Mobility aid Assistance by Mobile Manipulators

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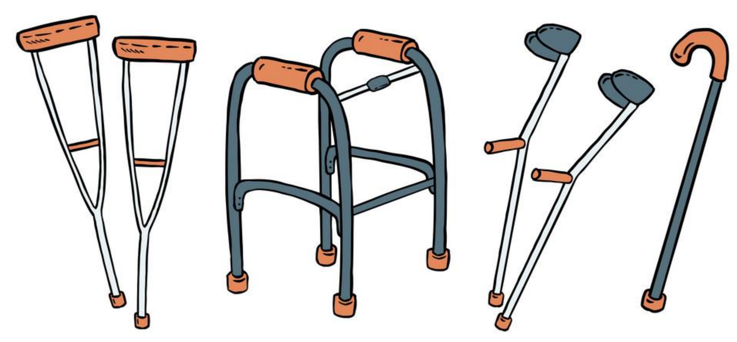
Introduction

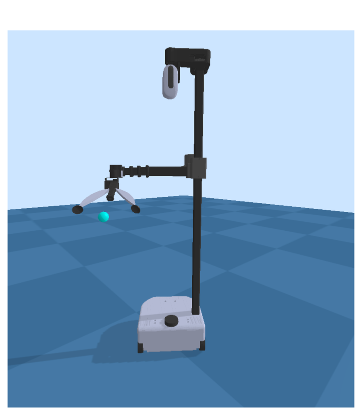
GOAL:

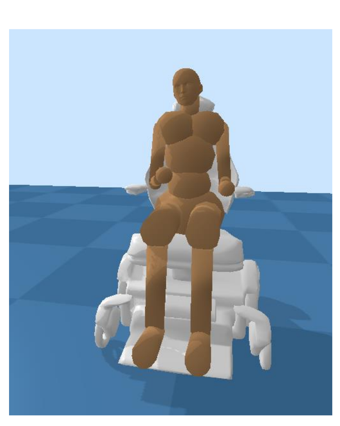
- Enable mobile manipulators to transport and handover complex objects such as canes, walkers, or crutches to the human users
- Robot collaboration with humans needs to be optimized and personalized to perform the interactional task.



Method

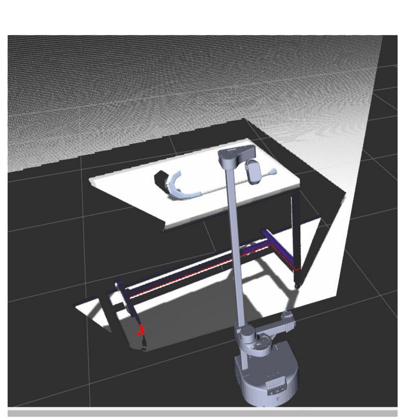
We use Assistive-gym [1] to create an environment consisting of a robot and an active human agent.

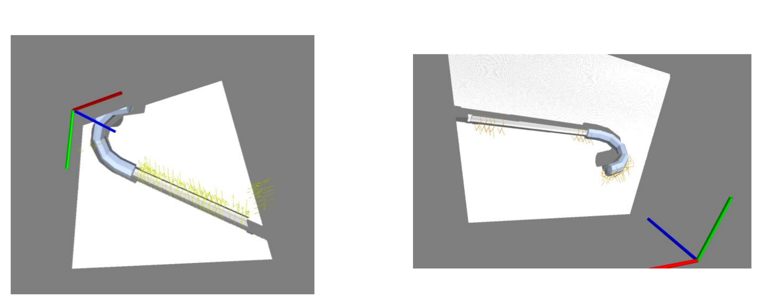




The mobile manipulator used is Stretch, and it has 5 DOF. Human sitting on a chair can move his arm to interact with the object.

