Preliminary Design Review: Traybot

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Scope

- Introduction
- Project goals
- Requirements in order to reach our goals
- Concept so far
- Simulation so far
- Gantt chart for project plan

- Hold all questions until the end
- Disconnection

Motivation

- Hospital staff must often care for many patients simultaneously.
- Delivering food or medicines to a patient suffering from an infectious disease requires time-consuming sanitization procedures.
- Risk is not completely eliminated
- Hand contamination with MRSA occurs as often when healthcare staff touch contaminated surfaces as with direct contact with an infected patient [11]
- A robot could be used to complete these tasks, freeing time for nurses to conduct more important tasks.

Introduction

The main idea for our project is to create a logistics health care robot capable of being able to distribute material around a hospital with the use of trays.

- Similar concepts have been implemented before…

Helpmate autonomous mobile robot (1991) [1]

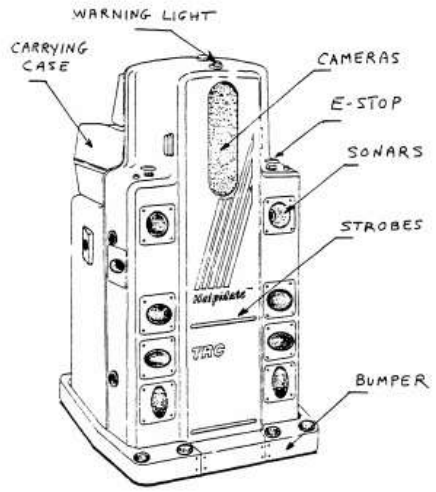


Figure 1a. HelpMate

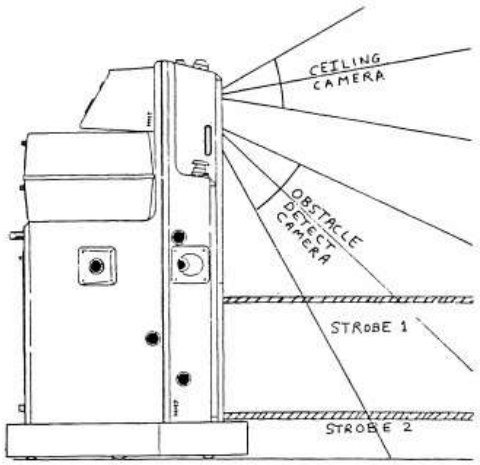


Figure 1b. Vision system

- An early implementation (~1991)
- Capable of transporting meal trays
- Locates itself using ceiling camera- Does not require modification of the environment
- Triple redundancy object avoidance- Bumper, Sonar, Structured light

Hospital mobile platform for logistics (2015)[2]

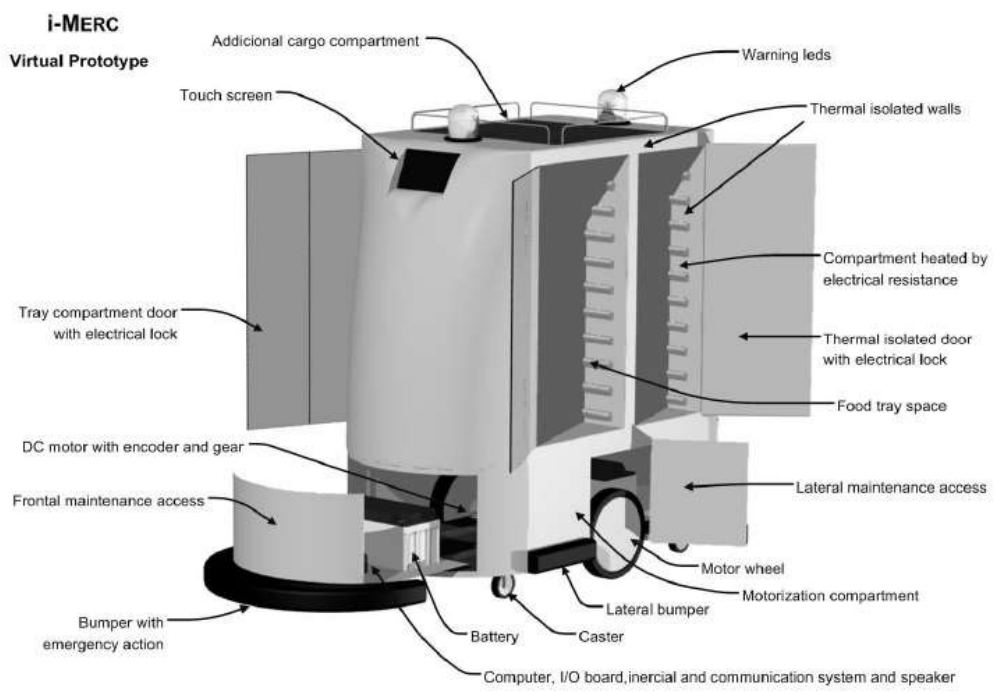
Key points:

