Trocomotor

Follower

ISDN 3002 Team MEC

Project **Trocomotor**

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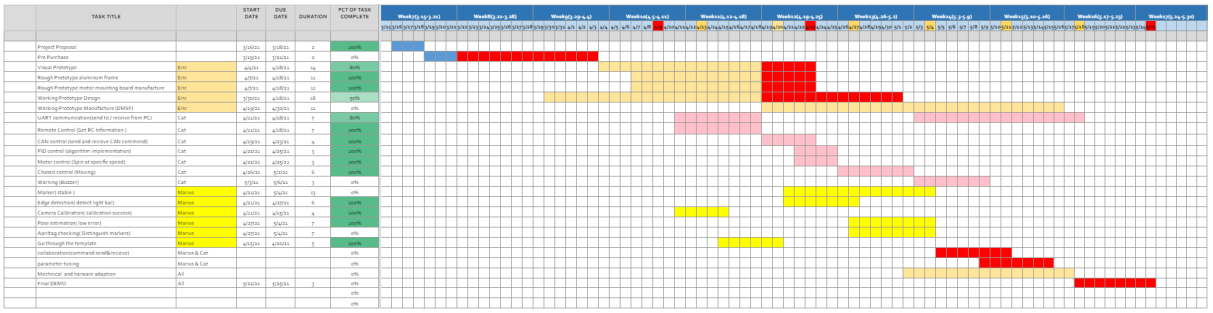
Process and Timelines

The project consists of mainly two parts. The problem definition part and the prototyping part. For the 1st to 6th week, we do interviews, site visits and shadowing, defining and redefining the problem. For the 7th to 13rd week we design and build the Proof Of Concept (POC) prototype.

A detailed Gantt Chart can be seen here: https://docs.google.com/spreadsheets/d/1bOhJ7IHA0vilDr3jceyJUyf2_KnEwY521k9hsB6Qjp0/edit?usp=sharing



Problem Redefinition & Ideation

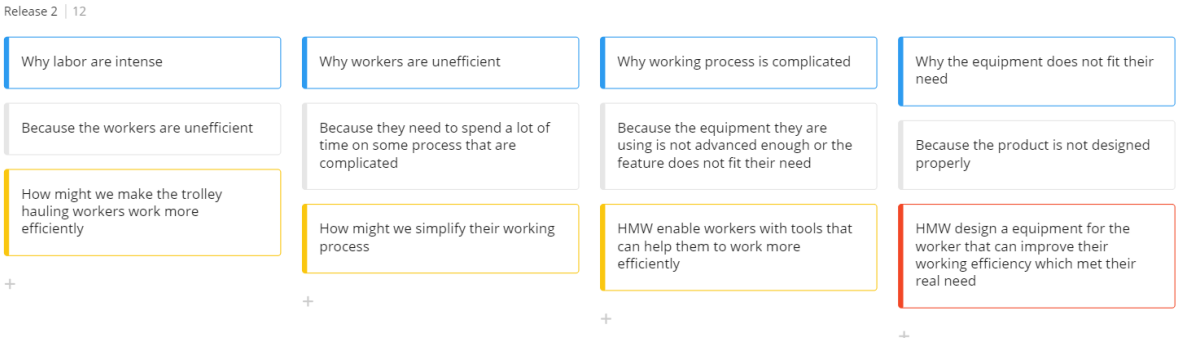
Problem given :

Autonomous Trolley hauling

(target: improve the labour intense problem in HKIA)

refine the problem :

How might we design equipment for the trolley hauling worker that can improve their working efficiency.



