411 Project Final Report:
SuperDuper Cat Toy

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ECE 411
Industrial Design Process

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1 Introduction

People love cats. Cat owners want their cats to be happy and healthy but often lack the free time needed to give their pets the exorcise that they need. We designed the SuperDuper Cat Toy to help alleviate this stress. With our innovative, motion sensing, laser cat toy, everyone's favorite feline friend can play all day while their owners are free to do whatever they need to do.

The SuperDuper Cat Toy is a motion sensing, self moving laser pointer that will keep any cat busy for hours. This system comes fully contained in a hard plastic dome to keep all of the components safe from fuzzy paws. This device can be ether wall or ceiling mounted and can be powered with batteries or a mini-USB cable.

We at the SuperDuper Cat Toy team believe that by creating an affordable, easy to use feline entertainment device, we can exploit a fairly large market consisting of busy professionals that love their cats but don't always have the time to give them the attention they need. Not only will this device help keep a cat happy and healthy, but it will also entertain them wile they are alone in the house keeping them from scratching furniture. The fact that this cat toy works even when no one but the cat is home, means that it is a much more versatile option than similar products that are currently on the market such as hand held lasers or floor based units that must be manually turned on and off everytime.

2 Design Considerations

In order to create a marketable feline entertainment device we decided to aim for the following baseline specifications.

Project Specifications

- Be activated by motion
- Be powered using a 9-volt battery or mini-USB cable
- Automatically turn off to conserve power
- Control the motion of a laser

Our requirements specifications are as follows:

	Engineering Requirements	Justification
	The device must have one or more inputs or sensors.	Project requirement.
	The device must have one or more outputs and transducers.	Project requirement.
	The device have one or more processing modules which control some of the outputs, based on the inputs.	Project requirement.
	The device must use a 2-layer PCB that is between 1 and 16 in2, with no side of the board being less than 1 inch or more than 12 inches.	Project requirement.
	The device must use components that can be hand-soldered or easily soldered in a crude reflow oven.	Project requirement.

Figure 1: Project Requirements Specifications

Marketing Requirements	Engineering Requirements	Justification
1	The device must respond to the movement of a cat.	The device is intended to provide 'automatic' entertainment, so it needs to be automatically triggered.
1	The device must direct a laser from within a dome casing.	A moving laser is a proven source of feline entertainment.
2	The device must not cost more than $59.	This is based on competetive market pricing analysis.
3	The device must operate from a battery source.	The battery provides a convenient power source for the customer.
4	The device will have automatic turn-off if no motion is detected within a 30-second time frame.	This is to conserve battery resources.
3	The device operates for minimum of 5 hours continuously from the 9V battery supply.	This is to provide substantial time frame for toy.
5	The device will be ceiling-mounted.	This will offer flexibility for the customer.
5	The on/off switch must be easily accessible.	This enables the customer to have ultimate control over the device's operation.
Marketing Requirements		
1	The product must provided a source of automated entertainment for cat.	
2	The product must have a reasonable cost, relative to current market	
3	The device must be easily powered for a minimum of 5 hours.	
4	The device should minimize battery usage.	
5	The device should be easy to use.	

Figure 2: Marketing Requirements Specifications

Once we established our basic specifications, we started the design process in earnest. The following is a short breakdown of how we decided to meet the aforementioned specifications. Due to the unavailability of mass produced printed circuit boards (PCB) that fit our needs, we will design our own. The laser will be controlled using two interconnected servos. Everything will be controlled using high-level C programming of an Arduino chip. The working components will be encapsulated in a enclosure that was originally designed to house a security camera. All components will be mounted on a raised platform inside the enclosure. The battery mount will be positioned under the component mounting platform. A removable mini-USB cord will be placed on the side of the enclosure. Finally a power switch will be mounted on the exterior of the enclosure.

3 Product Creation

The PCB for this project designed using Eagle CAD. After gathering feedback from the class instructors, teaching assistants, and running tests in Eagle CAD we made a number of adjustments to our original design. These revisions include the addition of a pull-up resistor for the reset and adjusting the dimensions off the power input line. The final design can be seen in Figures 1 and 2 below.

