Personalized Object Handover for Resting Human

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Introduction

Motivation

- Aging population will increase to 1.4 billions in 2030 and 2.1 billions in 2050 [1]
- Shortage of heath-care providers will continue to expand [2]

Objective

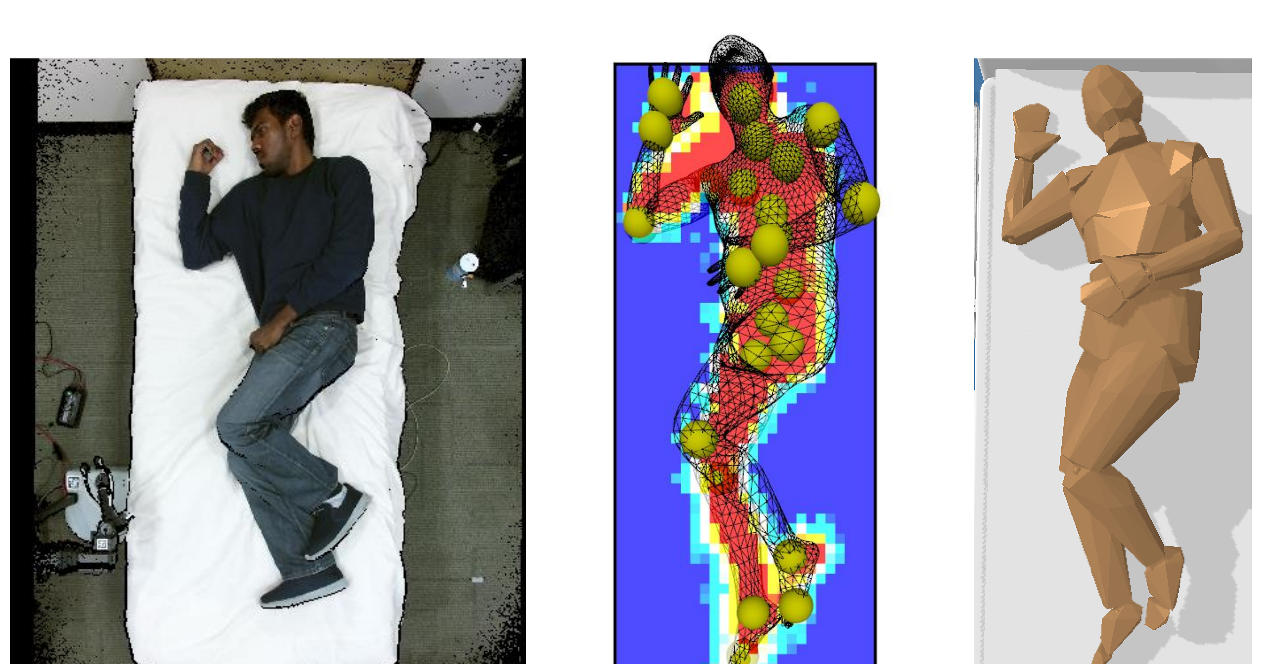
- Reduce burden for caregiver by let robot handover human on bed with daily life object.
- Personalized robot interaction for best human comfort.

The robot platform for personalized object Handover

Estimating human pose

A deep model [1] is used to infer the personalized mesh model (SMPL) [2] for each user using a depth image from an overhead camera.

From SMPL model, we created articulated human URDF model with 69 DOF that match the shape and size of the real subject.



From left to right: Human – Deep model estimation – URDF articulated model

Optimizing human comfort

SLP-3D dataset [3], which consists of 4590 SMPL files from 102 individuals with 45 body poses, is used in our research to represent various human pose and shape.

