Robotic Dumbwaiter
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Introduction

A small freight elevator is often called a Dumbwaiter. It can be a small box designed to carry lightweight freight such as dishes or books in a multistory building. They are called dumbwaiters because they are often used in restaurants. They can also be used to transport mail in an office tower. Dumbwaiters are usually driven by a small electric motor and pulleys. Safety is a major concern with dumbwaiters and commercial ones must be inspected and professionally maintained. The first electric elevator and dumbwaiter was introduced by Werner von Siemens in 1880. Today, they are very sophisticated and expensive to install. Small dumbwaiters can cost over $20,000 to build. This project was developed to build a simple system anyone can build for their home.

The RCX microcontroller used here is an old retired design that Lego used for the First Lego League robotic competitions. This robotic brain was used to design a dumbwaiter system. The microcontroller is programmed using Robolab software by Labview. Touch sensors activate when pressure is applied to them. Rotation sensors count how many rotations the motor rotates. When a weight is added to the dumbwaiter, it will automatically start and transport the item to the second floor.

Question

Is it possible to build a robotic dumbwaiter to carry lightweight objects from the first floor to the second floor in a house?

The objective of the Robotic Dumbwaiter project is to design a low cost product that anyone can build and use in their home. The idea was developed because many people often forget or have difficulty carrying small items up the stairs in their home. As a result, many houses have items stored on the stairway posing a safety hazard to people. This project has the potential to solve these problems.

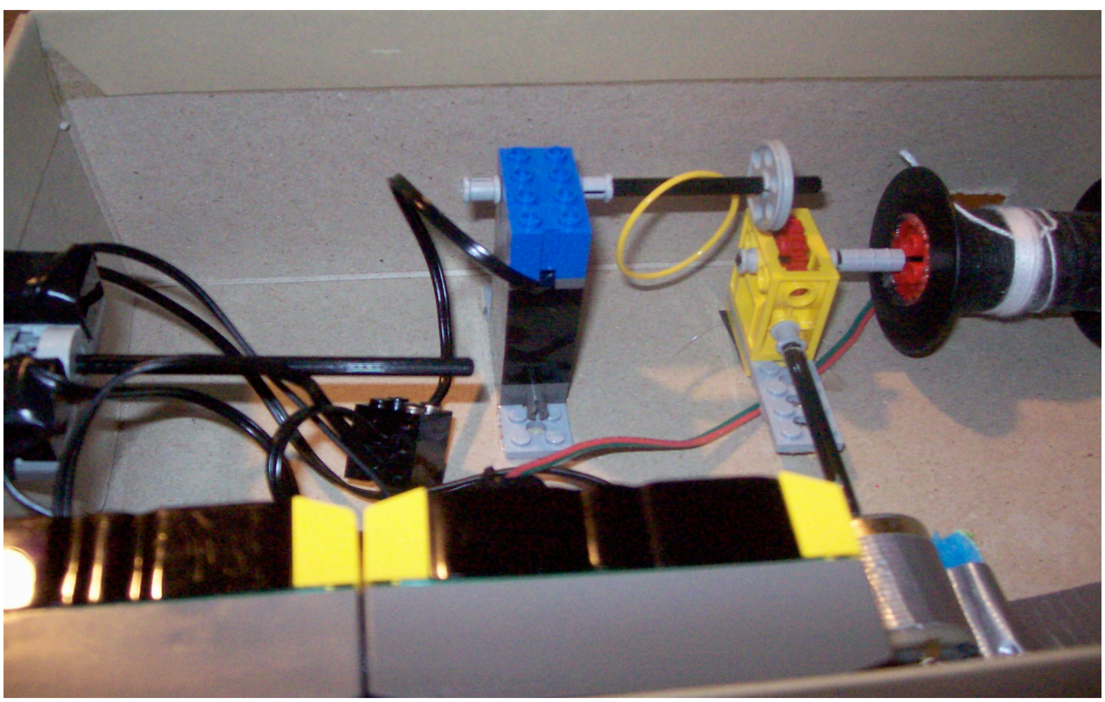
Hypothesis

The robotic dumbwaiter will be able to carry a minimum of two kilograms from the first floor to the second floor or a distance of 447 centimeters.

