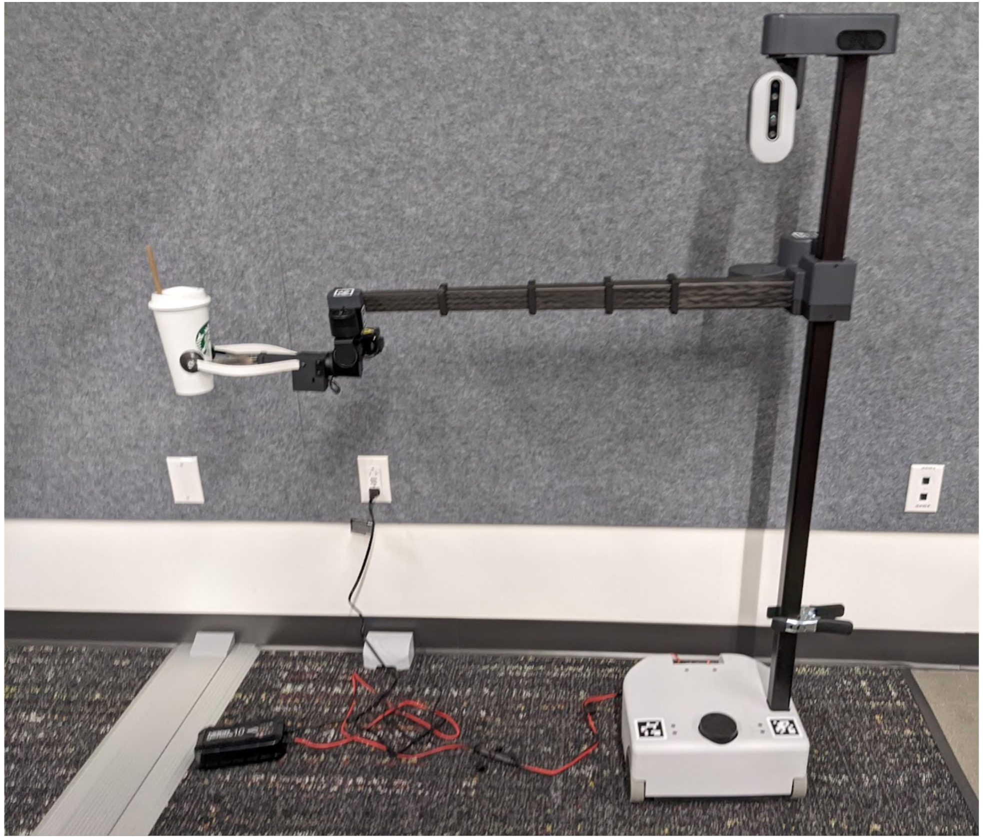
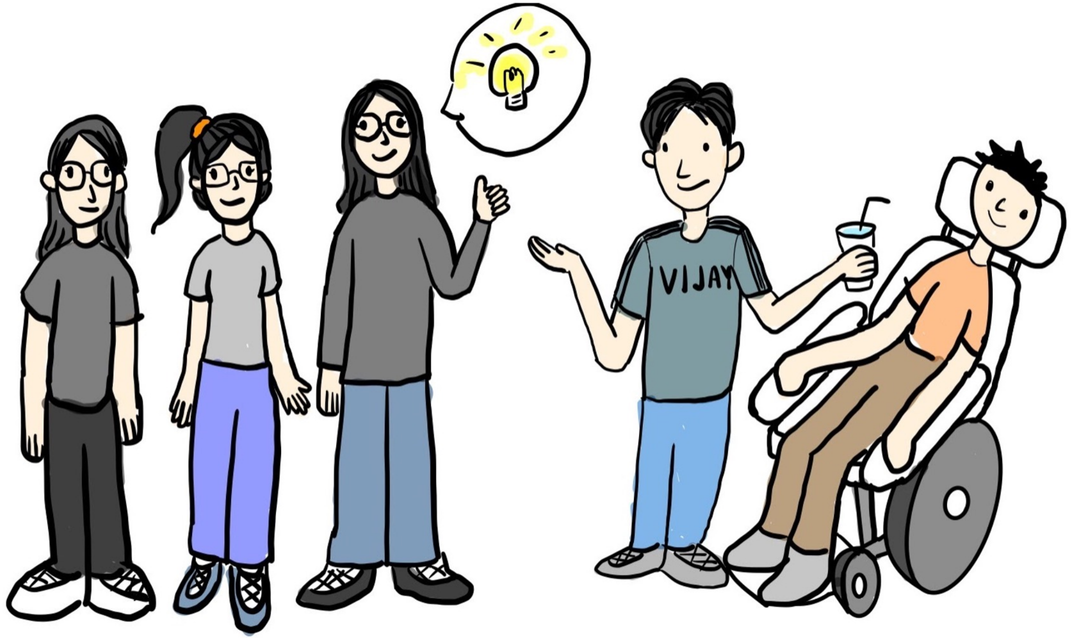
AquaBot

Assistive Drinking Robot for People with Mobility Impairments

By Angela, Hari, Cara

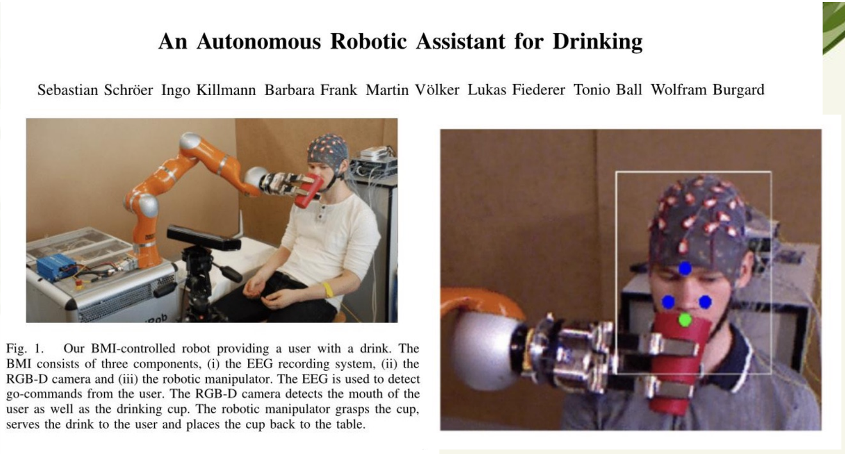


Our Friend's story is our motivation



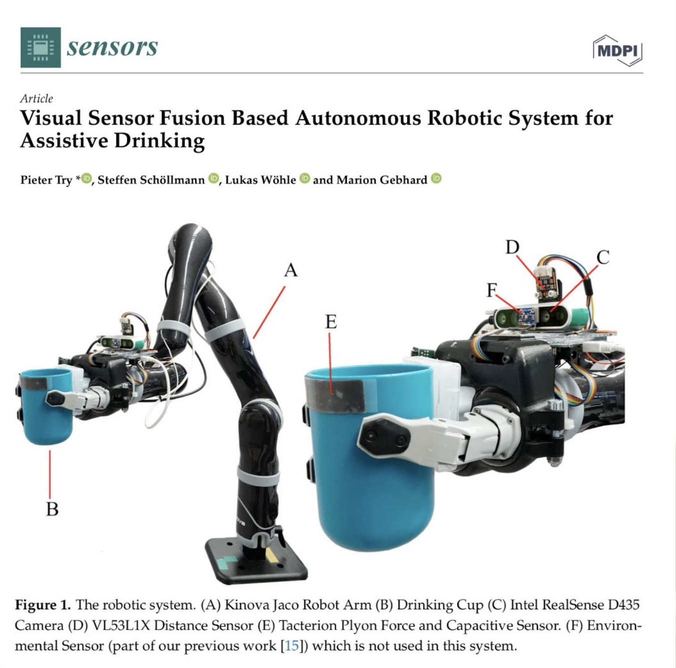
Our friend, Bob, is a caregiver for his brother, Bryant, who is quadriplegic. Bob feels guilty about rushing Bryant to finish his tea quickly.

