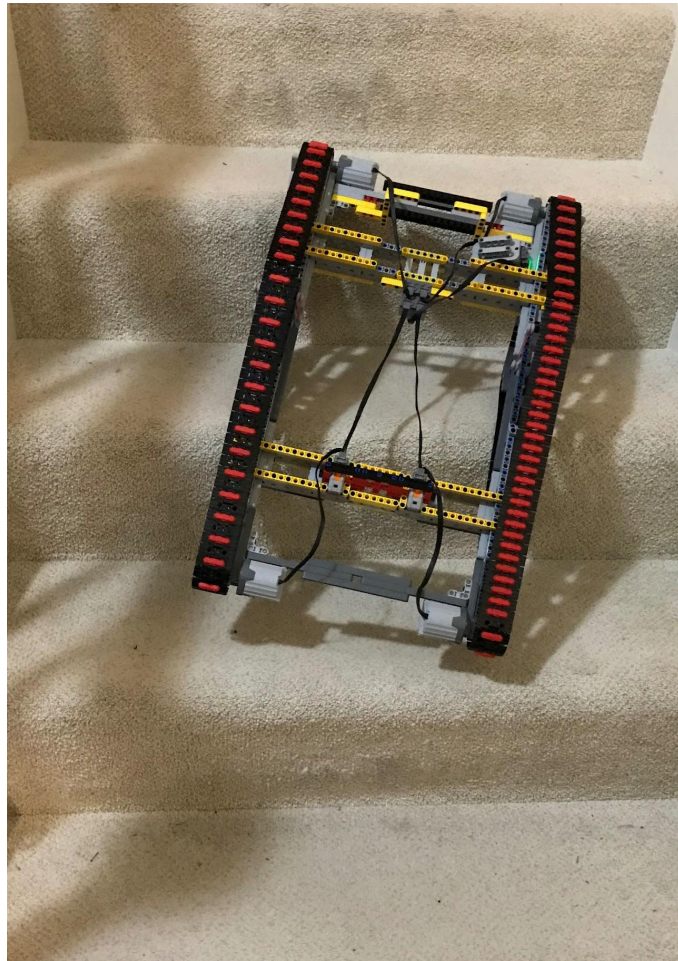


How do different types of robots perform while climbing stairs?

Robot Uprising



School

-Block

Wednesday, January 23, 2019

Abstract

The purpose of this experiment was to determine how different types of robots perform while climbing stairs. In the last decade, stair climbing robots have taken up an important role in militaries, and security agencies around the world, allowing robots to navigate areas with ease, and steady designs can ascend stairs with loads that humans can not. As a result. Despite this, there is still limited research relating to the field, and only a few designs are being used, despite their numerous downsides, making this experiment very useful since it tests and evaluates new stair climbing designs. The experiment tested 3 different designs of stair climbing robots built with LEGO, EL3VATOR, TIN3Y, and Y3LLOW, and evaluated them based on their speed, and ability to keep straight, and stay level with the ground. It was hypothesized that, if different types of stair climbing robots are used to climb stairs, the EL3VATOR robot will perform the best in stability and keeping straight because it lines itself up on each stair and stays level during its programmed sequence, but it will be outperformed in time by TIN3Y, due to EL3VATOR's long alignment process. The hypothesis was tested by building stairs out of cardboard boxes, and using MINDSTORMS EV3 sensors to collect data during the climb. The hypothesis proved to be correct, as EL3VATOR, on average, kept the straightest, and stayed the most level with the ground, despite this, it was far inferior to TIN3Y when it came to speed. Y3LLOW failed to ascend the stairs at all, as it lacked the power to do so.

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Introduction

The purpose of this project was to find out which type of robot stair climber performed the best while climbing stairs.

Problem

How do different types of robot stair climbers perform while climbing stairs?

Hypothesis

If different types of stair climbing robots are used to climb stairs, the EL3VATOR robot will perform the best in stability and keeping straight because it lines itself up on each stair and stays level during its programmed sequence, but it will be outperformed in time by TIN3Y, due to EL3VATOR's long alignment process.

