDAL
https://pdal.io/

Contact us!

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