VRC High School - Reverse Engineering Challenge

Explore Dash

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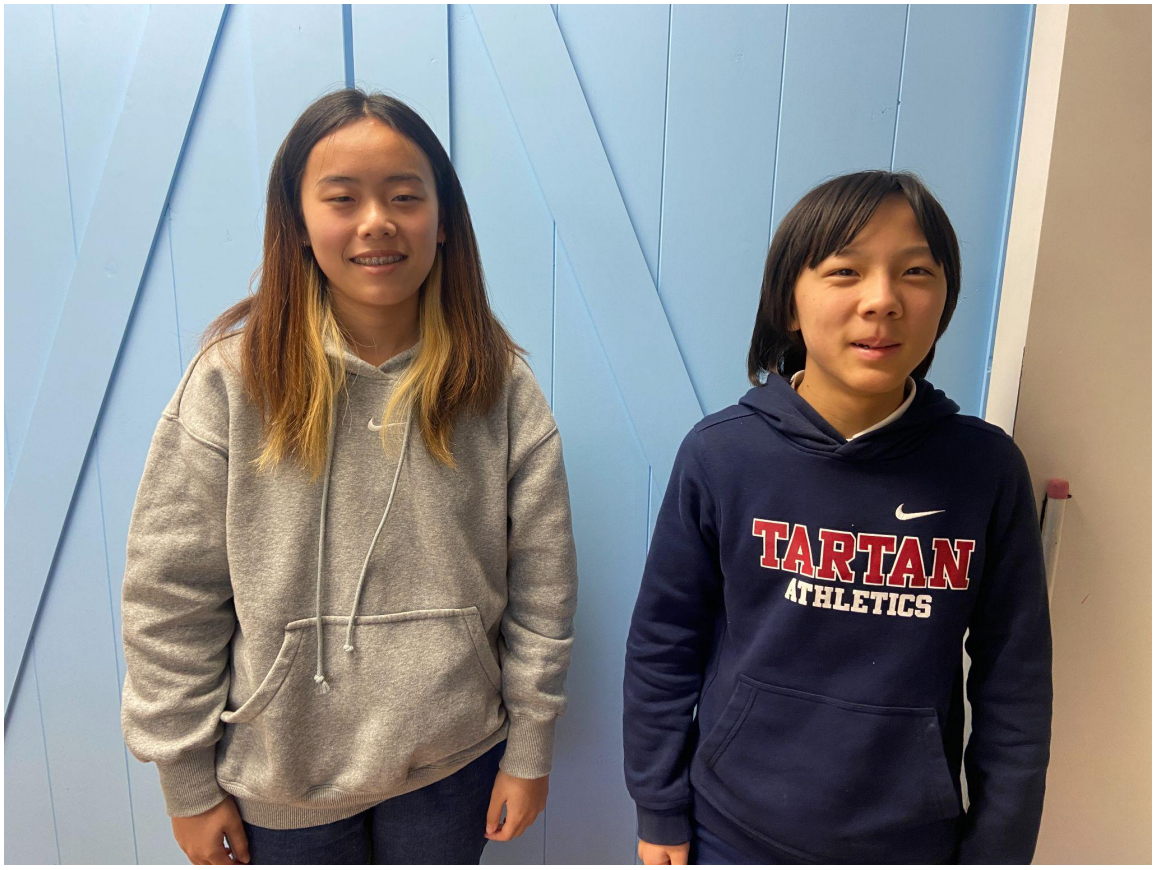
Introduction

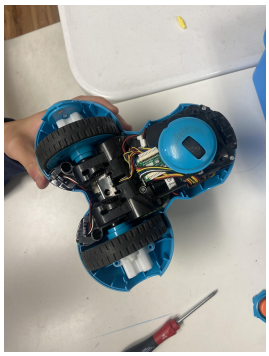
Our VEX team is made up of two members. We often work in a robotics lab containing students with different skill levels. While we are building our VEX Robotics Competition robot, we often see younger students play with robots that are pre-built and largely focused on programming rather than building.

Our robot is made up with aluminum channels, wheels, motors, etc. The design heavily relies on mechanics and we can tell by simply looking at it. The robot we are taking apart, Dash created by Wonder, on the other hand, has all the structures covered under the shell. It relies heavily on its electrical components. Curious about what is inside a modern day robot, we decided to take Dash apart to investigate it.

