BRADLEY UNIVERSITY

IEEE SoutheastCon Hardware Challenge

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Brian Roskuszka, Daniel Hofstetter
May 2, 2017

BRADLEY

Advisors: Dr. Jing Wang, Dr. Yufeng Lu, Dr. In Soo Ahn

Task 3 - Bring Down the Shields

Precise Knob Rotation

Gripper Arm Design Considerations

Rotation Mechanism

1. Precise multiple rotation turning (+- 15 degrees)
2. Size (small enough to fit with the 12 inch limit)
3. Power (able to rotate knob without slipping)

Gripping Mechanism

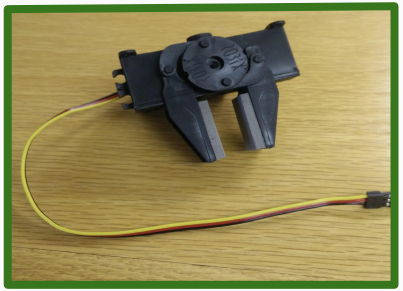
1. Grip strength (able to hold knob without slipping)
2. Able to release upon completion
3. Minimal tangling wires

Design Options: Rotation Motor

	Precision	Size	Power
Continuous Rotation Servo Motor	Low	Small	Medium
DC Motor with Rotary Encoder	Medium	Large	Large
Stepper Motor	**High**	**Medium**	**Medium**

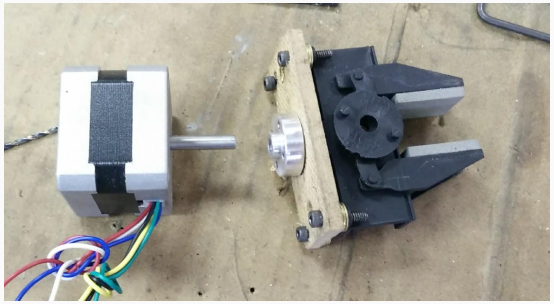
Gripper Arm Design Options

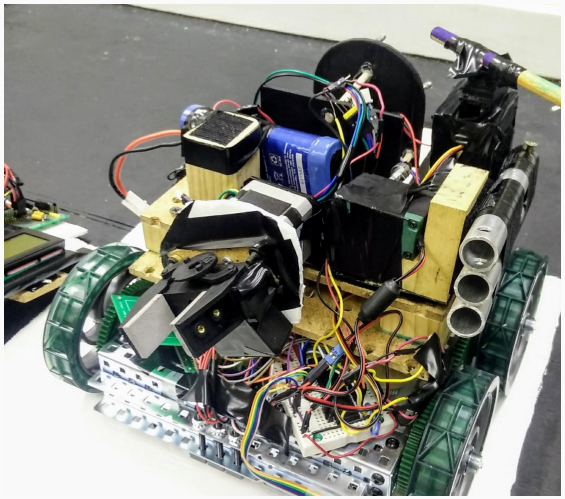
	Grip Strength	Can Release	Wire Tangling?	Difficulty to fabricate
Plate with Sticky Surface	Low/Mid	No	None	Easy
Spring Gripper with Release	Mid/High	No	None	Difficult
Servo Powered Gripper	**High**	**Yes**	**Maybe**	**Easy**



Task 3 Final Design

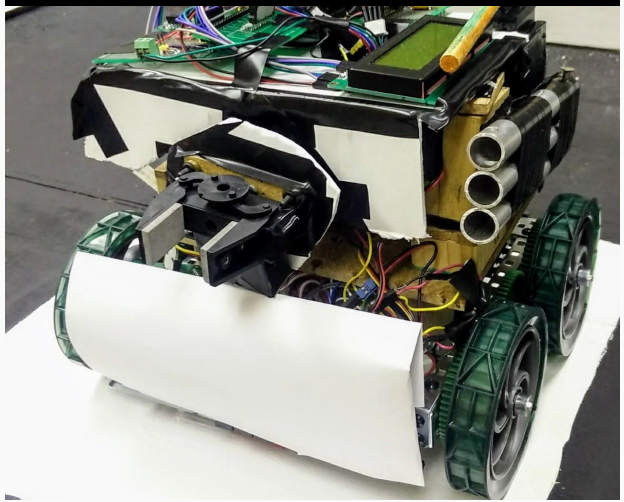
- Servo gripper arm
- Stepper motor
  - Powered via dual H-bridge
- Custom coupling mount
- Multiple mounting positions
- Rotation functions
  - Two functions for stepper motor rotation created one for 360° clockwise turn, another for 360° counterclockwise turn





Task 3 Testing and Conclusions

1. Test Servo Gripper
2. Configure Stepper Motor and Dual H-bridge
3. Program Rotation Functions
4. Test whole component
5. Mitigate Cord Tangling Risk