Procedure

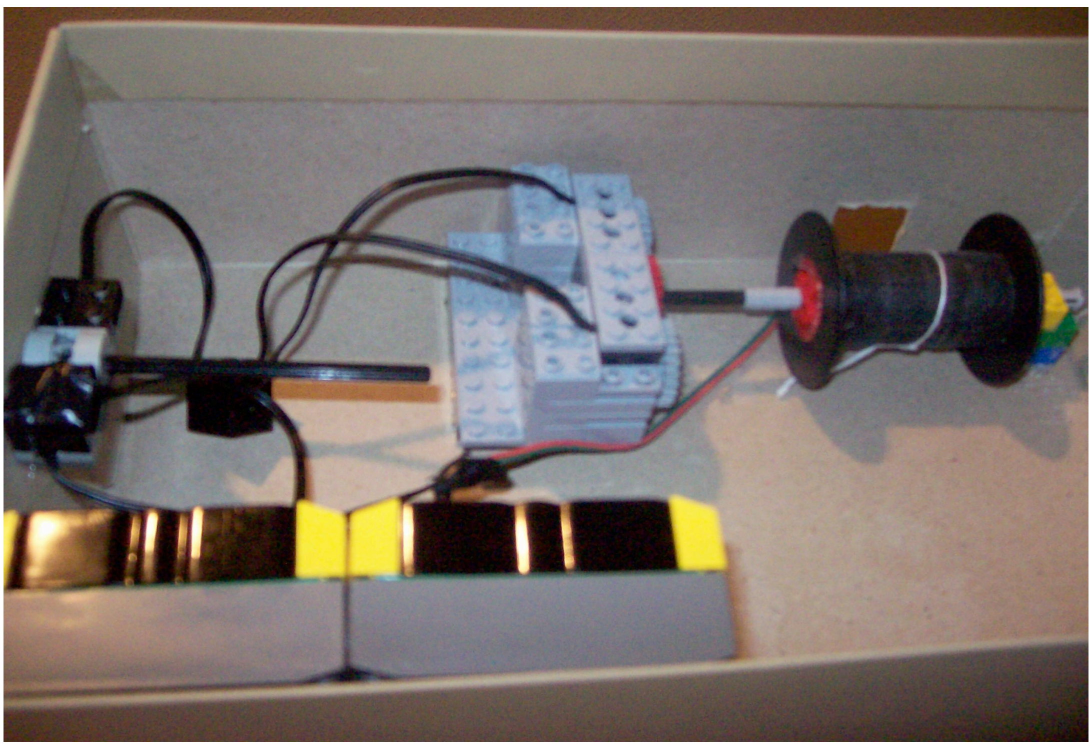
The robotic dumbwaiter was first designed on a computer using a digital tablet. Using Legos, Robolab® software, touch sensors, and motors, a robotic dumbwaiter was built to move lightweight objects up to the second floor a distance of 447 cm. A cardboard basket was designed to carry objects up the stairwell. Results showed that it is possible to move a 150 gram weight up the stairwell without any difficulties.

A 9-18VDC motor was purchased at RadioShack that could work with a Lego RCX microcontroller. To prevent the cable from ripping out of the RCX, a tether was added to the system. A box was then prepared by cutting holes for the start/stop switches and for the cables to run to the box . A rotary tool was used for this procedure. A Lego axle was glued in place to the motor axle. The gear box was assembled that included the motor and axle. A spool was added to wind the wire around. Two gears were glued to the inside that held the axles. Wires from the motor were attached to the pole reversing switch and then to the RCX's. A rotational sensor was put on a stand and rested the gear onto the gearbox. Wire was then stripped to go from the RCX's to the three sensors hot glued to the bottom of the shoebox. A piece of cardboard was then placed over the sensors. Wires were attached to an adaptor going from two wires to a Lego plug. The string length was measured by dropping a spool to the ground from the second floor. The other end of the string was taped to the balcony. The string at the first floor was tied to the spool and then to four strings on each corner of the shoebox. After the entire dumbwaiter was assembled, an initial experiment using the empty shoebox was attempted. This first design was a failure, the motor started and stopped and it appeared that the shoebox was too heavy. The shoebox was replaced with a McDonald's Happy Meal Box. The sensors were attached to the lighter box and a new string was attached. Data was collected with the empty box. After a few more attempts, the motor would not run because it burnt out.

