USELESS SHIPPING BOX

Useless Shipping Box
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ABSTRACT

This project consists of creating a robot that serves no useful purpose in the form of a self-wronging shipping box. The Useless Shipping Box was created as a modification of the traditional useless machine. The box's purpose is to adjust its' orientation when outside sources cause it to tip such that it always ends up oriented improperly. The project itself is designed as a useless device for entertainment. In the creation of this device, useful purposes have been considered. Modification of the technology could prove to be useful in industrial shipping scenarios for high priority packages which require a specific orientation.

1. INTRODUCTION

This project consists of creating a robot that serves no useful purpose in the form of a self-wronging shipping box. The robot is considered "self-wronging" because it always wants to orient itself such that the "this side up" label is upside down, with the arrow pointing toward the ground.

2. NOMENCLATURE

Arduino Uno – Microcontroller board with 14 digital input/output pins (of which 6 can be used as PWM outputs), 6 analog inputs, a 16 MHz quartz crystal, a USB connection, a power jack, an ICSP header and a reset button.

Flipper – Lever arm that is actuated by a servo to flip the robot.

Subframe – Main structure or "skeleton" of the robot that holds all components in place.

Prusa I3 – 3-D printer with 7"x7"x7" printing volume and heated bed. Prints ABS or PLA

Base – Printed from PLA, this structure holds the Arduino Uno, four servos, four micro-switches, all wires, and the 9V power supply. It also provides the structure for the bottom of the robot and holds four all-thread supports.

Roof – Printed from PLA, this structure carries the servo and micro-switch for the upper flipper, along with the upper end of the four all-thread supports.

3. METHODS

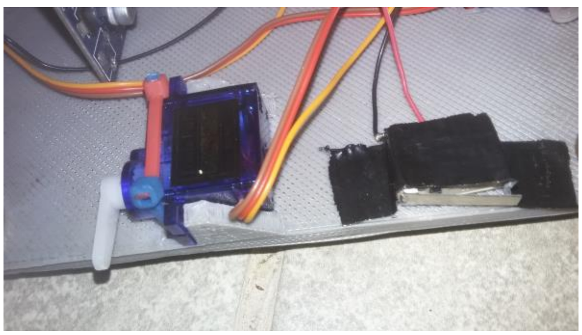
Overview

To accomplish the orientation adjustment, the box must be able to detect its' orientation, process this as an input, and have a physical means of adjusting its' orientation. To accomplish the orientation detection, a low cost micro-switch is placed on all sides of the box that are not desired to be on the ground. The switches are wires such that when depressed, current is allowed to flow to a digital pin of an Arduino Uno board. The Arduino board is programmed to detect the input to a digital pin, and run a specific sub-routine which adjusts the position of a servo motor. The servo motor is attached to the flipper that rotates the box 90 degrees to the next side. The process is then run again until none of the micro-switches are depressed.

Subframe

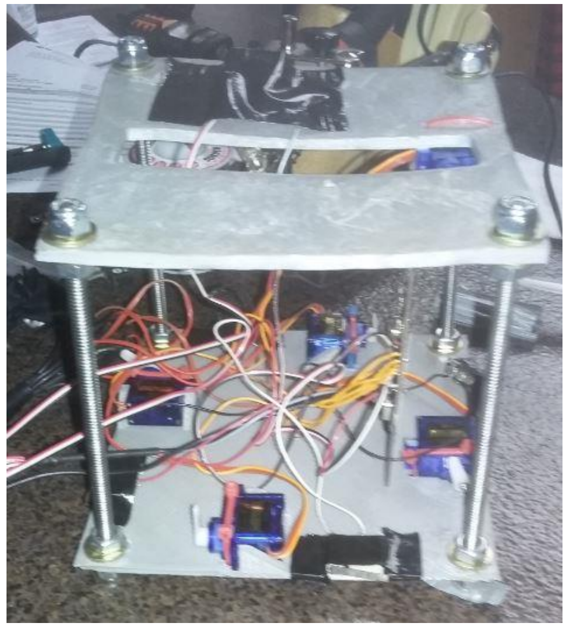
The main structure, or subframe, of the robot is a hybrid construction that consists of the 3-D printed base and roof held together by ¼-20 all thread. The hybrid construction expedited manufacturing time and allowed for ease of assembly. 3-D printing of the base and roof were handled by a Prusa I3 3-D printer and were printed in PLA. The priner setup is shown below.

The servos are affixed to the base and roof with zip-ties and extruded bosses in the 3-D printed base as shown below.



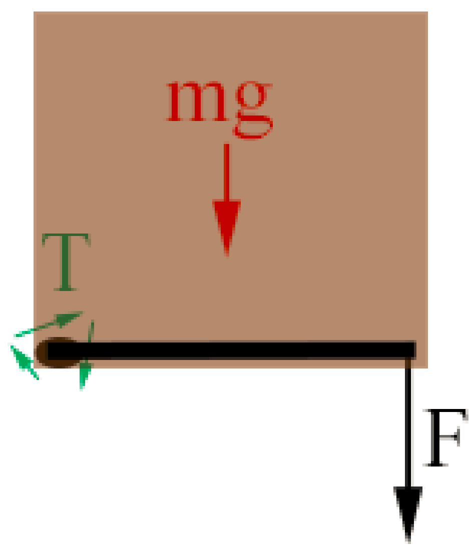
The micro-switches are affixed next to each servo with gaffer tape.

