WINDOW CLIMBING ROBOT

VERTICAL ONE

WHAT ARE WE TRYING TO SOLVE?

Approximately 635,000 people pass away due to falling whether it be job-related such as construction or just trying to clean a high-up window.

Our project aims to help aid in reducing this number slightly by targeting the window washing industry by creating a robot that has the ability to climb windows in order to accomplish numerous tasks.

HOW WE ARE SOLVING IT

Our design considers the dangers of scaling high windows with dangerous crosswinds and eliminates the potential for human injuries or even death. By utilizing a suction cup design we will be able to securely attach the robot to the window without worrying about it detaching and falling down and becoming a hazard if it were using vacuum suction cups which require active power.

OBJECTIVES

ON A WINDOW	ON THE GROUND
1. Stick to a window 2. Move at a speed of 1.5 meters/min 3. Climb up 24 ft 4. Support a payload of half a pound	5. Move at a minimum of 3 meters/min 6. Remote control from 24 ft away via Bluetooth

WHY?

1. See title. 2. Half the speed of a robot built at the City University of Hong Kong [1] 3. Average Height of a 2 story building 4. Enough to carry a small bottle of cleaning solution	5. Should move faster on the ground since it doesn't need to stick to a window 6. To be able to control the robot when it is 2 stories up

BACKGROUND RESEARCH

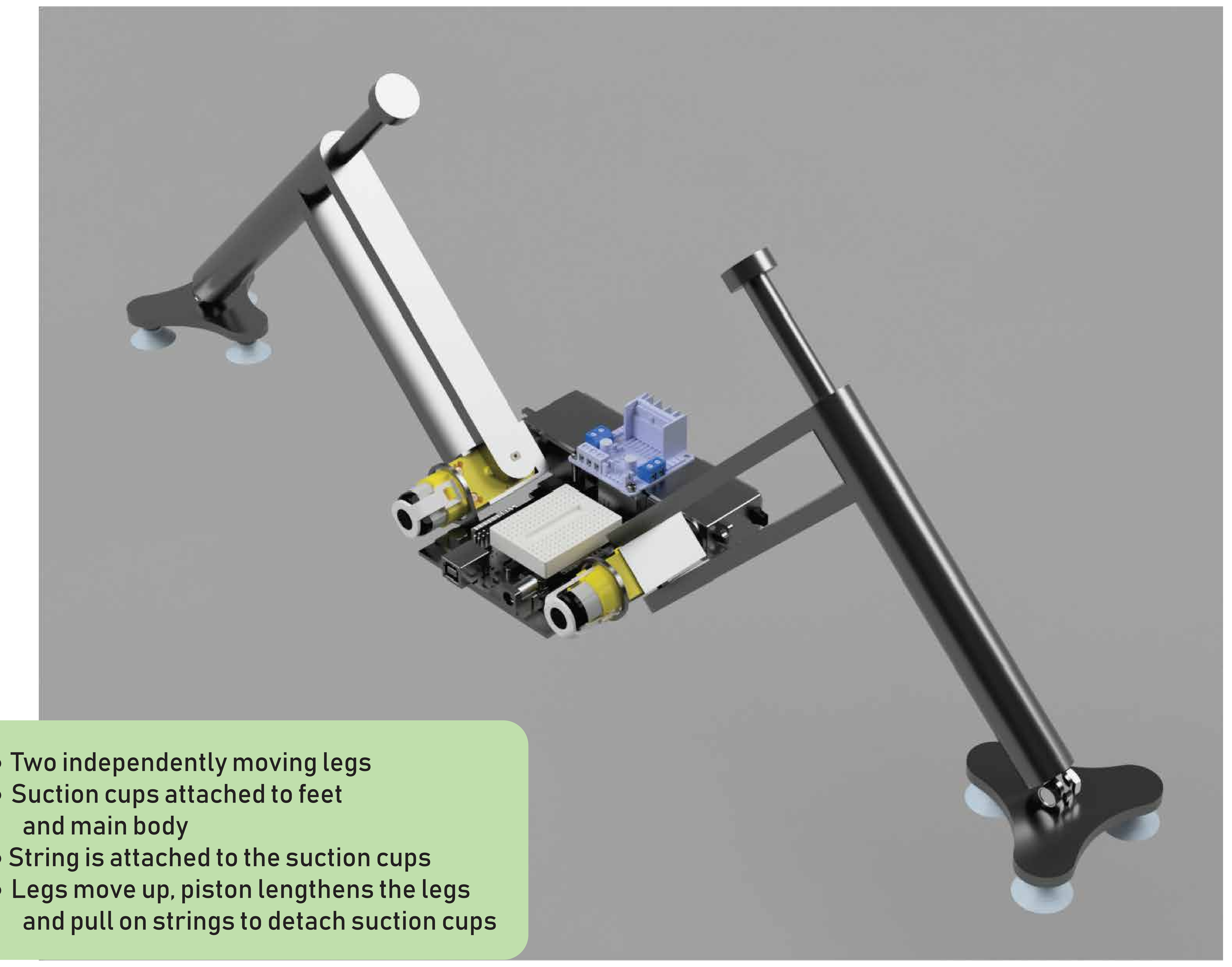
There are many window climbing robots on the market today that are available to consumers such as the "Climbatron Window Climbing Robot" sold on Amazon as a toy that 'walks' up the window. [2]