Review of Literature

A robot is something reprogrammable and multi-functionally designed to move things through programmed motions to perform different tasks. These robots work by using parts called effectors, which are tools that can be put on a robot to control it. Most effectors are used for whatever a robot needs to do. Some robots use different tools than others do because they are doing different tasks, or doing those tasks in a different way. The size of the wheels on a robot greatly affect how a robot works. The bigger the tire is, the slower acceleration it will have. Small tires will have a faster acceleration because motors generate a spinning force called torque, which makes the wheels push. A bigger pushing force results in a faster acceleration. The relationship between torque and force is: $\text{Force} = \frac{\text{Torque}}{\text{Distance from Center to Edge of Wheel}}$. The longer the radius of the wheel is, the smaller force there will be with the same amount of torque. Therefore, the larger the wheel, the smaller the force, meaning it will have a slower acceleration. Robots usually use motors in order to enable them to move around. A motor can only create a certain amount of power to make the wheel spin. Because of this the motor must trade off this power between torque, the amount of force which the motor can turn the wheel, and speed, the rate at which the wheel turns.

There are many different types of robots. Stair climbing robots, in particular, are very useful, and can be applied in many situations as military or security robots in places where stair climbing is essential to the mission. They can also walk around on normal terrain, if needed. There are many ways to make a robot climb stairs. Treads are very useful, as they can be used to

carry heavier loads, but what is used on the robot can depend on many things, including what the stairs are made out of and the dimensions of the stairs.

Stairs can be made of many things. Roller-compacted concrete, or R.C.C, is the second most common material. Steel is the most common. Some stairs may have a 40 to 60 mm concrete cover on them. The dimensions of stairways are heavily regulated. If the riser and tread dimensions are not within 4 to 7 inches and 11 to 14 inches, or if the tread depth of the stairs causes missteps, then the stairs will need to either provide a warning or be redesigned.

An easy and generally inexpensive way to make robots is by using LEGO. Most LEGO are made from a plastic called ABS, though some rare pieces are made from elastic parts which include materials called SBS or SEBS. There are many types of lego pieces, but the most important ones are the connector pieces. The LEGO TECHNIC connectors are what make the LEGO TECHNIC pieces fit together. They come in different sizes and resemble things like nails, staples, screws, bolts, and other items that may hold a structure together. Connector is a term which covers various different pieces that connect one piece to another piece. There are more connectors than any other type of piece.

When it comes to stair climbing, there are lots of differences between wheels and tracks, and deciding on the best type of locomotion depends on many factors. Some of these factors are the traction, ground pressure, suspension, and steering. Wheels have better traction, but for the best results, the terrain must be considered. Tracks are the better choice when you need to alleviate ground pressure, because tracks have a lower ground pressure than wheels, making them better suited for soft surfaces. Larger tires can be used with soft surfaces, but large tires do

not work all the time, as they can be limited by elements such as snow. Making a suspension system for a tracked robot is more difficult than building one for a wheeled robot. Suspension systems are important to traction, because they keep the tracks or wheels on the terrain. Wheels are much better at steering than tracks, and this can be translated much better maneuverability for the wheels.

Materials

- LEGO 31313 MINDSTORMS EV3 Set
- LEGO 42055 Technic Bucket Wheel Excavator Set
- LEGO 45544 MINDSTORMS Education EV3 Core Set
- LEGO 45560 MINDSTORMS Education EV3 Expansion Set
- 1 computer
- 1 roll of black electrical tape
- 6 pre-assembled 60.96 cm x 60.96 cm x 15.24 cm cardboard boxes
- 2 SBrick's
- 1 mobile device with the SBrick app
- 4 PF XL motors
- 2 Large PF Battery Boxes
- 1 roll of silver duct tape
- 1 roll of packing tape

Procedure

1. Gather all materials (see materials list)
2. Build the three robots, TIN3Y, Y3LLOW, and EL3VATOR, found in Appendix A.
3. Install the EV3 programming software, downloaded from lego.com.
4. Download the programs in Appendix A, and download each program to the corresponding robot using the EV3 programming software.
5. Construct a stairway by using the packing tape to tape the boxes together in a step and stairway pattern so that there are three steps, and the third step is twice as deep as the others, making sure to cover the entirety of each stair with the tape, and put 2 strips of silver duct tape on the corner of each stair.
6. Tape the edge of the white paper to the bottom of the bottom stair, and put a full line of black electrical tape on the ground parallel to the stairway at the edge of the paper, and put a second full line of black electrical tape at the beginning of the top of the third step.
7. Put TIN3Y facing towards the stairs, so that the color sensor on TIN3Y is above the center of the line of tape. Press the middle button on the EV3 brain brick, and step away from the robot.
8. Allow the robot to climb the steps.
9. Record the timer and rotation sensor data displayed on the screen of the EV3 brain brick.
10. Repeat steps 5-9 for 5 more trials.
11. Repeat steps 7-10 for Y3LLOW, and EL3VATOR.