Lots of research interests in drinking assistance robot


An Autonomous Robotic Assistant for Drinking

Sebastian Schröer Ingo Killmann Barbara Frank Martin Völker Lukas Fiederer Tonio Ball Wolfram Burgard

Fig. 1. Our BMI-controlled robot providing a user with a drink. The BMI consists of three components, (i) the EEG recording system, (ii) the RGB-D camera and (iii) the robotic manipulator. The EEG is used to detect go-commands from the user. The RGB-D camera detects the mouth of the user as well as the drinking cup. The robotic manipulator grasps the cup, serves the drink to the user and places the cup back to the table.


sensors

MDPI

Article

Visual Sensor Fusion Based Autonomous Robotic System for Assistive Drinking

Pieter Try *, Steffen Schöllmann, Lukas Wöhle and Marion Gebhard

Figure 1. The robotic system. (A) Kinova Jaco Robot Arm (B) Drinking Cup (C) Intel RealSense D435 Camera (D) VL53L1X Distance Sensor (E) Tacterion Plyon Force and Capacitive Sensor. (F) Environmental Sensor (part of our previous work [15]) which is not used in this system.

Whiskey bot:

Summary Table of Recent Work

Platform	Base	Interface with the user	Sensing modality for delivery	Navigation
Whisky bot	Fixed	EEG	N/A	No
Schroer et al. (2015)	Fixed	EEG	RGBD	No
Try et al. (2021)	Fixed	Full autonomy	Distance + RGBD + Capacitive sensor	No
Aquabot	**Mobile**	**Shared autonomy**	**RGBD**	**Yes**

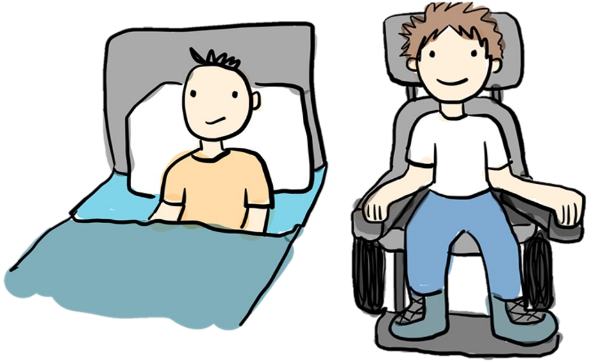
Value to Population

Dehydration is prevalent in people with mobility impairments

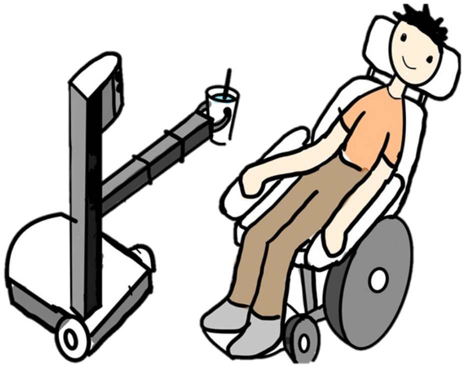
In 2014, 24 million people require assistance in ADL.

Problem Definition

Problem:
Dehydration



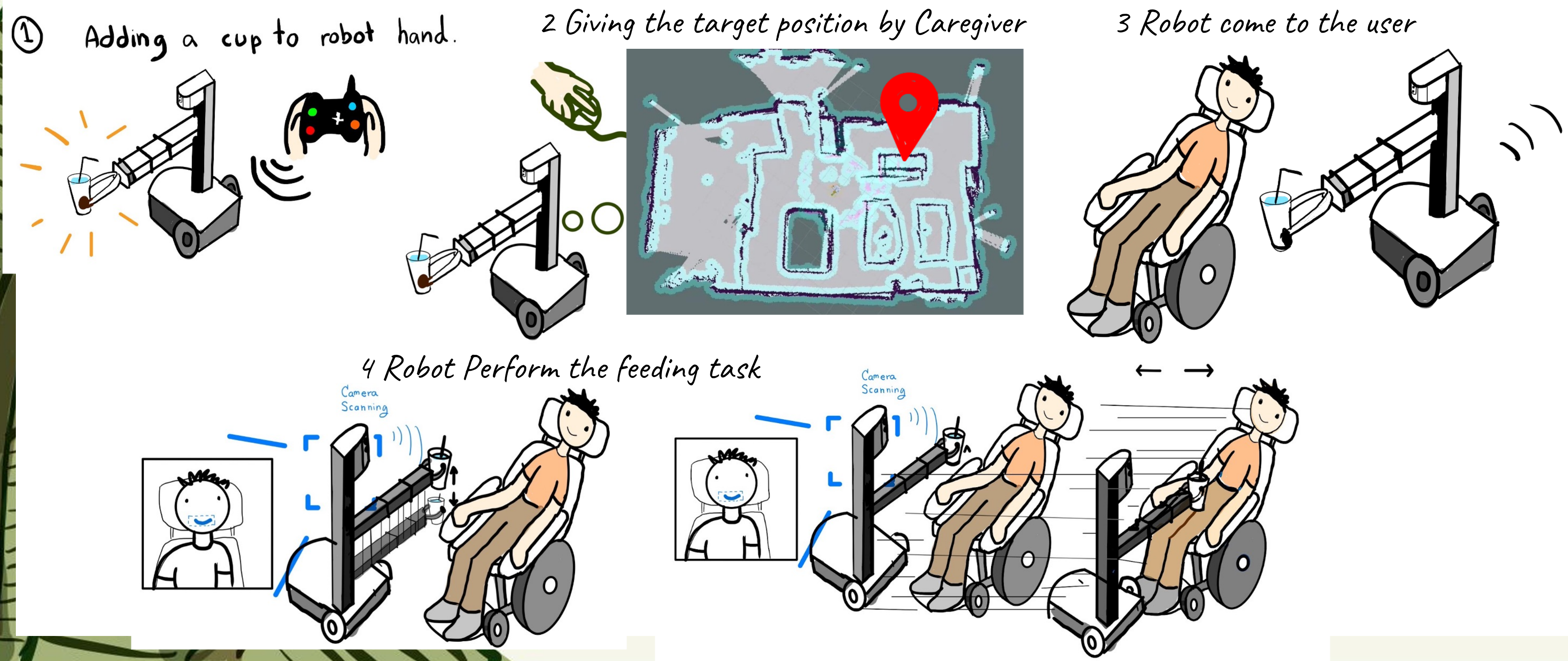
Population:
People with mobility impairments



Outcome:
Aquabot

An assistive drinking robot which helps caregivers deliver fluids to address dehydration in people with mobility impairments.

