Driven to Distraction: Self-Supervised Distractor Learning for Robust Monocular Visual Odometry in Urban Environments

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Challenge

Robust urban visual odometry (VO) with only a monocular camera.

Limitations with Baseline VO :
- can **fail** with large moving distractor (**ephemeral**) objects
- often requires **expensive stereo** cameras

Addressed with Robust Mono VO :
- predict **ephemerality masks** to ignore distractors
- predict **disparity** to give scale with only a monocular camera

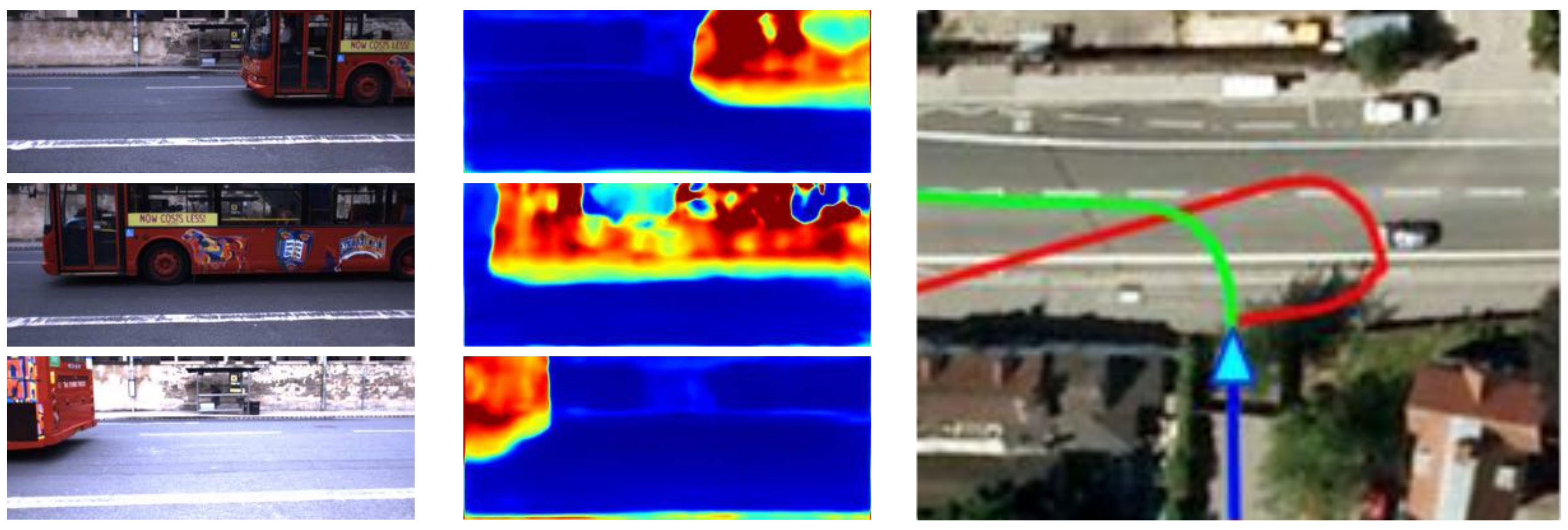
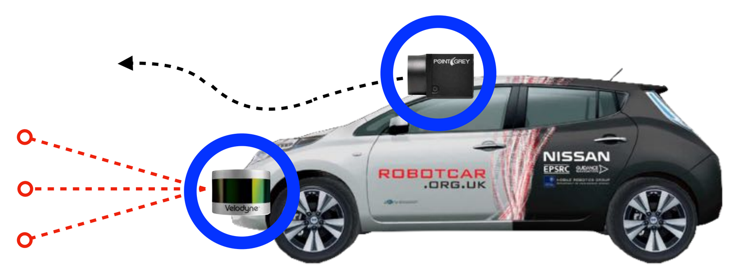