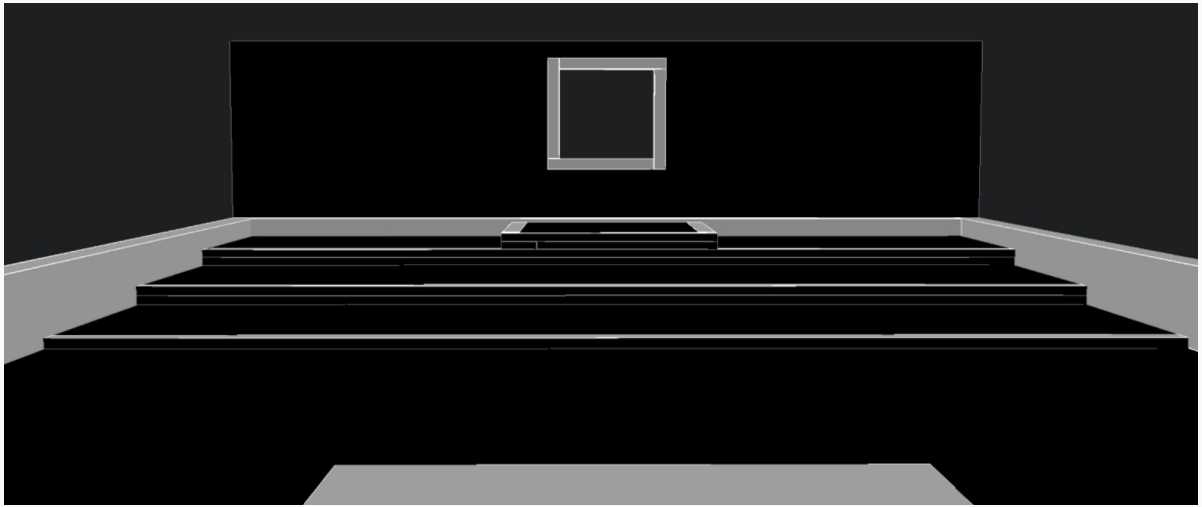
Fully functional when lined up within .25 inches

Task 4 - Fire Proton Torpedoes

Nerf Dart Firing

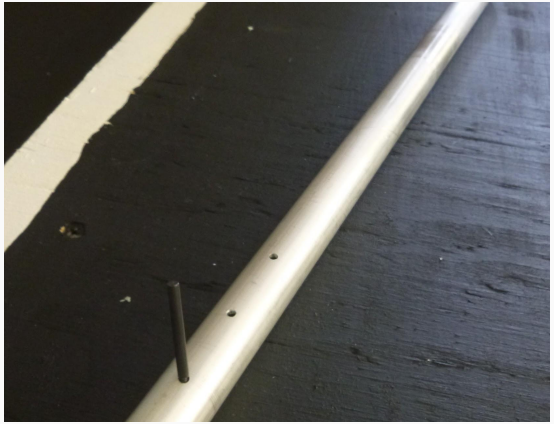
Design Considerations for Task 4

1. Accuracy
2. Step climbing
3. Size constraints



Design Options for Task 4

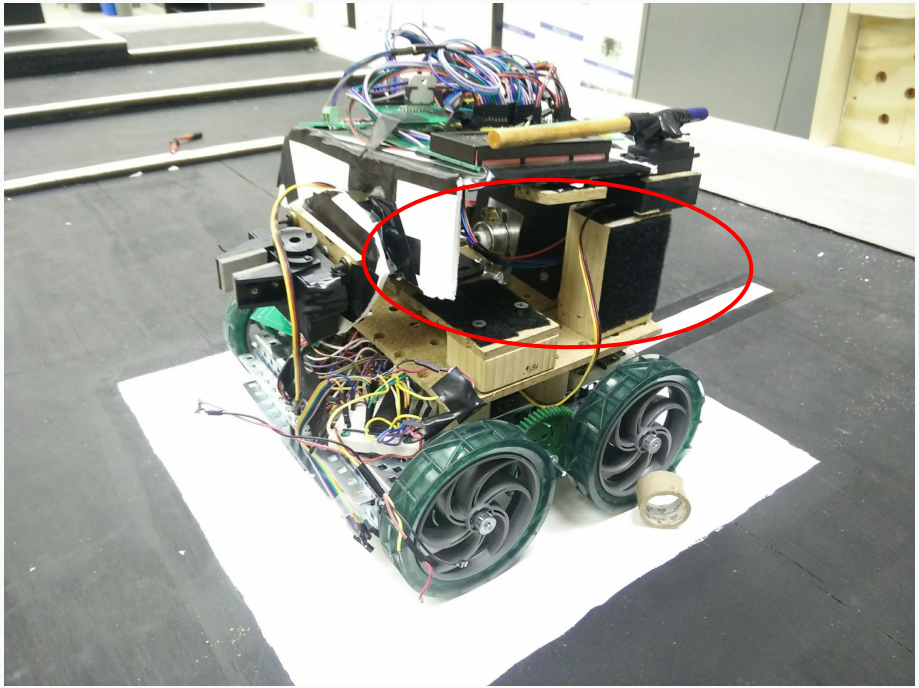
1. No Stage 4 mechanism (save space)
2. 3 Nerf Guns with servos to pull the trigger
3. **Custom made spring loaded gun with release pins**