Drinking assistance robot based on indoor localization

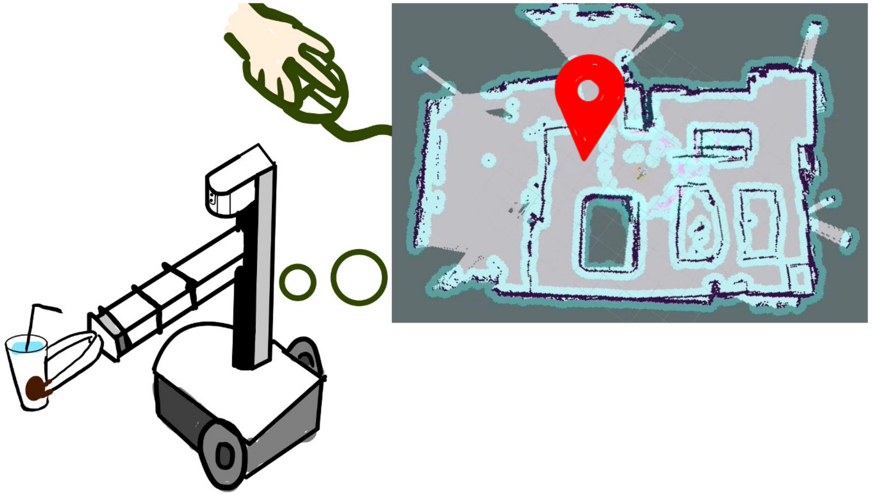


Provide goal to robot!