- A self aligning charging dock allows continued operation
- Sensitive material can be locked during transit
- **Omniwheels were avoided due to noise and vibration concerns – This can be minimized, but this is still an area of research[3]**
- Regenerative braking identified as method to extend duty time

System requires manual loading/unloading –

- **This gives the robot the potential to spread pathogens**
- **Bedbound patients may not be able to retrieve materials**
- **Empty containers cannot be retrieved whilst the patient is asleep**

(13) i-Merc: A Mobile Robot to Deliver Meals inside Health Services (prototype) (2006)[4]

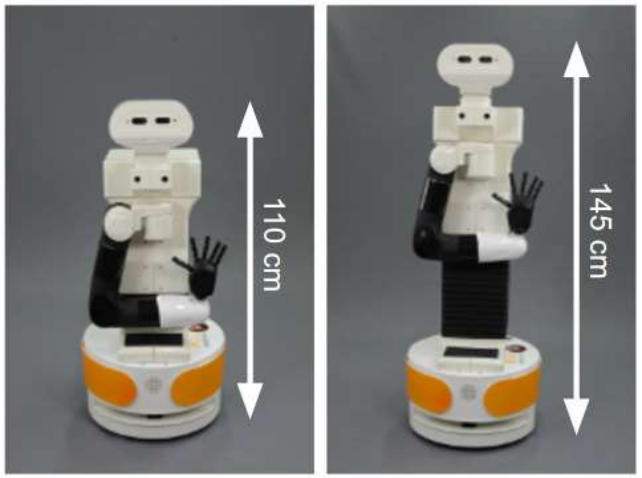


Key points:

- Identifies that "*quality of the food strongly influences the patients' recovery*."
- Keeps interior heated above 60 deg/c to prevent bacteriological growth

This temperature reduces the viral infectivity of various coronaviruses significantly over 1-30 minutes, depending on the strain. [5]

TIAGo: the modular robot that adapts to different research needs [6]



https://blog.pal-robotics.com/covid-19-and-our-robots-ready-to-help-fight-coronavirus-in-hospitals/

- Modular base (PMB-2) uses a differential drive
- Laserscanner, ultrasound used for environment sensing
- Upper body has 35cm adjustable stroke

To the best of our knowledge the bedside tray delivery/collection concept as rendered in the 2nd figure is not widely available.

Project goals

1. Create a mechanism for the robot to move vertically
2. Create a tray mechanism which can retrieve as well as dispense trays
3. Create a wheelbase which can cope with a smooth floor surface, which will allow the robot to be as agile as possible
4. Create a simple air filtration system

5. Keep It Simple Stupid (KISS)

Requirements in order to reach our goal

1. Scissor lift --> linear actuators (rack and pinion)

It should not be possible that at full lift extension, with the arm extended, that the robot overbalances.