Task 4 - Design Process

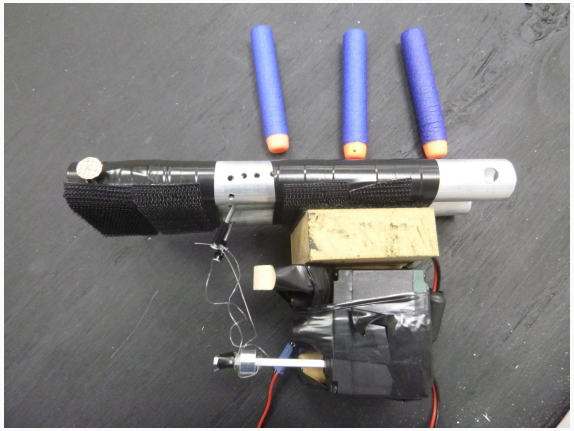
Design Progression

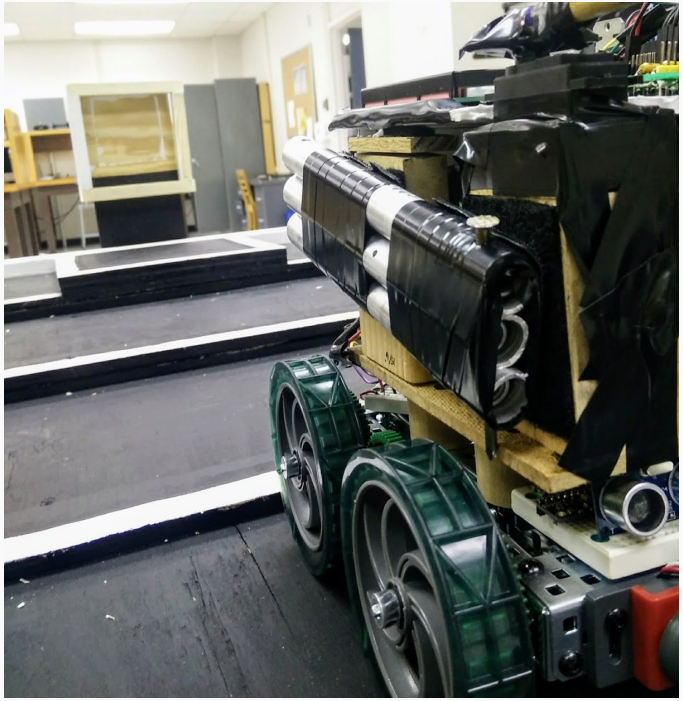
1. Forgo Task 4 - effort needed elsewhere
2. After Tasks 1-3 were complete, try to gain some points, if possible
3. Rearrange robot layout to afford some space
4. Quickly adapt prototype to fit within design constraints



Task 4 - Final Design

- Custom triple-barrel design
  - Loaded before competition
  - Metal tube - pull pin to release spring
- DC motor used to pull pins
- Aim can be calibrated before each run

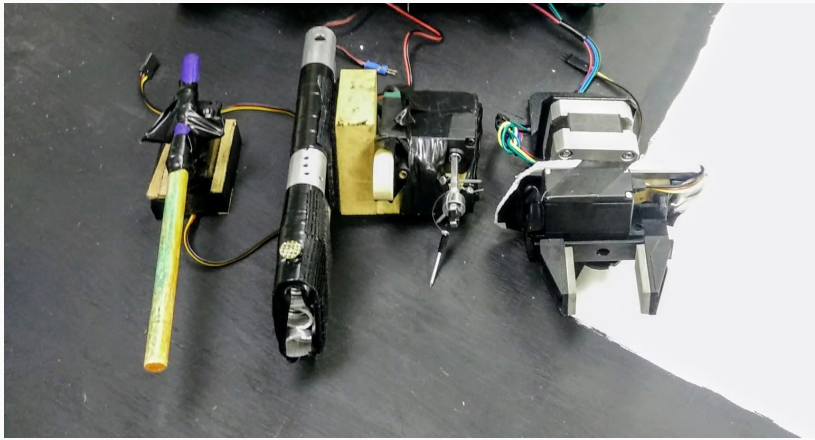




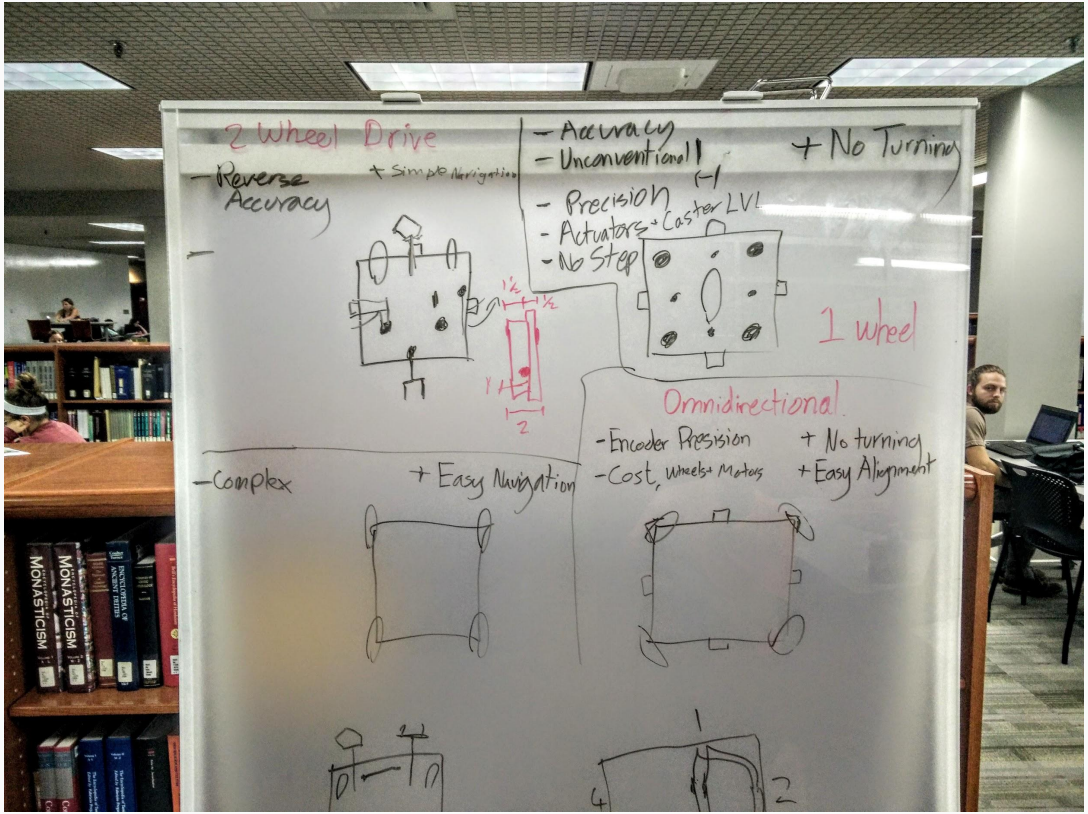
System Integration

System Integration - Design Considerations

- Must allow for easy assembly and adjustment at the competition
- Must have precise navigation especially for tasks 1 and 3
- Must fit within the 12” x 12” x 12” specification