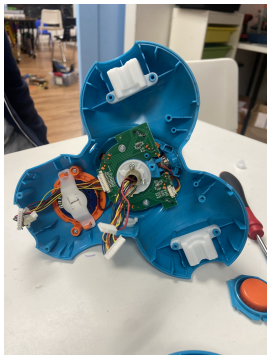
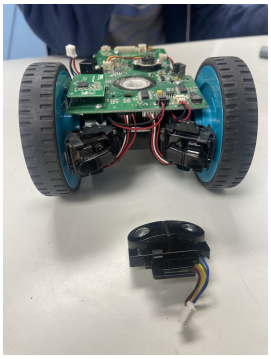


Steps of taking apart

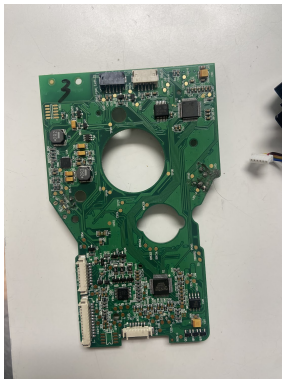
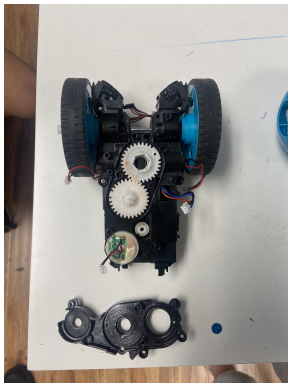
1. Unscrew the screws on the bottom shell and remove the bottom shell



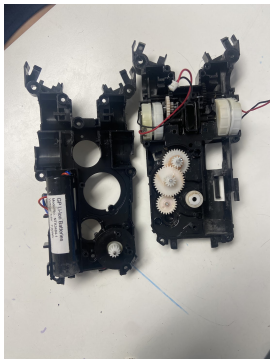
2. Unscrew more screws, take out the wires and then separate the motherboard from the shell along with wheels, wheel motors, and motor housings.

3. Separate the motherboard from other components

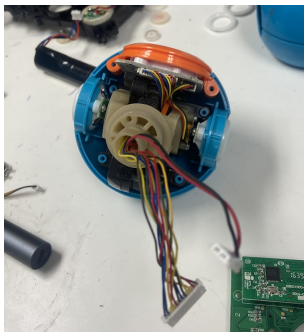



4. Separate wheels, motors and motor housings

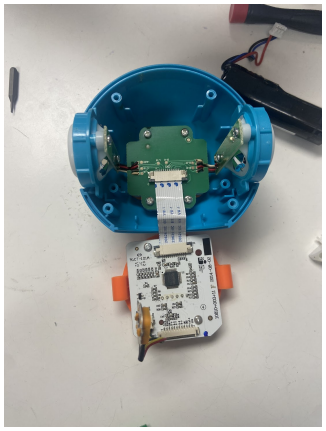


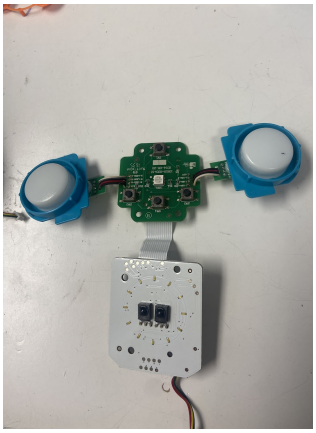
5. Separate speaker and infrared board from the bottom shell

6. Unscrew screws on the neck and separate the robot head from the body

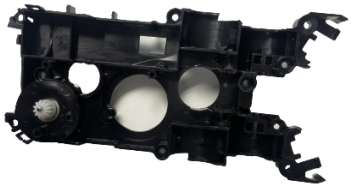


7. Split the dead shell into halves and take out head buttons and eye light board

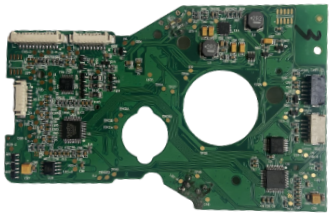
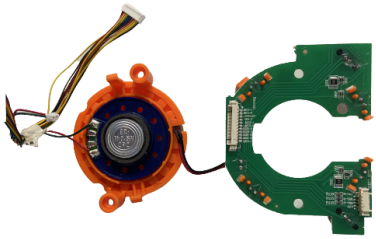
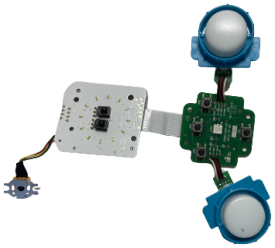




