Reducing drift in VO by inferring sun direction using a Bayesian CNN

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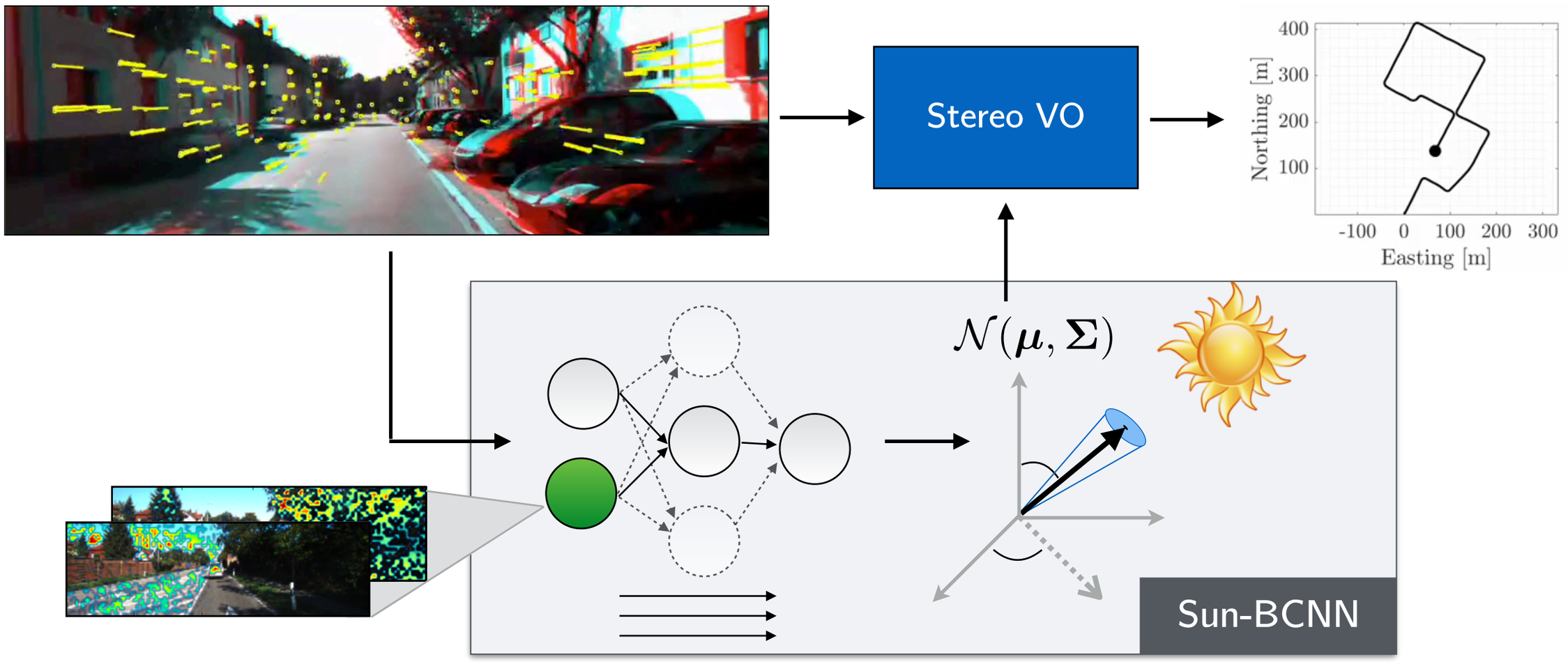