Proposed Robot Design Layouts



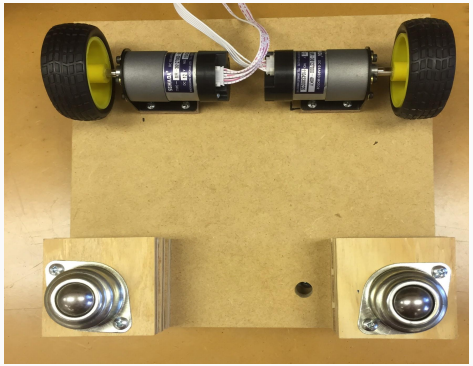
Chassis Construction - First Design

Great for preliminary testing

- One component on each side
- Rotating top platform for navigation simplicity
- Easy to turn, no slipping

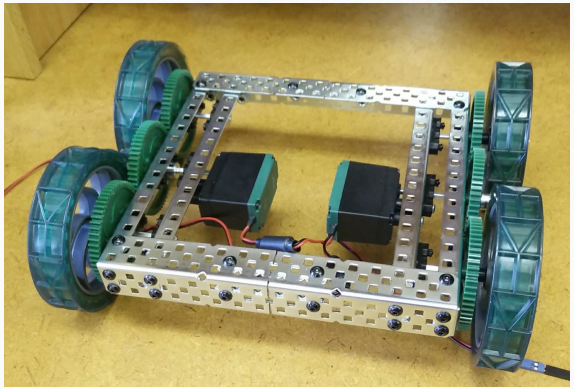
Limitations

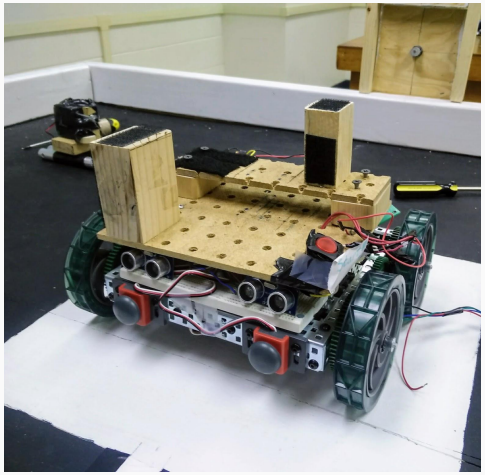
- Not enough space for electronics
- No easy way to configure wiring
- DC motors had a high starting torque required and were configured in reverse directions
    - Low navigation precision

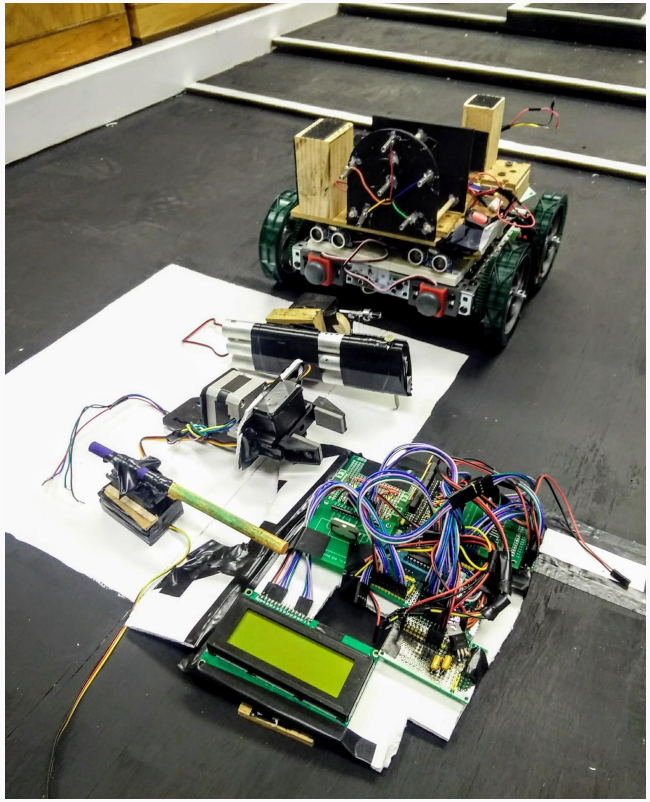


Chassis Construction - Final

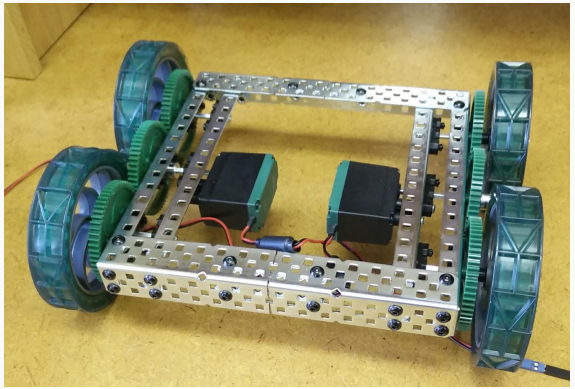
- Modular design
- Removable platform
- Removable components
- Adjustable component positions