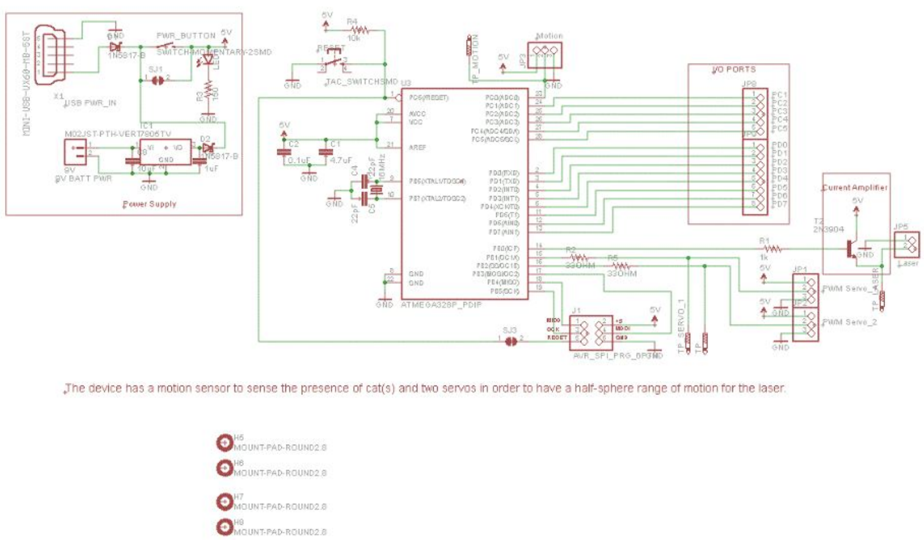

Figure 3: SuperDuper Schematic

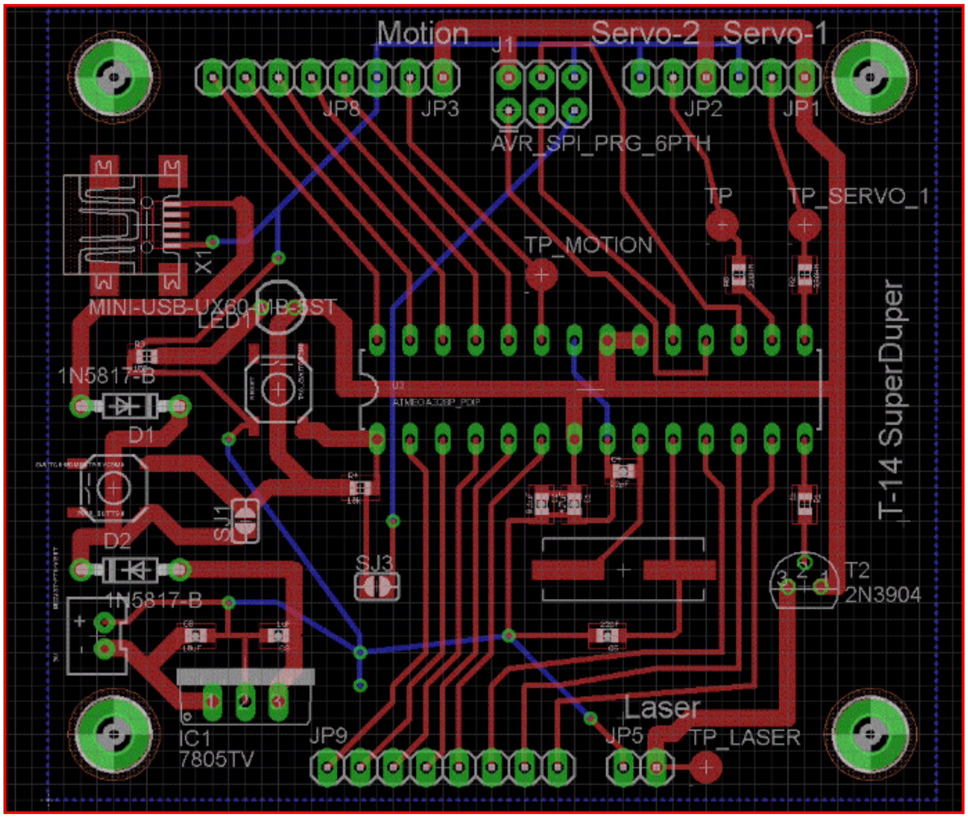

Figure 4: SuperDuper Board Layout

The Arduino code that was used in this project was based on open source servo controller code. Modifications where made to the code to allow it to control our servos, turn the laser on and off, and process the input from the motion sensor. We also needed to make adjustments to both the speed and range of the servo movement in order to ensure that the laser motion could be followed by a cat.

Our Arduino code is shown below:

superDuper_vII

```
const int sensorpin = A0; // A0 is the sensor pin
const int laserpin = 8;  // D8 is the lasor pin

int pos1 = 0;           // Variable to store myservo1 position
int pos2 = 0;           // Variable to store myservo2 position
int i = 0;

void setup()
{
  myservo1.attach(9);     // Attach the servo on pin 9 to the servo object
  myservo2.attach(10);    // Attach the servo on pin 10 to the servo object
  pinMode(laserpin, OUTPUT);
}

void loop()
{
  if(analogRead(sensorpin) >= 400){
    for(i=0; i<4; i++){
      digitalWrite(laserpin, HIGH);
      // Move both servos back and forth so fast that it blends into a circle
      for(pos1=0; pos1<=60; pos1+=1)
      {
        myservo1.write(pos1);
        delay(20);
      }



      for(pos2=0; pos2<=90; pos2+=1)
      {
        myservo2.write(pos2);
        delay(20);
      }
      for(pos1=60; pos1>=0; pos1-=1)
      {
        myservo1.write(pos1);
        delay(20);
      }
      for(pos2=90; pos2>=0; pos2-=1)
      {
        myservo2.write(pos2);
        delay(20);
      }
    }
    digitalWrite(laserpin, LOW);
    delay(3000);
  }
}
```