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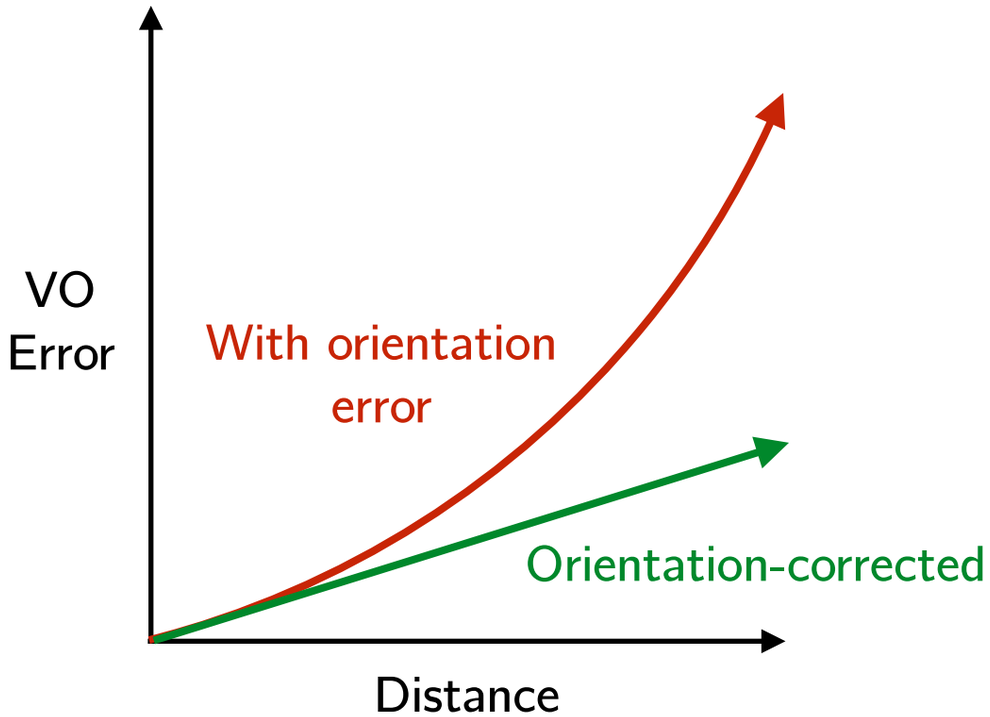
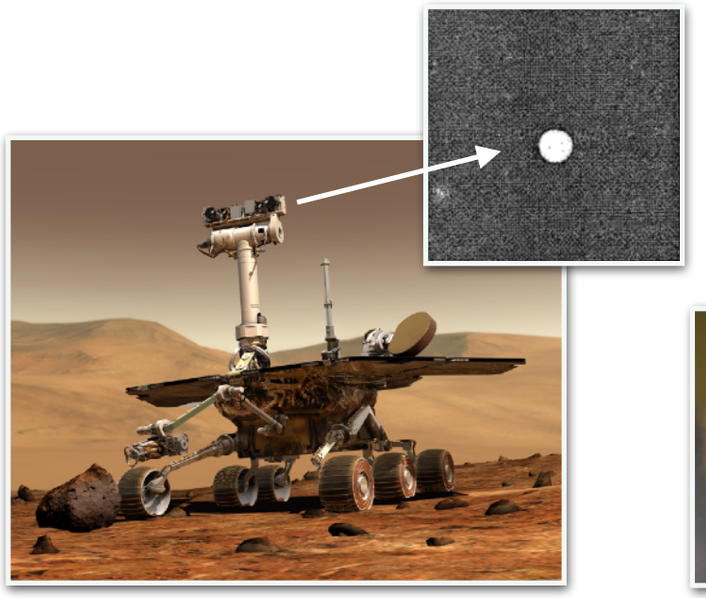
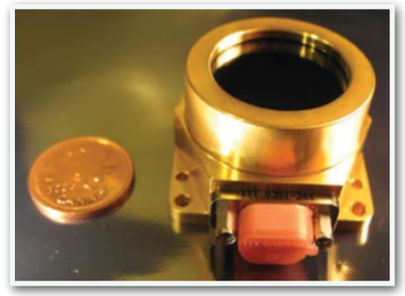
Sun-aided visual odometry

VO is a dead-reckoning technique and suffers from **super-linear error growth**, largely due to **accumulated orientation error**





Specially oriented camera
(e.g., MERs)



