Plan2Vec:

Unsupervised Representation Learning by Latent Plans

Ge Yang, *[1] Amy Zhang, *[1] Ari S. Morcos,[1] Joelle Pineau,[1,2] Pieter Abbeel,[3] Roberto Calandra[1]

[1]Facebook AI Research, [2]McGill University,
[3]UC Berkeley EECS

BERKELEY ARTIFICIAL INTELLIGENCE RESEARCH

We use representations to plan and navigate the world

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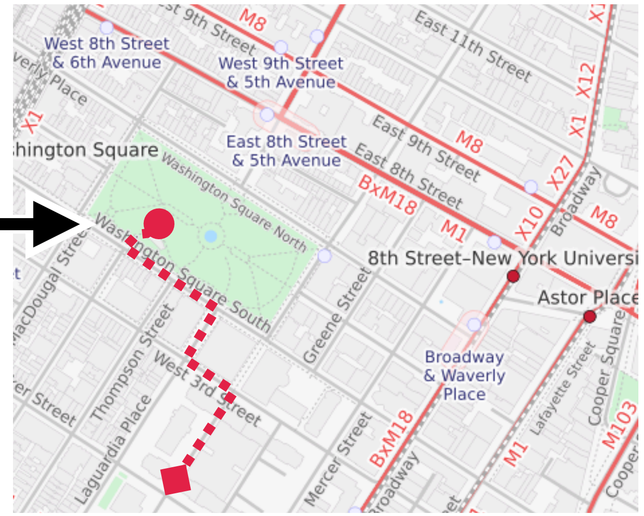
Washington Square



Street Map

Learning plannable representations that inform long-horizon structures, is an open challenge.

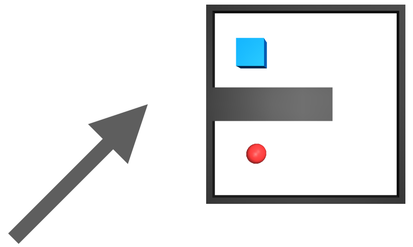
Plan2vec

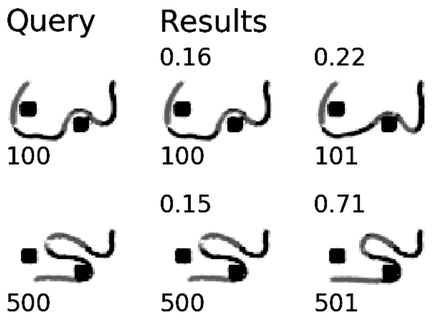
- entirely passively from sequences of images
- by constructing a graph with near-neighbor distances, and distilling long-horizon path-integrals with graph-search.

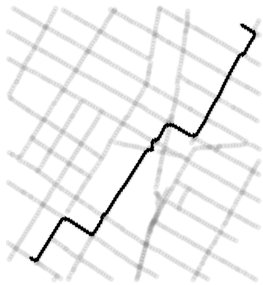
Results

Three Domains

- Simulated visual navigation
- Deformable object manipulation [1]
- StreetLearn [2]





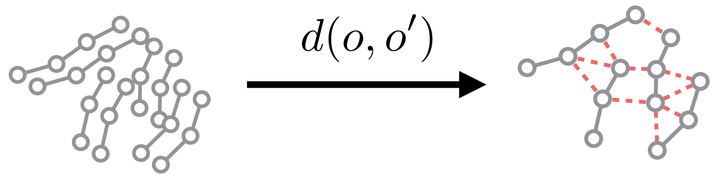


[1] Wang et al 2019 [2] Mirowski et al, 2018

Plan2vec

semi-supervised learning

1. Learning to construct the graph



Plan2vec

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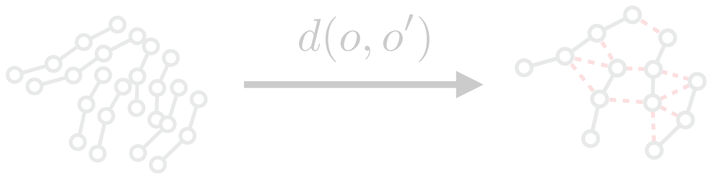
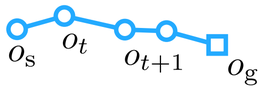