Variables

Independent Variable:

Type of Robot

Dependent Variables:

Time Elapsed

Maximum Horizontal Angle

Maximum Vertical Angle

Controlled Variables:

Stair Properties

Data Collection Methods

Light Intensity

Battery Charge Level

Data

Robot Name	Trial 1: Time Elapsed (Seconds)	Trial 2: Time Elapsed (Seconds)	Trial 3: Time Elapsed (Seconds)	Trial 4: Time Elapsed (Seconds)	Trial 5: Time Elapsed (Seconds)	Trial 6: Time Elapsed (Seconds)	Average: Time Elapsed (Seconds)
EL3VATOR	45.82	48.62	54.08	58.19	48.8	49.67	50.86
TIN3Y	7.31	6.72	6.79	7.01	6.61	6.78	6.87
Y3LLOW	FAIL	FAIL	FAIL	FAIL	FAIL	FAIL	FAIL

Table 1: Time elapsed during the climbs

Robot Name	Trial 1: Maximum Angle (Vertical)	Trial 2: Maximum Angle (Vertical)	Trial 3: Maximum Angle (Vertical)	Trial 4: Maximum Angle (Vertical)	Trial 5: Maximum Angle (Vertical)	Trial 6: Maximum Angle (Vertical)	Average: Maximum Angle (Vertical)
EL3VATOR	3°	4°	3°	6°	7°	4°	4.5°
TIN3Y	33°	30°	29°	29°	30°	29°	30°
Y3LLOW	FAIL	FAIL	FAIL	FAIL	FAIL	FAIL	FAIL

Table 2: Maximum vertical angle during the climbs

Robot Name	Trial 1: Maximum Angle (Horizontal)	Trial 2: Maximum Angle (Horizontal)	Trial 3: Maximum Angle (Horizontal)	Trial 4: Maximum Angle (Horizontal)	Trial 5: Maximum Angle (Horizontal)	Trial 6: Maximum Angle (Horizontal)	Average: Maximum Angle (Horizontal)
EL3VATOR	5°	8°	8°	6°	13°	5°	7.5°
TIN3Y	13°	6°	6°	11°	7°	12°	9.16°
Y3LLOW	FAIL	FAIL	FAIL	FAIL	FAIL	FAIL	FAIL