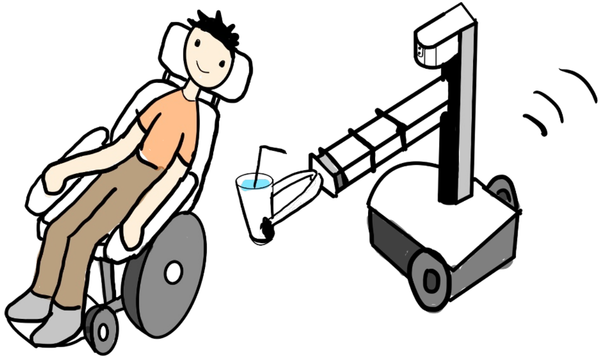
https://youtu.be/wI_AECFJkrE

Task Decomposition - Navigation

1. User tell the robot where to go by pointing to target position in the map.

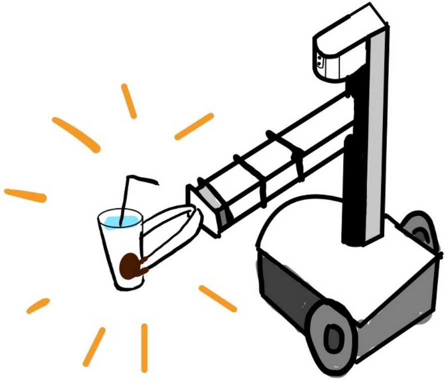


2 Robot come to the user in the target position.

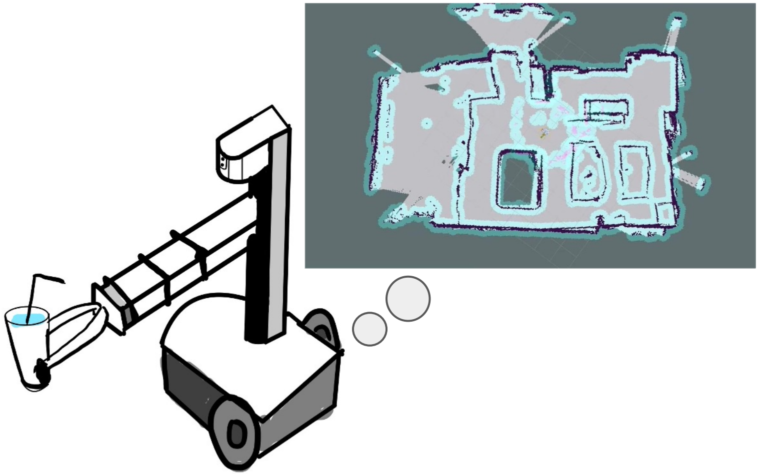


Assumptions

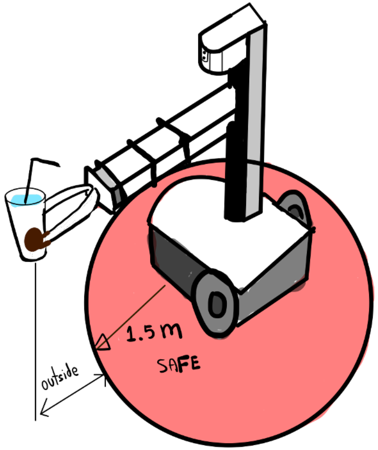
1 Robot has a cup on it's hand



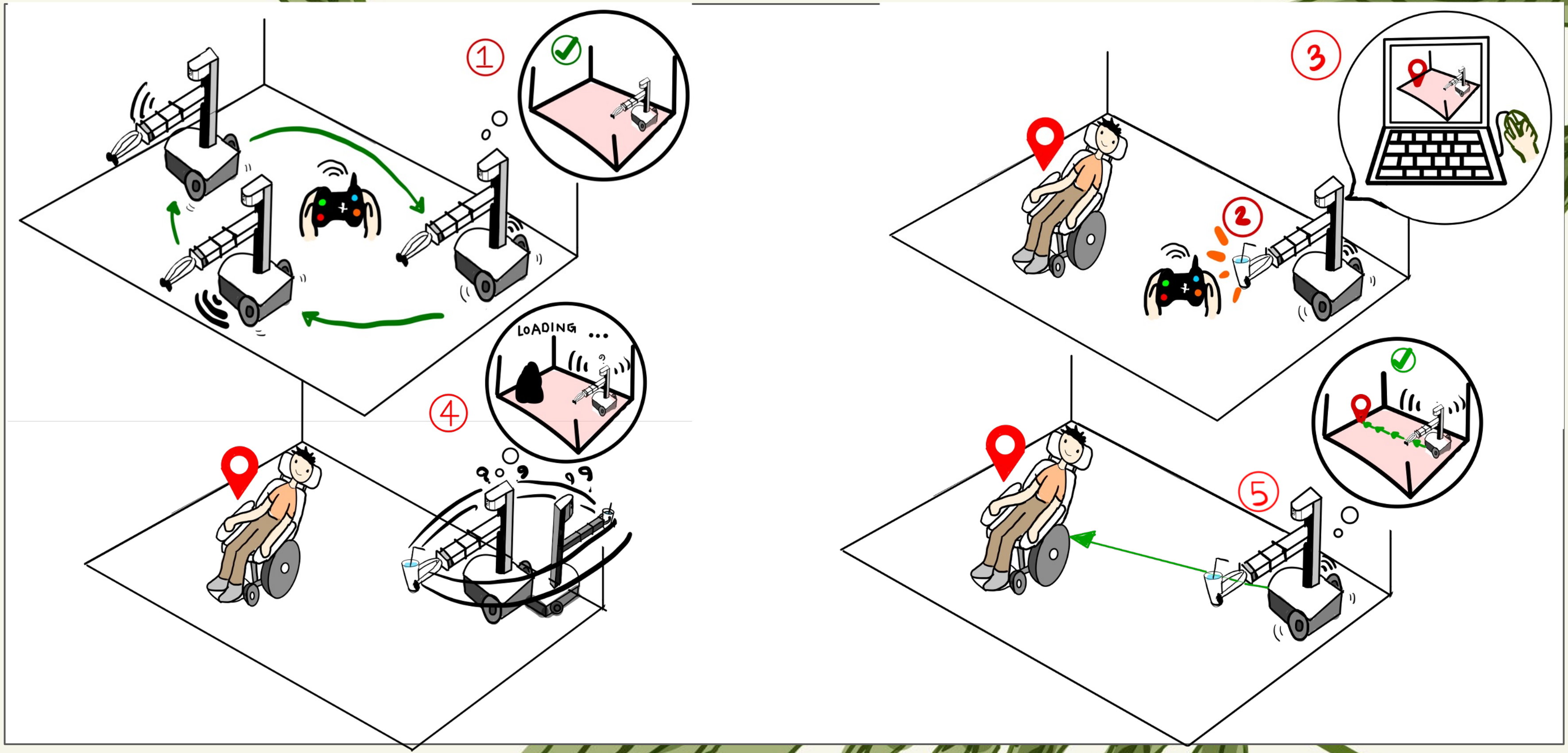
2 Robot has a map of the room



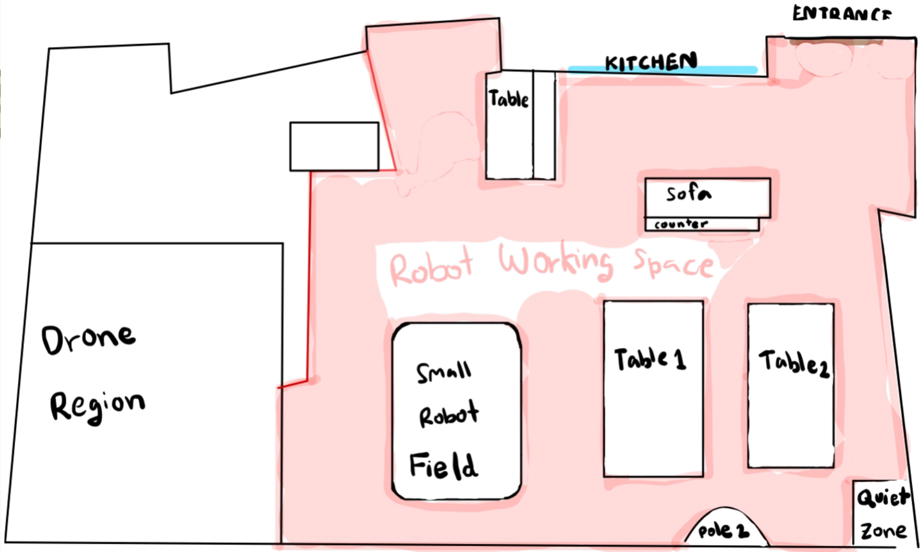
3 Robot has a 1.5 m safety distance from the user. The arm is longer than the safety distance.