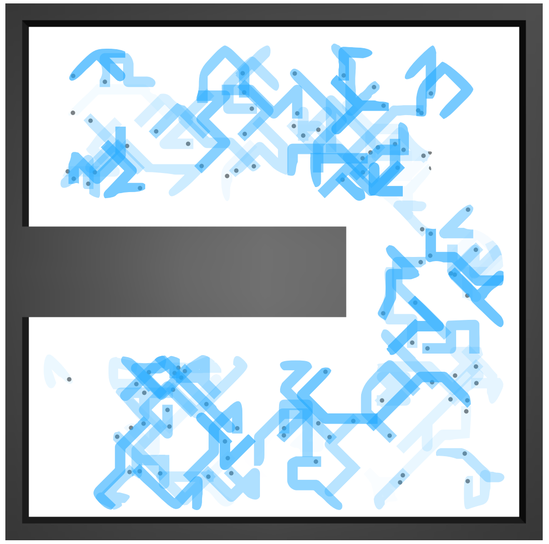
2. Learning long-horizon distance relationships by extrapolation via planning



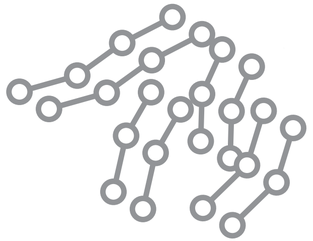
$$V(o, o_g) = -\sum_i d(o_i, o_{i+1})$$

Step-1: Building the Graph

Camera View

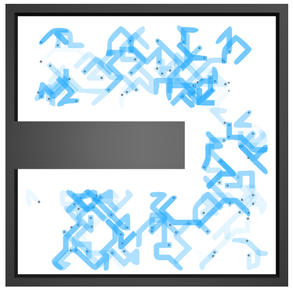


Sequential Data



[1] Savinov et al, 2018

Step-1: Building the Graph



Local Metric

$d(o, o')$

$$d(x, x') = \begin{cases} 1, & \text{1-step apart} \\ 2, & \text{further away} \end{cases}$$

$$L_d = |d(x_t, x_{t+1}) - 1| + |d(x, x^-) - 2|$$

[1] Savinov et al, 2018

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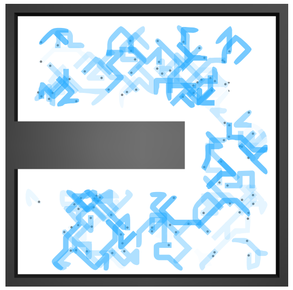

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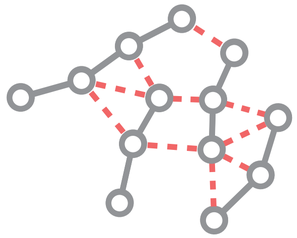

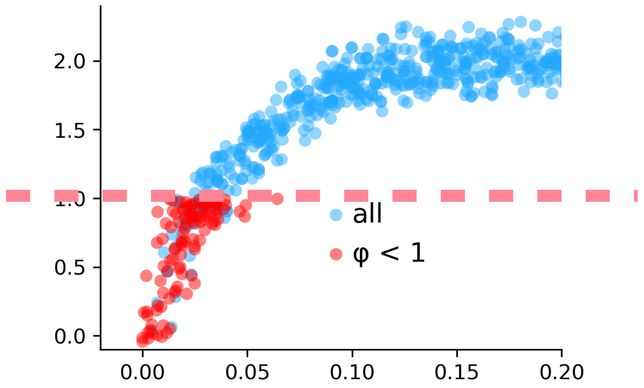

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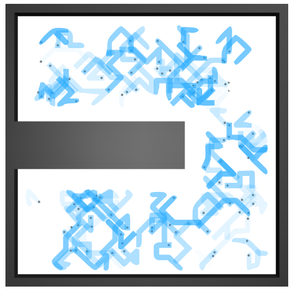

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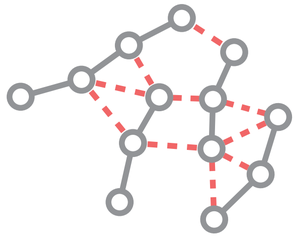