Research carried out, divergent thinking and ideation concepts

Technology 1:

Magnetic/Marker Tracking

pros:

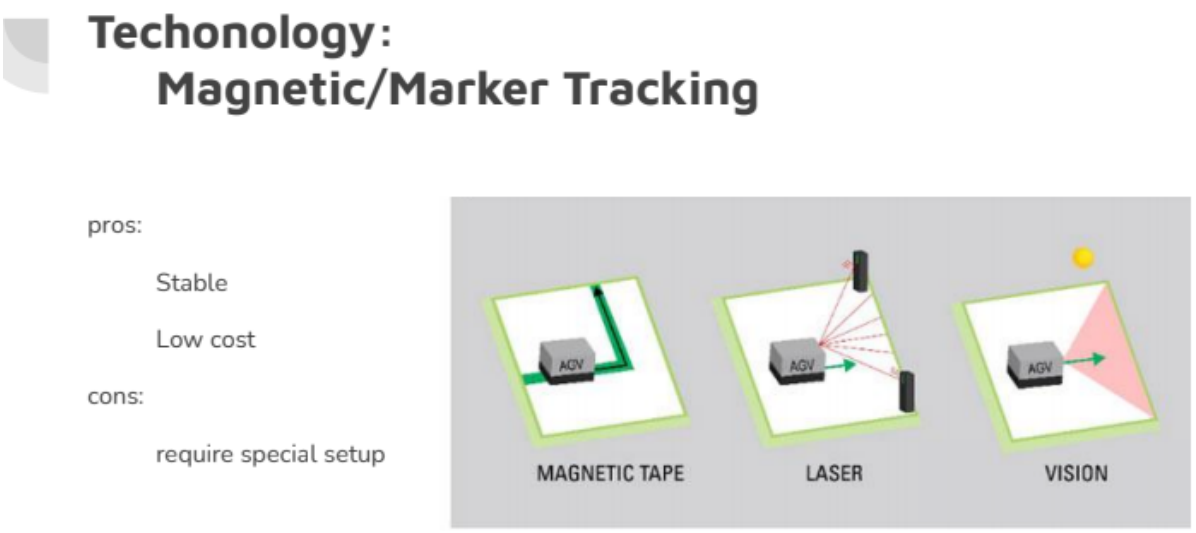
1.More stable in the running process

2.cost is low once the setup is complete

cons:

1.require special setup on ground

2.hard to maintain and setup in airport environment



Technology 2:

Laser/Vision SLAM

pros:

1.No need of environment deployment

2.Respond speed is faster

cons:

1.High development cost

2.High cost of laser/vision device

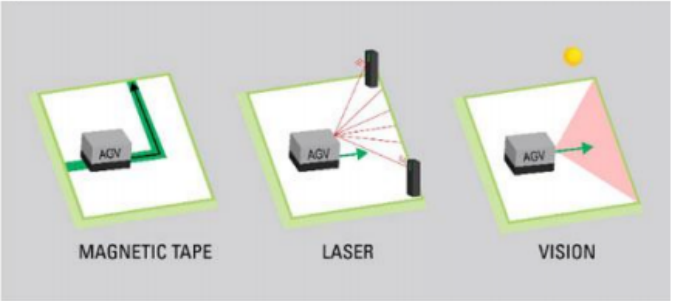
Techonology:
Laser/Vision SLAM

pros:

- No deployment cost
- Respond faster

cons:

- High development cost
- High device price



Specification

The specifications are what we want to present to our clients, which are the most important factors for convening our clients.

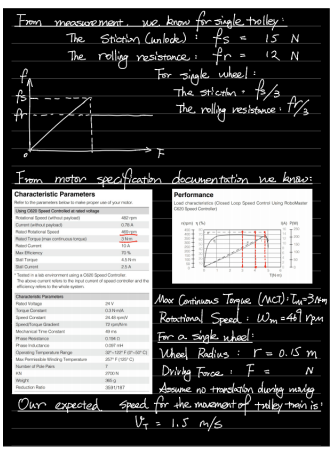
Interaction considerations

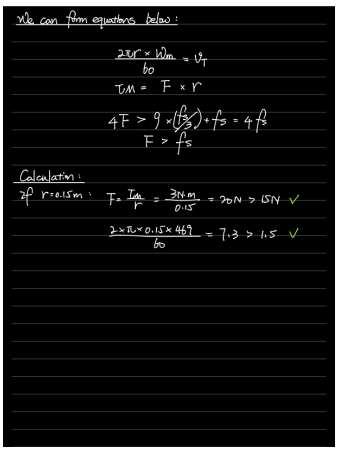
	Yellow light	Green light		
Constant	/	Disconnect		
2 HZ	Manual-mode standby	Connected Standby		
5 HZ	On normal manual operation	/		