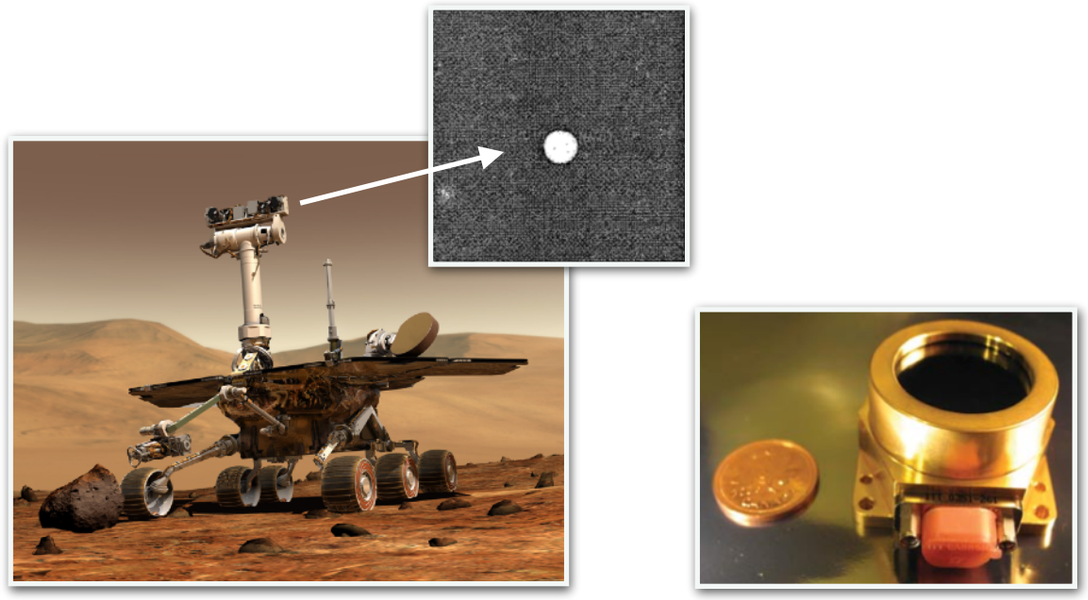
Specialized sun sensor

Drift can be reduced using **absolute orientation information** (e.g., observing the sun)

Simultaneous localization and... sun sensing?

Do we really need a **hardware sun sensor** or **specially oriented camera**?

In other words, do we need to look at the sun to see the sun?



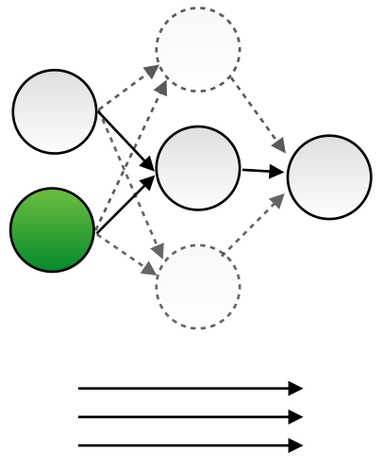
What if we could **infer** the direction of the sun from **environmental cues**?

Sun-BCNN: A Bayesian CNN for finding the sun

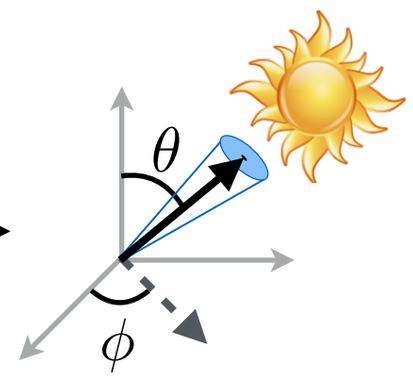
We would like to estimate a **3D sun vector** and an associated measure of **uncertainty** by learning a model **from data**

