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’Snow Problem Robot Technical Walkthrough for INFINITE RECHARGE

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***Abstract*—This white paper discusses the various subsystems and aspects of the robot, their development, technical details, effectiveness, and desired improvements.**

I. Introduction

THIS document will go through the technical details of our 2020 robot, Hyperion. We will first discuss our robot’s overall strategy, and then we will look at the five component subsystems: the intake, which collects POWER CELLS, the hopper, which stores and moves them through the robot, the shooter, which shoots POWER CELLS to the high goal, the climber, which extends a hook and then lifts the robot onto the GENERATOR SWITCH, and the spinner, which rotates and positions the CONTROL PANEL. We will also discuss three other broad components of our robot: the superstructure that supports all the other elements, the electronics subsystem and the various things we did to improve the aesthetics of our robot.

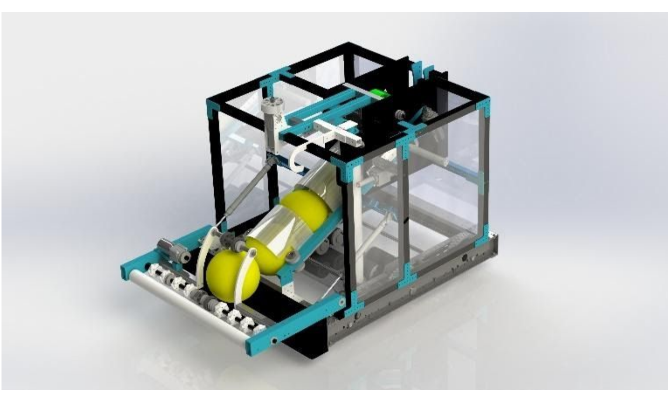

Fig. 1. Final Render of Hyperion

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II. Subsystems

A. *INTAKE*

The intake is responsible for controlling POWER CELLS on the ground, centering them along the width of the robot, and bringing them into the hopper.

1) Concept

The intake has three sets of rollers: a flat friction roller in front that controls loose POWER CELLs, a set of mecanum wheels that centers them once they are controlled, and a small set of rollers with polychord going to it higher up to bring them into the robot. The entire mechanism hinges into the robot and is deployed with a cylinder.

2) Development

Prototyping revealed the necessary positions for the various wheels and rollers on the intake. These positions were set and supports were designed. The hinge points to bring the mechanism into the starting configuration were selected in order to avoid conflict with other subsystems. The cylinder mounting points were placed after the robot structure was completed.

3) Execution

The final intake consists of two 2X1 Aluminum rectangular tubes with the mechanism held between them. At the tip is a 1.75” OD PVC pipe with grip tape on it which is mounted with bearings to a fixed half inch hex shaft spanning the entire distance. This is driven by polycord by the next shaft in, which is a live hex shaft with four 2” ThriftyBot mecanum wheels to either side and two 2” VexPro polyurethane flex wheels. Sheets of thin polycarbonate were placed between the set of mecanums and the bumper to maintain control of the POWER CELL. The next shaft is only in the middle portion and offset up and in with standoffs. It is also driven with polycord by the main shaft. This shaft moves the POWER CELL over the bumper and into the hopper once it is centered. The main shaft is driven by an AndyMark Redline motor through a 4:1 Sport planetary gearbox. Timing belts are used to connect to the motor shaft. The entire assembly rests on the front bumper when deployed. Two 6” pneumatic cylinders are used to deploy the mechanism.

4) Effectiveness

The intake was mostly effective in containing POWER CELLs, but did struggle to properly bring them into the robot and pass them to the hopper. The many independent shafts and bars spanning the intake often flexed in relation to each other, causing bands to loosen and power to be partially lost in certain parts of the intake. This also occurred between the motor and the main shaft. This flexing is also likely the reason that the geometry occasionally allowed POWER CELLs to not enter the hopper properly. This flexing also put more stress than expected on the mechanism, at one point breaking a 3D printed part holding the outermost PVC intake roller. The intake was sometimes unreliable when acquiring and centering POWER CELLs due to the amount of contact the rollers had with the element.