The Arduino Ono micro-controller and a 9V battery power supply are secured to the base and not the roof of the subframe to lower the CG of the robot when in its' home position. This assists the servo motors in flipping the robot. A photo of the completed subframe prototype is shown below



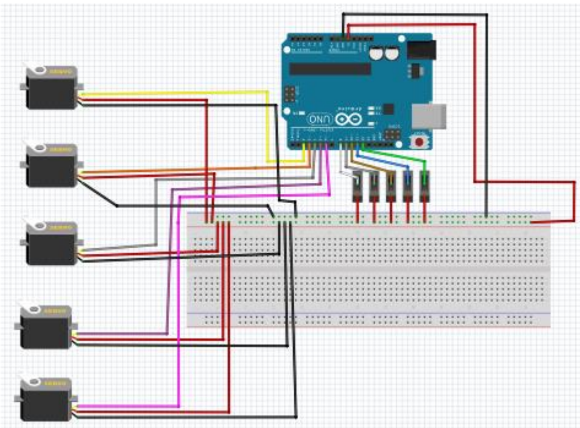
Flipper

The flipper is printed in PLA and is attached to the servo motor output shafts with an interference fit. The interference fit allows the proper transfer of torque to the flipper so that the robot is able to flip. Below is a free-body diagram that was used to determine the torque needed by the servo where T is torque,



Electronics

Power is supplied to the servos and micro switches through an Arduino Uno micro-controller via a nine-volt battery. The battery powers the circuit board via the voltage in, and ground pins. The servos require 5V power, which is transformed via circuitry inside the micro-controller. All servos have 3 wires, common power, ground, and signal control. Common power, and ground are always connected to the servos, and the signal wires each have their own digital pin set as an output for control. Two digital pins are required for the control of each side of the box, one for servo control, and another to read the input from the micro-switch which is used to detect orientation. A circuit diagram of the electronics is shown below.



Code

The basis of the code is very simple, for a given side, there is an input pin, and an output pin. The input pin is set to read the value of a micro-switch. When the box is not resting on the side in question, the switch is open, and no voltage is read. When the box tilts, and the side in question contacts the ground, the switch closes, attaching the input pin to the constant 5V pin, causing the pin to read high. The output pin is configured to send a signal to the servo which causes a 90 degree rotation, thereby causing the box to tilt. The orientation of the servo motors is such that on four sides, a single servo movement will adjust the orientation to be correct. The absolute upside down position requires two movements to correct its' orientation, however adjustment of the code is not required. When the box moves the servo on the very top, its' orientation is adjusted so that one of the sides is then tripped, and two movements are made. Each side operates independently, however the geometry of the box allows for flawless operation.

```
#include <Servo.h>

Servo myservo;  // create servo object to control a servo
// twelve servo objects can be created on most boards

int pos = 0;    // variable to store the servo position

void setup() {
  myservo.attach(9);  // attaches the servo on pin 9 to the servo object
}

void loop() {
  for (pos = 0; pos <= 180; pos += 1) { // goes from 0 degrees to 180 degrees
    // in steps of 1 degree
    myservo.write(pos);              // tell servo to go to position in variable 'pos'
    delay(15);                       // waits 15ms for the servo to reach the position
  }
  for (pos = 180; pos >= 0; pos -= 1) { // goes from 180 degrees to 0 degrees
    myservo.write(pos);              // tell servo to go to position in variable 'pos'
    delay(15);                       // waits 15ms for the servo to reach the position
  }
}
```

4. RESULTS

Successful operation of the code, micro-switches, and servos was accomplished. Of the five servos required and ordered, one was shipped DOA and as such, full operation of the robot could not be demonstrated. Cooling issues on the extruder nozzle of the Prusa I3 caused distortion of the roof, and inability to complete the print of the flippers.

5. DISCUSSION / LESSONS LEARNED

Technical issues prevented complete operation of the Useless Shipping Machine. On the manufacturing end, failure of the extruder cooling fan on the Prusa I3 caused imperfect and failed prints of the roof and flippers, respectively. The source of this failure is still being investigated at this time. A potential solution is to power the cooling fan from a separate, direct 5V power source. This will provide a simpler and more robust cooling solution as opposed to the current one that is processed through the printers' microcontroller.

On the supply end, dud electronic components were not accounted for. Of the five required and ordered servos, only four were operational. A 20% scrap rate will be included when ordering economical electronics from second hand sellers from now on.

6. CONCLUSION AND FUTURE WORK

The Useless Shipping Box consisted of creating a robot that serves no useful purpose in the form of a self-wronging shipping box. The Useless Shipping Box was created as a modification of the traditional useless machine. The box's purpose is to adjust its' orientation when outside sources cause it to tip such that it always ends up oriented improperly. The project itself is designed as a useless device for entertainment.

Alternative methods for rotation the box are considered in the form of accelerometers and gyros to detect orientation and flywheels on motors for rotation. In this way, the shape of the box is not altered while rotating, reducing the chance of damage to the contents within.

In the creation of this device, useful purposes have been considered. Modification of the technology could prove to be useful in industrial shipping scenarios for high priority packages which require a specific orientation at all times such as bio-hazardous and extremely fragile material. One major limitation to this application is cost. An analysis of current loss versus the cost of implementation self-correction boxes must be examined in order to determine feasibility

ACKNOWLEDGMENTS

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