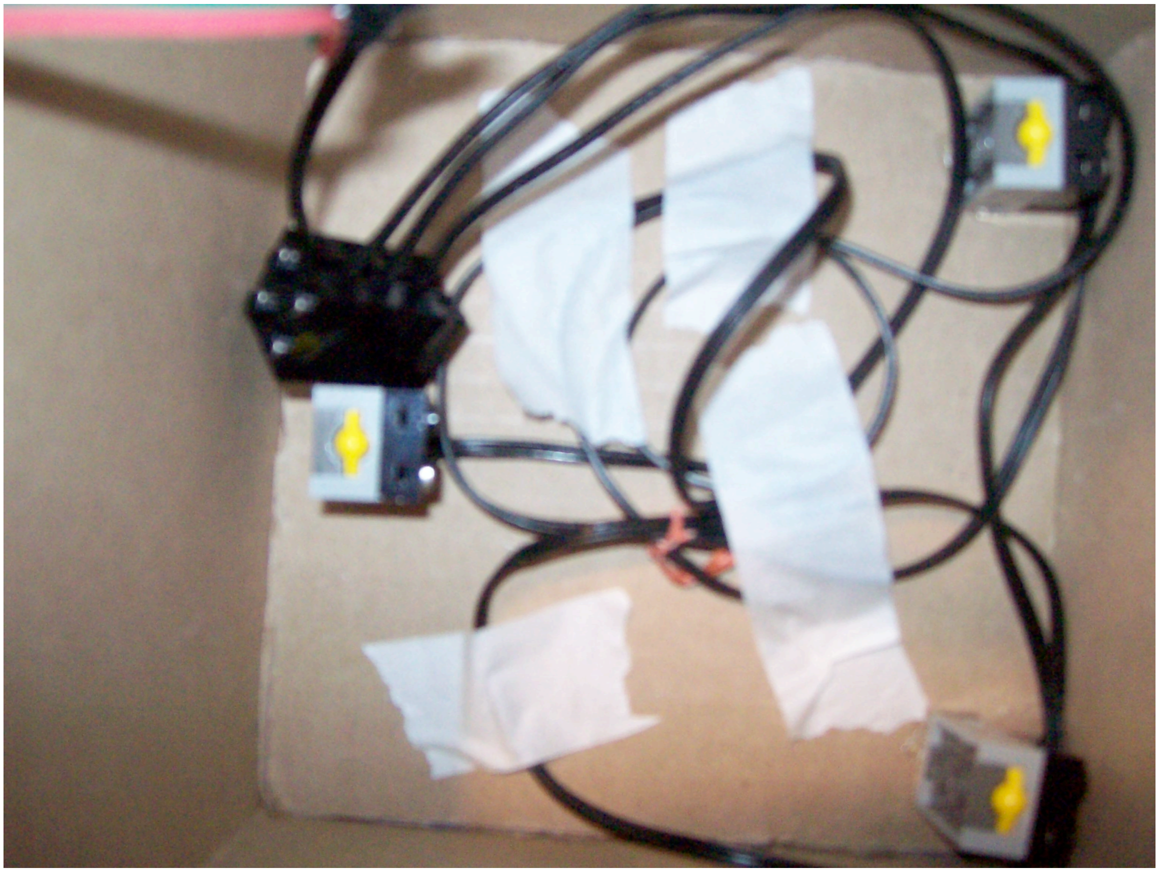


Robotic Dumbwaiter – First Design

A new second design was tried using RCX motors instead of the motor purchased from RadioShack. The motors were wired together and the polarity was checked. They were then attached to the gearbox. The dumbwaiter ran too slow so the gearbox was removed. Balance calibration weights and fishing sinkers were used for the experiments. This system ran well and data was collected for 0, 50, 100, and 150 gram weights. The dumbwaiter could not transport a weight higher than 150 grams.