5) Improvements

The largest improvements to the intake would likely come from various strengthening structures. Extra structure in the middle of the width of the intake to hold the distance between the various intake rollers would likely help solve many of the issues observed. The fact that external polycarbonate sheets were added to limit the motion of the POWER CELL indicates that the intake potentially could have been made shorter as well. The geometry of the transition from the intake to the hopper should be revisited and modified slightly to prevent the case that POWER CELLs get stuck between the two stages. The 3D printed part that broke could be remade out of metal or redesigned to be thicker or a denser print fill to handle the necessary stresses. In addition, minor tuning changes to the position of the rollers could be made to improve reliability of acquiring and centering POWER CELLs

B. HOPPER

The hopper is tasked with being able to hold up to 5 POWER CELLS and transport them from the intake to the shooter at the correct angle and position.

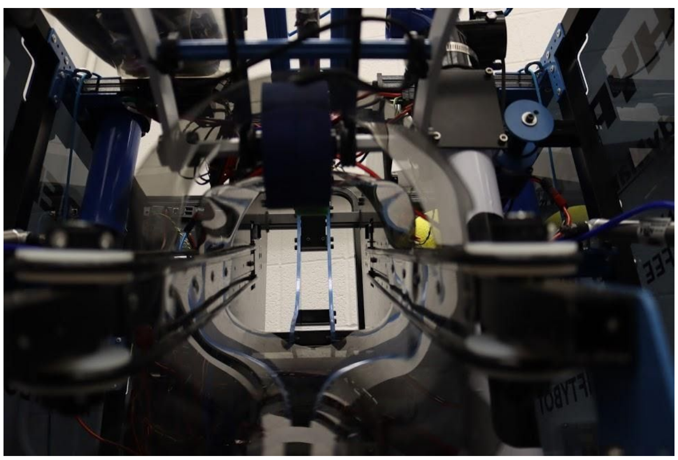

Fig. 2. Inside the hopper

1) Concept

The hopper uses 2 sets of polycord belts on either side of the POWER CELL to move it through the robot. A tube contains the POWER CELLs as they move up the robot. Cylinders at the end of the hopper block POWER CELLs from entering the shooter inadvertently while allowing the hopper to continue taking in more POWER CELLs.

2) Development

The correct spacing between the pulleys to hold and move the POWER CELLs while still allowing sliding when necessary to prevent premature shooting was determined experimentally and the main rails and tube were designed. The to and from positions for the hopper were determined by the intake and shooter respectively, which also determined the angle of travel, while the length needed to be at least capable of holding 4 POWER CELLs. (one will stay in the intake stage) The cylinder, drive motor, and mounting positions were all dependent on the shooter design.

3) Execution

The hopper consists of 2 lengths of 1X1 aluminum tube with a set of 2 2” pullies at both ends with polycord between them for a total of 8 pullies at 4 lengths of polycord. The pulleys on either side are 8.25” apart, or 6.25” cord to cord. Each side is powered by a separate BAG motor through a VersaPlanetary 10:1 gearbox mounted at the top of the hopper by the shooter. Two pneumatic cylinders are placed on either side of the hopper just before the top pulley that block the path when extended. The entire path of the hopper is wrapped in thin polycarbonate to form a tube shape that contains the POWER CELLs as they move.

4) Effectiveness

This part of the robot seemed to work as expect and designed. It was held in place on both sides at three different points along it’s length to keep it very sturdy. The cylinders successfully prevented POWER CELLs from exiting the hopper while allowing other POWER CELLs to move up.

5) Improvements

The main improvement that could be made to the hopper is the transition from the intake to the hopper, which occasionally leaves POWER CELLs floating between the two. This is already mentioned in the intake section, but this issue could likely also be solved by modifying the design or length of the hopper.

C. SHOOTER

The shooter has the responsibility of propelling POWER CELLS into the high goal from the hopper.