- The maximum extension of the lift should be limited.
- Only one arm may extend at any given time in order to the movement of the centre of mass.
- The robot will abort picking a tray if it is overloaded
- As much weight as possible should be located in the base of the robot in order to maintain a low centre of mass

Scissor lift Advantages and disadvantages

Positives

- Compact design
- Larger reach compared to linear actuators

Negatives

- Weight distribution causing un-stability problem

Rack and pinion

Benefits:

- Addresses weight distribution problem
- Limited reach- addresses the stability issue

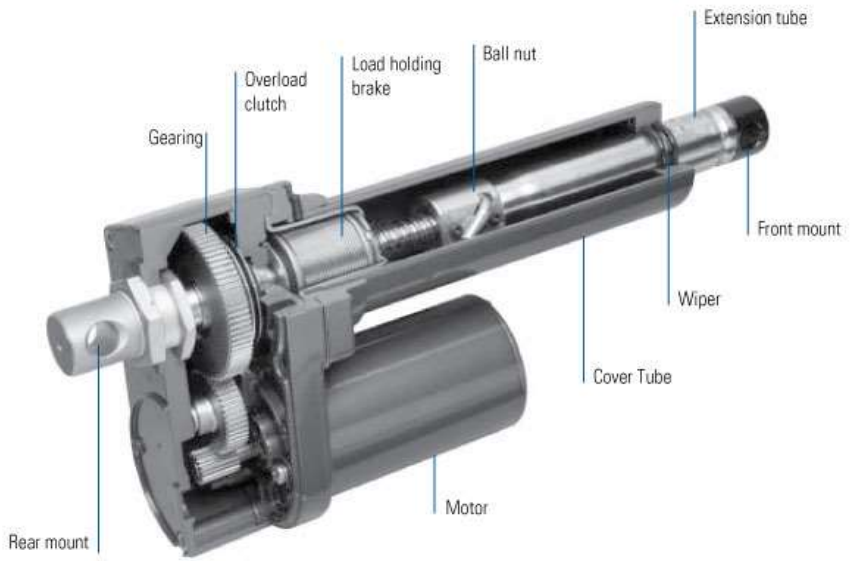
Disadvantages:

- Requires high torque to drive

Ballscrew

Benefits:

- Addresses weight distribution problem
- Limited reach- addresses the stability issue
- More precise and efficient than leadscrews
- Requires less torque than rack and pinion



2. Square tray --> circular tray Belt drive / rack and pinion

The robot is not required to handle varying individual objects to accomplish its task as they are contained in a tray. Therefore the trays design can be optimized to allow straightforward picking, placing and stowage.

- Use of a circular shape avoids tray yaw alignment problems when collecting
- A very loose fit, ~1cm, of the tray in the jaw accommodates any other angular misalignment. These are assumed to be minimal for any reasonably level surface.
- A curved outer lip allows a simple actuated pin to lock the tray in place when inside the jaws.
- The end of the pin should be rubberized to prevent trays rattling during transport
- A bright, saturated colour is used to aid in the trays detection and the robots subsequent visual servoing.

Duplicate arms with jaws are used, one for each tray slot. This incurs redundancy of the two motors needed for each arm (one for extension, the other to actuate the pin). However, it allows each arm to fully secure its tray inside the robot during transport. Additionally, this aids in keeping a smaller footprint for the robot as no space is required to accommodate a travelling arm mechanism.