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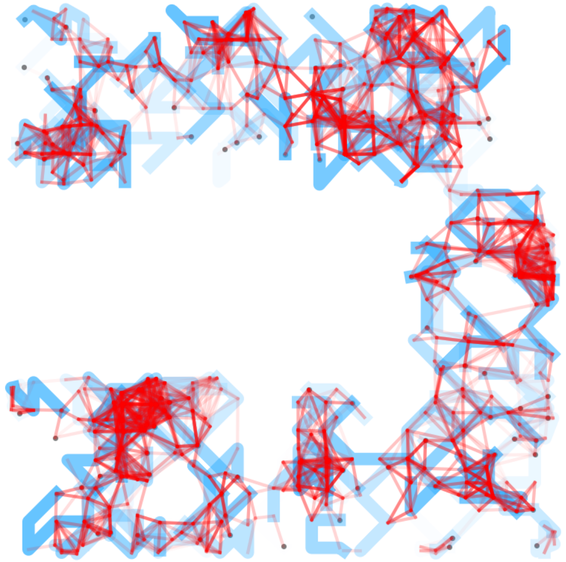

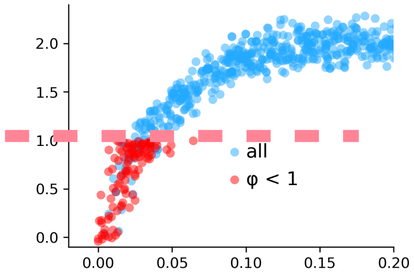

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Plan2vec

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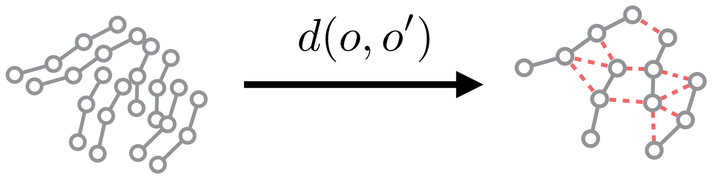
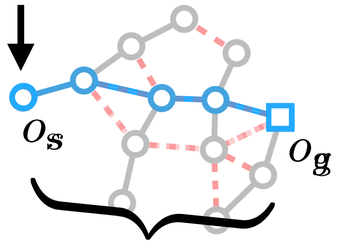


2. Learning long-horizon distance relationships by planning

Step-2: Learning by Planning

How do we learn D(o, o')?



1. sample $\langle o, o_g \rangle$
2. plan with Dijkstra's
3. Learn $D(o, o_g)$ by regressing towards $D(o, o_g) = -\sum_i d(o_i, o_{i+1})$

Plan2Vec: Learning by Planning

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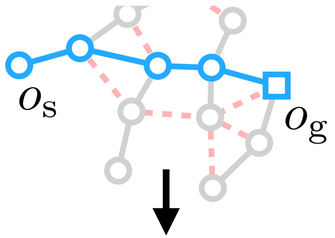
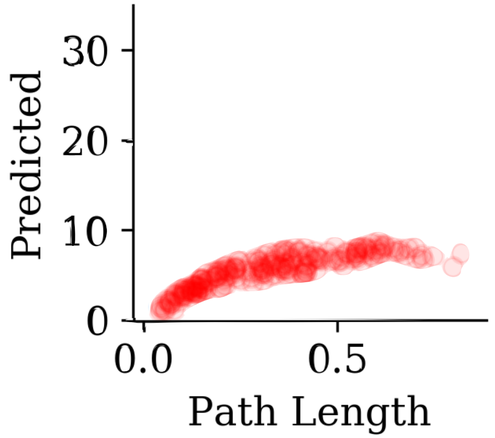
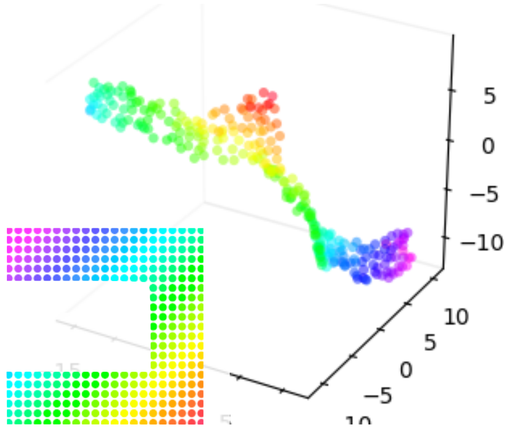


Now, does this work?