Implementation

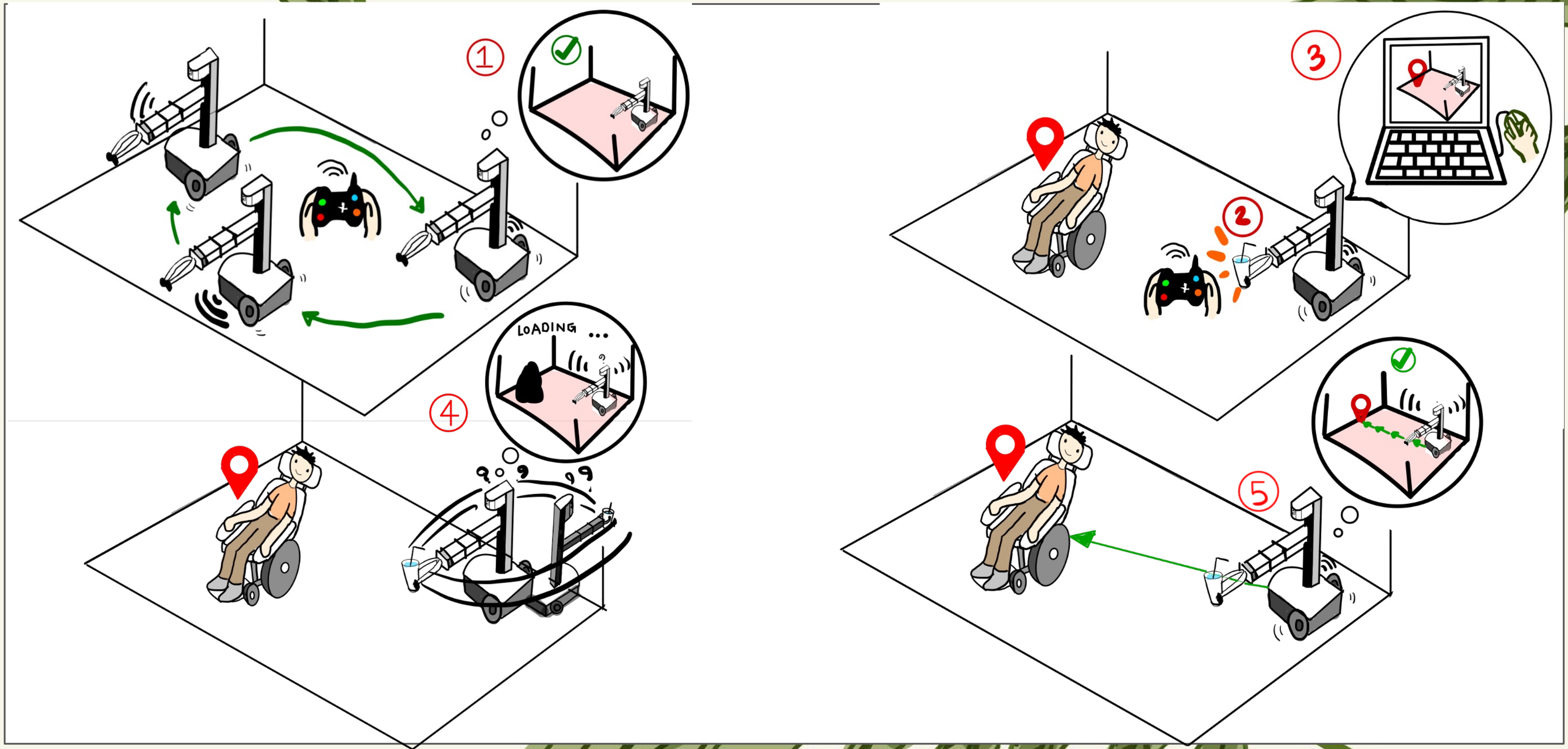


AI Maker space

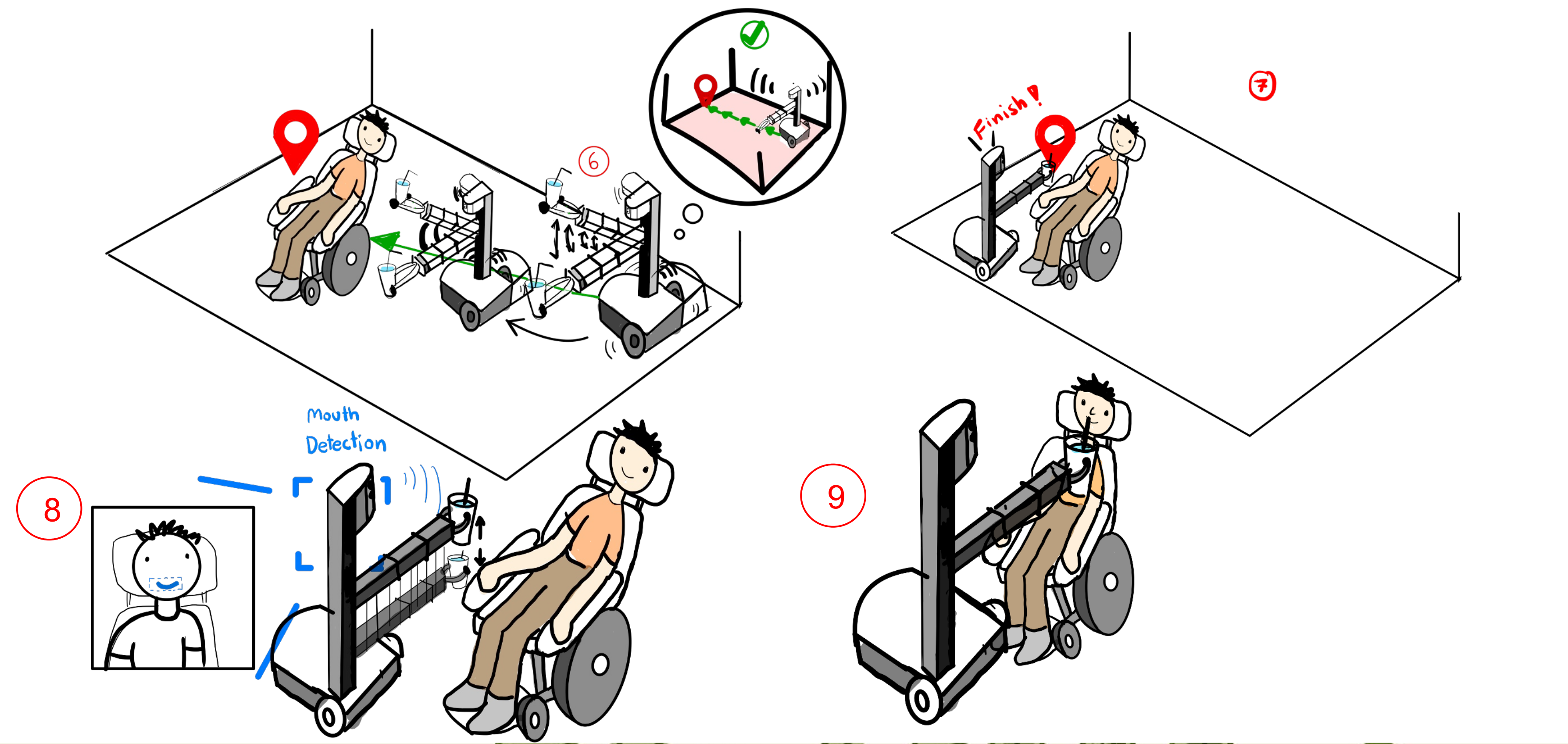


Robot Map

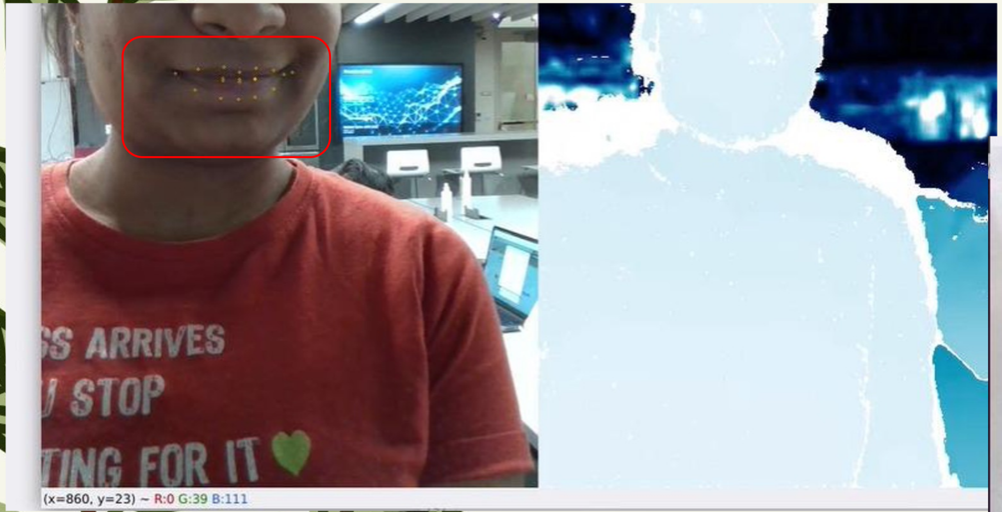
Implementation



Implementation



Mouth detection system

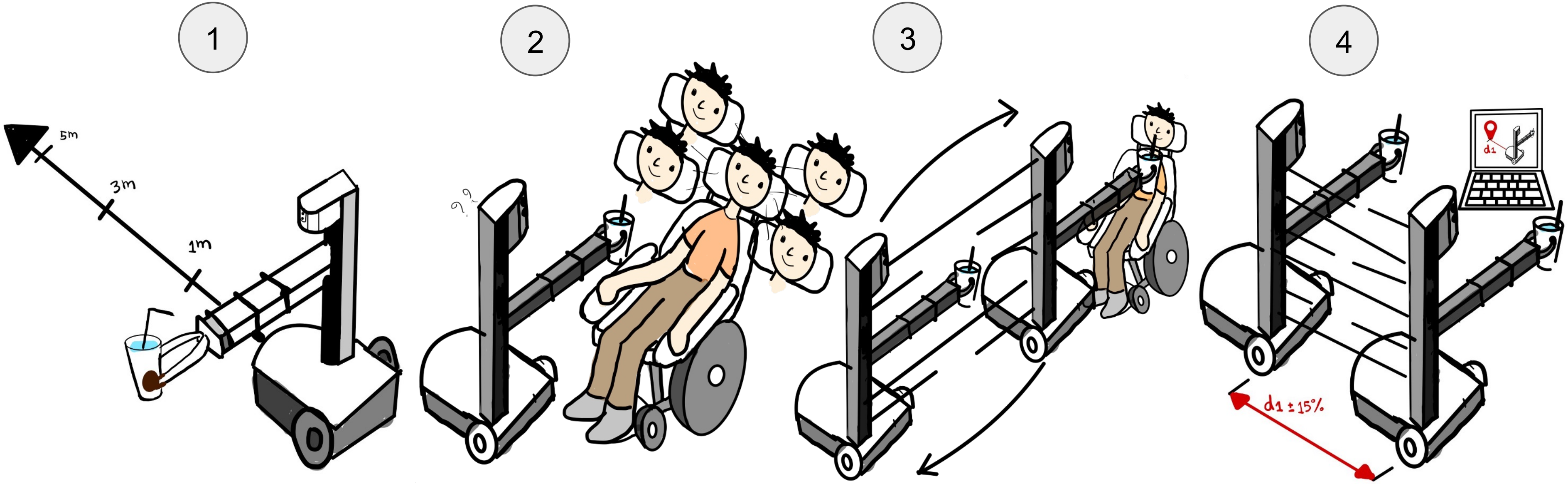


Closed mouth detection

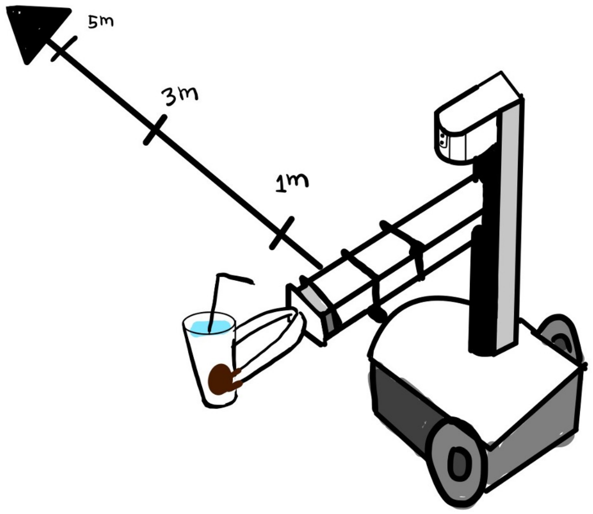
Open mouth detection

Live Demonstration

We do 4 Evaluation tasks to test the robot performances