Pick and Place

3. Mobile Base Requirements

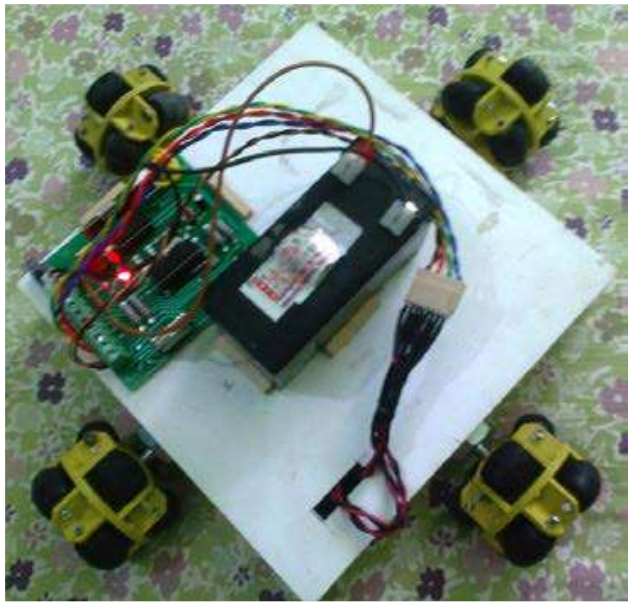
- Zero radius turning, is required as the mobile base is used to orientate the arm
- Platform must provide sufficient stability, as centre of gravity can be raised
- High braking force should be possible
- A long lifespan
- Low noise
- Able to accommodate small floor irregularities, such as carpet ridges or door thresholds

There are several candidates…

Omniwheels and Mecanum wheels

Advantages

- Holonomic- Any vector of (x, z, w) may be used without prior adjustment
- Requires only single actuator per wheel



Experimental Analysis of Mecanum wheel and Omni wheel [8]

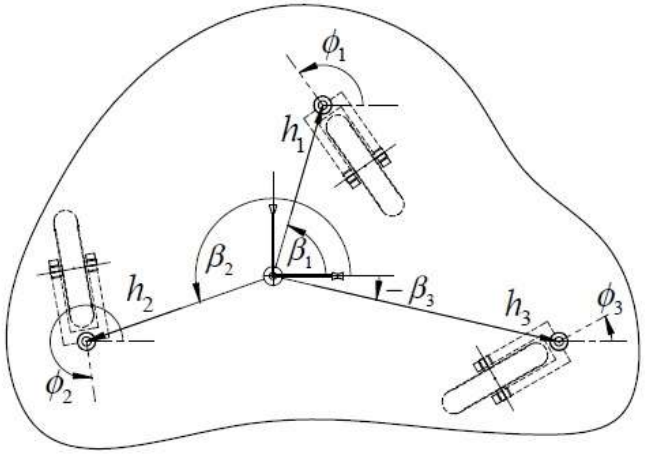
Disadvantages

- Discontinuous wheel contact [7], can cause noise, may impact durability
- Does not receive natural suspension capability provided by inflated tyres
- Smaller point contact reduces grip
- Vulnerable to small ground irregularities
- Maximum torque from all motors cannot be utilized simultaneously for forward motion, braking

Powered caster vehicle (PCV)

Advantages

- Holonomic- Any vector of (x, z, w) may be used, but prior adjustment is required
- Allows use of conventional wheels, tyres
- Maximum torque from all motors can be utilized simultaneously for forward motion, braking



[9] Development and Control of a Holonomic Mobile Robot for Mobile Manipulation Tasks

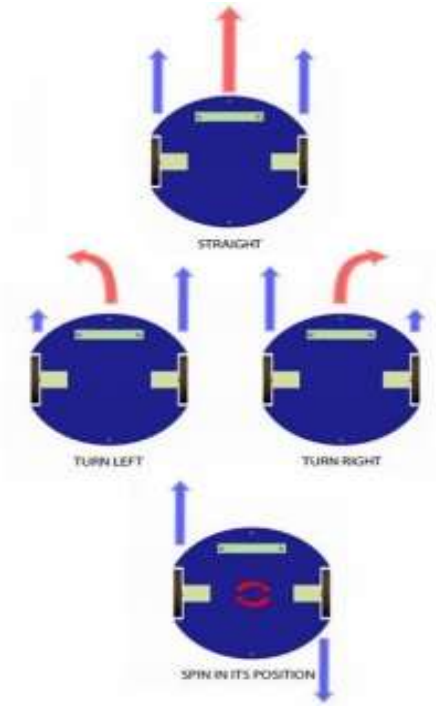
Disadvantages

- Additional steering actuation required for each driven wheel
- Steering is required before generated motion can be produced
- Steering all wheels at once to specify new vector can cause sudden disturbances [9]