RGB image

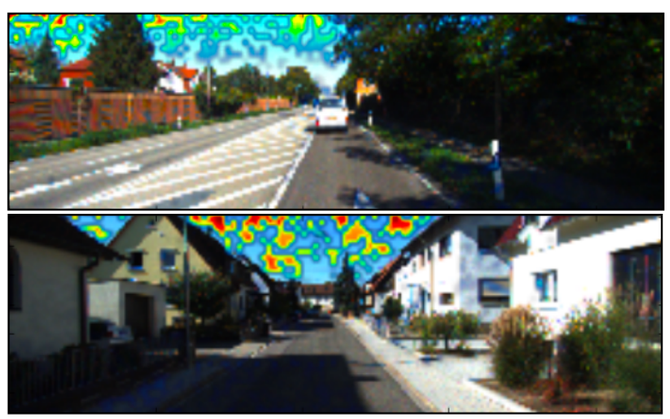
Bayesian GoogLeNet



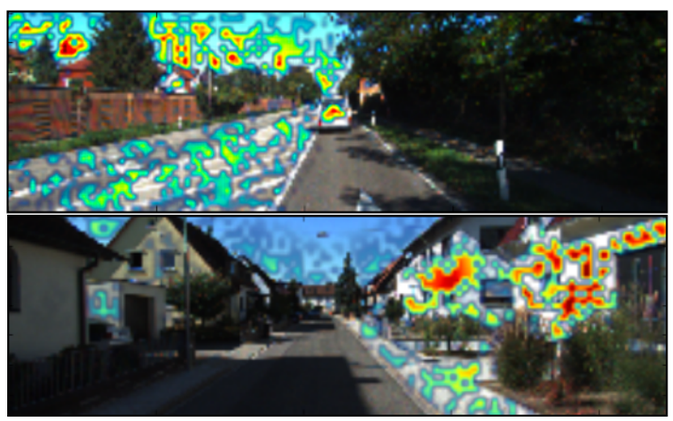
Stochastic passes with **dropout**



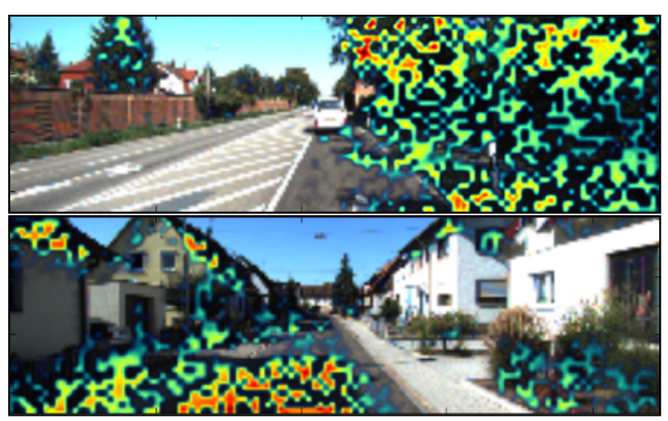
3D sun vector with **uncertainty**
(Azimuth + Zenith)