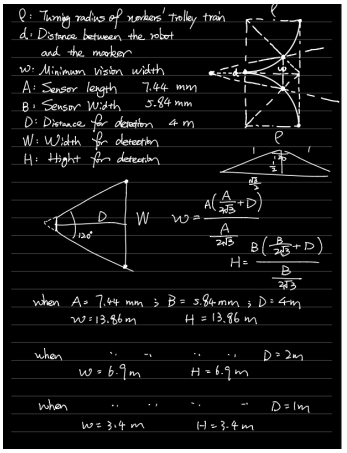
The interaction consideration mainly contains the consideration of human interactions. Since the follower cannot show information to the users directly, we add a light for interaction. The table above shows how the light and sound act.

Engineering analysis

This section presents some analysis we conduct during our project. Here we calculate the specifications of the motors and Specifications of cameras. That helps us to select the motors and cameras.







Target specifications

Size: 738*432*215 mm

Weight: 10KG

Carrying capacity: 10 Trolley (200KG)

Operation Speed: 0.5-1 m/s

Tag detection range: 1-4m

Tag detection frame rate: 30 HZ

Latency: <15 ms

Obstacle detection range: 0 m

Battery: 3 hrs

Final specifications

Size: 625*410*1100 mm

Weight: 14KG

Carrying capacity: 10 Trolley (200KG)

