SoutheastCon 2022 Hardware Competition

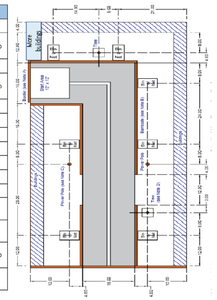
Chase Garner Sawyer Hall Lexi Sheeler Daniel Summers Advisor: Mr. Jesse Roberts

Executive Summary

The purpose of the project was to design and build an autonomous robot to compete in the 2022 IEEE SoutheastCon Hardware Competition. This year's competition theme was Mardi Gras. Teams were challenged to design a robot to clean up after a Mardi Gras parade. The robot should be capable of grabbing beads from trees, placing them into "trash bins" or throwing them into nets, and relocating a pedestrian from the street to the sidewalk.

Gameplay

Points	Task	Repeatable?	Max Qty
+1 pt	Pushing a mars/mallow off the roadway	One-Time	1
+1 pt	Each bead dropped into a bin	Per Bead*	Qualifier: 20 Semi-Final: 30 Final: 40
+1 pt	Each trash bin with one or more beads in it	Per Bin	4
+2 pts	Each bead thrown into a fish net	Per Bead*	Qualifier: 20 Semi-Final: 30 Final: 40
+1 pt	Each fish net with one or more beads in it	Per Net	3
+2 pts	Having a display	One-Time	1
+2 pts	Playing a song	One-Time	1
+2pts	Having a display that lights up	One-Time	1
+2 pts	Leaving the start square	One-Time***	1
+5 pts	Traversing the track, one direction (half loop)	One-Time	1
+10 pts	Completing the track, both directions (full loop)	One-Time	1
+10 pts	Qualified Entry In Promotional Design Competition	Per Run	1
	Penalty penalties cannot reduce points below the amount of non-punishable points		
-1 pt	Each bead left on roadway	Per Bead*	Qualifier: 20 Semi-Final: 30 Final: 40
-5 pts	Touching any obstacles: barricade, trash bin, building, or power line	Per Obstacle**	10



Measure of Success	Target Value
Size Specification	12"x12"x12"
Bead Pick %	90%
Bead Pick Time	20 Seconds
Shot Accuracy	95%
Shot Time	20 Seconds
Net Detection	100%
Beads in All 3 Compartments	Pass/Fail
Marshmallow Moved	85%
Traversal Speed	2 ft/s
Run Time	<3:00
Run Points	40

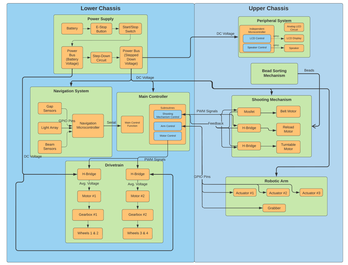
Figure 1. Competition Layout and Scoring

1. Begin on Starting Square
2. Collect Beads from Trees on each end of Track
3. Place/Fire Beads into Cups/Nets
4. Return to Starting Square

While traversing the track, a marshmallow must also be pushed off of the roadway through a gap in the barricades. Points can be lost by leaving beads along the roadway or by colliding with or damaging elements of the track.

After examining the opportunities to score points, the team calculated that focusing entirely on shooting the beads and ignoring placing them in cups would yield a higher point total. This influenced the team to design a robust, accurate shooting mechanism.

System Block Diagram



Schedule

Event	Date
Structural Design Complete	December 1, 2021
Detailed Design Complete	January 26, 2022
Trial Runs	March 1, 2022
Improvements	March 30, 2022
Competition	March 30 - April 1, 2022
Final Results	April 20, 2022
Final Presentation	April 28, 2022

Left to Right: Chase Garner, Sawyer Hall, Alexis Sheeler, Daniel Summers

Design

- **Chassis:** The chassis was 3D modeled to verify that the size constraint was met. It was divided into an upper and lower section connected by a turntable to maximize maneuverability. It was constructed with laser-cut 1/8" and 1/4" sheets of acrylic.
- **Power:** The total maximum current consumption of the system was calculated at 4.8 Amps. For improved safety and life-cycle time, a 6000 mAH LiFePO4 battery was selected.
- **Navigation:** The navigation system utilizes a PD control algorithm and feedback from infrared sensors to navigate the track. Ultrasonic sensors are used to detect and avoid barricades.
- **Arm:** The robotic arm was chosen for its long reach, and control routines for picking beads and moving the marshmallow were written. An Adafruit Servo Shield was implemented to generate up to 16 PWM signals using only 2 Arduino pins and its own timer.
- **Vision:** Using a Raspberry Pi running an OpenCV Python Script and two USB cameras, the Vision System samples discrete points along the track to determine the location of targets. This information is communicated to the central Arduino via Serial Communication over UART.
- **Shooting Mechanism:** A Matlab script was written to calculate the appropriate launch angle and velocity of the beads. This velocity determined the necessary motor rpm. A magazine subdivided into 3 compartments allowed the beads to be separated for up to 3 shots.