Figure 5: SuperDuper Arduino Code

The design and fabrication of the structural components such as the component mounting platform and the motion sensor mount where done in an ad hoc way. Wood was used as the main building material due to the ease with which it can be manipulated using hand tools. The platform was originally designed to be a four legged table like device with the legs straddling the PCB. This design had to be modified because the PCB ended up being larger than first anticipated therefore a three legged design was used. The motion sensor mount was created using pieces of wooden dowel and a cross member that was carved out of a stick. The last structural to be considered are the brackets used to hold the servos. These where created in a fabrication facility that one of our team members works at and further modified to ensure that all of the components would fit inside the enclosure.

Our Bill of Materials is shown below:

T14 Super Duper BOM

Item Name	Vendor	Part number	Qty	Shipping	1+ list price	10+ list price	1000+list price
PIR motion sensor	sparkfun	SEN-08630	1		$ 9.9500	8.96	7.96
Servo (micro size)		ROB-10333	2		$ 10.9500	9.86	8.76
AVR 28 Pin 20MHz 32K 6A/D- ATMega328P		COM-09061	1		$ 4.3000	3.87	3.44
Quarton Laser Module VLM-650-03 LPA (Economical Dot Laser)	Digikey	VLM-635/650-03	1	FREE	$ 13.1800	$ 12.63	7.125
Plastic Security CCTV CCD Dome Shape Camera Housing Cover Black	Amazon/Uxcell**	N/A	1	FREE	$ 6.9900	$ 6.51	5.08
1uf smd capacitor	Mouser	81-gmr18r61e105ka12	4		$ 0.0260	0.021	0.015
0.1 uf smd capacitor	mouser	81-gmr39x104k25	4		$ 0.0130	0.009	0.006
22pf smd capacitor	Mouser	581-06033a220j	4		$ 0.1000	0.085	0.068
10uf smd capacitor	Mouser	71-298d1x06r3mt	2		$ 1.2500	1.15	0.96
10k ohm resistor	Mouser	667-erj-3gey102v	2		$ 0.0120	0.009	0.0065
1k ohm resistor	Mouser	667-erj-3egyj102v	2		$ 0.0120	0.009	0.0065
330 ohm resistor	Mouser	660-rk73b1jttd332j	4		$ 0.0090	0.0075	0.0057
150 ohm resistor	Mouser	667-erj-3geyj151v	2		$ 0.0120	0.009	0.0065
linear voltage regulator	Mouser	512-lm7805ct	1		$ 0.4600	0.39	0.27
Shottky diode	Mouser	512-in5817	2		$ 0.2790	0.21	0.14
Circuit board	oshpark	super duper	1		$ 8.0000	6	4
				per unit tota	$ 55.54	49.7295	$ 37.85

Figure 6: SuperDuper Bill of Materials

4 Results

Once everything was built we began testing with the following results. While most of the project requirements where met we where unable to fit the battery holder under the component mounting platform due to lack of space, the legs needed to be shortened substantially to ensure the servos would have a full range of motion. It was also noted that when the project operated continuously for any considerable amount of time the voltage regulator would get fairly hot. This is a possible concern due to the fact that this component is in a tightly confined area surrounded by various wires and may create a fire hazard if the device runs continuously. Another issue is that even if we had been able to fit a 9 volt battery into the enclosure, the current draw of the device is high enough that the battery would only last around 1.5 hours of continuous use. Finally removing the chip in order to reprogram it was problematic because it required dis-assembly of the entire project and removing the chip from the housing on the PCB was difficult to do without binding the pins.

5 Conclusion

Wile we where able to hit most of our stated project specifications, as the SuperDuper Cat Toy stands today it is not ready to be taken to the market. Some modifications to the current design should be implemented to ensure that it is a more viable product. For instance, a custom enclosure that will ensure that there is plenty of room for the servos and the battery could be designed. Using three AAA batteries rather than one 9 volt battery would reduce the power drawn by the electrical components by decreasing the voltage. The range of motion of the servo that holds the laser should be reduced to create a smaller path for the cats to follow. The controlling code should be modified to allow both servos to move at the same time allowing for more interesting shapes than a simple rectangle. The use of surface mounted components, a smaller SMD Arduino, and reducing the size of the PCB would cut down on parts costs as well as power consumption.

With the aforementioned modifications in place and a well designed marketing plan, the SuperDuper Cat Toy has the potential to revolutionise cat ownership across the globe. The future of feline entertainment is upon us.