Table 3: Maximum horizontal angle during the climbs

Results

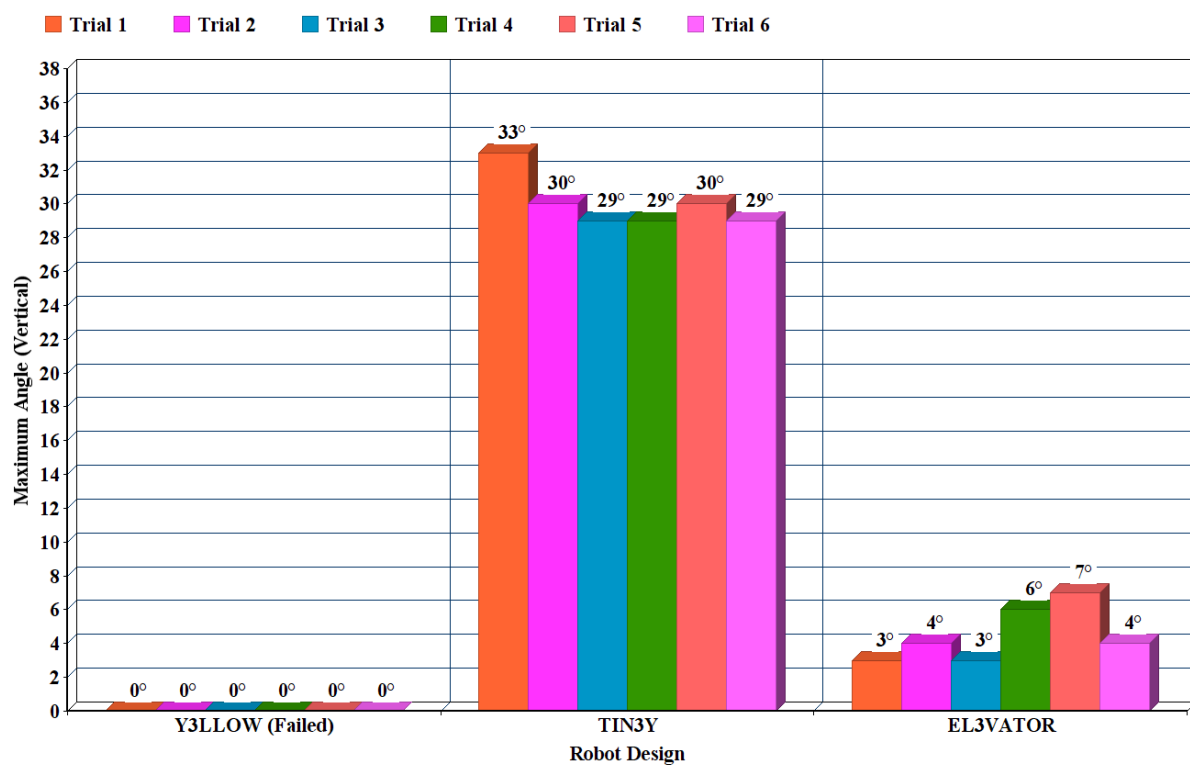


Figure 1: Maximum vertical angle during the climbs

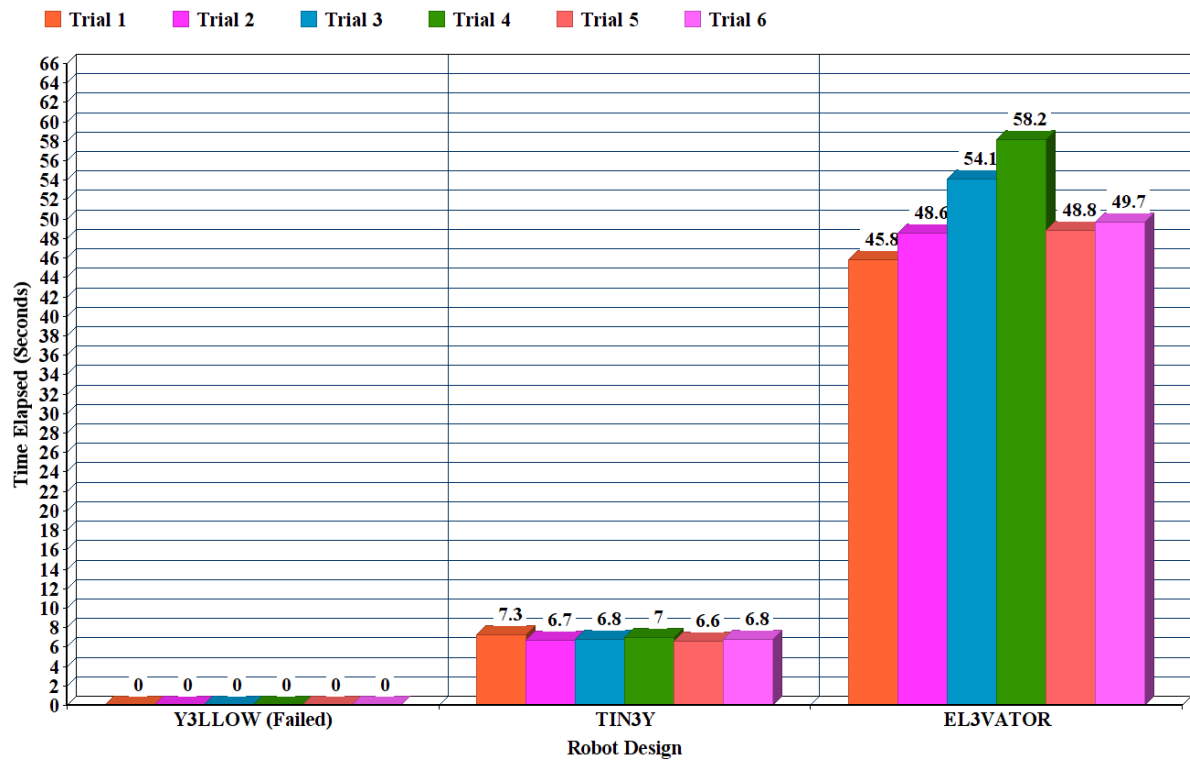


Figure 2: Time elapsed during the climbs

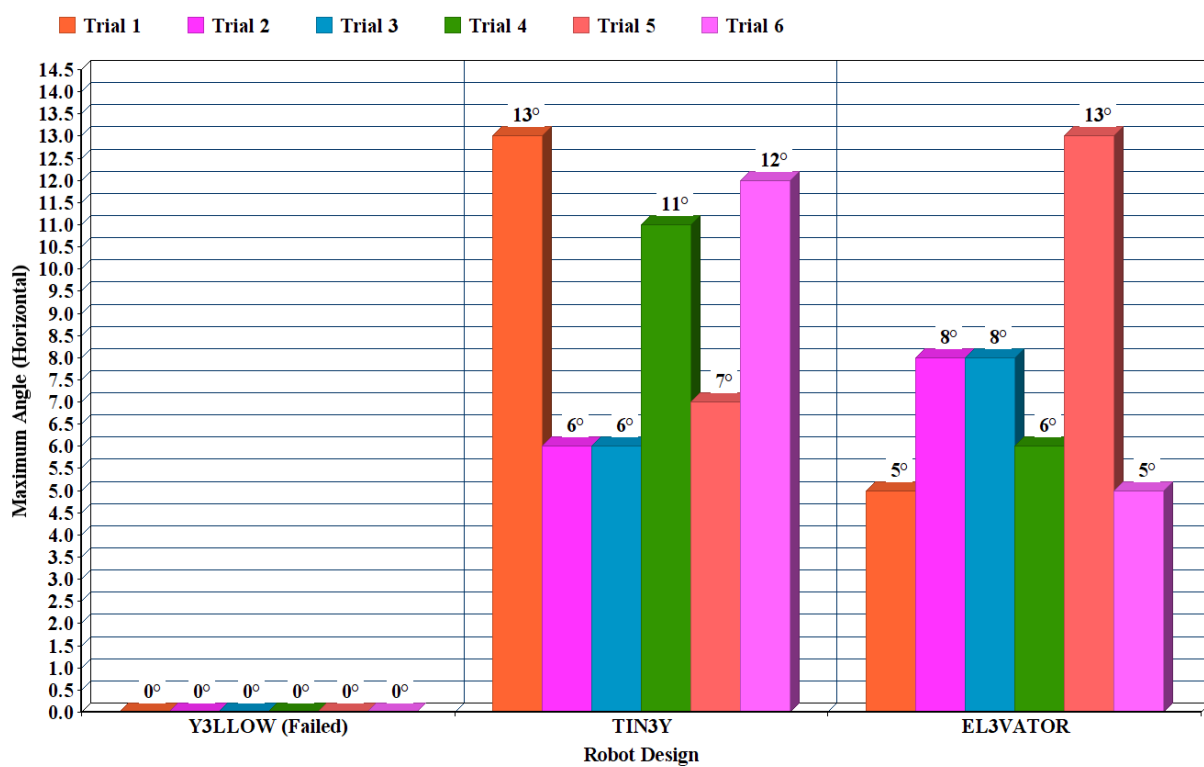


Figure 3: Maximum horizontal angle during the climbs

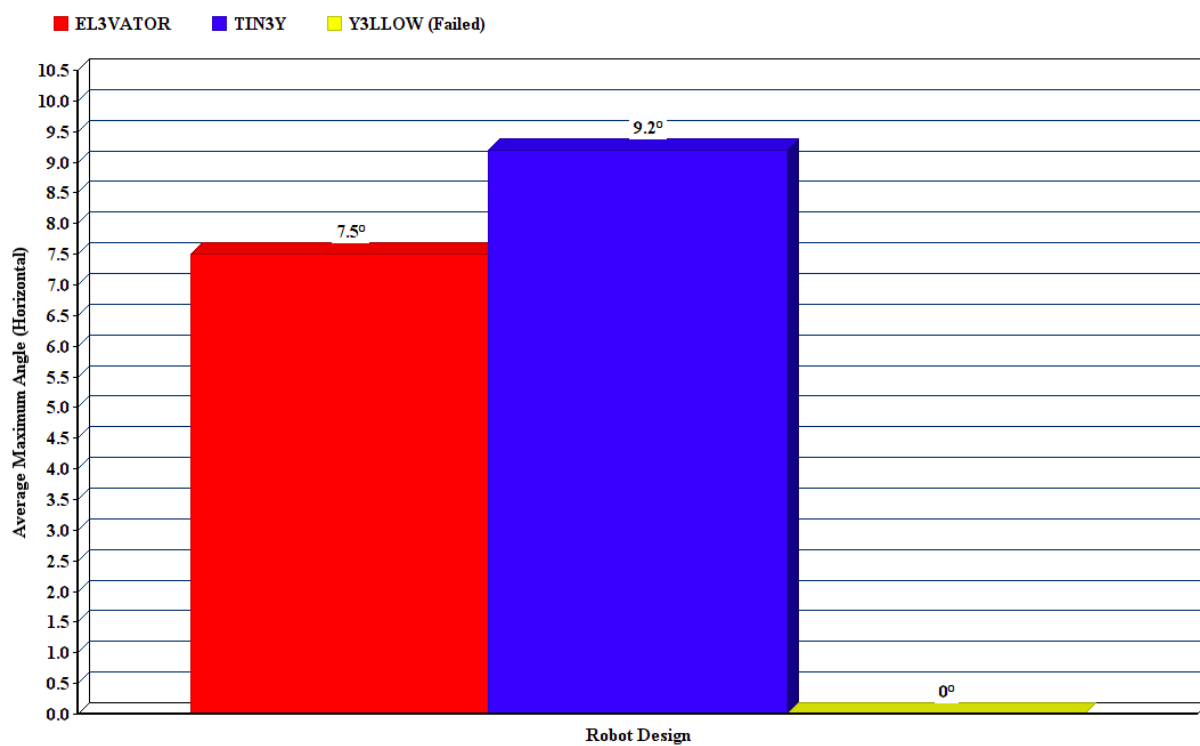


Figure 4: Average of the maximum horizontal angles during the climbs

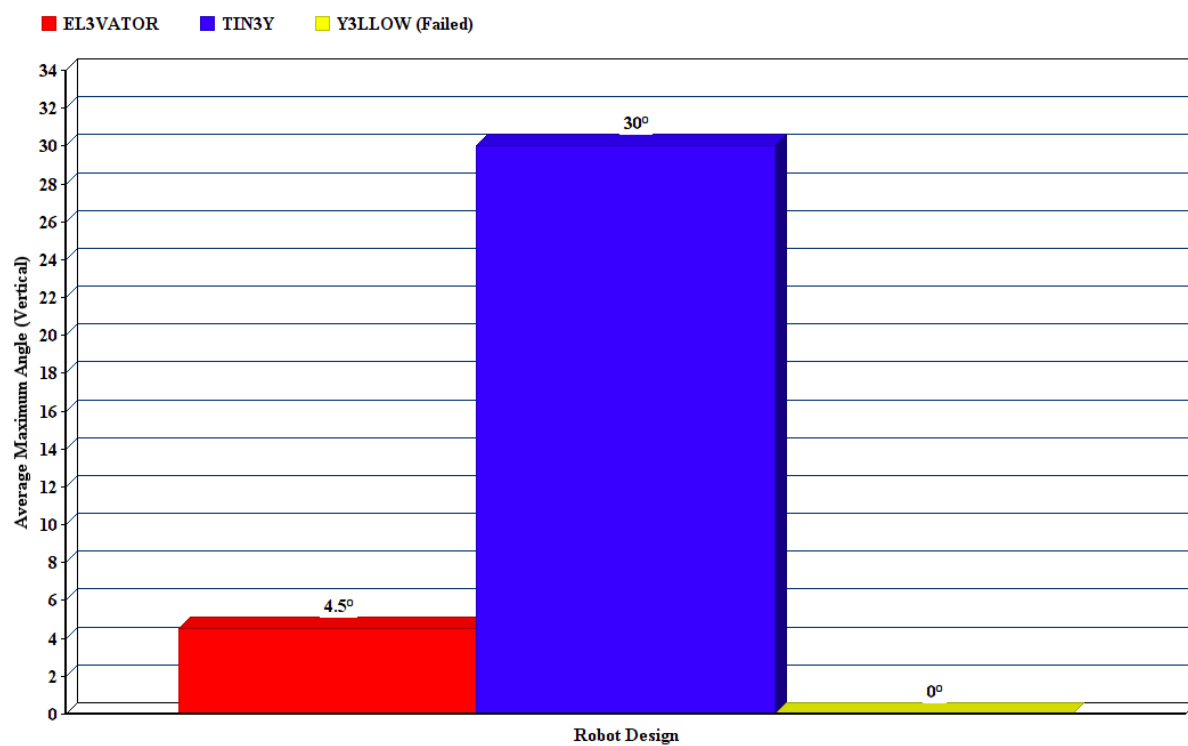


Figure 5: Average of the maximum vertical angles during the climbs

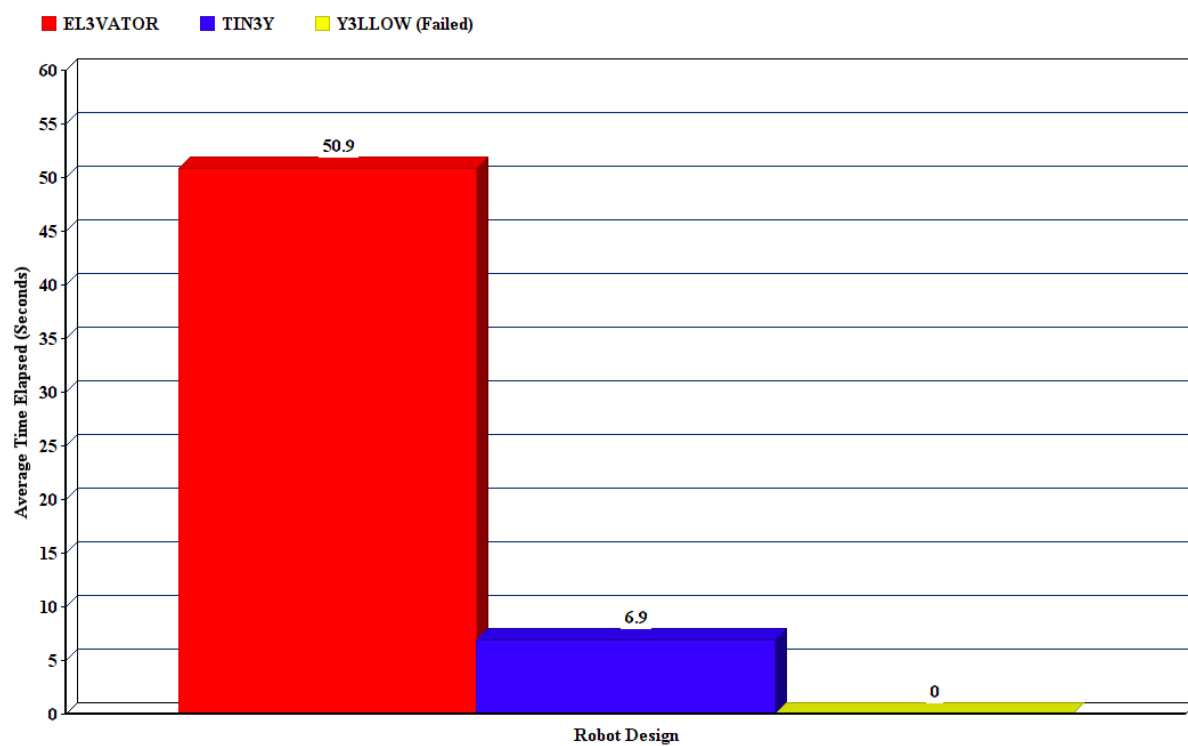


Figure 6: Average time elapsed during the climbs

Conclusion