The commercial window climbing robots that currently exist use vacuum suction cups that require a pump to be continuously running. [3] Other designs that used active mechanisms include the VertiGo Robot from Disney Research that used two fans to generate enough directional thrust to adhere itself to any vertical surface. It also had four wheels making it an all-surface-orientation terrain vehicle. [4]

Our design is largely based on that of a Ritsumeikan University design. Suction cups are attached to a belt that act as the treads of the robot. [5]

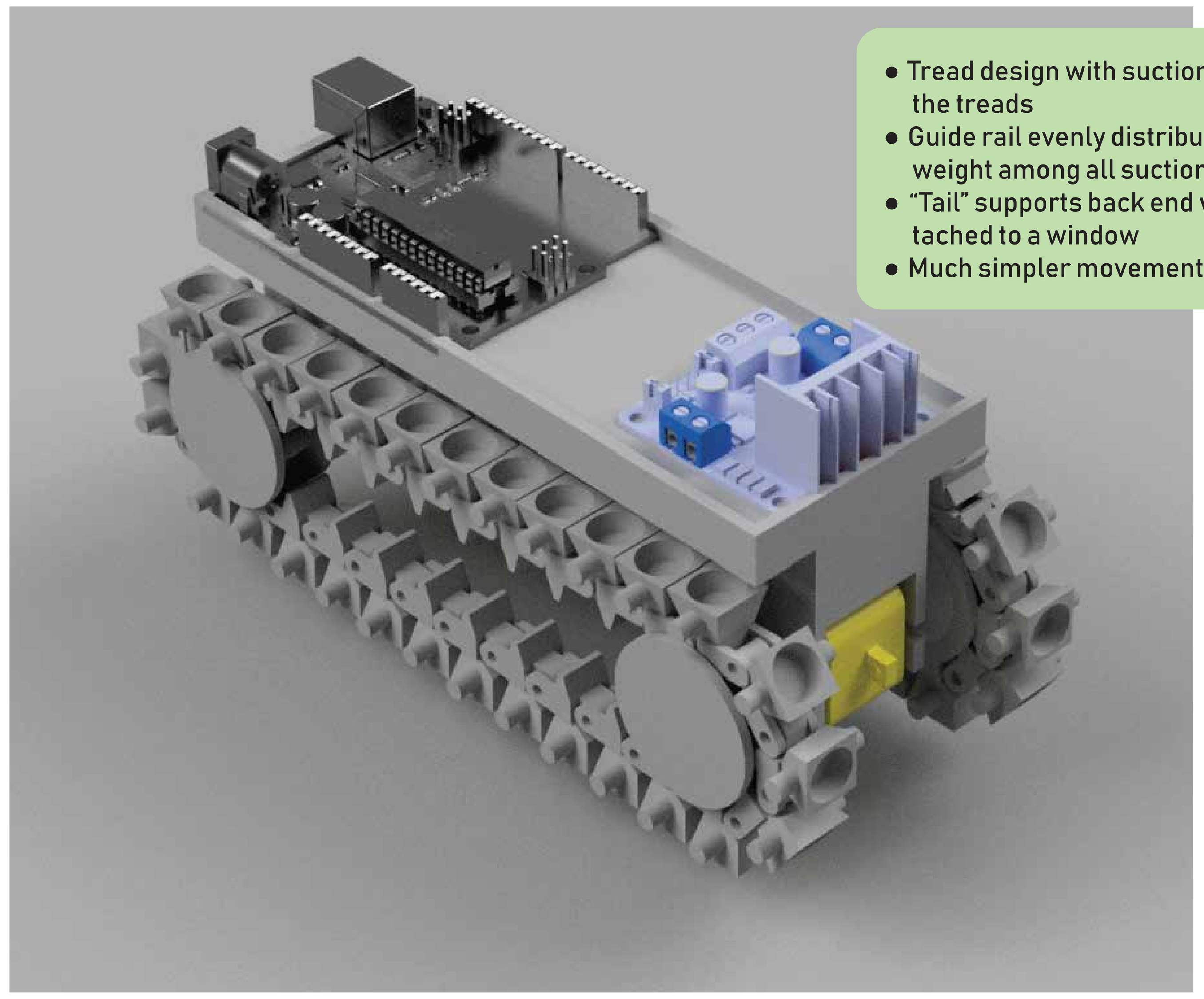