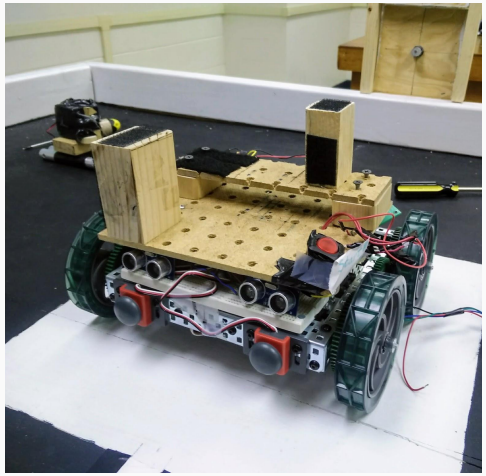


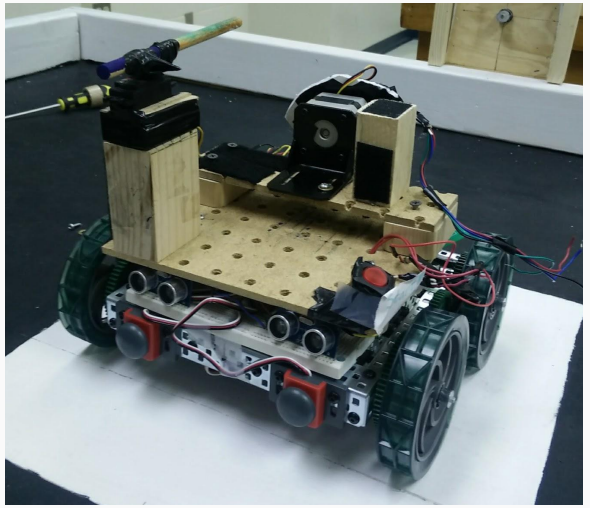




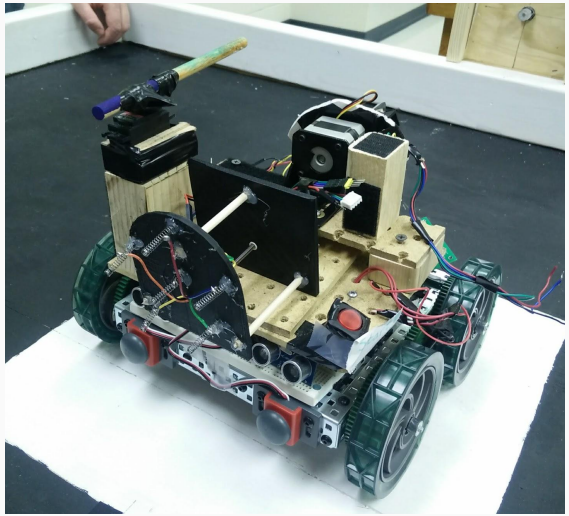
Robot Chassis Construction

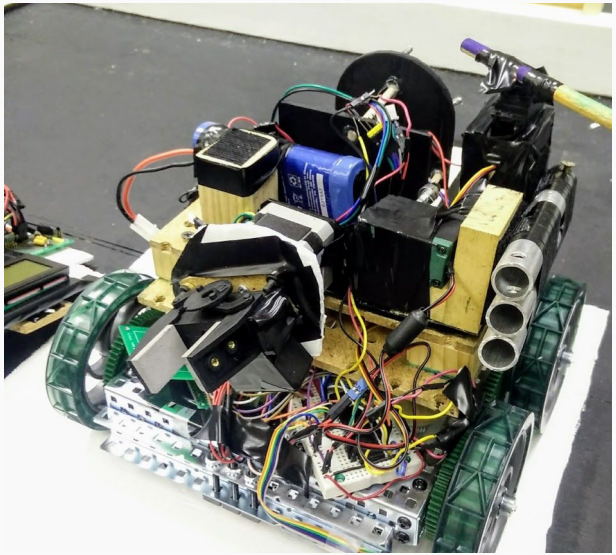


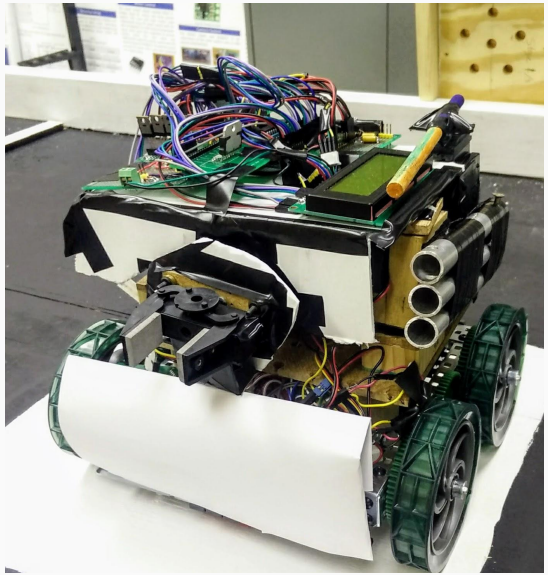




Robot Chassis Construction

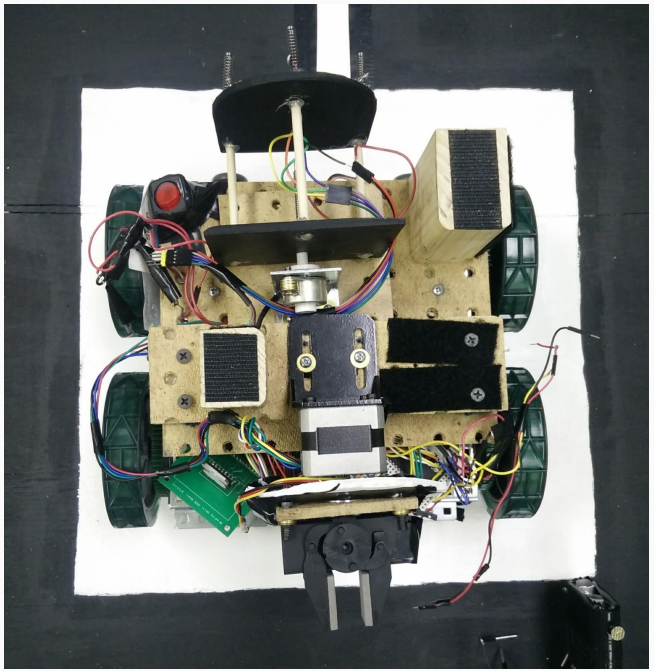




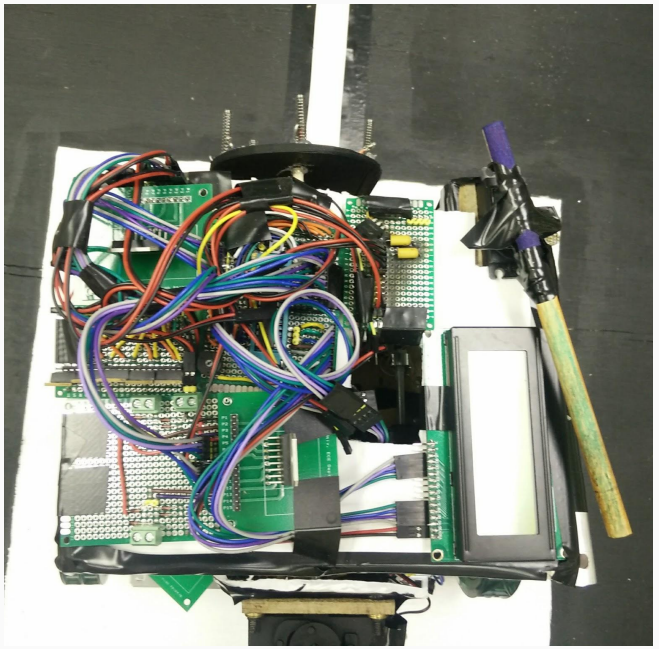


Modular Components and Spacing