It was hypothesized that, if different types of stair climbing robots are used to climb stairs, the EL3VATOR robot will reach the lowest maximum horizontal and vertical angles, because it lines itself up on each stair and stays level during its programmed sequence, but it will be outperformed in time by TIN3Y, due to EL3VATOR's long alignment process. This was proven to be correct, as EL3VATOR was significantly slower than TIN3Y when ascending stairs, but had significantly lower vertical angles, and slightly lower horizontal angles. The Y3LLOW robot performed the worst, as it was unable to ascend the stairway due to its dimensions.

Discussion

If conducting this experiment again, it would be recommended to attempt the experiment on different kinds of stairs, since that would make the data more accurate. It would also be recommended to modify the design for Y3LLOW, to allow it to climb up the stairs used, as it was not able to do so with the current design, which therefore diminished the amount of data that was collected. It would also be suggested to include additional robot designs and trials, as this would greatly increase the accuracy and amount of data collected. Additionally, the EV3 brain brick being used to collect data proved to be heavy, causing the robots to be less mobile, so if the experiment was done again, it would be useful to use a lighter source for processing power.

Real World Application

Stair climbing robots can be applied for military and security purposes in urban environments when stair climbing and mobility is important to the task or mission at hand. Because the robot is not only a stair climbing robot, it can also be used in areas and on terrain where normal wheeled robots would generally operate. Stair climbing robots can also be used for caregiving for older people, as they can maneuver all around the house and alert someone if something goes wrong. This is important because most robots would not be able to get onto another floor without being carried. Another thing stair climbing robots are beneficial for is allowing wheelchairs to climb the stairs. This is important because wheelchair users generally have to install an elevator in their house, which can be costly, since they otherwise cannot get up the stairs. However, with stair climbing technology, expensive elevators do not need to be installed as their wheelchair can climb the stairs for them.