Metric



Embedding



Plan2vec

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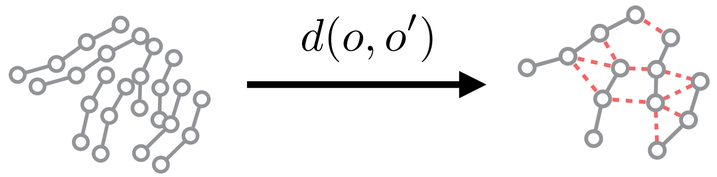
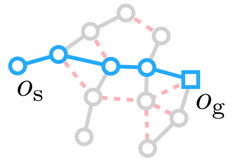


2. Learning to extrapolate by planning

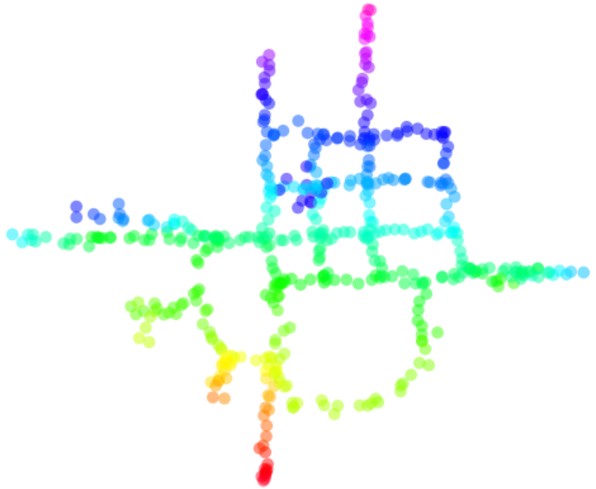


$$V(o, o_g) = -\sum_i d(o_i, o_{i+1})$$

StreetLearn Dataset

Camera View [1]