Non Electrical components

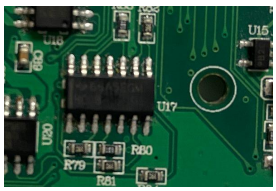
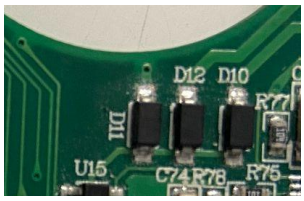
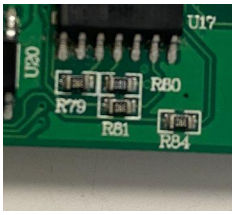
Picture	Name	Description
	Head	Top of the robot outfitted with 4 buttons, 12 LED eye and 2 colored LED ears
	Body	Main body of the robot outfitted with power buttons, chest LED, and drive train
	Wheel and axle	How to robot moved around, connected to the geared down drivetrain motors
	Buttons	Buttons for the user to interact with the robot on the top of his head or a power button on his side
	Motor housings	Housings to hold the motor and battery unit

Electrical components

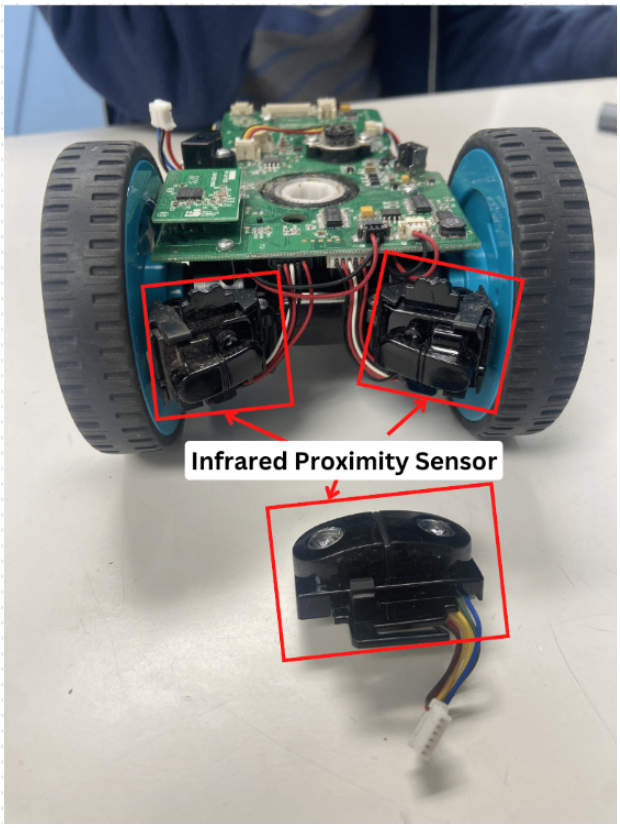
Picture	Name	Description
	Motherboard	Main brain of the robot, responsible for processing, power regulation, bluetooth, motor control, led control, microphone and speaker processing and more.
	Infrared sensor	Proximity sensors used to determine distances infront and behind the robot. Equipped with blinders to limit range
	Speaker and infrared board	Board responsible for speaker output along with infrared messages from other robots
	Head buttons and eye light board	Board in the robots head with 4 buttons for user input. Also controlls the 12 white LEDs for the eye.
	Battery	18650 Battery - 2200 mAh - 3.6V. Powers the entire robot

	Wheel Motors	Motors attatched to the wheel, used to move the main body of the robot.
	Neck Motors	Motors attached to the neck of the robot, used to move the head up and down

Surface mounted components

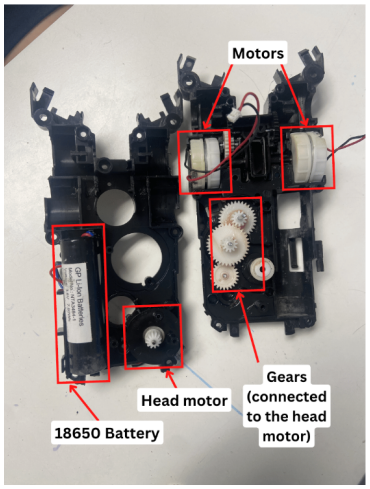
Picture	Name	Use and datasheet
	HC08 - Quadruple 2 input AND gates	AND gate that outputs true only if both inputs are true https://www.ti.com/lit/ds/symlink/sn54hc08-sp.pdf?ts=1673575834171&ref_url=https%253A%252F%252Fwww.google.com%252F
	2R2	Power inductor https://www.alldatasheet.com/datasheet-pdf/pdf/1411746/AITSEMI/2R2.html
	107A	Capacitor used to store a small amount of electricity https://www.alldatasheet.com/view_datasheet.jsp?Searchword=107A
	SED3	Surface mounted diode that only allows electricity to flow in one direction https://www.alldatasheet.com/view_datasheet.jsp?sSearchword=SED3&sPage=2&sField=0
	SMD resistors	Surface mounted resistors of 100 and 390 ohms of resistance https://datasheet.lcsc.com/lcsc/1811141352_Ever-Ohms-Tech-CR1206FR360P05R_C245443.pdf
	nRF51822	2.4 GHz Bluetooth microcontroller for communication to electronics https://infocenter.nordicsemi.com/pdf/nRF51822_PS_v3.1.pdf
	N572F072	23 MHz microcontroller for controlling motors and button inputs https://pdf1.alldatasheet.com/datasheet-pdf/view/1135201/NUVOTON/N572F072.html