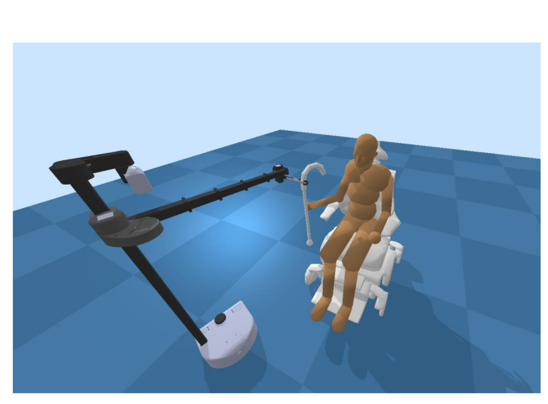
We use Grasp-net [2] to generate 6DOF grasps for the robot to pick the cane from starting point.





Robot picks the cane by the geom. center

The robot generates action to deliver the cane, and the human gets the cane from the robot.



The robot and human agent perform an optimized handover of the cane by learning the affordance and comfort of human-arm through the joint-reward scheme.

$$Human\ Comfort(X_j, i) = \text{f\_torque}(X_j, i) + \text{f\_joint\_angle}(X_j, i)$$

$$where\ \ X_j = PoseX\ wrt\ frame\ j\ and \quad i = Human\ posture$$

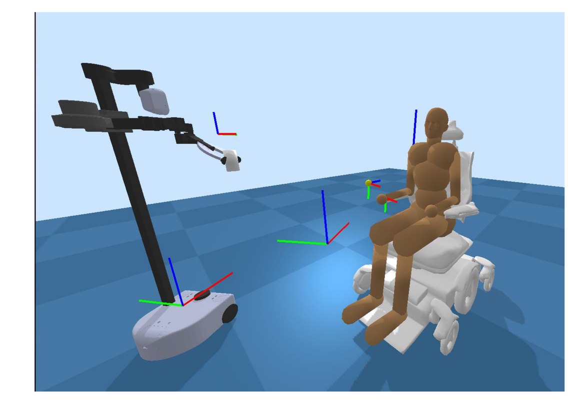
Human comfort [3] depends on sitting posture; Our agent learns the task sampled across various poses.

Evaluation

We are using simulations to investigate collaborative policies that outperform single-agent approaches.

I = C - Max(R,H)

I : Collaborative Improvement
C : Robot and Human performance
R : Only Robot performance
H : Only Human performance



Object Handover in Assistive Gym

We used multiagent PPO [4] to train both the robot and the human at the same time

Results:

Total 100 episodes [ObjectHandover] 200 iteration steps on each episode

	Successful trials	Unsuccessful trials	Task quality [0, 1]	$\frac{successful\ trial}{unsuccessful\ trial}$	Mean Reward
Baseline (B)	47	53	0.47	0.89	769 points
Without Human actions (R)	54	46	0.54	1.18	872 points
With Human actions (C)	74	26	0.74	2.85	1072 points

Only Human movement without Robot (H) Task quality =0

Collaborative improvement (I) = C - Max(R,H) = C - R = 0.2 (Task quality ↑)

Future Directions

- Develop a framework to include other complex objects
- Personalize the task wrt to individual humans
- Analyze the task on relative human-centric frames

Conclusions

- Positive collaborative improvement for assistive-task when human is involved in the loop.
- The robot hands the walking aid to humans with minimal effort configuration of both agents.

Acknowledgements

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References

[1] Erickson, Zackory, et al. "Assistive gym: A physics simulation framework for assistive robotics." *2020 IEEE International Conference on Robotics and Automation (ICRA)*. IEEE, 2020.
[2] Sundermeyer, Martin, et al. "Contact-graspnet: Efficient 6-dof grasp generation in cluttered scenes." *2021 IEEE International Conference on Robotics and Automation (ICRA)*. IEEE, 2021.
[3] Cakmak, Maya, et al. "Human preferences for robot-human hand-over configurations." *2011 IEEE/RSJ International Conference on Intelligent Robots and Systems*. IEEE, 2011.
[4] Schulman, John, et al. "Proximal policy optimization algorithms." *arXiv preprint arXiv:1707.06347* (2017).