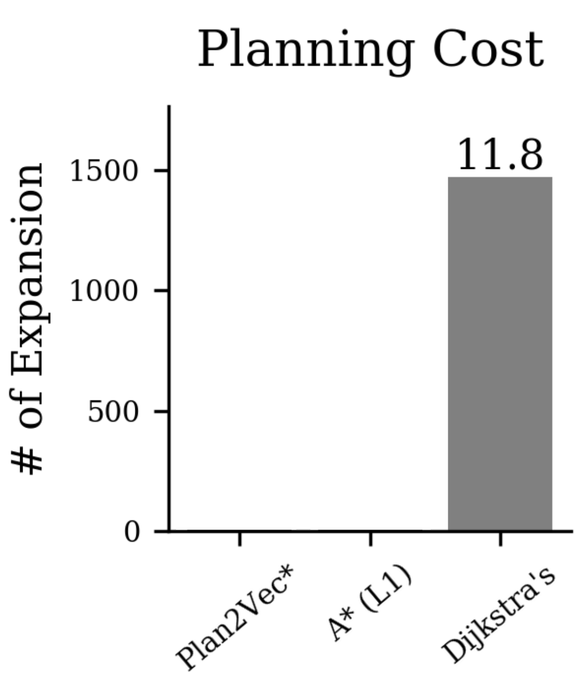
Learned Metric Map

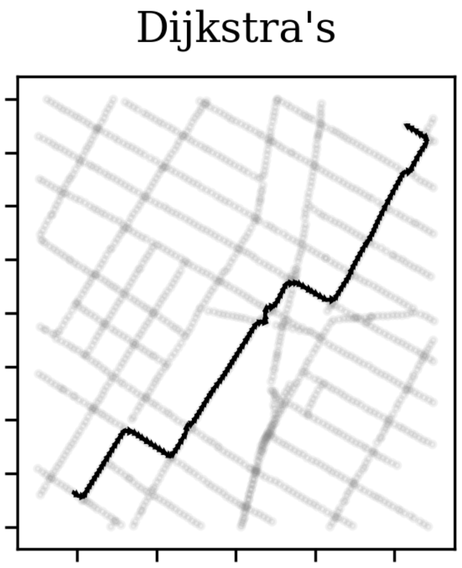


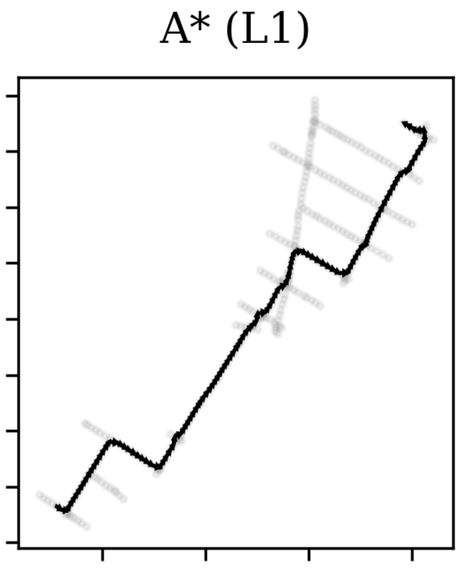
[1] Ge Yang, for illustration

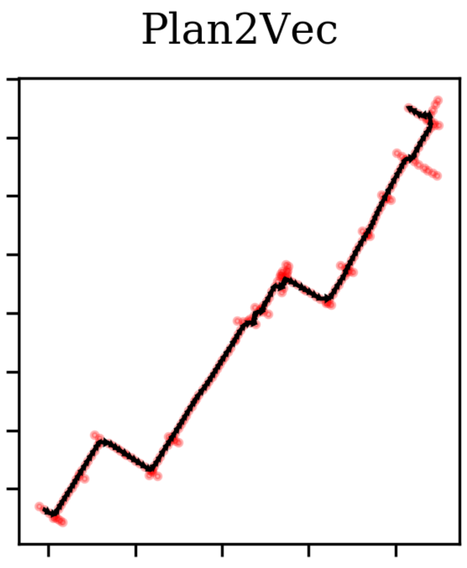
StreetLearn Dataset

Learned representation reduces planning cost



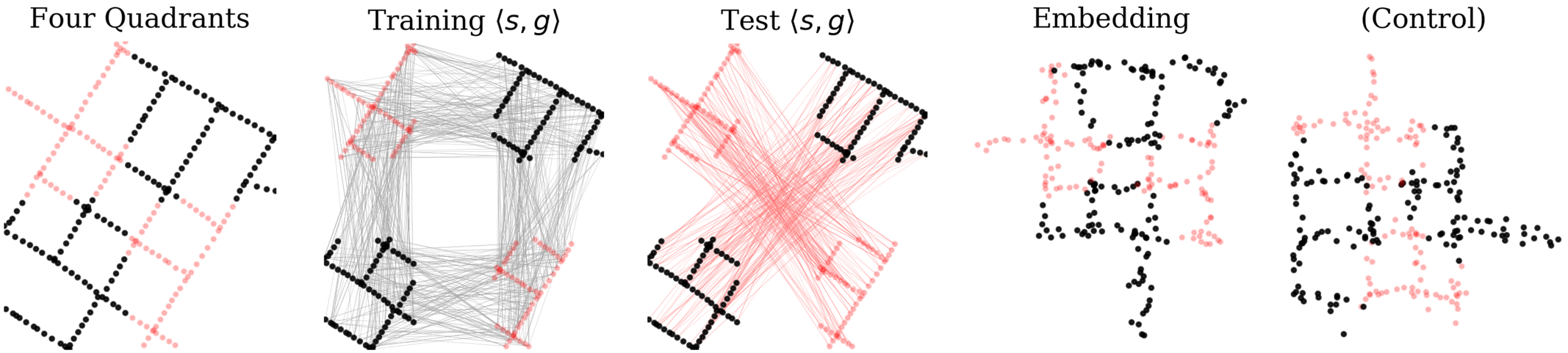






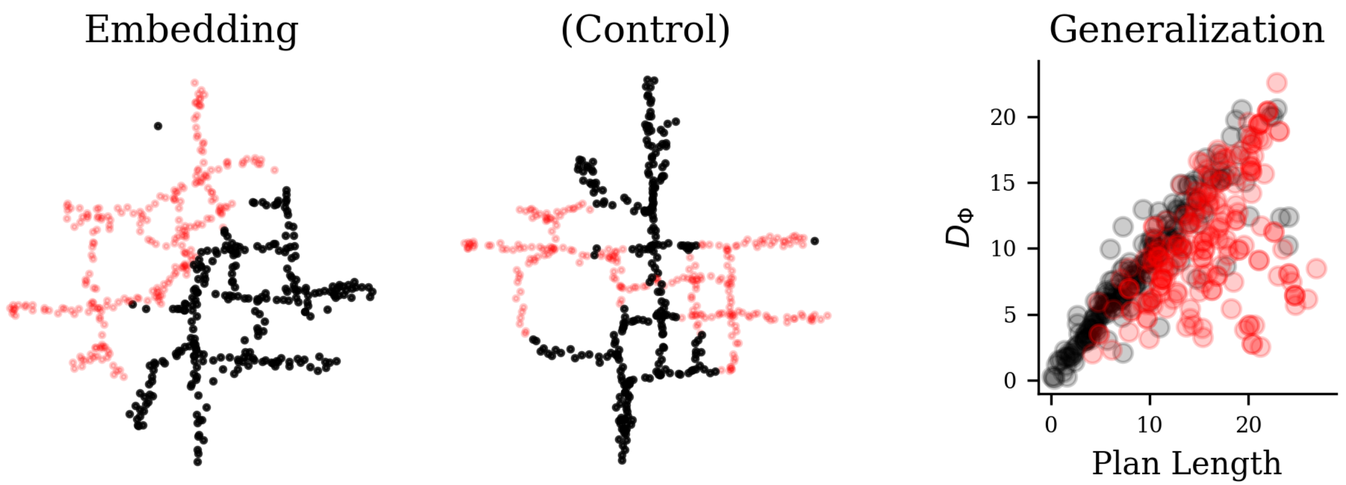
Generalization

Quadrants



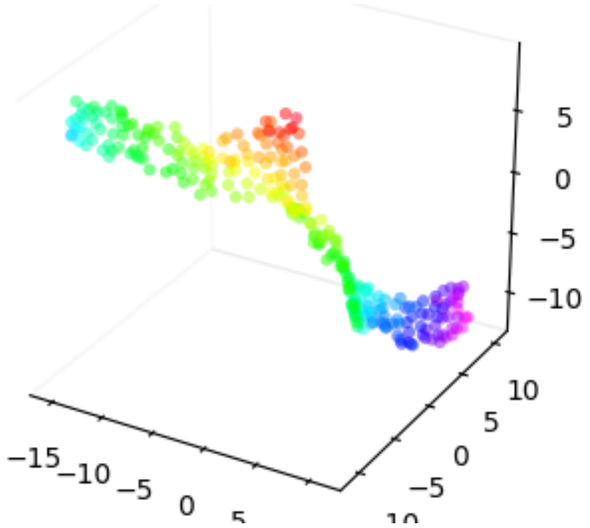
Generalization