As the robot climbs the surface, since its center of mass is located above the surface, a moment (a torque) is created that wants to pull the robot off. To counteract this, a tail was added to generate a torque in the opposite direction. Another solution to this problem was to also add a support rail that would distribute the force on the suction cups evenly. [5]

PROTOTYPE 1



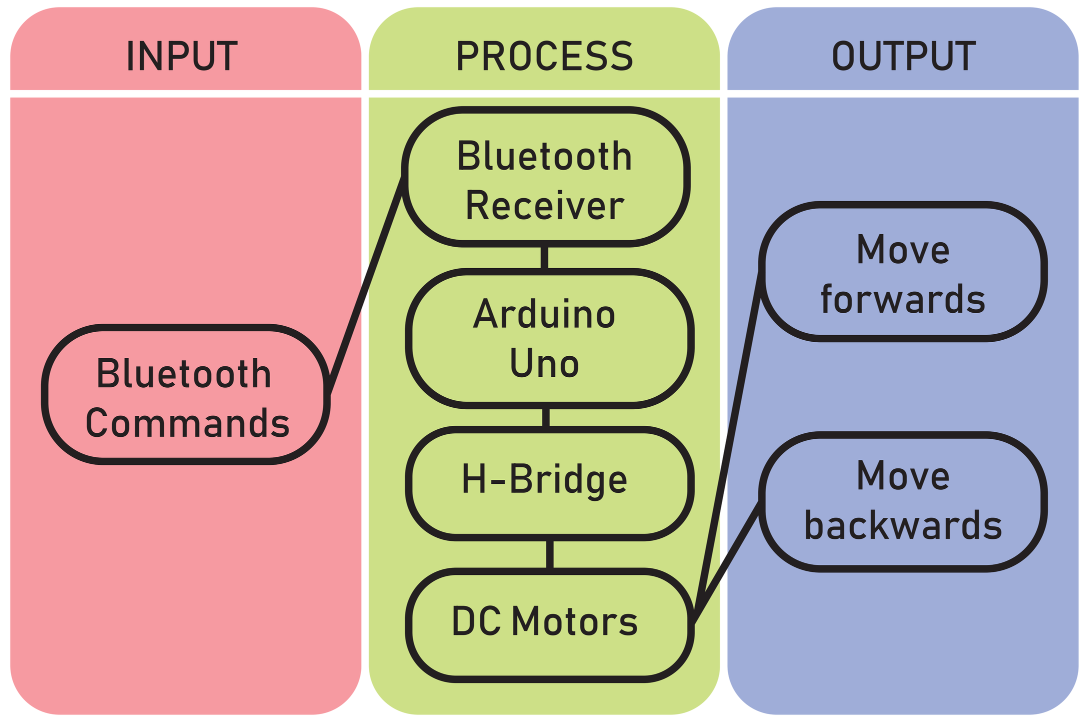
- Two independently moving legs
- Suction cups attached to feet and main body
- String is attached to the suction cups
- Legs move up, piston lengthens the legs and pull on strings to detach suction cups