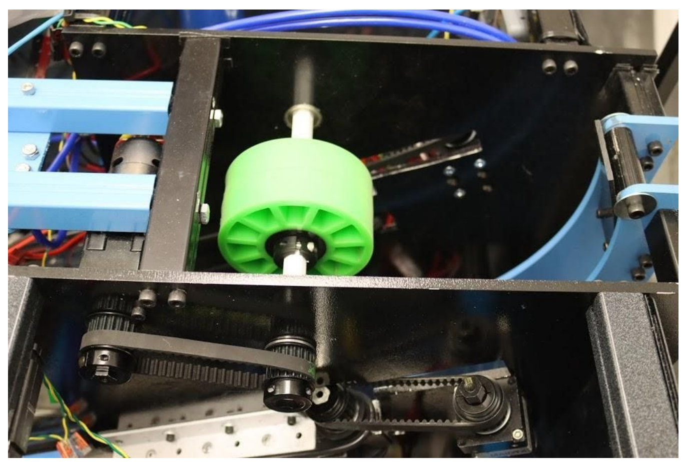

Fig. 3. The shooter and hopper drive motor

1) Concept

The shooter uses two adjacent compliance wheels to spin and move the POWER CELLs along a rigid backing. The timing of shooting is handled by the hopper.

2) Development

The overall design for the shooter is one that we have used many times before, and so we knew would work. With the given size constraints, we moved the shooter all the way to the back top of the robot, and calculated the angle of shot required to be able to hit the inner goal, although this also requires setting the motor speed correctly. This angle of exit from the shooter was implemented in the design by modifying the back POWER CELL guides. The static (non-spinning) compression of the ball was set to be ¾” based on experience from previous robot designs. The low durometer wheels meant that at high speeds the wheel would expand and additional compression would be applied to the ball.

3) Execution

For this shooter, we used two 35A (green) AndyMark compliant wheels driven at both sides of the same shaft by 775pro motors with 4:1 VersaPlanetary gearboxes on them. The supports used to contain and guide the POWER CELL through the shot were all made of ¼” plate aluminum.

4) Effectiveness

The shooter was able to consistently get POWER CELLs into the high goal when contacting the wall as planned, although we did not achieve the inner goal. The precision also dipped as the robot battery died, while this would not be a problem during a 2 ½ minute match. The back plate also had another small guide plate added to it to improve the accuracy of the shot.

5) Improvements

Using a lower gear reduction would allow us to have a higher output speed and thus a higher arc, allowing us to shoot into the inner goal. The support and backing plates could likely be made from a thinner, lighter material to reduce weight. Having a small built-in way to calibrate the angle of the shot may also have been beneficial, while we did this by filing and adding material.

D. CLIMBER

The climber is tasked with attaching to and supporting the robot by the GENERATOR SWITCH.

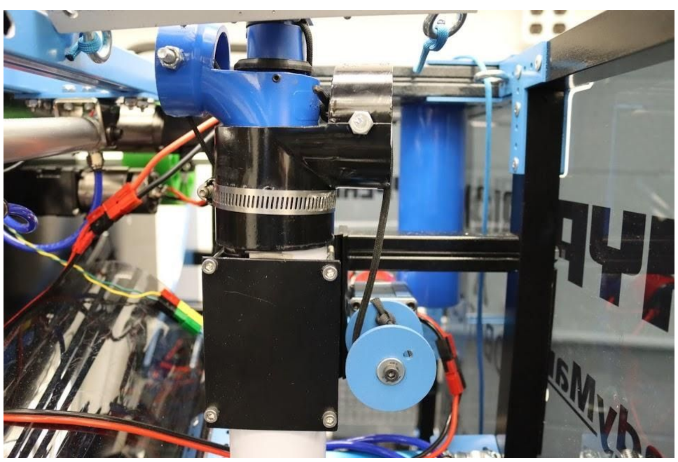

Fig. 4. Climbing telescope stages

1) Concept

A telescoping extension raises a hook in the air that is then placed over the bar by driving. The hook is attached to two ropes that are guided through either side of the robot to prevent our robot from spinning or tilting. The winch pulls on these ropes from the bottom center of the robot.

2) Development

After determining the number of telescope stages required, the design was perfected to allow it to be raised with minimal force by adding pullys to guide the ropes. This could be placed anywhere in the robot since it is only for the hook delivery. The hook was then designed to be able to be easily delivered, release from the telescope, and maintain friction with the bar in the case that the bar were to become tilted (for example, when climbing with another robot.) The climb winch was simply placed in the bottom of the robot. The eye bolts for guiding the climb ropes were placed after the robot was built in order to set them close to the center of gravity.