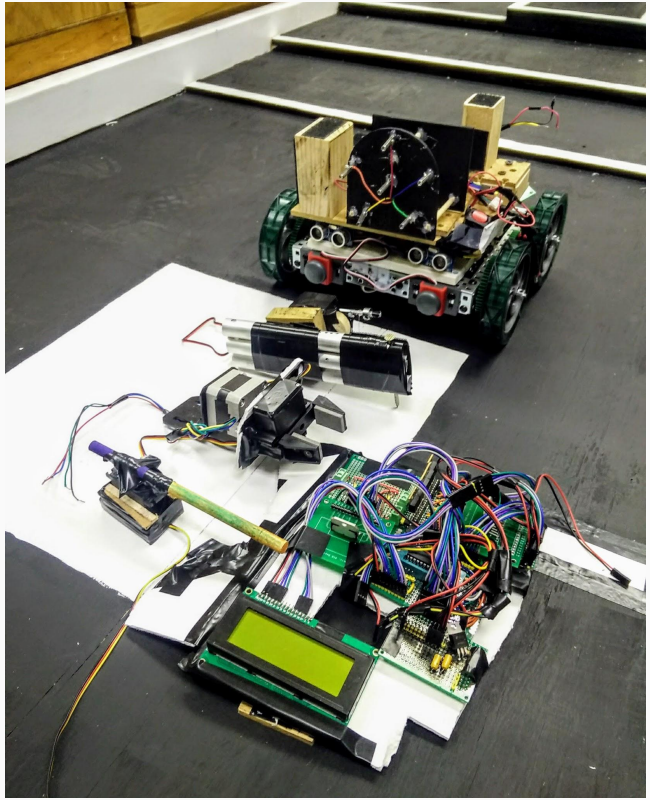
Top View Without Circuitry



Top View With Circuitry

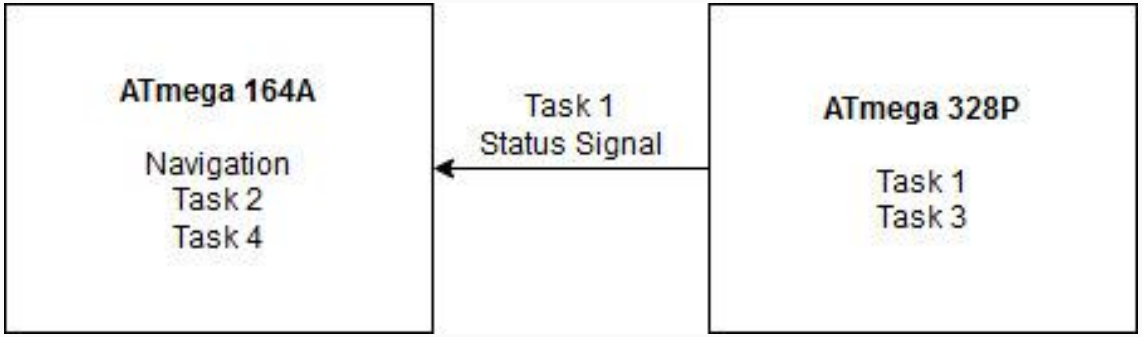


Modular Components



System Integration - Software

- Two microcontrollers needed due to I/O pin constraints
- ATmega 164A - 44 pins - Navigation, Tasks 2 and 4
- ATmega 328P - 28 pins - Tasks 1 and 3
- Minimal communication - operates using delays
- Task 1 status signal sent to Navigation