PROTOTYPE 2

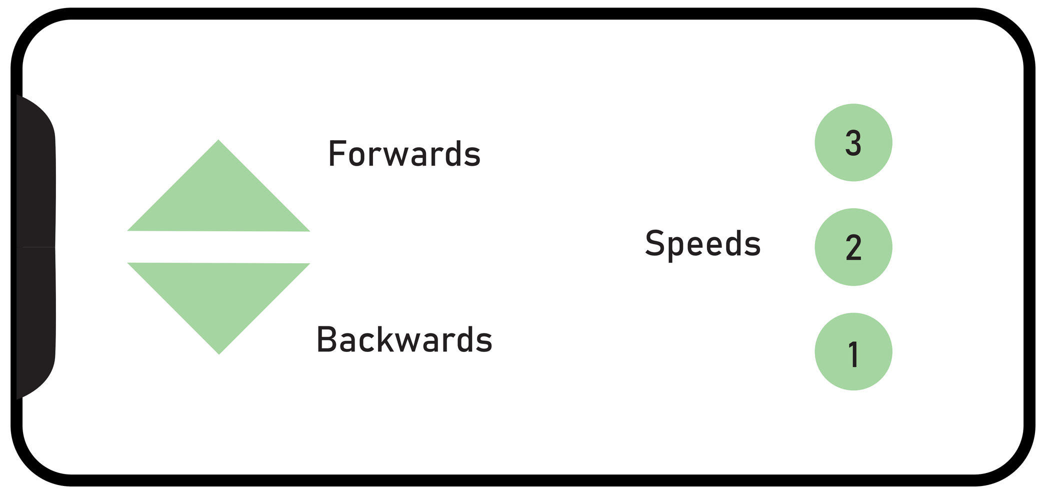


- Tread design with suction cups on the treads
- Guide rail evenly distributes the weight among all suction cups
- "Tail" supports back end when attached to a window
- Much simpler movement