Operation Speed: 2m/s

Tag detection range: 5m

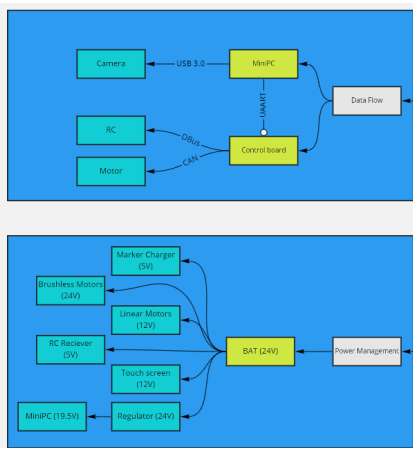
Tag detection frame rate: 30 HZ

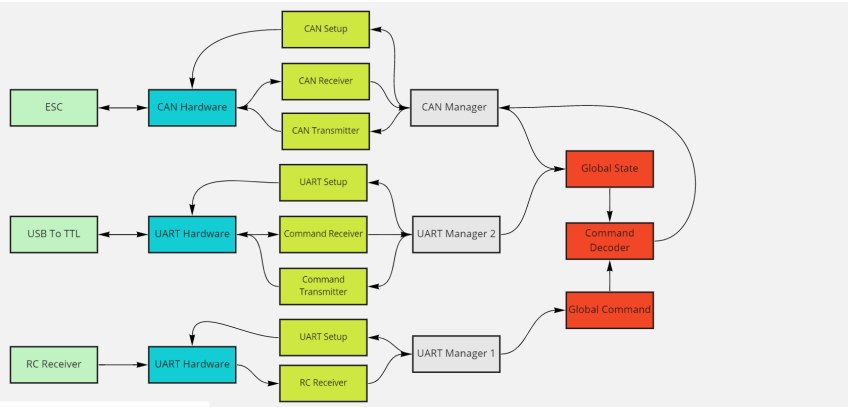
Latency: 2 ms

Obstacle detection range: 0.7m

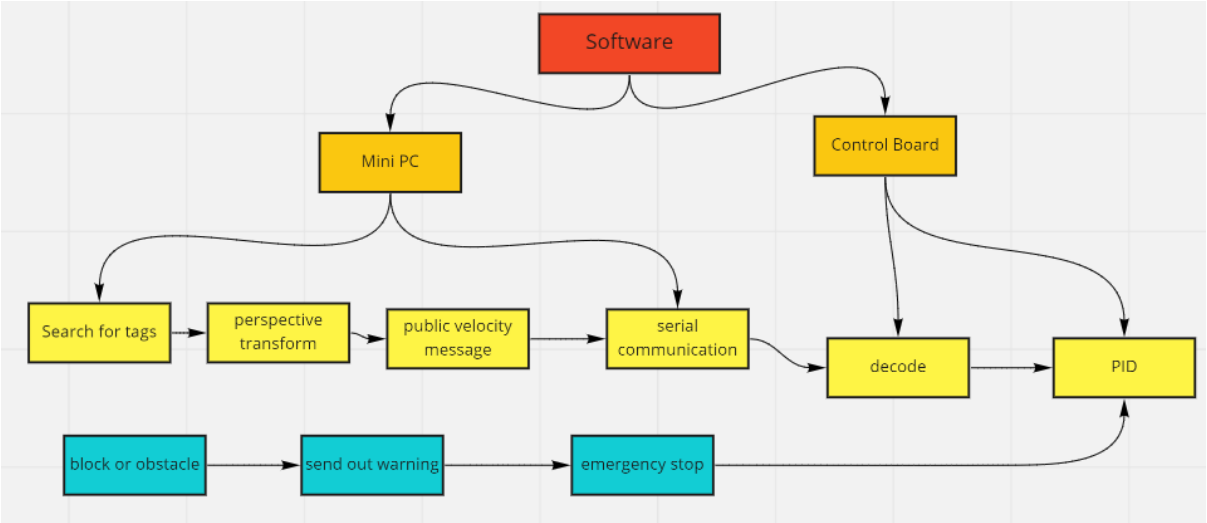
Battery: 3 hrs

Hardware specifications





Software specifications



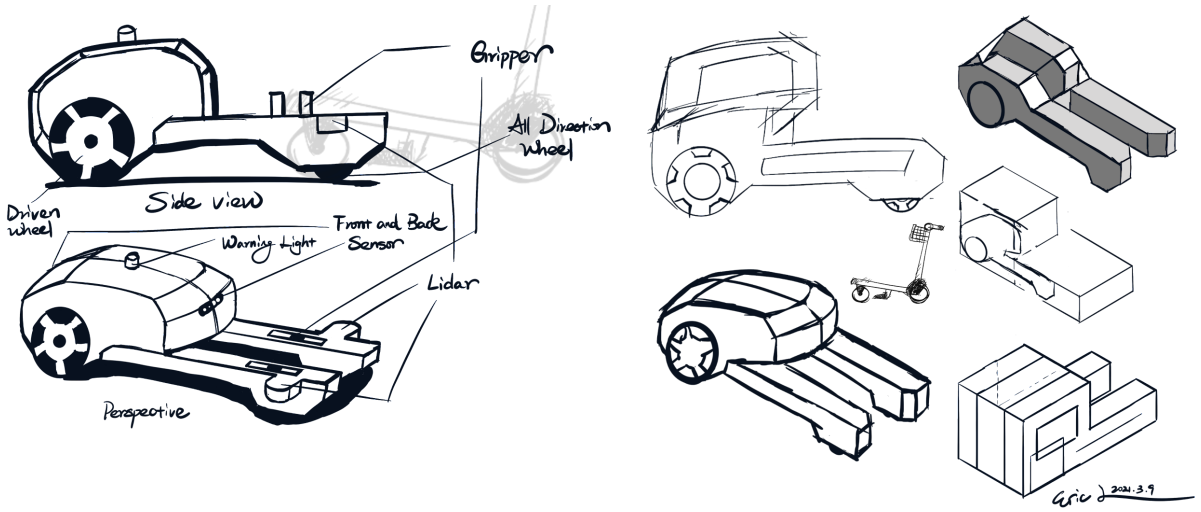
Proof of Concept

Proof of concept, visual prototypes, and functional prototype.