Sky



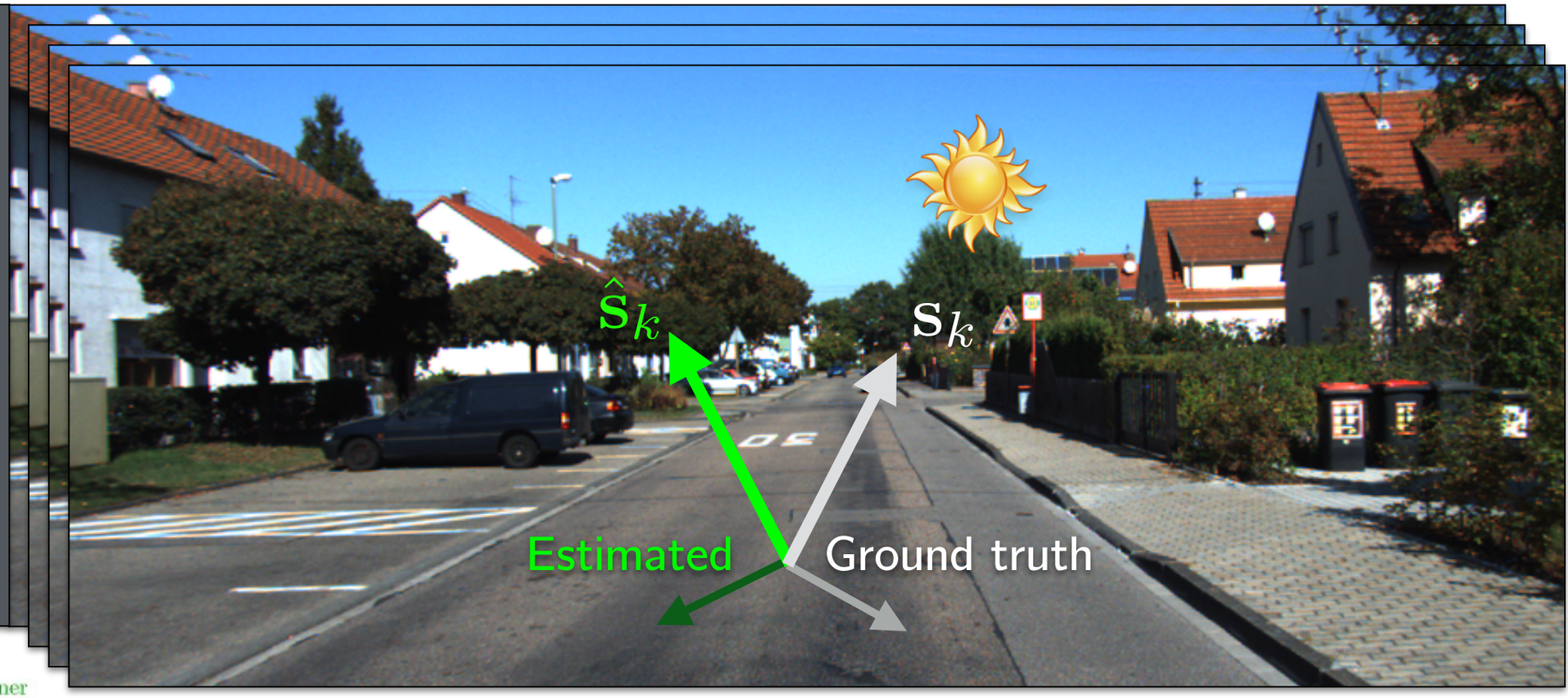
Well lit regions



Shadows

Training: KITTI odometry benchmark

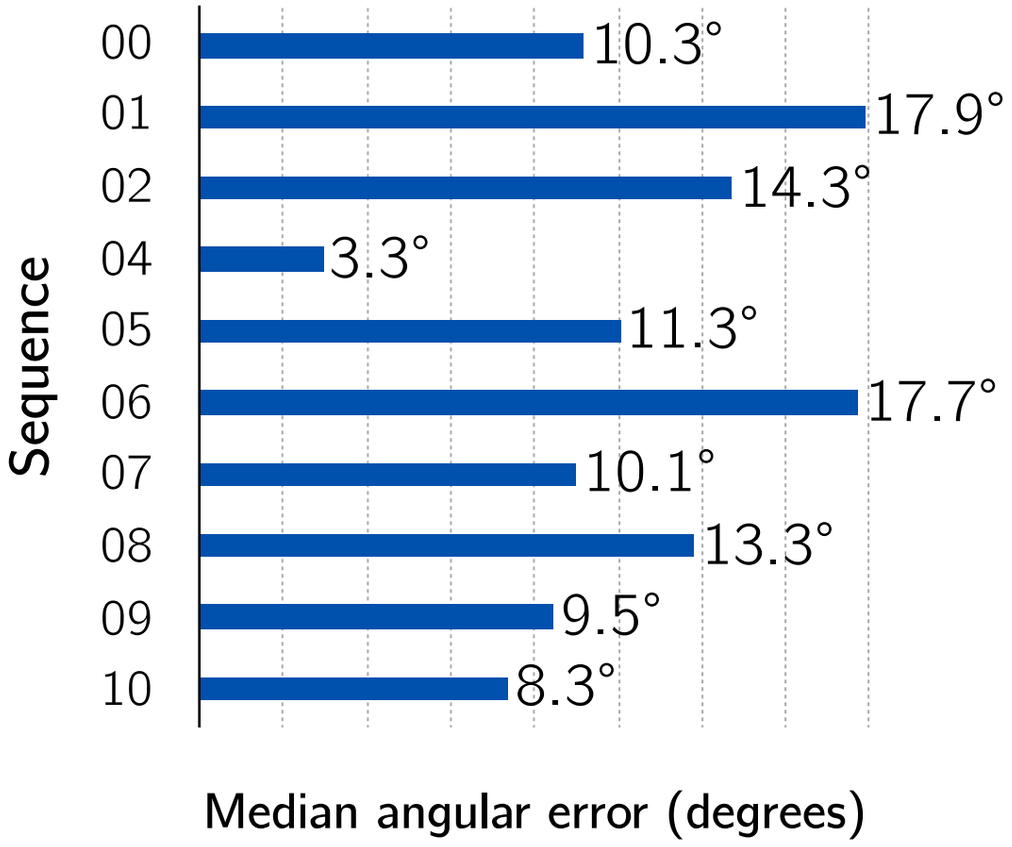
- 10 sequences
- 9/1 test/train split for each sequence
- 20k images per training set
- 1k epochs per training set



Ground truth? GPS-INS data from the KITTI dataset and a solar ephemeris model