Image Sequence | Ephemerality Mask | Baseline VO | Robust Mono VO

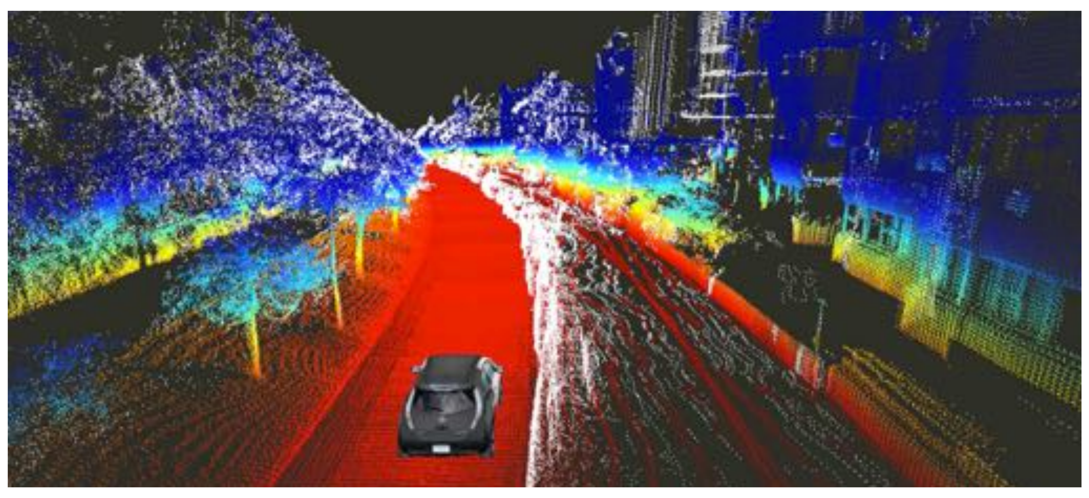
Training

1. Prior Mapping

Collect **numerous overlapping traversals** with a **stereo camera** and **LIDAR scanner.**



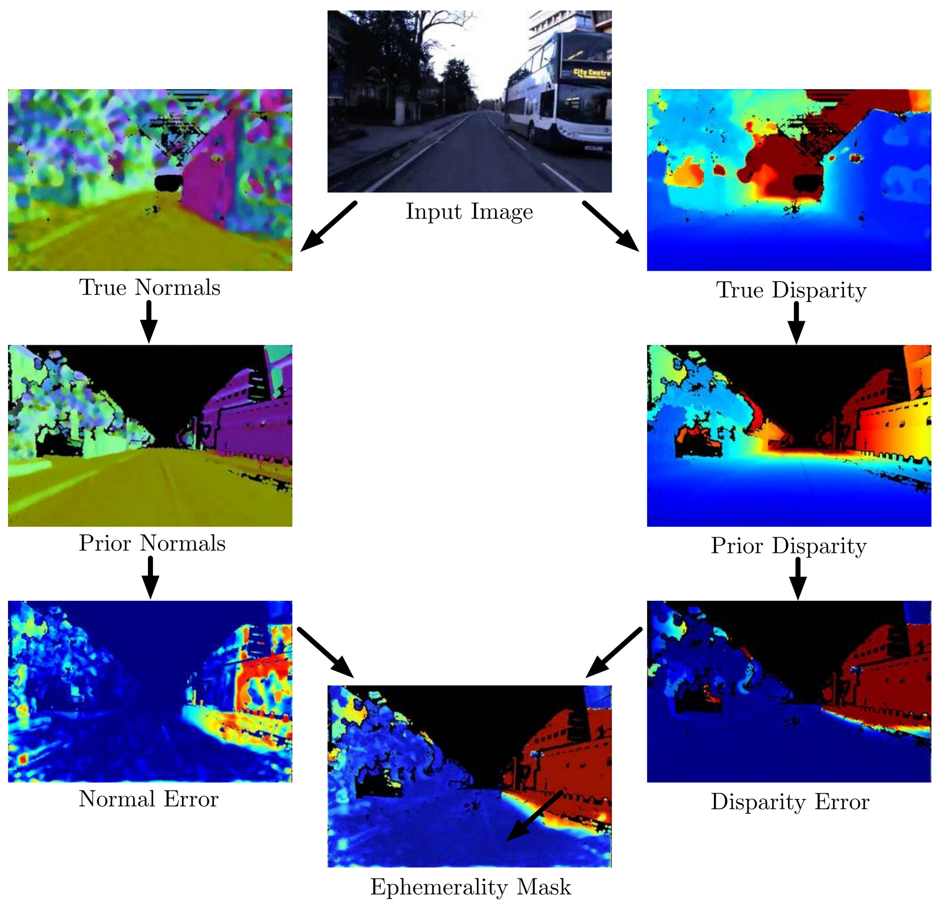
Remove **ephemeral points** (white) with an entropy-based, multi-session mapping approach.



