Carnegie Mellon University

Robotics Capstone Project

System Development Review

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1 Build Progress

RH: Add preface

1.1 Electromechanical Updates

As shown below in Fig.1.1, we have built a physical robot prototype that incorporates chassis, painting mechanism, and locomotion system. Chassis is made of laser patterned acrylic. It is designed to be as compact as possible because smaller robots are less likely to collide with each other during drawing operations. This prototype proves that the chassis' current cutout sizes have no clearance issue with moving components.

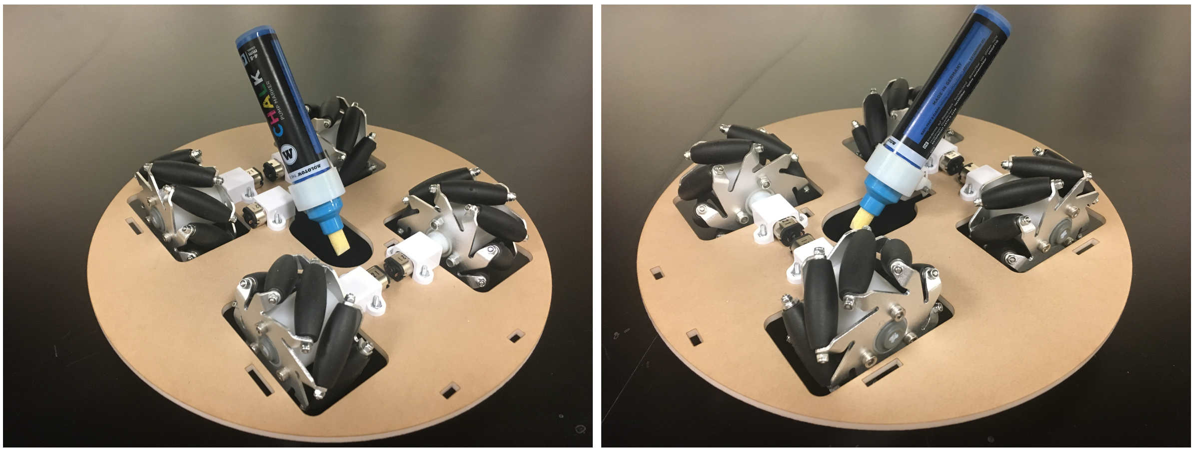


Figure 1: Prototype Overview, from left view (left) and right view (right)

Painting mechanism composes a 3D printed chalk holder and a micro gear motor which is shown in Fig.1.1. The driving motor is mounted to the chassis via an off-the-shelf motor case. When designing the chalk holder, four internal ribs are added inside the holder to securely hold the chalk marker in place while allowing users to easily switch out the marker. A thin cap is added on the bottom of the chalk holder to prevent the chalk marker from sliding out while drawing. One flaw of this design is that the holder's D-shaft cutout is a little undersized. Therefore, the chalk holder broke while pressing the motor shaft through. This problem will be addressed in the next iteration.

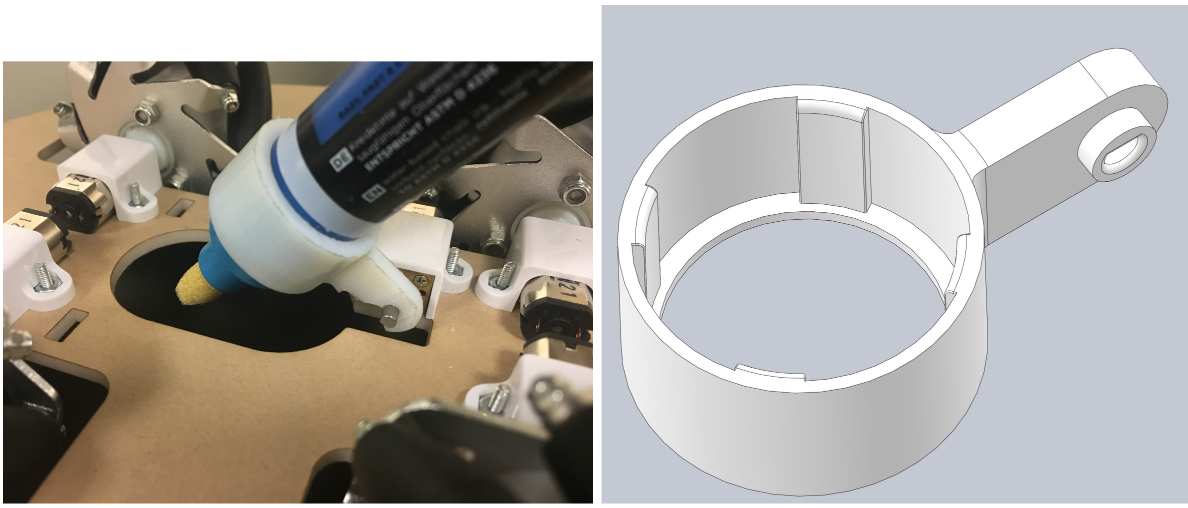


Figure 2: Painting Mechanism (left), Chalk Holder CAD (right)

Fig.1.1 shows the locomotion system. Four Mecanum wheels are oriented in a "X" shape to minimize motor workload. These wheels are connected to driving motors through 3D printed wheel adaptors.

These adaptors contain two segments: standard Lego technic axle and D-shaft housing. Like the chalk holder, the D-shaft cutout is a little undersized. Therefore, we had to press fit the motors in.