3) Execution

4 stages of PVC tube were used to create the telescope which was powered up by separate lengths of nylon cord in a cascade configuration. The telescope was powered by an AndyMark RedLine motor with a 16:1 AndyMark Sport gearbox. The climb winch was powered with two CIM motorsattached to an AndyMark super shifter gearbox of which the shifter was not used.

4) Effectiveness

The delivery system is good at raising the hook, but because it is made of concentric circular tubes, it could not control the orientation of the hook as it rose which often twisted to the side, causing driver lineup with the bar to be difficult. The hook worked well and stayed in place once delivered even when the bar was angled or swinging. The winch would slowly back drive, resulting in the robot falling to the ground after the match.

5) Improvements

Using a square telescope or some other way to maintain the orientation of the hook as it is risen would likely be the best improvement to this design. Alternatively, a multihook could be made so that any orientation of the mechanism would catch the bar. A rachet should be attached to the climb winch to prevent the robot from lowering after the match, even if slowly. This system was also heavier than necessary. A lighter gearbox with lighter motors could have been used to lift the robot.

E. SPINNER

The Spinner is the wheel and actuation mechanism towards the front of the robot that is capable of rotating and position the CONTROL PANEL.

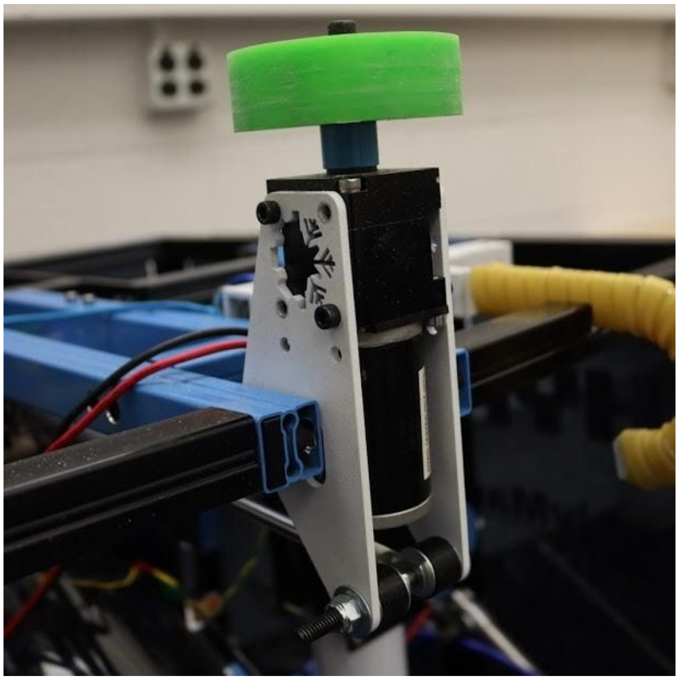

Fig. 5. Spinner shown in the up position

1) Concept

The spinner is a wheel that can actuate from a position inside the robot to a horizontal position at the proper height to contact the CONTROL PANEL. This assembly is mounted so that in the down position it is at the max height of the robot, allowing us to contact the CONTROL PANEL with minimal extension.

2) Development

Because we want to be able to drive under the trench run, we needed the spinner to actuate up and down some way. It was determined that the best way to do this was by rotating the assembly up and down. The key hinge points and cylinder size were determined, and the correct links and supports were made to fit.

3) Execution

The spinner consists of one 35A (green) 3” AndyMark compliant wheel mounted directly to a 10:1 VersaPlanetary gearbox powered by a BAG motor, all of which actuates with a 4” stroke pneumatic cylinder. At its lowest position, the robot is 27” tall, or 1” under the trench run. When extended, the center of the wheel is aligned with the center of the bottom sheet of polycarbonate on the CONTROL PANEL. Due to differences in our game elements, the wheel was spaced to a slightly different position on the shaft in order to contact the CONTROL PANEL as desired. The models show the correct position for a regulation field.

4) Effectiveness

The spinner was very effective at moving and accurately controlling the position of the CONTROL PANEL. When applying full power, the wheel did slip, and it appeared to undergo a lot of wear very quickly, although both of these observations were made with a wooden CONTROL PANEL, which is likely less ideal for both of these.