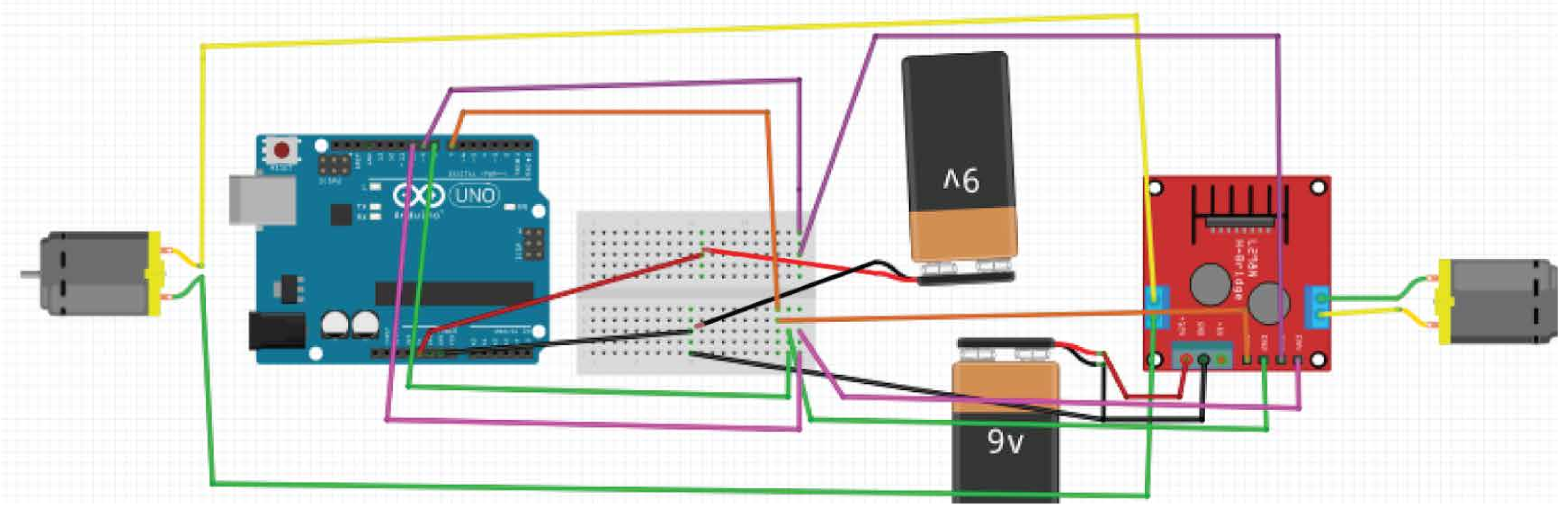
INPUT/OUTPUT DIAGRAM



APP CONTROLS



ELECTRICAL SCHEMATIC



RESULTS

We were able to achieve certain goals such as being able to carry a payload, exceed our objective of reaching 3 meters per minute on the ground, and be remote controlled via Bluetooth from a distance of at least 24 m. However, due to time constraints, we could not ultimately climb a window.

CONCLUSION

In review, one of our largest hurdles was the manufacturing of our parts using the 3D printers. They would frequently fail and ate up a lot of time in restarting and watching the print.

Halfway through, our first prototype was scrapped due to the unexpectedly complicated walking motion that could not be completed in time. For our latest design, the next steps are printing the remaining necessary parts, assembling, and testing it.

REFERENCES: [1] Sun, Dong, et al. A Climbing Robot for Cleaning Glass Surface with Motion Planning and Visual Sensing. A Climbing Robot for Cleaning Glass Surface with Motion Planning and Visual Sensing, https://pdfs.semanticscholar.org/20a7/9cd5462d990e149ace76a7d375bbc0df8475.pdf.
[2] "Climbatron Window Climbing Robot." Amazon, Amazon, www.amazon.com/Climbatron-Window-Climbing-Robot/dp/B00CF49564.
[3] The Sydney Morning Herald, The Sydney Morning Herald, 11 Sept. 2018, www.smh.com.au/technology/winbot-x-review-robot-window-cleaner-impressive-not-that-effective-20180907-p502at.html.
[4] "VertiGo Robot." Disney Research, www.disneyresearch.com/publication/vertigo/.
[5] Yoshida, Y., & Ma, S. (2011, December). A wall-climbing robot without any active suction mechanisms. Retrieved March 16, 2019, from https://ieeexplore.ieee.org/document/6181587

ACKNOWLEDGEMENTS: S/O to Andrew Wolfram , our lovely TA who has helped guide our group and allowed us to reach where we are today. Additional S/O to Amanda Nguyen, our awesome EPE who has bestowed upon us her natural passion for engineering.