Differential drive with castors

Advantages

- Allows use of conventional wheels, tyres
- Capable of zero radius turns
- Only one motor required per wheel
- Maximum torque from all motors can be utilized simultaneously in forward motion and braking



[10] Visually guided mobile robot

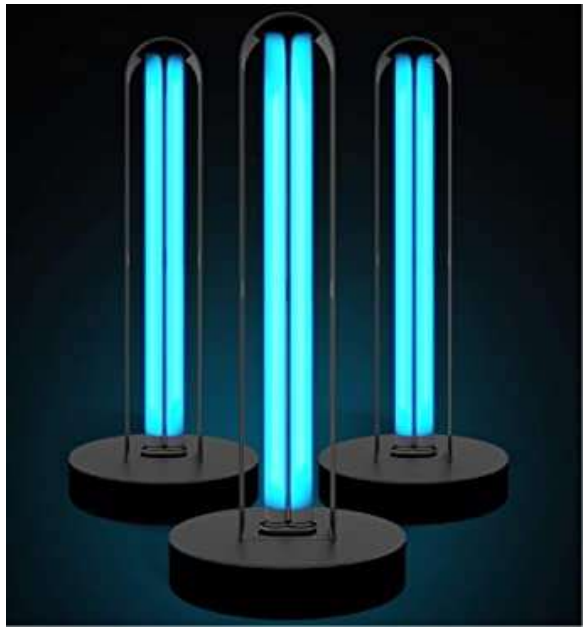
Disadvantages

- Unable to move laterally (non-holonomic)

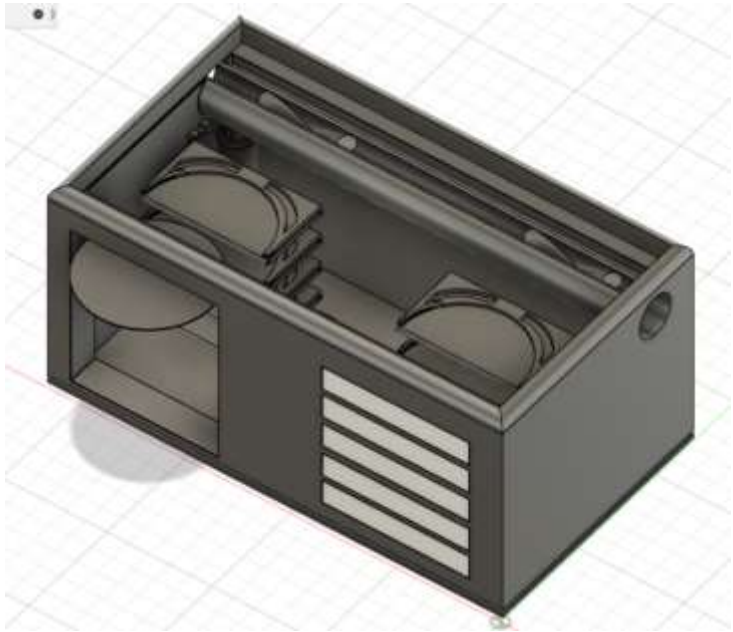
https://www.innovacareconcepts.com/en/blog/news/power-wheelchair-types/

