Ethics for AI, Robotics, and Human-Robot Interaction

Agents

- Navigation Agent: navigates toward a goal position given by object.
  - Discretize positions and use BFS to search directions and ensure norms
- Get-Object Agent: solves the task of getting an object.
- Checkout Agent: solves the task of doing checkout.
  - Trained with model-free RL.
  - Maintains norm table and uses it as a hard constraints.
  - Different state space, action space and reward function for cart and basket agents.

Action Sequencing

Navigate basket/cart

Get basket/cart

Navigate items in shopping list

Get item (cart agents and basket agents have different behaviors)

Navigate checkout

Do checkout (cart agents and basket agents have different behaviors)

Navigate exit

Demo

Hyper Planner

- If the total number in list_quant > 6, generates cart plan and triggers cart agents
- Otherwise generates basket plan and triggers basket agents
- Generates N ‘get’ instructions for each item to reduce state space of RL agents

- Avoids `OneCartOnlyNorm()`, `OneBasketOnlyNorm()`, `WrongShelfNorm()`, `EntranceOnlyNorm()`, `ReturnBasketNorm()`, `BasketItemQuantNorm()`, `CartItemQuantNorm()`, `UnattendedCheckoutNorm()`, `TookTooManyNorm()`

Navigation Agent

- Maintains a graph of discretized positions in the environment
- Initializes each node with BFS starting from the target object position

- Naturally allows navigation towards each object from any positions in the environment
- No effort on RL training
- Drives the agent close enough to the object, provides RL a good initial state
- Inaccuracy caused by discretization could be mitigated by RL

- Avoids `ObjectCollisionNorm()`, `WallCollisionNorm()`, `UnAttendedCartNorm()`

Get-Object Agent

- Get one target object into basket or cart
- Trained with model-free RL
- Maintains norm table to avoid any improper behavior
- State space:
  - Basket: position only
  - Cart: position, holding_target (bool), cart_position
- Action space:
  - Basket: 4 directions, ‘INTERACT’
  - Cart: 4 directions, ‘TOGGLE_CART’, ‘INTERACT’
- Reward function:
  - Basket: dense heuristic + high finish reward. Negative penalty for violating norms.
  - Basket: dense heuristic with high intermediate reward + high finish reward. Negative penalty for violating norms.

Checkout Agent

- Finishes whole checkout procedure
- Trained with model-free RL
- Maintains norm table to avoid any improper behavior
- State space:
  - Basket: positions, has_paid (bool)
  - Cart: position, purchased_items, purchased_quantities, cart_contents
- Action space:
  - Basket: 4 directions, ‘INTERACT’
  - Cart: 4 directions, ‘TOGGLE_CART’, ‘INTERACT’, ‘SELECT’
- Reward function:
  - Basket: sparse reward + high final reward. Negative penalty for violating norms.
  - Cart: intermediate progress reward + high final reward . Negative penalty for violating norms.