Visual Navigation in Real-World Indoor Environments Using End-to-End Deep Reinforcement Learning

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Visual navigation using deep reinforcement learning

problem description:

- agent (robot) moves in a 3D environment using a set of discrete actions (forward, rotate-left, ...)
- it uses an RGB camera as its only sensor
- goal is given by an image

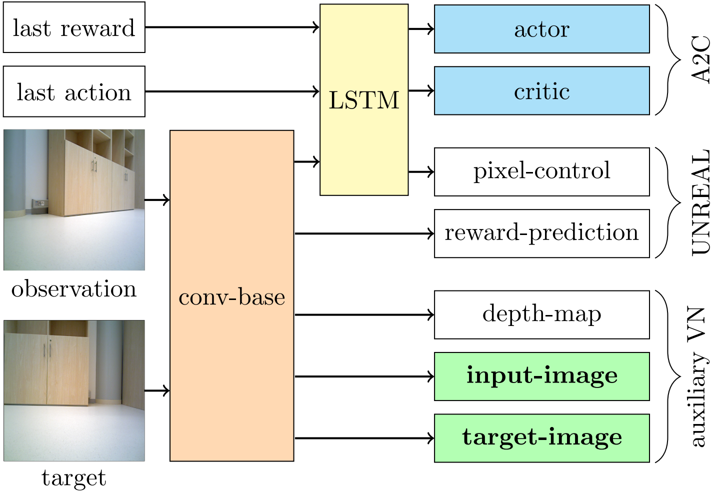
deep reinforcement learning visual navigation:

- does not need an explicit map of the environment
- current approaches applied mostly to simulated scenarios
- agent relies on the simulator to stop the navigation after the goal is reached – this cannot be used in real-world navigation

Environment simulator - DMHouse

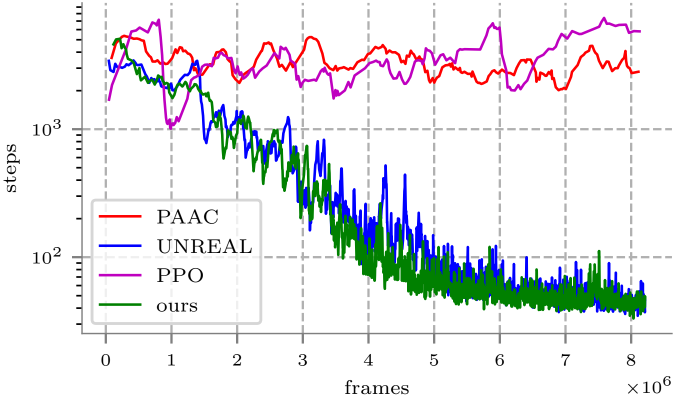
- deep reinforcement learning requires lots of images, training in real-world is not feasible
- fast 3D rendering engine designed
- capable of domain randomization (changing the placement of object, lightning conditions)

Architecture



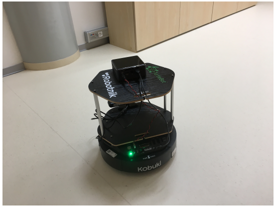
Training in simulated environment

- based on PAAC; number of parallel agents is 16
- takes approximately one day on single GPU
- PAAC and PPO fail to converge; outperforms UNREAL
- after training, 100% accuracy; avg. episode length is 42 for our method while only 46 for UNREAL



Real-world experiment

- to transfer the trained policy, we propose the following pipeline:
  1. agent is trained in DMHouse simulator
  2. images from the real-world environment are automatically collected
  3. agent is fine-tuned on the collected images
  4. agent is deployed to the real-world environment
- during training, we use curriculum learning and gradually increase the distance between the initial position and the goal
- in the real-world environment the agent (TurtleBot) reached a 0.3-meter neighbourhood of the goal in more than 86.7%



Conclusion & future work

- visual navigation using DRL, where the goal is given by an image
- novel DRL method based on PAAC enabling direct deployment of trained policy on real robots
- uses changed reward scheme and auxiliary tasks
- designed 3D environment simulator capable of domain randomization
- evaluated on real-world mobile robot, achieving satisfactory accuracy

future work:

- evaluate in larger environments with continuous motion of the robot
- perform experiments using a motion capture system for better accuracy
- improve domain randomization, allowing direct transfer