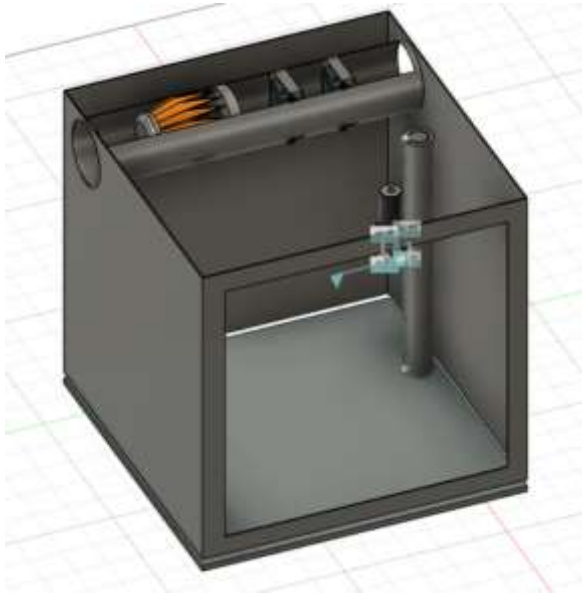
4. Air filtration system

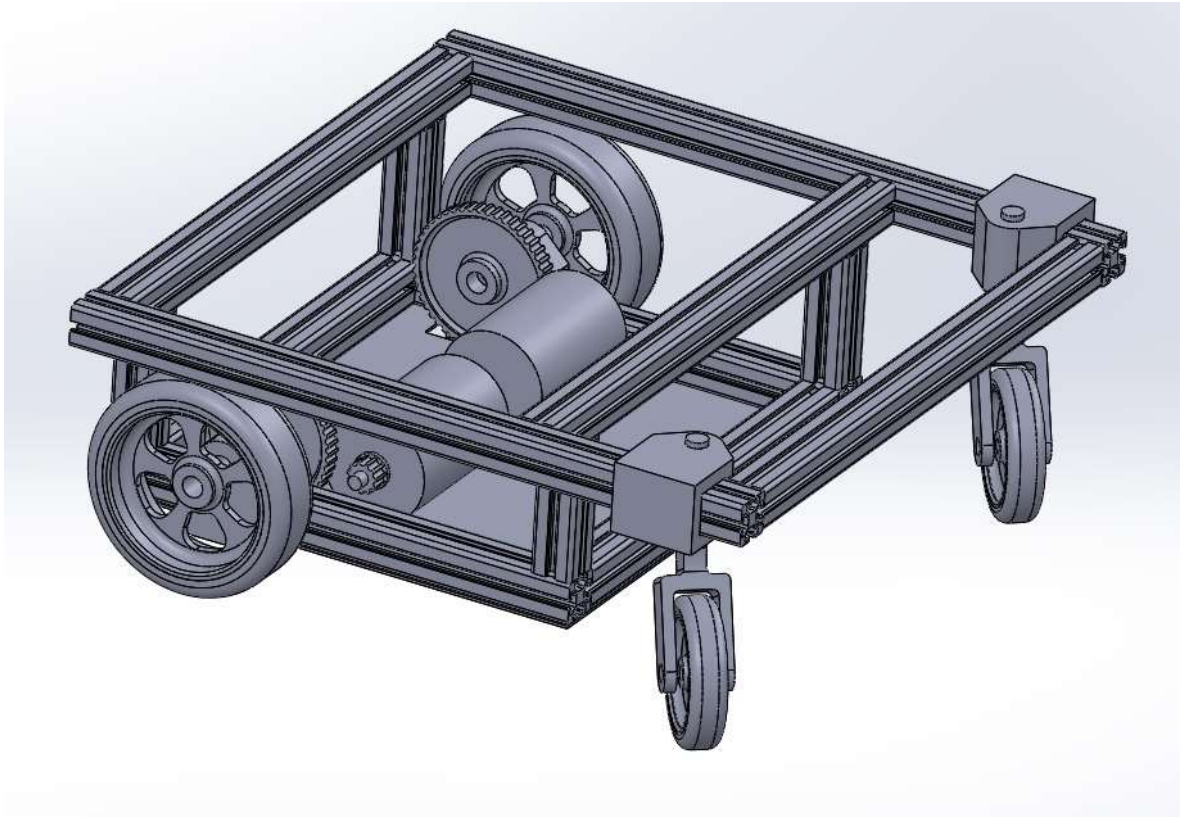
- Needs to have a low profile (not interrupt the main task of the robot)
- Filters need to be easy to change
- UVC light must be confined to reduce contact with humans