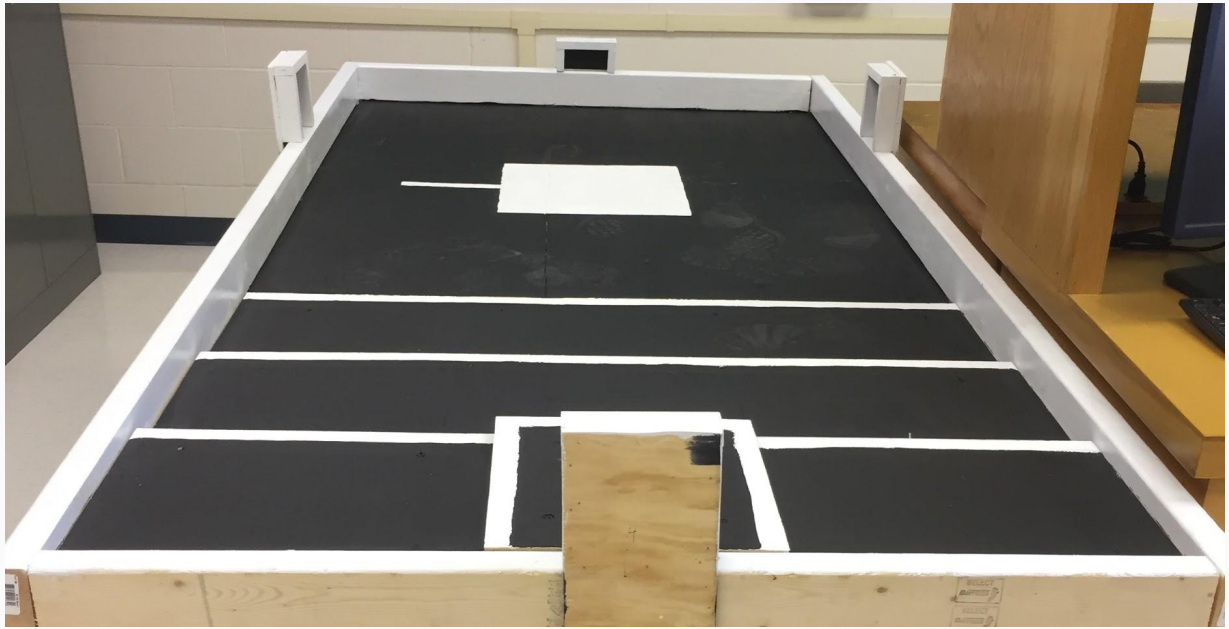
Project Management

Division of Labor

Team member	Significant Contributions
Daniel Hofstetter	Task 2
Brian Roskuszka	Task 3; Robot Design and Layout
Cameron McSweeney	Tasks 1 and 4; Circuit construction
Kendall Knapp	Navigation; Robot Design and Layout