Proof of concept (POC), also known as proof of principle, is a realization of a certain method or idea in order to demonstrate its feasibility, or a demonstration in principle with the aim of verifying that some concept or theory has practical potential.

Sketch

We start our POC journey with sketching out the figure.

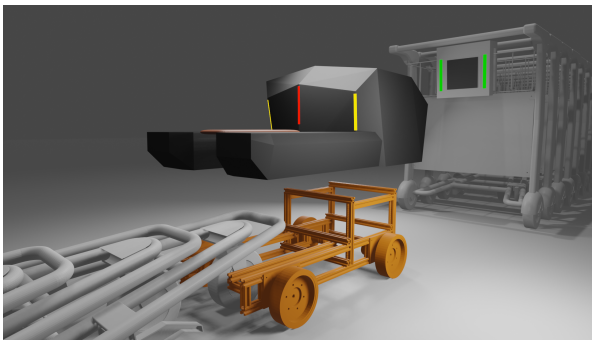


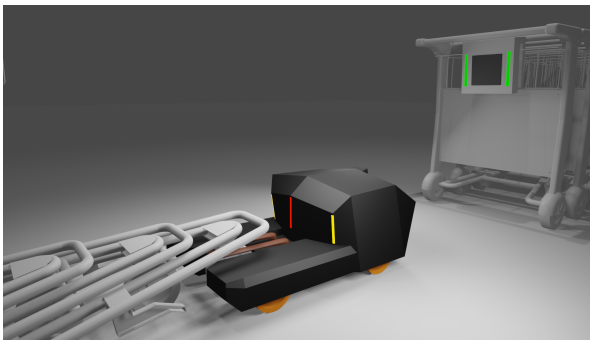
As shown in the sketching figure, we have a brief outlook of our Trocomotor Follower with some of the functions integrated on it. The basic functions consist:

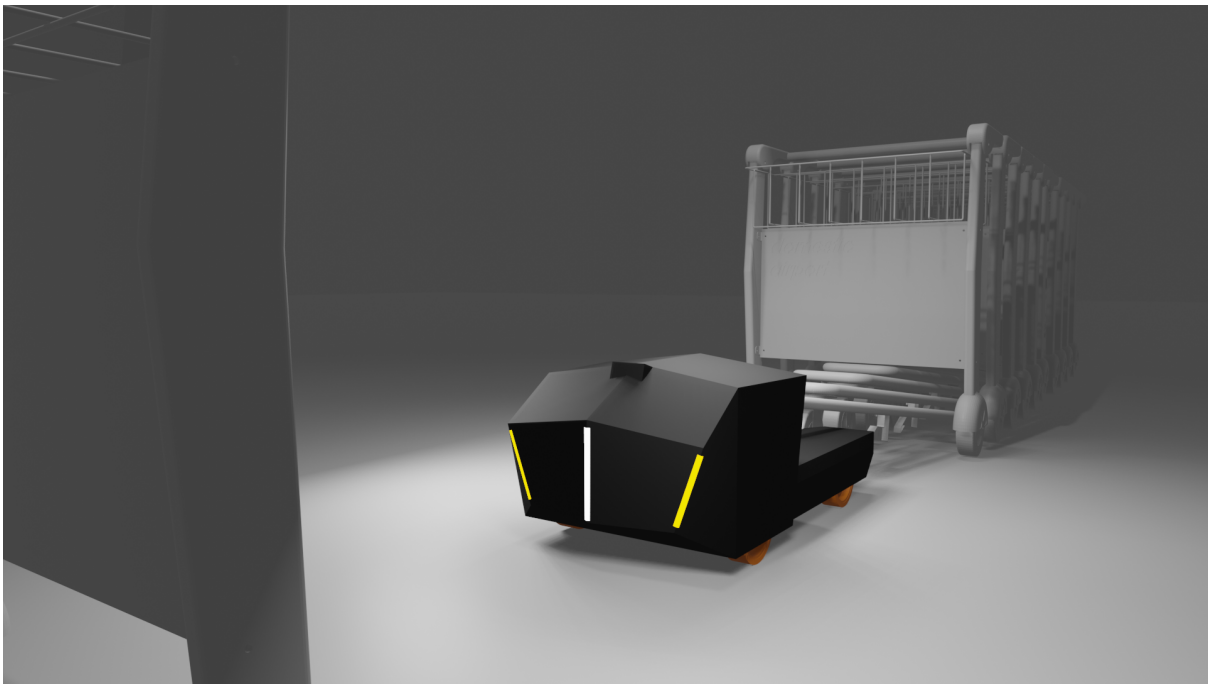
1. Moving
2. Gripping
3. Warning
4. Perception