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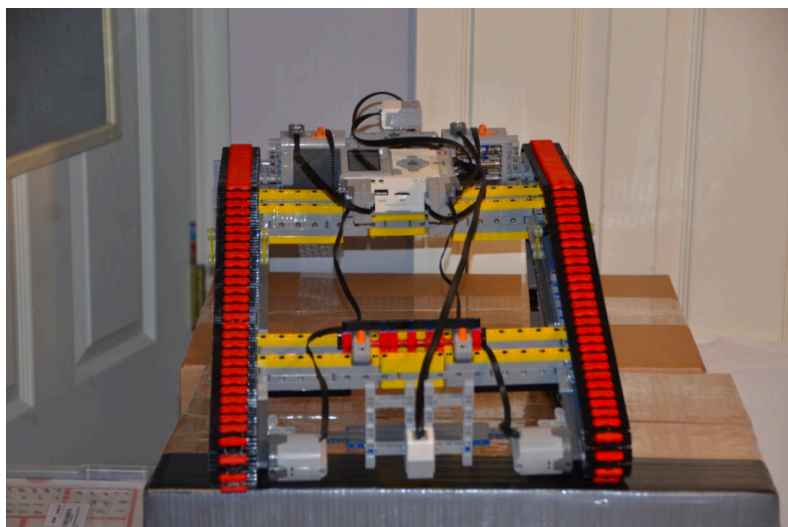
<https://www.intorobotics.com/wheels-vs-continuous-tracks-advantages-disadvantages/>

Appendix A

Robot Designs and Programs

TIN3Y

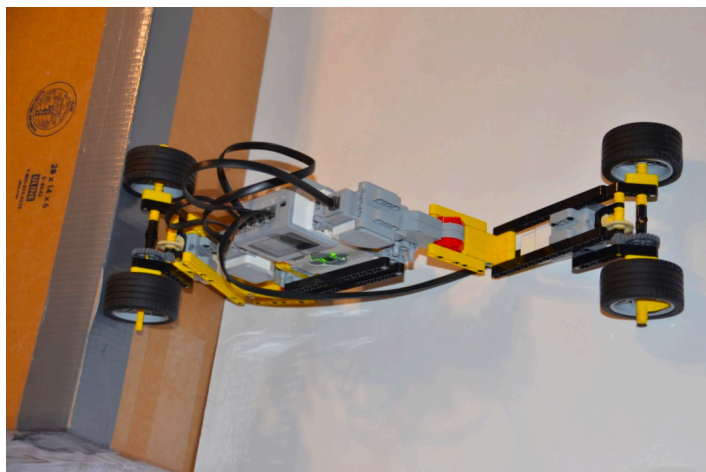
Design:



Program: <http://www.filedropper.com/stairclimberdatalogging>

Y3LLOW

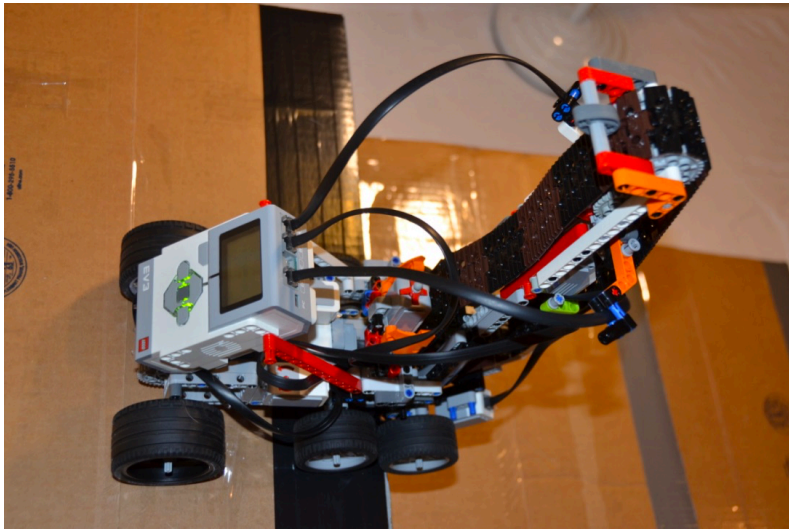
Design:



Program: <http://www.filedropper.com/stairclimberdatalogging>

EL3VATOR

Design:



Program: http://www.filedropper.com/stairclimberdatalogging_1