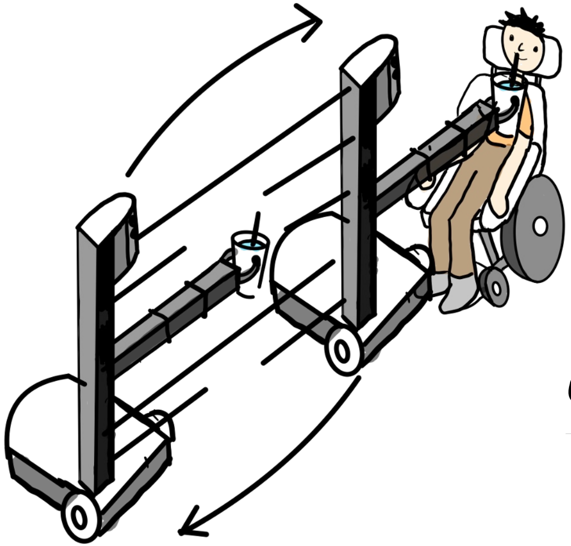


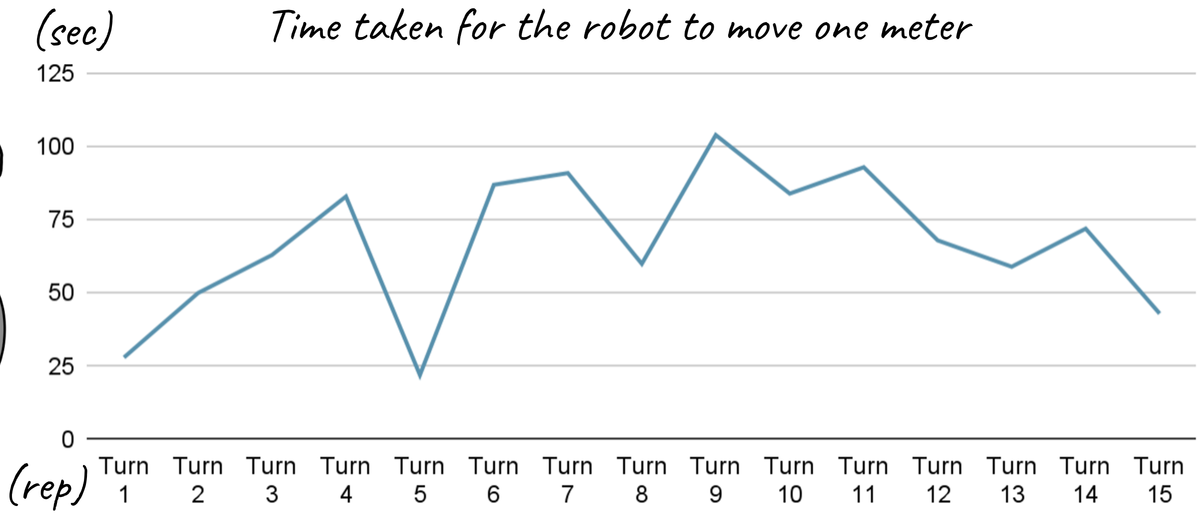
How far the robot can reach?



Destination Distance	Time Taken(secs)	Is goal achieved?
1m	55	Yes
3m	78	Yes
5m	180	Yes
7m	350	Yes
10m	558	Yes

How accurate is the robot in performing repetitive tasks?



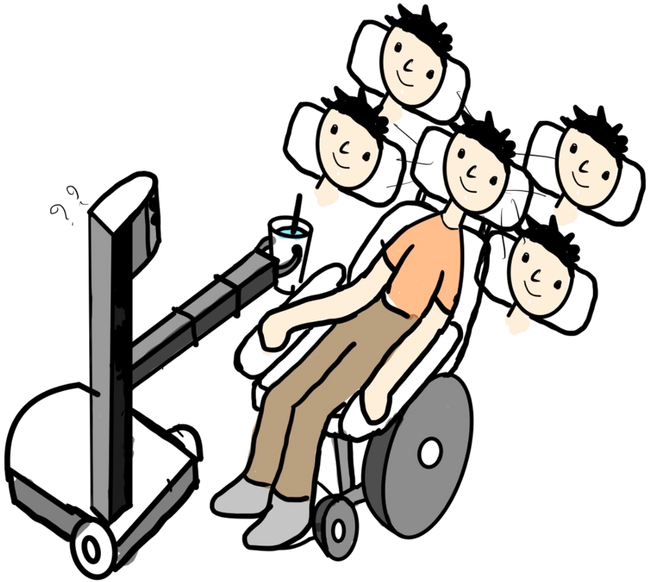


Success task = the robot move in to the target position within 100 seconds.