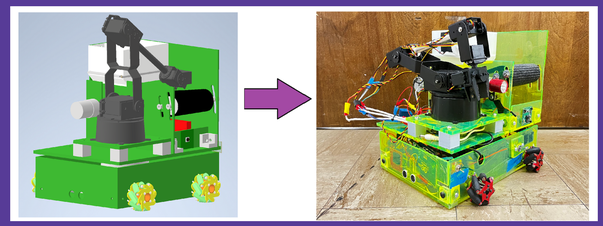


Figure 2: Complete 3D Model and Constructed Robot

Acknowledgements

The team would like to thank Mr. Jesse Roberts for his guidance and the Department of Electrical and Computer Engineering for the opportunity to represent the University at SECON 2022. Additionally, thank you to Dr. Andy Pardue, Mr. Conard Murray, Mr. Jeff Randolph, and the TTU iMakerSpace Team.

Experimentation and Results

Trial Runs of the Competition were conducted to measure the capability of the system. Over 25 tests, of which 20 were full competition runs, were conducted in order to collect adequate data and normalize means. Emphasis on bead pick rate, shooting accuracy, total points scored, and battery depletion were made.

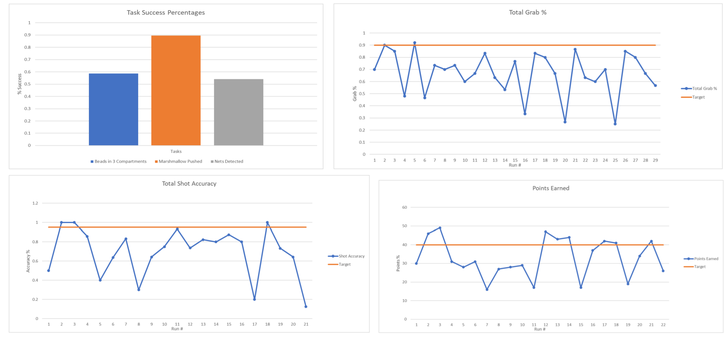


Figure 3. Experimental Results

The results show that the majority of points lost were caused by inconsistent bead picking. Issues with the bead picking system are the cause of many other performance issues of the robot. Instances of completely missed shots, getting stuck, and 0 beads being grabbed from tree 2 were almost always caused by beads being dropped on the road. Either the robot would become stuck on these beads, or the Ultrasonic Sensors would mistake the beads on the road for a wall, causing the robot to stop short of its target.

Bill of Materials

Subsystem/Component	Qty.	Unit Cost	Total Cost
Central Controller			
Arduino Mega	1	$ 34.25	$ 34.25
		Total	$ 34.25
Vision System			
Raspberry Pi	1	$ 149.99	$ 149.99
Camera	2	$ 29.99	$ 59.98
		Total	$ 209.97
Peripherals			
Arduino Uno	1	$ 20.98	$ 20.98
Screen	1	$ 9.99	$ 9.99
LEDs	1	$ 7.99	$ 7.99
Audio Shield	1	$ 34.95	$ 34.95
		Total	$ 73.91
Arm			
Arm	1	$ 399.00	$ 399.00
Arm Servo	1	$ 17.50	$ 17.50
		Total	$ 416.50
Drive Train			
Wheels	1	$ 70.94	$ 70.94
H-Bridge	2	$ 8.99	$ 17.98
Motor	5	$ 24.95	$ 124.75
IR Sensors	4	$ 8.99	$ 35.96
Ling Following Sensors	3	$ 7.00	$ 21.00
		Total	$ 270.63
General			
Gameboard supplies			$ 182.09
Hardware			$ 160.27
		Total	$ 342.36

Subsystem/Component	Qty.	Unit Cost	Total Cost
Chassis			
Acrylic	4	$ 19.32	$ 77.28
		Total	$ 77.28
Turntable			
Motor Mount	1	$ 19.95	$ 19.95
Motor	1	$ 34.99	$ 34.99
		Total	$ 54.94
Shooting Mechanism			
Belt	1	$ 20.98	$ 20.98
Compartment Motor	1	$ 19.95	$ 19.95
Coupling	1	$ 4.99	$ 4.99
Shaft	1	$ 8.02	$ 8.02
Bearings	3	$ 9.56	$ 28.68
Driver Motor	1	$ 24.95	$ 24.95
		Total	$ 107.57
Power			
Emergency Stop	1	$ 12.99	$ 12.99
Start/Stop Switch	2	$ 14.85	$ 29.70
Wall Wart	1	$ 16.99	$ 16.99
Buck	1	$ 15.99	$ 15.99
Buck Boost	1	$ 55.99	$ 55.99
Power Bus	3	$ 9.49	$ 28.47
Battery Charger	1	$ 35.95	$ 35.95
Battery	2	$ 120.00	$ 240.00
		Total	$ 436.08
Grand Total			$ 2,023.49