Sample image from SLP3D dataset

Assistive-Gym [4] is used to create a simulated environment consisting of a robot and an active human agent. Three objects – cane, cup, pill are chosen to represent handover objects

Sample handover goals for cane, cup and pill

Using CMAES, our method trying to maximize human comfort by minimize the following cost function

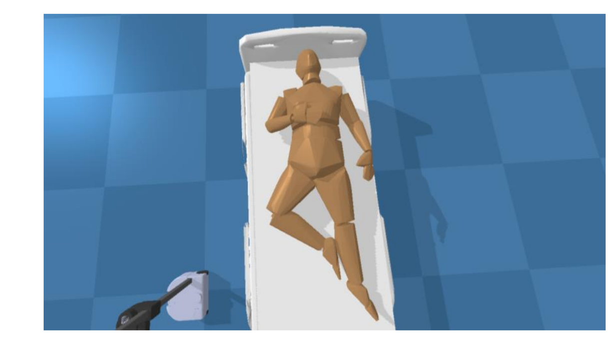
$$f_{cost} = f_{cost\ human} + f_{cost\ robot}$$

The human cost function is calculated using kinematic and dynamic properties.

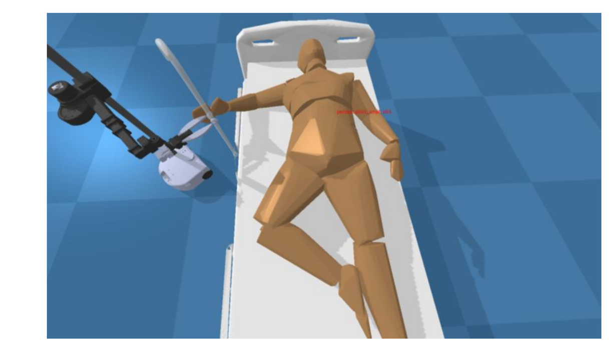
$$f_{cost\ human} = w_1 C_{position\ displacement} + w_2 C_{energy\ change} + w_3 C_{joint\ manipulibility} + w_4 C_{joint\ torque} + w_5 C_{joint\ mid-angle\ displacement} + w_6 C_{collision}$$

Result

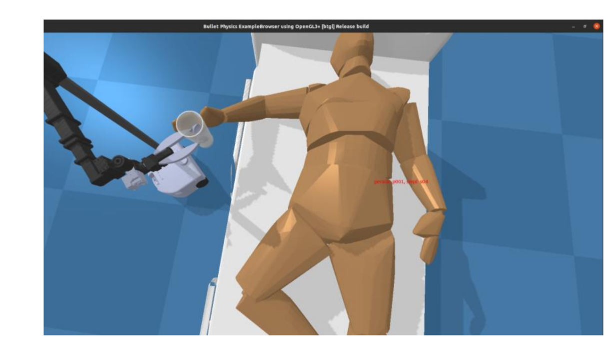
Reasonably good result are obtained from the simulation for various objects, human body and human pose.



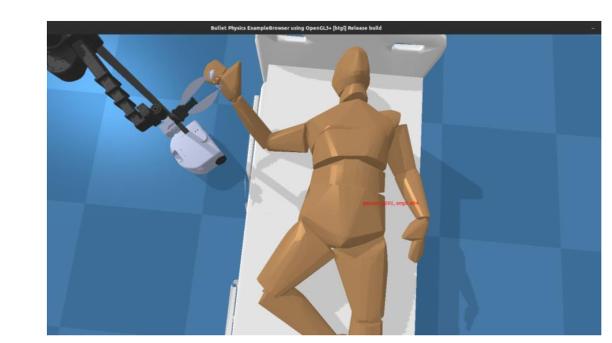
Original position



Cane handover



Cup handover



Pill handover

Using result from simulation, we can improve our existing pipeline to let object handover happen in real-world

Handover in real-world using naïve optimizer

Future Work

- Improve system performance for real-time optimization
- Conduct user study to collect feedback on system usefulness and ease of use

Acknowledgements

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References

[1] Henry M. Clever, Patrick Grady, Greg Turk, Charles C. Kemp, BodyPressure – Inferring Body Pose and Contact Pressure from a Depth Image, IEEE Transactions on Pattern Analysis and Machine Intelligence, 2022.

[2] Murtaza, Muhammad Ali, et al. "Real-Time Safety and Control of Robotic Manipulators with Torque Saturation in Operational Space." 2021 IEEE/RSJ International Conference on Intelligent Robots and Systems (IROS). IEEE.