Success rate = (No. of success task/No. of total experiment) x 100%

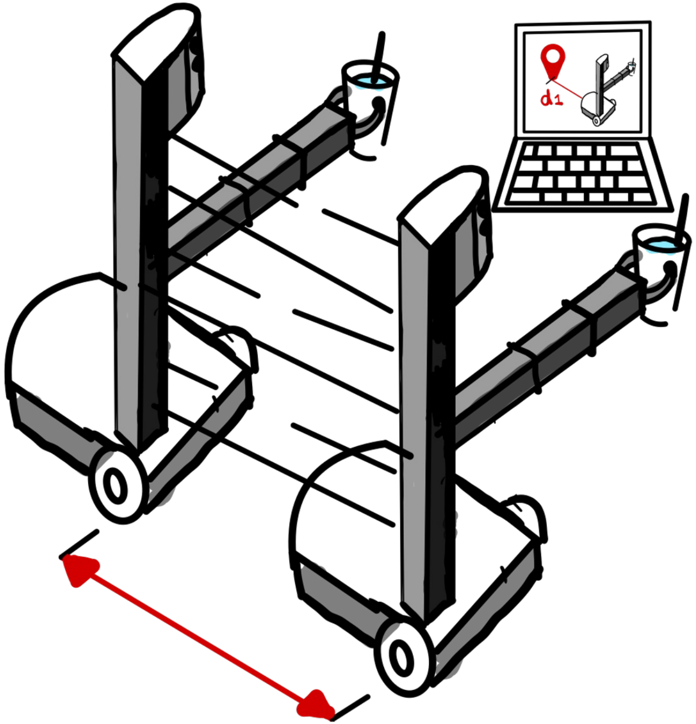
= (14/ 15)*100 = 93%

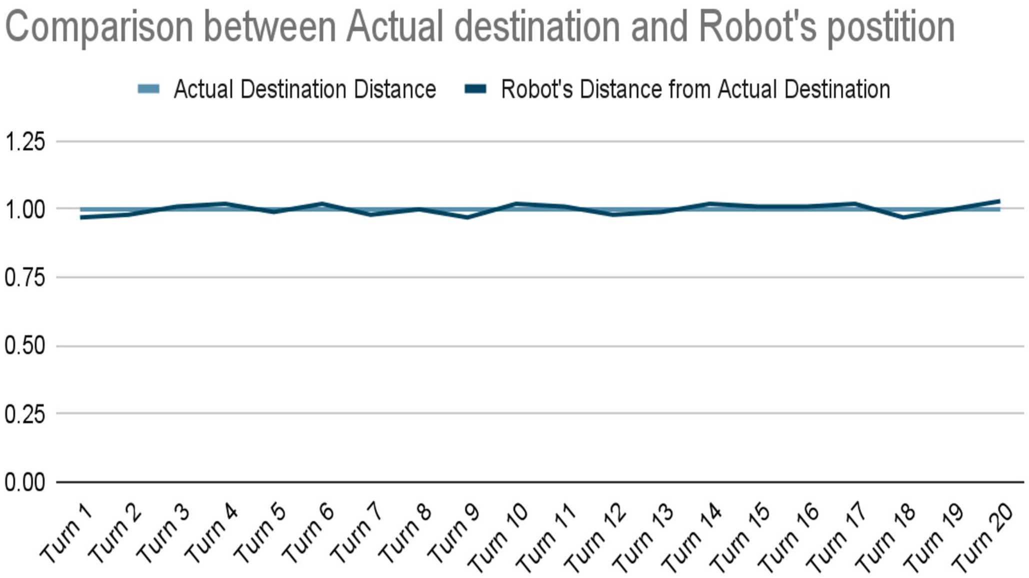
How accurate is the robot in performing repetitive tasks?



Robot provided water every 9 out of 10 times!!!

Error rate in reaching the destination:





Error rate Calculation:

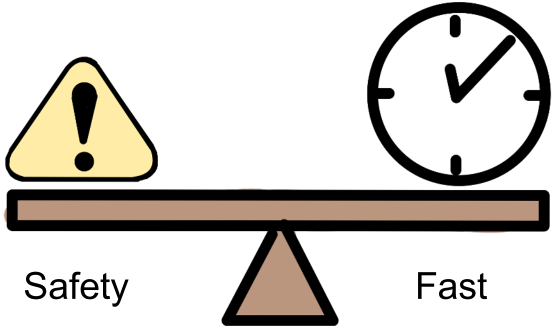
Squared errors:= Σ (Actual Destination Distance - Robot's position) ^2

Mean Squared error:= squared errors / Total no.of experiments

Root Mean squared error:=$\sqrt{}$ Mean squared error

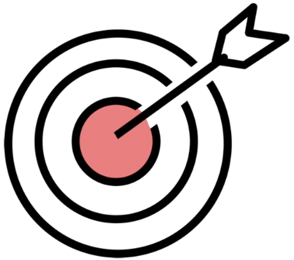
Error rate: 1.7%

There are 3 main challenges that we found in general

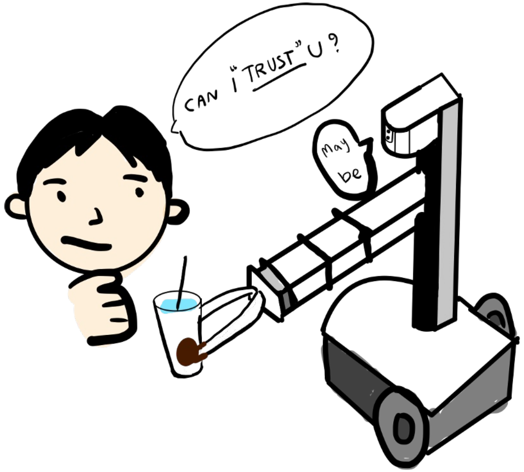


Safety

Fast



Accuracy

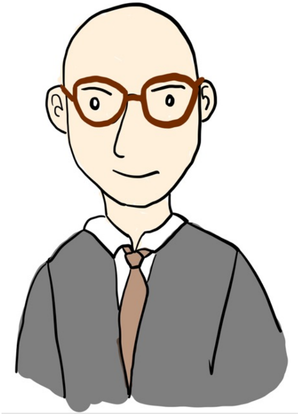


Human - Robot Interaction

Interaction with stakeholders

Henry Evans and Jane Evans

Bob and Bryant



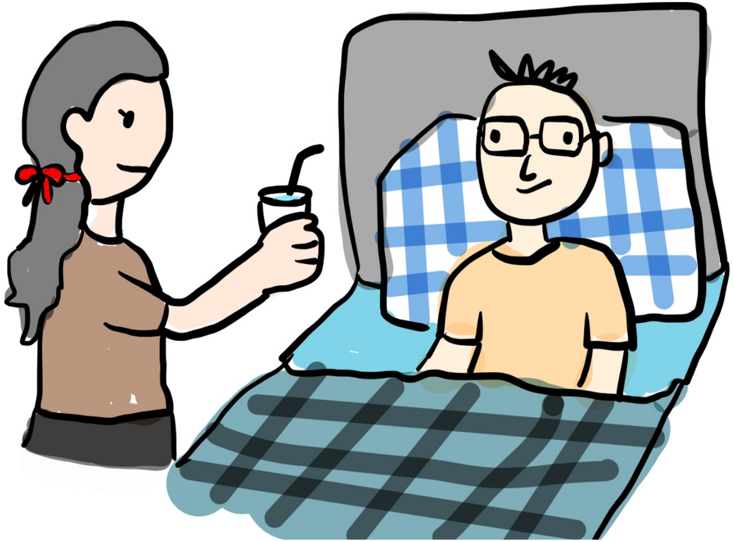
Prof.Edward

Henry and Jane Evan

Believes it is beneficial to most quadriplegics

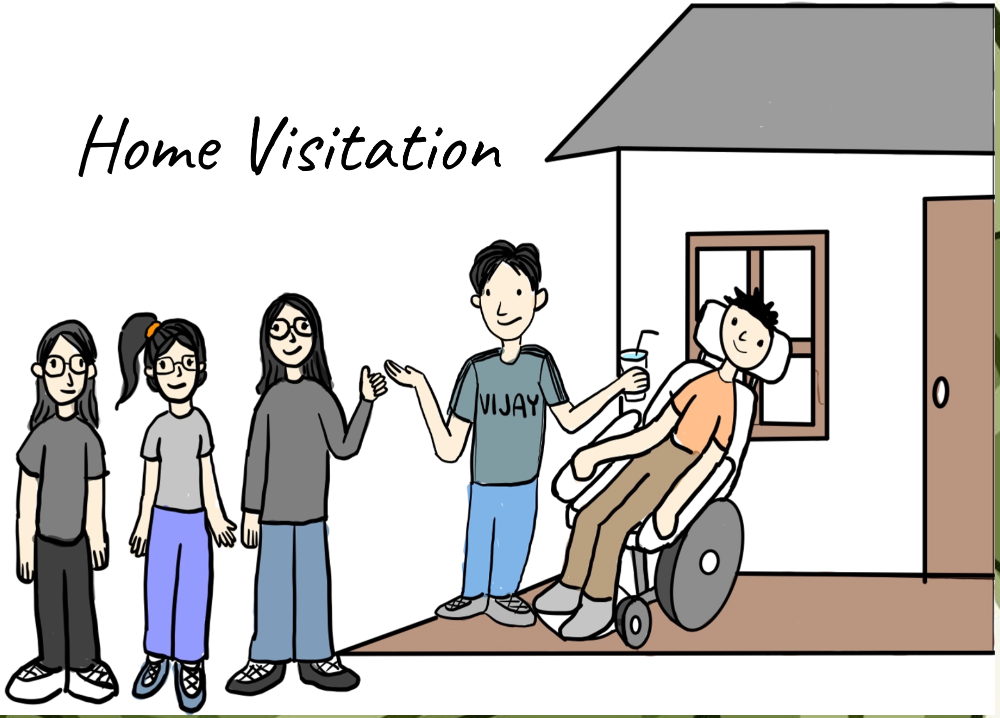
> "If it takes less time for me to do a task than to set up a system to do it for me, I would just do it." - Jane