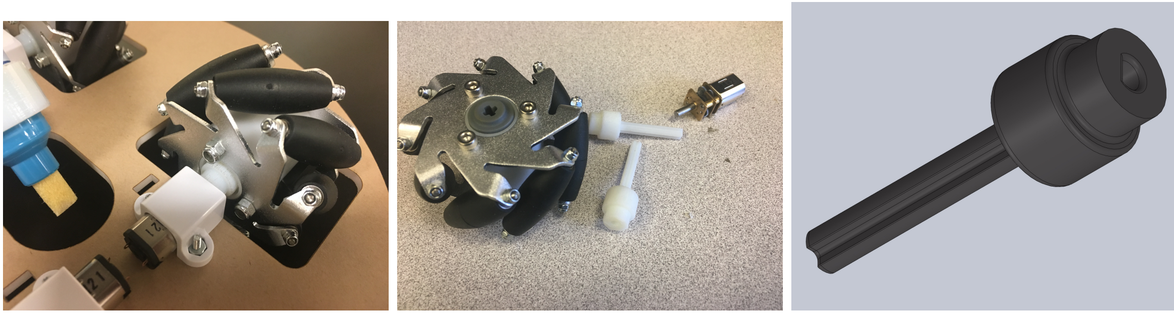
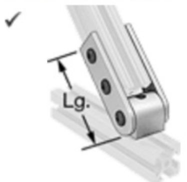


Figure 3: Locomotion System (left), Locomotion System Components (center), Wheel Adaptor CAD (right)

Besides mechanical update, motor controller code was also completed. However, we did not get enough time to wire all electronics to this prototype and test the code. This would be the next step of system development.

Since we have enough left-over budget, we plan to use 80/20 aluminum frames, instead of wood, to construct the camera jig. The jig will be built using components listed in Fig.1.1. We are in the process of testing camera's optimal height, and will then incorporate that information to the camera jig CAD design.

Pivots for Single Rails



Inline and Inline/Perpendicular

Pivots provide smooth, consistent motion at the junction between two rails.

For Rail Ht.	Lg.	Color	Material	Mounting Fasteners Included		Each
Inline						
1"	3"	Silver	Anodized Aluminum	Yes	47065T191	$16.33
1 1/2"	4 1/2"	Silver	Anodized Aluminum	Yes	47065T13	18.43
Inline/Perpendicular						
20mm	2 3/8"	Silver	Anodized Aluminum	Yes	5537T219	17.73
30mm	3 5/8"	Silver	Anodized Aluminum	Yes	5537T865	20.17
40mm	4 3/4"	Silver	Anodized Aluminum	Yes	5537T221	21.07
45mm	5 1/2"	Silver	Anodized Aluminum	Yes	5537T222	21.70

Single Standard Rails—Aluminum

Hollow

T-Slot Wd.

Profile

Hollow rails are lighter and more economical than solid rails.

Rail Ht.	Rail Wd.	Rail Construction	T-Slot Wd.	Center Hole Dia.		Lengths 1 ft.	2 ft.	3 ft.	4 ft.	5 ft.	6 ft.	8 ft.	10 ft.
Silver Anodized													
1 1/2"	1 1/2"	Hollow	0.32"	0.26"	47065T102	$7.76	$15.04	$21.78	$26.90	$33.33	$39.31	$51.36	$61.94
30mm	30mm	Hollow	8mm	7mm	5537T97	5.84	9.47	13.09	16.73	20.36	23.98	31.24	38.49
45mm	45mm	Hollow	10mm	10mm	5537T103	8.44	14.03	19.98	25.80	30.50	35.96	48.22	59.02

Corner Brackets for Single Rails

Three-Way Outside Corner

Outside corner and **three-way outside corner brackets** require tapped holes to connect rails.

For Rail Ht.	Color	Material	Lg.	Mounting Fasteners Included		Each
Three-Way Outside Corner						
1"	Silver	Anodized Aluminum	1"	Yes	47065T244	$9.86
1 1/2"	Silver	Anodized Aluminum	1 1/2"	Yes	47065T245	10.78

Figure 4: 80/20 Parts

1.2 Software Update

1.2.1 Communication

1.2.2 Locomotion

1.2.3 Localization

1.2.4 Scheduling, Distribution and Planning (SDP)

In order to our SDP module, we first had to add a few basic UI elements. We laid out a file format for specifying the lines to be drawn and wrote the UI functionality to parse the data in.

Given the data the next step is to distribute the work between the two robots, offline. We will later describe a first pass distribution algorithm along with the UI developed to visualize its results. We will conduct further testing to see if a more advanced algorithm is needed. Luckily, this can be done in parallel with other developments since we have fixed the input and output of the system, allowing us to swap in different distribution tactics. The output of the distributor is a set of vectors that specify the plan for each robot. These vectors will then be handed off to the locomotion module, described above, that will follow each of them in sequence. Therefore, this gives us two next steps: to integrate the planning with the locomotion and to develop a collision avoidance strategy.

To handle collisions, we will start off with a naive strategy. We define a robot's *boundary* as a fixed radius circle around robot, where the radius exceeds that of the robot to provide cushion. As each robot moves, it will check if the other robot's boundary intersects with its own boundary. If this condition is true, one robot (Bad) will stop execution, allowing the other robot (Blue) to pass until the condition is false. While we believe this method will always prevent collisions, it may not be the most efficient. Therefore we will implement this and test accordingly to check performance.

For our distributor, we developed a very greedy method. **RH: describe scheduling algo**

2 Project Management

3 Risk Management