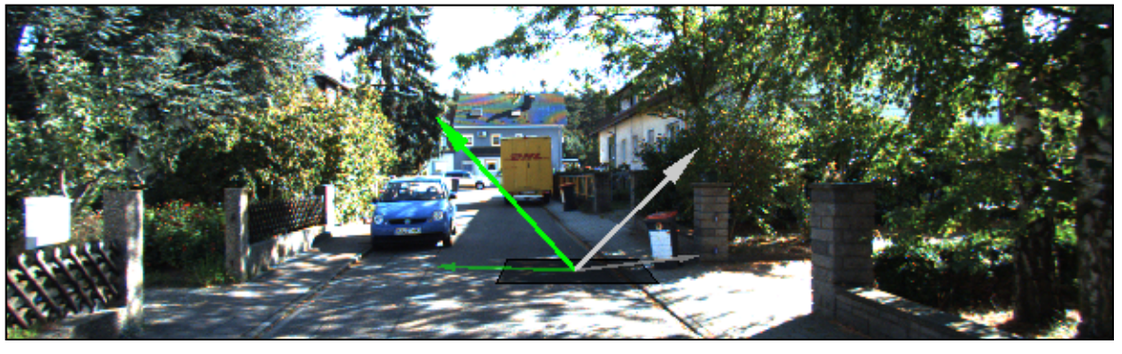
Loss function? Cosine distance $\mathcal{L}(\hat{\mathbf{s}}_k) = 1 - (\hat{\mathbf{s}}_k \cdot \mathbf{s}_k)$

Testing: KITTI odometry benchmark



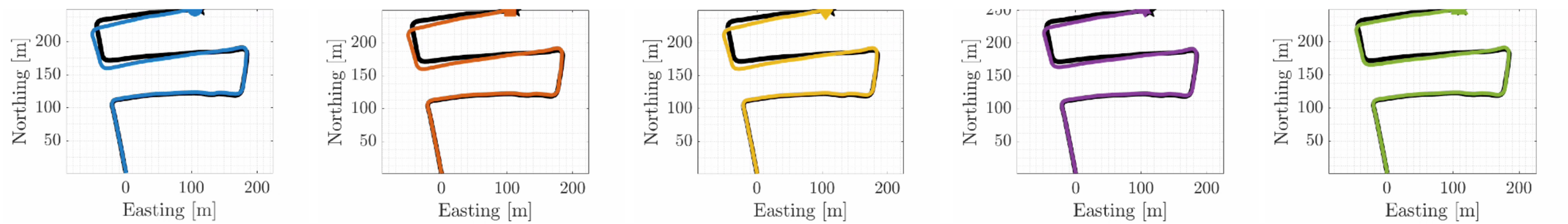
We consistently obtain **< 18 degrees median angular error**, but some sequences are better than others.