5) Improvements

If this robot were to run for a full competition season, it may be worthwhile to consider using a different wheel that has less grip but would wear slower and so require replacement less. Because our robot is not designed to operate with autonomous controls, sensors were not added to this mechanism. For this mechanism, we would recommend either a camera mounted near it or the use of a color sensor to determine the position of the wheel.

III. Extras

Various other parts of the robot did not have dedicated teams or people associated with their design or implementation, but are still worthy of discussion nonetheless.

A. Superstructure

The rectangular superstructure of the robot was only designed after all functional parts of the robot were in place. This was important since it allowed us to design the subsystems as flexibly as possible with minimal constraints. Each of the subsystems was designed and placed in the model floating in its own space. For example, the intake was positioned based on the floor and the bumpers, while the spinner was positioned based on the desired max height of the robot. Once all subsystems were placed as desired in the model, superstructure bars were placed to hold them in place. For this, a combination of 1X1 tube extrusion and 1X1 AndyMark extrusion were used. Rivets, gusset plates, and tapped peanut holes were used to permanently assemble the superstructure.

B. Electronics

The electronics for Hyperion are placed vertically along the back side of the robot under the shooter. This position was chosen after the rest of the robot was designed, so that the placement of the electronics did not impact more critical systems. Our motor controllers include Sparks, Victor SPs, Victor SPXs, and Talon SRXes. The Talon SRXes are used for speed control of the shooter.

C. *Aesthetics*

Once the design of the robot was complete a color for each part was decided upon and the parts were powder coated or spray painted. Snow Problem’s robots always follow the same color scheme being mostly black with blue and some white highlights. The base frame and superstructure is all black with gusset plates and mechanisms highlighted in blue and a select few parts highlighted in white. The coloration on Hyperion was achieved using an in-house powder coating setup, as described in our 2017 white paper on powder coating. For the final robot, we exclusively use dark tinted polycarbonate, which gives the robot a more professional look than clear polycarbonate. The decals on the shroud are adhesive vinyl cut on our Silhouette Cameo. This year we also used a REV Blinkin LED driver to control our LEDs on the superstructure, which act as our robot signal light– they’re on when the robot is, slowly blinking blue when enabled, and pulsing pink when disabled. We are extremely happy with the Blinkin driver, and can’t recommend it enough to teams looking to easily and painlessly control LEDs. The pneumatic tubing we used on this robot is from Automation Direct, and matches the color scheme of our robot.

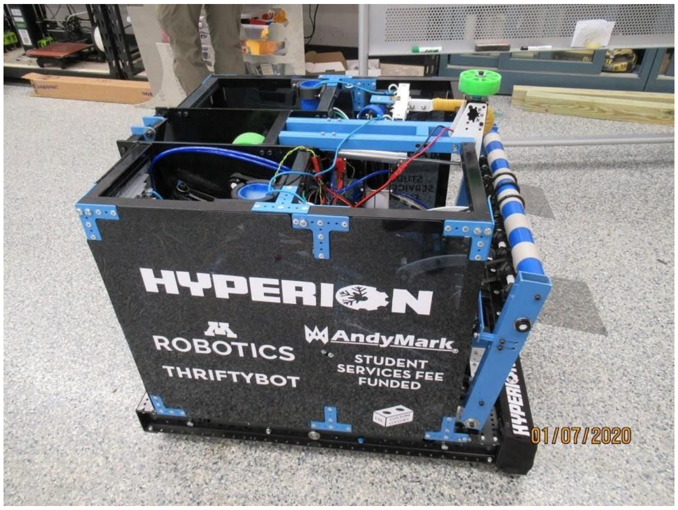

Fig. 6. Hyperion with side panels

Appendix

Contacting The Authors

Team ’Snow Problem may be reached in order to ask questions on our Chief Delphi thread, on Twitter (@SnowProblemz), or via our Twitch stream during the three day build. After the build, we will still be answering questions on the thread and via email (robotics@umn.edu). We are doing this for you, the FRC community, and are happy to answer questions and discuss our designs with you.