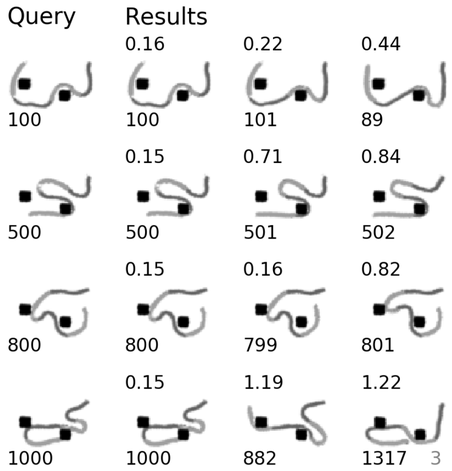
Failure cases: importance of long-horizon plans

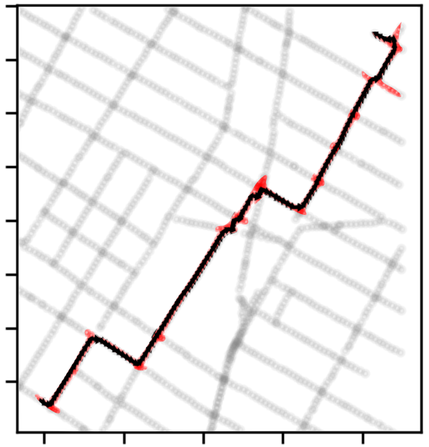


Conclusion

We can learn representations that capture long-horizon relationships, by constructing a graph and making plans.







Collaborators

Ge Yang, Amy Zhang, Ari Morcos, Joelle Pineau, Pieter Abbeel, Roberto Calandra





We can learn representations that capture long-distance relationships, by constructing a graph and making plans.