Picture	Name	Use and datasheet
	6 Axis IMU	Used to determine position and motion from the robot. Critically important to accurate robot movements https://datasheet.octopart.com/MPU-6500-InvenSense-datasheet-138896167.pdf



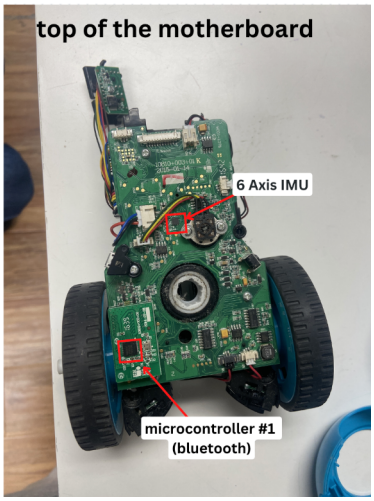
Findings

After disassembly and analyzing the components we found that modern robotics are quite different from other devices. Most of the logic and control is done within the microcontrollers on the board and it is impossible to track the flow of logic and power throughout the robot. We were able to identify several mechanical subsystems throughout the robot and identify the purpose of groups of components on the board.

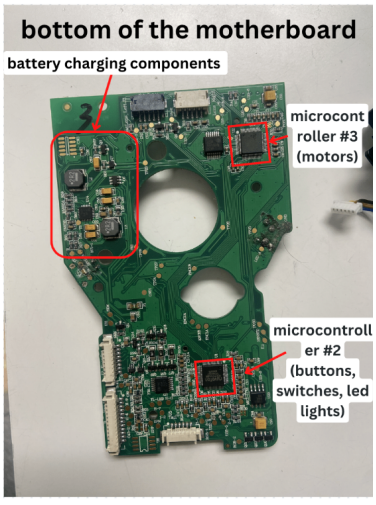


On the bottom of the robot sat the majority of the motors land mechanical abilities of the robot. There are 3 motors on the bottom, 2 dedicated to driving and 1 for the robots left and right head movement. Here is where the battery is also located.

In the middle of the robot sat the motherboard where we were able to identify the battery charging component, 3 different microcontrollers, the 6 axis IMU, and many others to control the robot.



The head of the robot contained many things. The first is the motor that controls the head's up and down movement. There was a board that connected to LED lights on the eyes and lights connected to both opposite sides of the head. The final thing in the head are 4 buttons, which can be used to execute commands.



Conclusion

In this project, we learned how to take a pre-built robot apart and found out the structures behind it. Compared to the competition robot we are working on right now, we saw how different structures serve for different functions. There are robots that heavily rely on mechanics, and there are also robots that rely more on electrical components. Although the focus of one robot might be leaning towards one area, the electrical components must work with the mechanical parts to make the robot function. Ultimately, this experience allowed us to explore different areas in robotics and led us to a better understanding of engineering. We look forward to implementing the takeaway from this challenge to further projects!

Sources and References

Data sheets

https://www.ti.com/lit/ds/symlink/sn54hc08-sp.pdf?ts=1673575834171&ref_url=https%253A%252F%252Fwww.google.com%252F

https://www.alldatasheet.com/datasheet-pdf/pdf/1411746/AITSEMI/2R2.html

https://www.alldatasheet.com/view_datasheet.jsp?Searchword=107A

https://www.alldatasheet.com/view_datasheet.jsp?sSearchword=SED3&sPage=2&sField=0

https://datasheet.lcsc.com/lcsc/1811141352_Ever-Ohms-Tech-CR1206FR360P05R_C245443.pdf

https://infocenter.nordicsemi.com/pdf/nRF51822_PS_v3.1.pdf

https://pdf1.alldatasheet.com/datasheet-pdf/view/1135201/NUVOTON/N572F072.html

https://datasheet.octopart.com/MPU-6500-InvenSense-datasheet-138896167.pdf

Robot disassembly

https://www.youtube.com/watch?v=ulEiazA4BUk

https://www.makewonder.com/

https://www.youtube.com/watch?v=HfPTajqroOI [13:20-20:00]