Concept so far

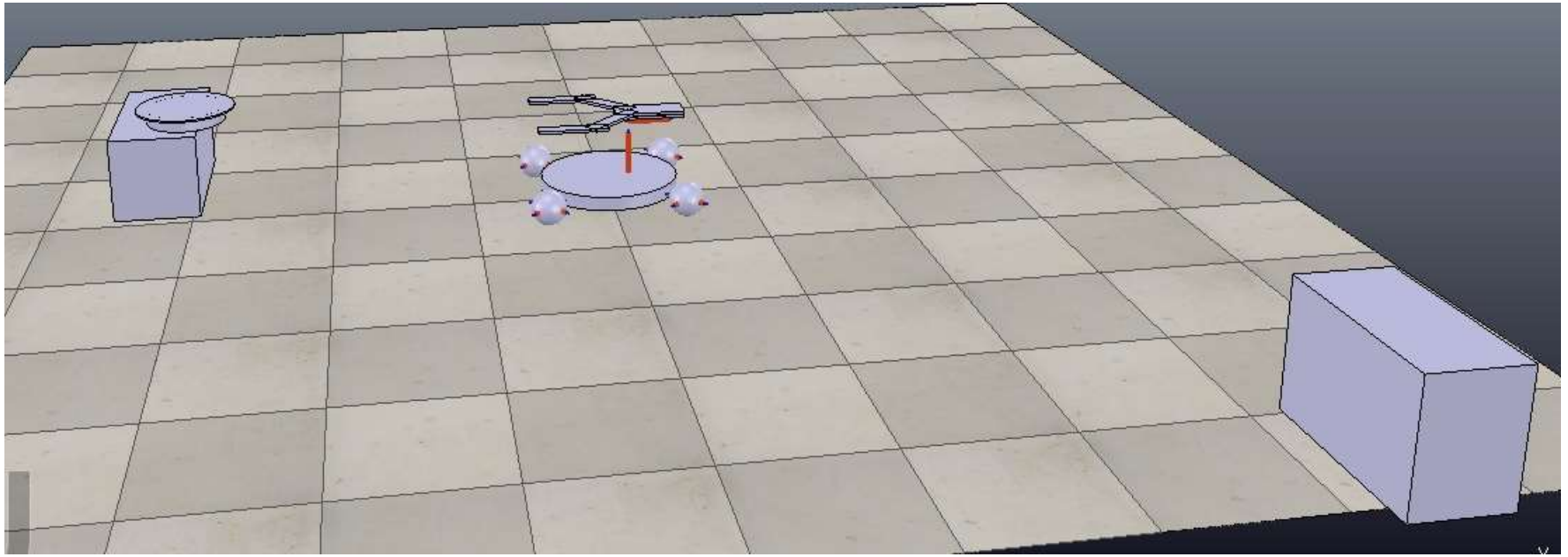






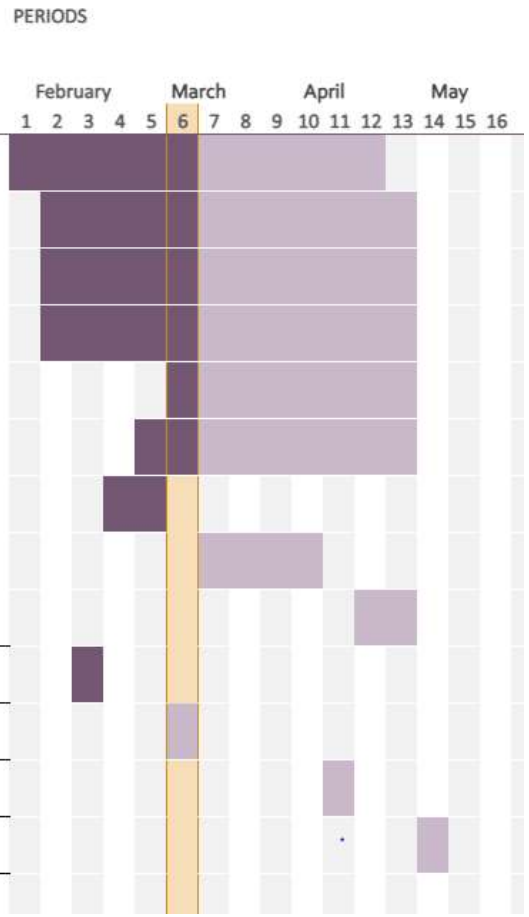
- Base measures 0.5x0.5x0.185 metres
- High torque DC motors avoid the need for a gearbox
- Belt reduction used for quiet running
- Driven wheels at front aid maneuverability, and provides more grip when braking

Simulation so far



Project plan

ACTIVITY	Responsibility	PLAN START	PLAN DURATION	ACTUAL START	ACTUAL DURATION	PERCENT COMPLETE
Research	J + B	1	12	1	12	50%
Concepts/mechanisms	J + B	2	12	2	12	45%
Design (main body)	J	2	12	2	12	45%
Design (wheelbase)	B	2	12	2	12	45%
Simulation (fusion)	J	6	8	6	8	20%
Simulation (CoppeliaSim)	B	5	9	5	9	30%
Evaluation (Proposal)	J + B	4	2	4	2	100%
Evaluation (PDR)	J + B	7	4	7	4	0%
Evaluation (CDR)	J + B	12	2	12	2	0%
Project proposal	J + B	3	1	3	1	100%
PDR	J + B	6	1	6	1	0%
CDR	J + B	11	1	11	1	0%
Final presentation	J + B	14	1	14	1	0%



Risks and possible mitigations

Robot collision:

- Speed limited to walking pace
- Triple redundant obstacle sensing (bumper, ultrasound, RGBD)

Internal contamination with pathogens:

- Internal space kept above 60c for food storage or suitable temperature for specific medication.
- Internal space heated above 75c when empty and charging
- Lower slots utilized first, so that clean trays are always above any potentially infected trays

References/added points

