Mapping Navigation Instructions to Continuous Control Actions with Position-Visitation Prediction

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Motivation

• For wide adoption, robot control interfaces should be:
  • Accessible
  • Expressive

• Natural language fulfills these criteria

• Combining natural language with

Go towards the blue fence passing the anvil and tree on the right
go between the mushroom and flowers chair the tree all the way up to the phone booth
Following Natural Language Instructions is Hard

It requires:

- Visual Perception
- Spatial Reasoning
- Language Understanding
- Language Grounding
- Control

**Modular approaches**

- Image
- Instruction

Hard to scale knowledge representations

**Single-model approaches**

- Image
- Instruction

Neural Network

Difficult learning
Lacks interpretability

action
Our approach: Two-Stage Decomposition

Stage 1
Planning with Position-Visitation Prediction

Stage 2
Action generation

Position-Visitation Distributions

Stopping Probability
Visiting Probability

Image
Instruction

→

→ action
Stage 1: Position Visitation Prediction

Predicted distribution is inferred with the input of instructions embedded in the map.

A convolutional image encoder-decoder architecture conditioned on natural language.
Stage 2: Action Generation

No dependence on language → simple control problem.

Training experience not limited by availability of natural language data.

Position-Visitation Distributions

Transform to Egocentric

Pose

Egocentric Position-Visitation Distributions

Fully Connected NN

Continuous Velocity Command
Learning

Stage 1
Supervised learning

- Predicted Distributions

- Loss

- Human Demonstration Visitation Distributions

Stage 2
Imitation Learning

- Human demonstration trajectory

- Oracle → Gold Action

- Human Demonstration Visitation Distributions

- Stage 2 → Action

- Loss
Evaluation & Results

- Realistic simulator powered by Microsoft AirSim
- Real, crowdsourced natural language instructions from the LANI corpus
- We achieve state of the art: ~41% success rate

We are releasing this benchmark! https://github.com/clic-lab/drif
Generalization to Predicting State-Visitation Distributions

• Our approach generalizes to predicting state visitation distributions in an approximation of the true MDP.

• If the MDP approximation is good, then the learned policy has bounded suboptimality with regard to the true MDP.
Thank You!