Robotic Dumbwaiter – Second Design



Robotic Dumbwaiter – Second Design

Data

Two variables were studied, weight versus the time to reach the second floor. Only the second design with RCX motors yielded satisfactory results. The raw data from the first design with the RadioShack motor is shown below. No weights could be added to the dumbwaiter.

1	**34.83 Seconds UP**	**14.09 Seconds DOWN**
2	26.93 Seconds UP	12.45 Seconds DOWN
3	31.60 Seconds UP	12.23 Seconds DOWN
Average	31.12 Seconds UP	12.92 Seconds DOWN

Raw Data – First Design

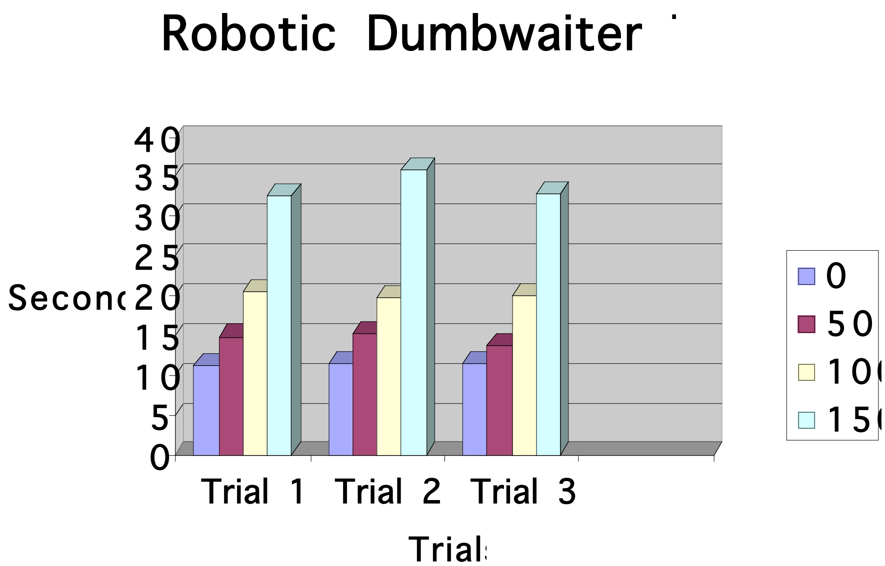
The second design with the RCX motors yield much better results. Each weight of 0, 50, 100, and 150 grams was tested three times to test consistency. The raw data from the experiments are shown below. The robotic dumbwaiter did not perform at weights greater than 150 grams.

Grams	Trial 1	Trial 2	Trial 3	Average
0	11.28	11.47	11.47	11.41
50	14.85	15.22	13.72	14.60
100	20.41	19.69	20.03	20.04
150	32.66	35.78	32.88	33.77

Raw Data – Second Design

Results

As seen from the data, the experiments were very consistent. The higher the weight, the longer it took the dumbwaiter to reach the second floor. The fastest time, a little over 11 seconds resulted when an empty box was used to test the robotic dumbwaiter. The longest time was about 34 seconds when 150 grams was added to the box. These times are all reasonable for the dumbwaiter.



Conclusions

The data shows that it is possible to build a robotic dumbwaiter for less than three hundred dollars. The hypothesis was incorrect because the robot lifted a maximum of 150 grams. The information gathered here can be used to design a stronger version by adding gears to the motor. The design of the robotic dumbwaiter is simple making it easy for anyone to build one for home use. Since commercial dumbwaiters cost in the thousands of dollars, this approach saves much money.

Applications

Applications for the robotic dumbwaiter include transporting medications and other lightweight objects to the second floor of a house. This will help people who find it difficult to climb stairs or are forgetful. The dumbwaiter can also be used to bring items down from the second floor. Safety and cleanliness in the house is also a concern when cluttered stairways exist. Therefore, the robotic dumbwaiter will transport items but also keep the house clean and safe.