[1] S. J. King and C. F. Weiman, "Helpmate autonomous mobile robot navigation system," in Mobile Robots V, 1991, vol. 1388: International Society for Optics and Photonics, pp. 190-198.

[2] C. A. A. Calderon, E. R. Mohan, and B. S. Ng, "Development of a hospital mobile platform for logistics tasks," Digital Communications and Networks, vol. 1, no. 2, pp. 102-111, 2015.

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[5] M. Klompas, "Coronavirus disease 2019 (COVID-19): protecting hospitals from the invisible," ed: American College of Physicians, 2020.

[6] J. Pages, L. Marchionni, and F. Ferro, "Tiago: the modular robot that adapts to different research needs," in International workshop on robot modularity, IROS, 2016.

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[8] S. Soni, T. Mistry, and J. Hanath, "Experimental Analysis of Mecanum wheel and Omni wheel," International Journal of Innovative Science, Engineering & Technology, vol. 1, no. 3, pp. 292-295, 2014.

[9] R. Holmberg and O. Khatib, "Development and control of a holonomic mobile robot for mobile manipulation tasks," The International Journal of Robotics Research, vol. 19, no. 11, pp. 1066-1074, 2000.

[10] K. A. S. ALJabri and M. S. N. Al-Din, "Visually Guided Mobile Robot."

[11] D. J. Weber, D. Anderson, and W. A. Rutala, "The role of the surface environment in healthcare-associated infections," *Current opinion in infectious diseases,* vol. 26, no. 4, pp. 338-344, 2013.

Thanks for listening!!

Questions??