VAEs for Camera Relocalization

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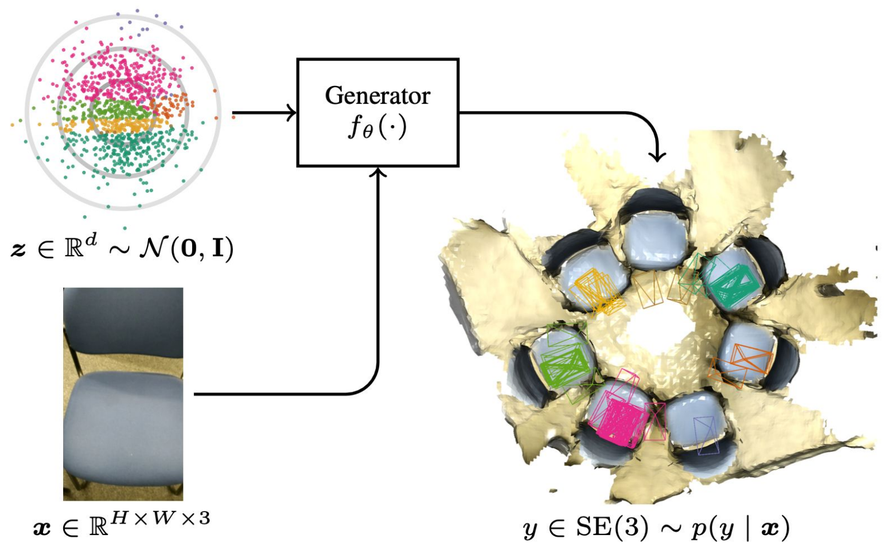
Summary

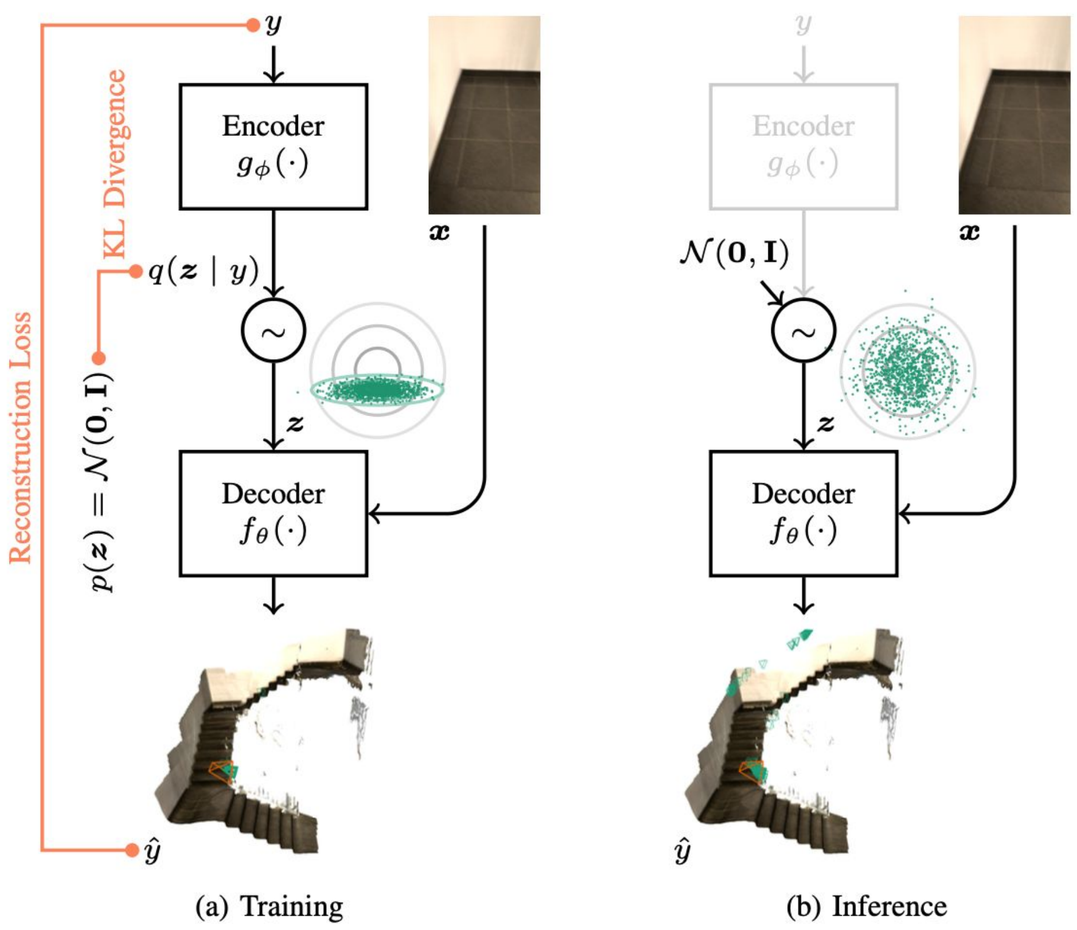
Use a *VAE* to model the conditional distribution of *camera poses* given *image observations*