Though we show an initial idea of the solution, it is not our final decision and the design keeps changing during the later prototyping process.

Visual Prototype







The visual prototype is produced in Blender. Based on the sketch, we make small modifications to the model, considering some of the manufacturing factors.

A brief framework also can be seen here in this visual prototype. Through the picture you can see that we divide the robot into functional parts and exterior design physically. For the prototype, a functional not aesthetic prototype is built to first fulfill the functionality and then an exterior is added on it while tuning of the robot is in progress.

CAD & Manufacture


The CAD file is produced by SolidWorks. As seen the physical prototype is again modified a little bit compared to the visual prototype. We modified the robot to make it easy to be manufactured, cheap and simple.

The Trocomotor Follower consist of following subsystem:

1. Chassis (made of aluminum profile)
2. Electronics:
    a. Mainboard (RoboMaster Type A)
    b. Warning light and sound control
    c. Camera (Industrial camera)
3. Obstacle detection system (Ultrasonic array)
4. Connecting structure (Made of aluminum profile)

Problems encountered and remediation

During the development process, we encountered countless problems. It is impossible to list them all out. In this section, some important problems and the final solution to them will be shown.

1. Problem: Low code efficiency.

   Reason: The program runs in a single thread and is always blocking.

   Solution: Use multi thread, interrupts and callback functions.

2. Problem: Motion of follower is discontinue

   Reason: The detection is discrete

   Solution: Repeat last command until time out

3. Problem: Follower works abnormal

   Reason: Module conflict and follower execute confit commands

   Solution: Centerialize commands generation with priority judgement.

Product Performance.

Test results:

chasis movement	proper functioning (turning is a bit hard under heavy loading)
apriltag following	proper functioning
remote control	proper functioning
obstacle detection	proper functioning (sometime unstable , detection angle is small)

Potential improvements:

1. Real-world testing
2. Better obstacle detection

   replacing better ultrasonic sensor or using radar will improve the performance

3. adding data report
4. Localization
5. additional subsystems.

Product Costing

Prototype Development Cost (HKD)

Item	Price	Amount	Price
Wheel	100	4	400
Motor with ESC	900	4	3600
Battery	1200	1	1200
Camera	200	1	200
Mini-PC	5000	1	5000
Control board	500	1	500
Framework	0	1	0
Exterior	0	1	0
Total	10900		

Estimate Manufacturing Cost (HKD)

Item	Price	Amount	Price
Wheel	100	4	400
Motor with ESC	900	4	3600
Battery	1200	1	1200
Camera	200	1	200
Mini-PC	800	1	800
Control board	500	1	500
Framework	500	1	500
Exterior	300	1	300
Total	7500		

Reflection

Overall, the project goes well and the final product almost reaches our target specifications. For the Trocomotor Follower. Some sub-system, such as the obstacle detection, could be improved. Due to development limitations, such as time limitations, we choose some overkill components. That part could be saved in the future. When it comes to the development process, the process is quite smooth going. But some parts could be done better, such as the time assignment in the final exam period.

Conclusions

In general, we think the trocomotor follower fulfills most of our expectations and the completion level is satisfying. However, as mentioned above,there still remains a distance for the trocomotor follower to be deployed in a real world environment. It is clear that some parts can be reduced to a lower level while some need to be improved .But it fulfills the job as a function prototype to verify our assumption and for us to better modify it in the future.