Sun-BCNN performs better with **strong directional illumination cues**



Visual odometry: KITTI odometry benchmark

VO Trajectories



Without sun

Ground Truth

Lalonde (Lalonde et al. 2011)

Lalonde-VO (Clement et al. 2016)

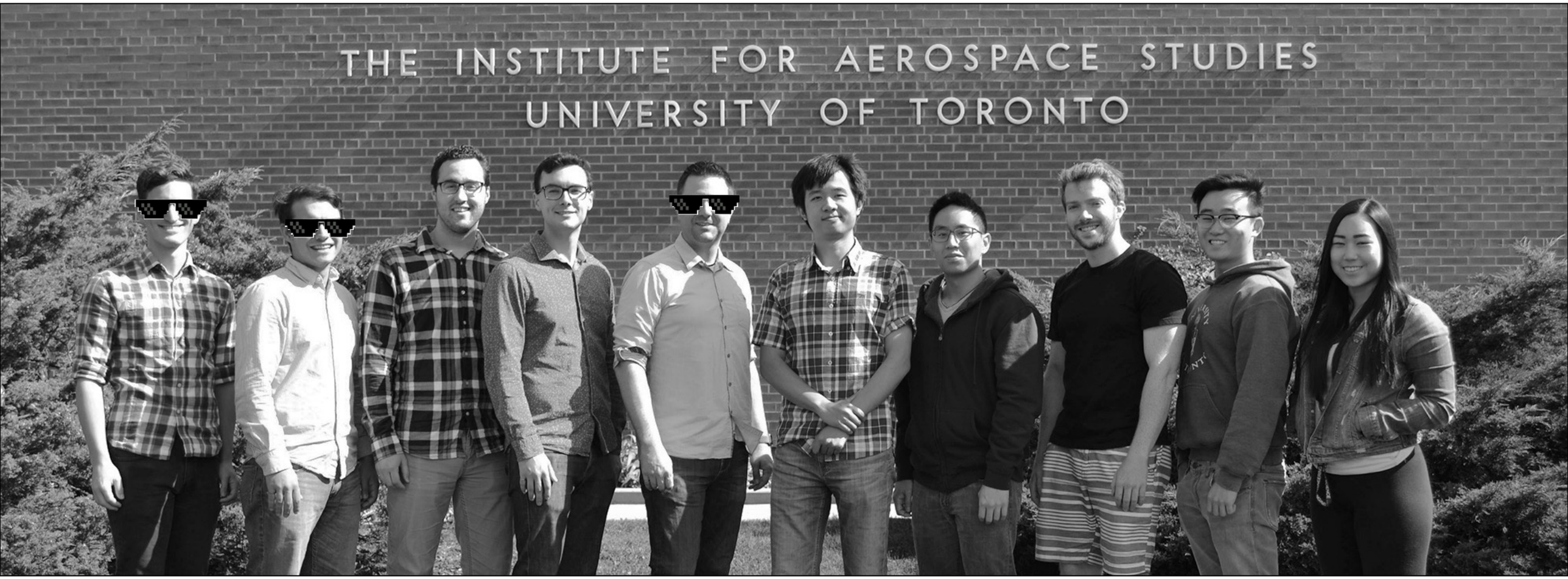
Sun-CNN (Ma et al. 2017)

Sun-BCNN (ours)

Thank you!

Caffe implementation of Sun-BCNN

github.com/utiasSTARS/sun-bcnn



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