Competition and Results

Testing for Competition

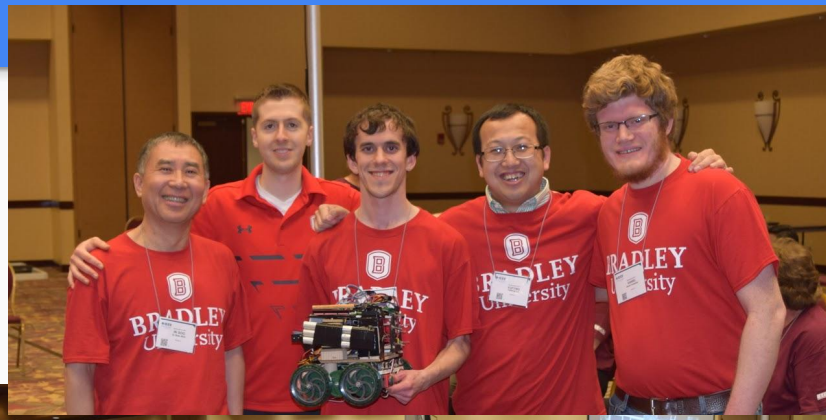


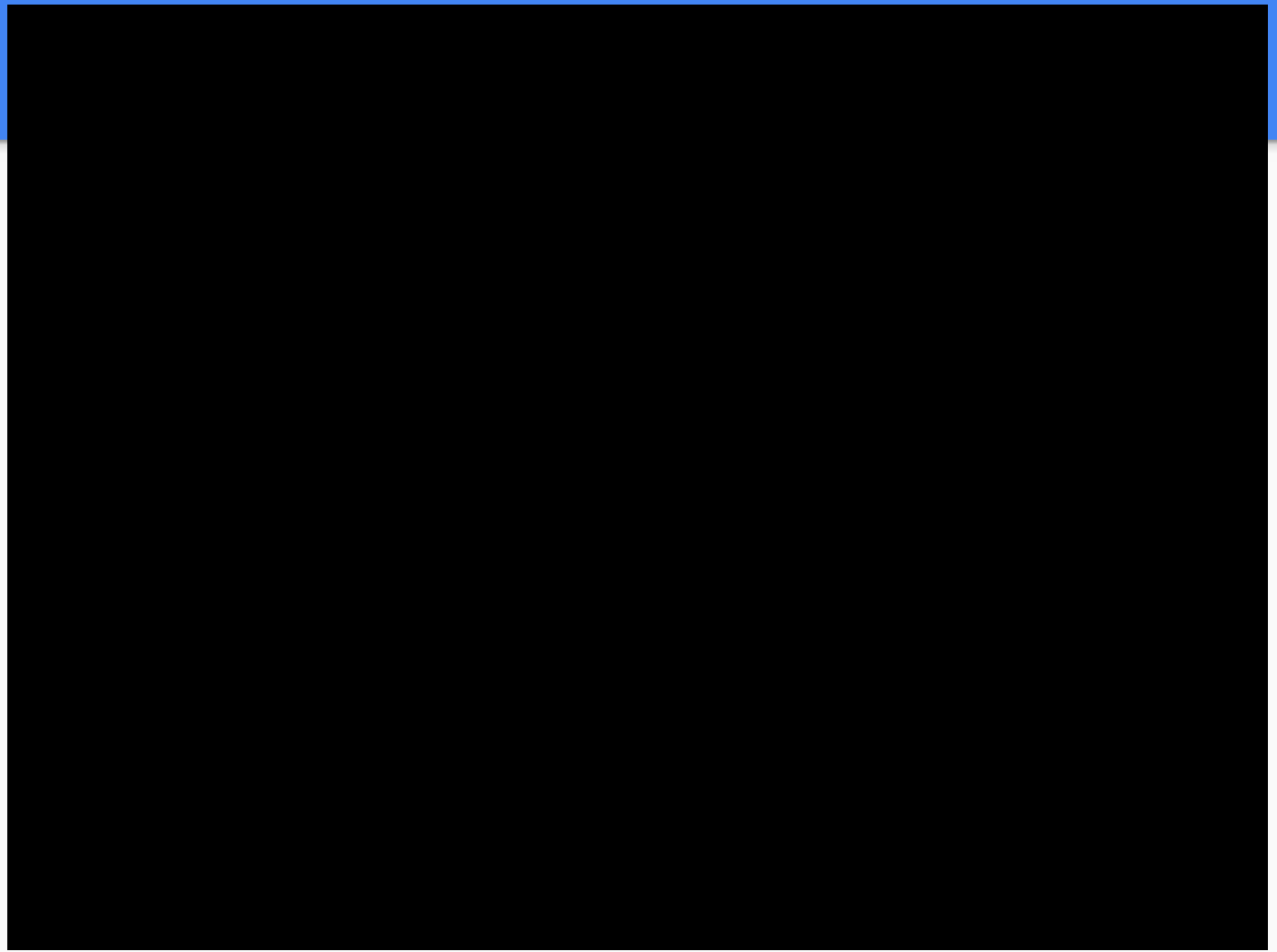
Testing Results and Changes

- At the Competition
  - Test vibration sensor more sensitive than official sensor: Made robot ram wall in lieu of dowel rod
  - Task 4 not aligned properly: Adjusted navigation slightly
  - Official stage 1 higher than test stage: Raised Task 1 hardware to correct height
  - Line following inconsistent: Reprogrammed to omit IR inputs
  - Task 3 did not align properly: Unresolved issue

Competition Results

- 3 rounds, ranked by total points
- 9th place out of 51 teams
- 2nd place in our division of 8





Discussion

Discussion

- Testing helped us solve problems before the competition that would have otherwise gone unnoticed
- Modular design worked well at the competition
- Vision system was too inaccurate and complex to implement on this project
- Last minute addition of the dart firing mechanism for Task 4 gained more points

Improvements

- Increase accuracy of navigation
  - Decrease looseness in gears
  - Improve IR sensor readings
- Solve alignment with Task 3 knob
- Improve method for rotating knob
- Implement vision system
- Increase inter-microcontroller communication

Conclusion

Conclusion

- Lessons Learned
  - Collaboration is key
  - Always plan time for unexpected delays
  - Be prepared for quick modifications
- Goals Completed
  - Applied classroom theory to a real-world project
  - Built teamwork and project management skills
  - Represented Bradley in IEEE
  - Presented in the Student Scholarship Expo

References

References

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[8] K. Winer, "Arduino sketch for MPU-9250 9DoF with AHRS sensor fusion,” github.com, Apr. 1, 2014 [Revised Jan. 10 2017 by B. Wilkins]. [Online]. Available: https://github.com/sparkfun/SparkFun_MPU-9250_Breakout_Arduino_Library. [Accessed Jan. 28, 2017].

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Parts List

Parts Cost - Totals

Arena:	$68
First Chassis:	$46
Final Chassis:	$0
Task 1:	$28
Task 2:	$22
Task 3:	$34
Task 4:	$9
Total:	$207

Parts List - Arena

• 2 Quarts Paint	$20
• Wood	$40
• Vibration Sensor	$3
• Rotary Encoder	$5
Total	$68

Parts List - First Chassis

•	2	Drive motors	On hand
•	8	Diodes - voltage protection	On hand
•	2	Caster wheels	$6.50
•	1	4’x8’ particle board - platforms	$20
•	1	Rotating Lazy Susan device	$4.50
•	1	Motor	On hand
•	2	Sonar distance sensors	On hand
•	1	Lead Acid battery	$15
Total			$46

Parts List - Final Chassis

•	1	Base Supports	On hand
•	1	Gears and Wheels	On hand
•	2	DC Motor	On hand
•	n/a	Velcro strips	On hand
•	1	2’x3’ Pegboard	On hand
•	1	3’ length of 2x4	On hand
•	1	Presentation Board	On hand
•	1	Roll of Electrical Tape	On hand
•	1	2” Dowel Rod	On hand

Total cost: $0

Parts List - Task 1

•	1	Linear Movement Stepper Motor	$20
•	6	Springs	On hand
•	5	Logic-level FETs	$5
•	1	Diode	On hand
•	1	LCD screen	On hand
•	1	2.2kΩ resistor	On hand
•	1	Proto-board	$3
•	1	Dual H-Bridge	On hand
Total			$28

Parts List - Task 2

• 1	Servo Motor	On hand
• 1	Magnetic Field Sensor	$16
• 1	Logic Level Converter	$6
• 1	Dowel Rod Arm	On hand
Total		$22

Parts List - Task 3

•	1	Gripper Kit	$16
•	1	Servo Motor	$10
•	1	Stepper Motor Mount	$8
•	1	Stepper Motor	On hand
•	1	Dual H-Bridge	On hand
Total			$34

Parts List - Task 4

• 3	Springs	$9
• 3	Pins	On hand
• 3	Barrels	On hand
• 1	DC Motor	On hand
Total:		$9