2. Ephemerality Labelling

Automatically, with **no manual labelling**, compute reference **ephemerality masks**, $\mathcal{E}$, as a weighted difference between the static and true disparity, d, and normals, $\mathbf{n}$:

$$\mathcal{E}_i = \gamma \left\| d_i^S - d_i \right\|_1 + \delta \cos^{-1}\left(\mathbf{n}_i^S \cdot \mathbf{n}_i \right)$$



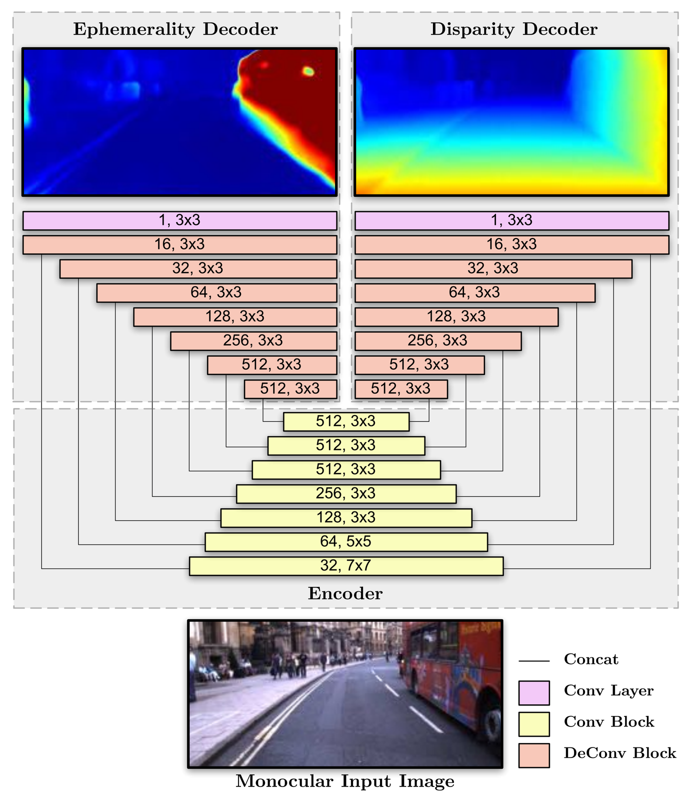
3. Network Training

Train a convolutional neural network to predict **ephemerality masks** and **disparity** from only monocular input images.

$$L = L_{ephemerality} + L_{disparity}$$

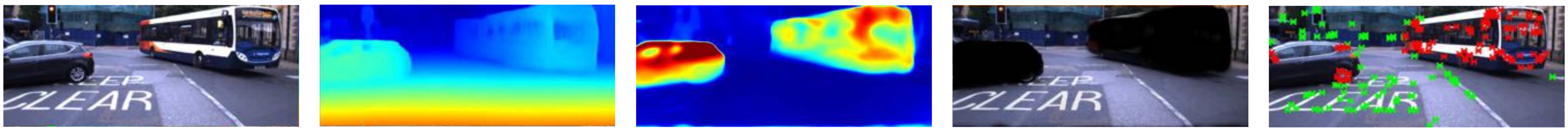
$$L_{ephemerality} = \|\hat{\varepsilon} - \varepsilon\|_1$$

$$L_{disparity} = \sum \alpha L_{recon} + \beta L_{smooth} + \gamma L_{SSIM}$$



Deployment

At run-time:
- **only requires a monocular camera**
- **operates in real-time** (CNN at 50Hz)
- **ephemerality** disables features in Sparse VO
- **ephemerality** weights photometric residuals in Dense VO
- **model-free distractor segmentation**
- substrate for **dynamic obstacle detection**



Input Image | Disparity | Ephemerality Mask | Robust Dense VO | Robust Sparse VO

Results

Over 400km of the Oxford RobotCar Dataset, we demonstrate:

- **reduced odometry drift**
- **significantly improved egomotion with large distractors**

Ephemerality mask predictions in challenging urban environments

Conclusion

Introduced **ephemerality masks**, the likelihood that a pixel corresponds to distractor objects.

Automatic self-supervised approach with **no manual labelling.**

Only requires a **single monocular camera** to produce **real-time, reliable ephemerality-aware visual odometry to metric scale.**

More Information

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