Henry doesn't have the ability to swallow so this prototype won't be useful for him, but he is excited to work with us to perfect the prototype for feeding.



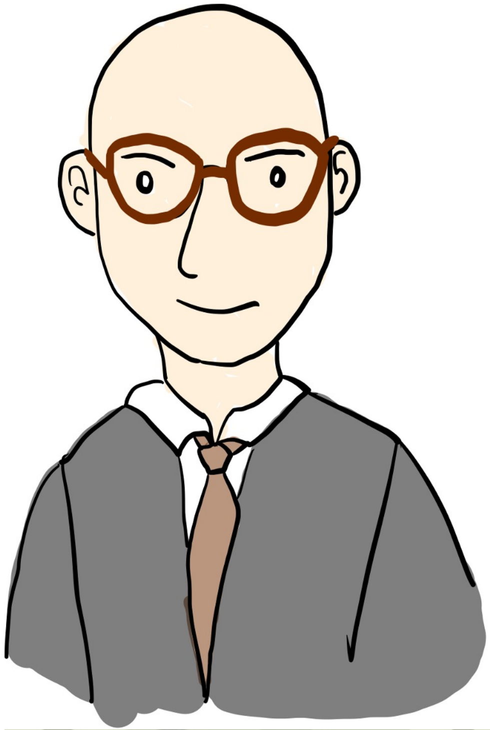
Home Visitation- Bob and Bryant's family

- Bryant can talk, type, and eat.
- Short time observe their environment and living.
- He is excited to use the robot. - "If it has high accuracy, I will use the system!"
- He is also interested in autonomous grabbing feature.



Tech transfer expert - Prof. Edward

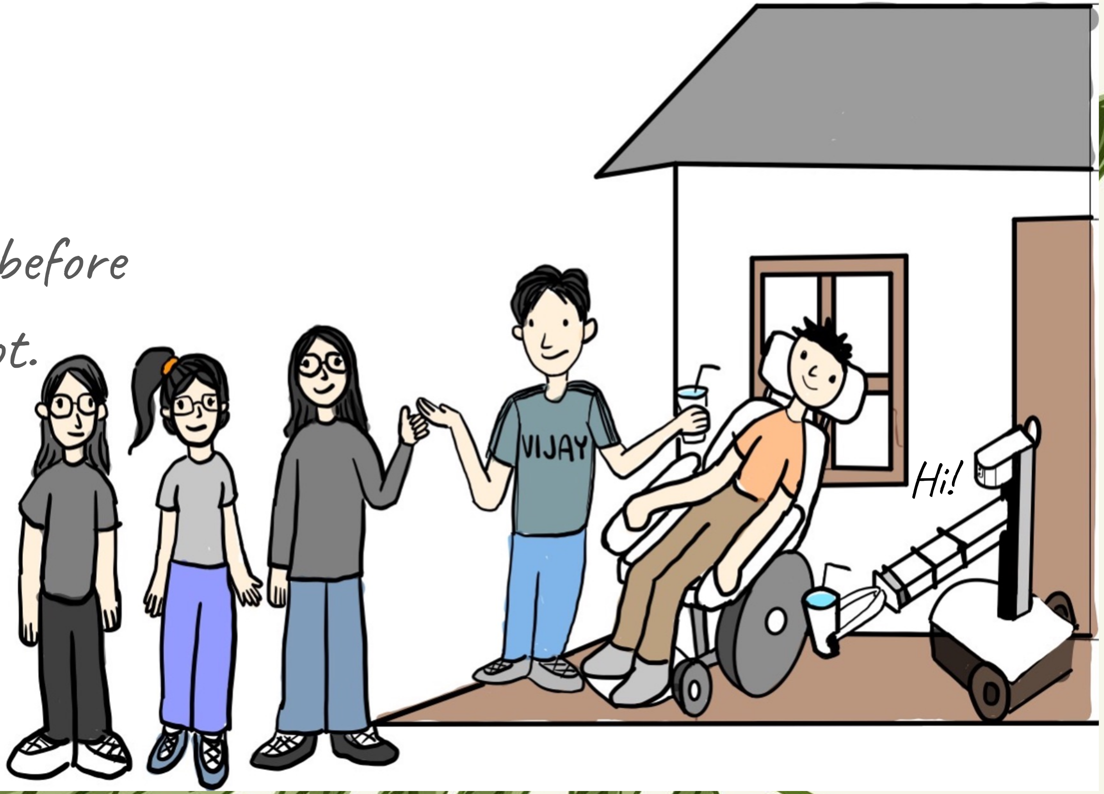
- Should make it **fully autonomous**
- Useful for people who have mobility impairments, eg. quadraplegic, severe tremor, or cerebral palsy patient.
- Should continue do clinical trials for next step to research grant.
- Think about how to balance safety and timing constraints.
- More extensive testing.



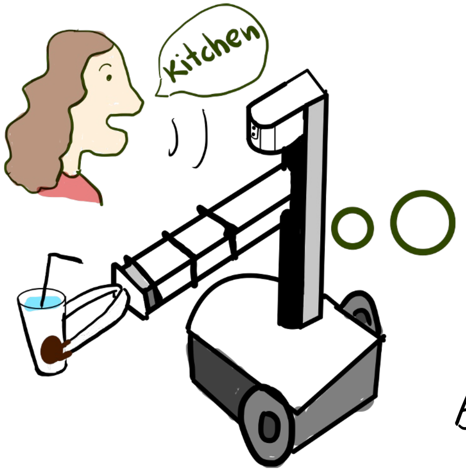
Further study - Experimentation

Clinical Trial need

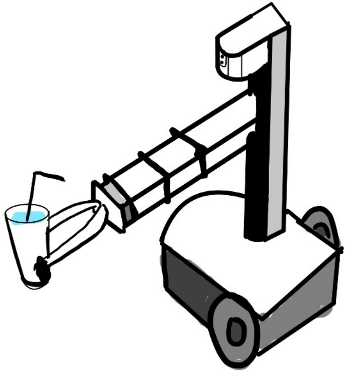
- receive feedback from users before developing new feature to robot.
- Getting measurable outcome



Future Work



Better interface with the user, e.g., voice commands



Autonomous Grabbing of different liquids at different location