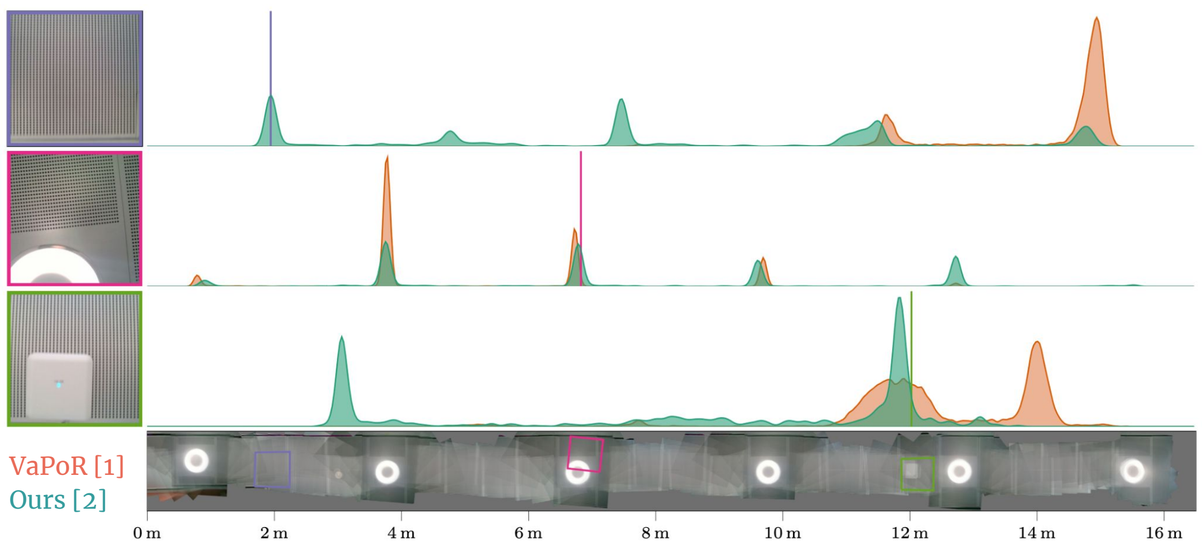
Modeling Aleatoric Uncertainty

Aim: handle data ambiguity e.g. repetitive structures

How: sample poses from latent prior and through the decoder



Result: multimodal posterior distributions for ambiguous queries



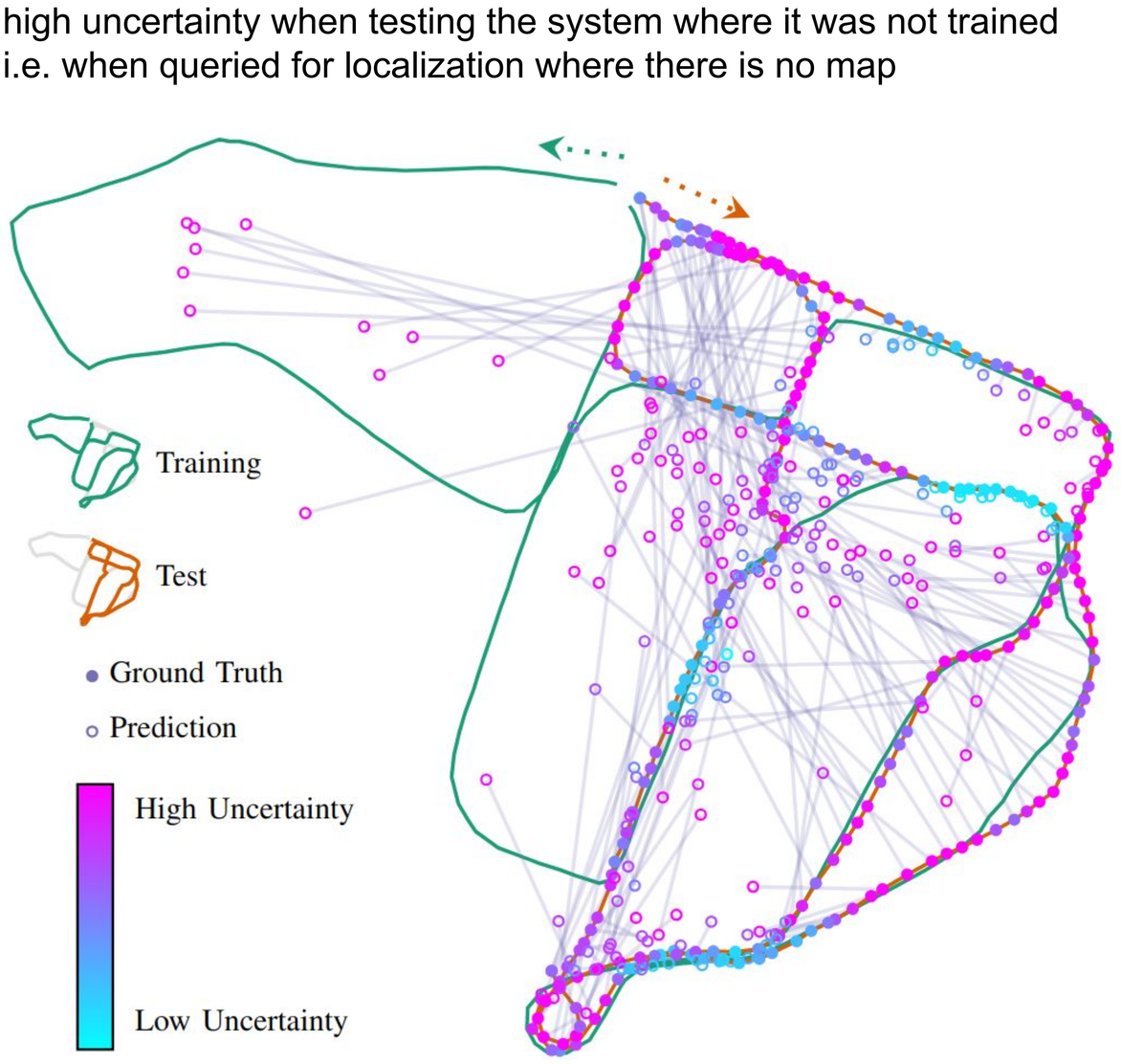
Quantifying Epistemic Uncertainty

Aim: handle knowledge limits e.g. localization outside the map

How: evalue likelihoods by importance sampling through the encoder

$$\begin{aligned}\log p(y \mid \boldsymbol{x}) &= \log \int p(y, \boldsymbol{z} \mid \boldsymbol{x}) d\boldsymbol{z} \\ &= \log \int \frac{q_\phi(\boldsymbol{z} \mid y)}{q_\phi(\boldsymbol{z} \mid y)} p(y, \boldsymbol{z} \mid \boldsymbol{x}) d\boldsymbol{z} \\ &= \log \mathbb{E}_{q_\phi(\boldsymbol{z}|y)} \frac{p_\theta(y \mid \boldsymbol{z}, \boldsymbol{x}) p(\boldsymbol{z})}{q_\phi(\boldsymbol{z} \mid y)}\end{aligned}$$

Result:
high uncertainty when testing the system where it was not trained
i.e. when queried for localization where there is no map



[1] Zangeneh, F., Bruns, L., Dekel, A., Pieropan, A., & Jensfelt, P. A Probabilistic Framework for Visual Localization in Ambiguous Scenes. IEEE ICRA 2023.

[2] Zangeneh, F., Bruns, L., Dekel, A., Pieropan, A., & Jensfelt, P. Conditional Variational Autoencoders for Probabilistic Pose Regression. IEEE/RSJ IROS 2024.

[3] Zangeneh, F., Dekel, A., Pieropan, A., & Jensfelt, P. Quantifying Epistemic Uncertainty in Absolute Pose Regression. *Under Review*.

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