



February 16, 2015

Dr. Andrew Rawicz
School of Engineering Science
Simon Fraser University
Burnaby, BC V5A 1S6

Re: ENSC 440 Functional Specifications for a Motion Sensing Cat Toy

Dear Dr. Rawicz,

Please accept the following document as functional specifications for our Motion Sensing Cat Toy. We aim to design and implement a cat toy that is more interactive and lively for cats to have an enjoyable and fun chase. Our design consists of an ellipse shape toy that will sense motion and roll to attract the cat's attention.

The purpose of this functional specification is to provide an overview of the functionality requirements for our project. Our team will use this document as guideline through the completion of the product.

CatStone consists of four motivated, innovative, and talented fourth-year engineering students: Jjay Chen, Genevieve Wong, Xiang Wu, and Jason Xu. If you have any questions or concerns about our proposal, please feel free to contact me by phone at 778-889-0830 or by e-mail at gsw5@sfu.ca.

Sincerely,

Genevieve Wong
Chief Executive Officer
CatStone

Enclosure: Functional Specification for a Motion Sensing Cat Toy



Functional Specifications for a Motion Sensing Cat Toy

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Executive summary

As living quality enhances with technology, more and more cat owners are willing to invest on better quality cat toys to enhance their cat's living quality as well. Although cats are known to equip the skills of turning everything, such as newspaper strips, paper bags, and milk ring, into their toy, they still desire for something more interactive, lively, and safe.

Cats are very fond of all sorts of ball shaped toys. The movement of a ball along a surface mimics the movement of scampering mice or other prey animals, which will entice cats to chase. Furthermore, some of these toys allow owners to insert treats or catnip into them to make the experience for their cats more rewarding and exciting. Others have bells, small objects, or LED lights inside them to make noise or lights to attract the cat's attention. Some common types of ball toys are wadded-up paper balls, Mylar balls, Ping-Pong balls and sponge balls. The disadvantages of these products are that they will remain motionless until cats approach them. This makes these toys less attractive and the cats will eventually lose interest in playing with them.

The development of Purrsuit will be done in two stages. In the first stage, Purrsuit will be build based on its main functionality, which is when a cats' presence is sensed, Purrsuit will roll to attract its attention to play. Upon the completion of this stage, Purrsuit will be upgraded to be able to recognize the cat's position and roll away from the cat in order to engage a chase.

This document outlines the functional requirements for each component of Purrsuit. These requirements are to ensure proper performance, safety, and quality of Purrsuit. User documentations are also provided to prevent confusion and improper use. It is intended for the designers, developers, and testers of the system as guideline and updated as necessary.

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Glossary

CCPSA	Canada Consumer Product Safety Act
CPSC	Consumer Product Safety Commission
CSA	Canada Standards Association
MTBF	Mean Time Between Failure

1. Introduction

Purrsuit is the purr-fect toy for your furry little friend. It is a cat toy that can detect a cat's approach and react to roll towards the opposite direction, mimicking a fearful escaping prey for the cat to pursuit. Unlike most cat toys, Purrsuit will deploy into action without the need of the cats' initiation. Its unique ellipse shape makes the toy wobble when rolling away, increase its attractiveness. In addition, an ellipse shape makes the toy impossible to 'tip over' and become unable to move. Thus, giving cats an unlimited amount of fun chase. The requirements for Purrsuit, as proposed by CatStone, are described in this functional specification.

1.1. Scope

This document outlines the detailed functional specifications of Purrsuit. It describes the functionality of the system including the shell, offset weights, sensors, microcontrollers, and the overall system functionality. Furthermore, requirements listed in this document will be used as guidelines for the design, development, and testing of Purrsuit to ensure safety and reliability.

1.2. Intended Audience

This functional specification is intended for use by all members of CatStone. Our team will refer to this document as overall design goals through development. This documentation will also be used as a reference by the marketing department when promoting the product to potential investors or consumers.

1.3. Classification

The functional requirement specification is shown as follows:

[Rn-p]

'R' is an abbreviation for requirement, 'n' is the functional requirement number, and 'p' stands for one the following three development stages:

- I. Proof-of-Concept stage only
- II. Ongoing development (both proof-of-concept and final production) stage
- III. Final production stage only

2. System Requirements

2.1. System Overview

Purrsuit is an oval toy ball, which is able to roll away from cats upon their approaching. Four sensors will be attached inside the toys to detect the presence of cats in all directions and provide the location feedback to the microcontroller. Based on the location data received by the microcontroller, Purrsuit will roll away from the cat in the opposite direction. The following figure shows the working procedure of this cat toy:

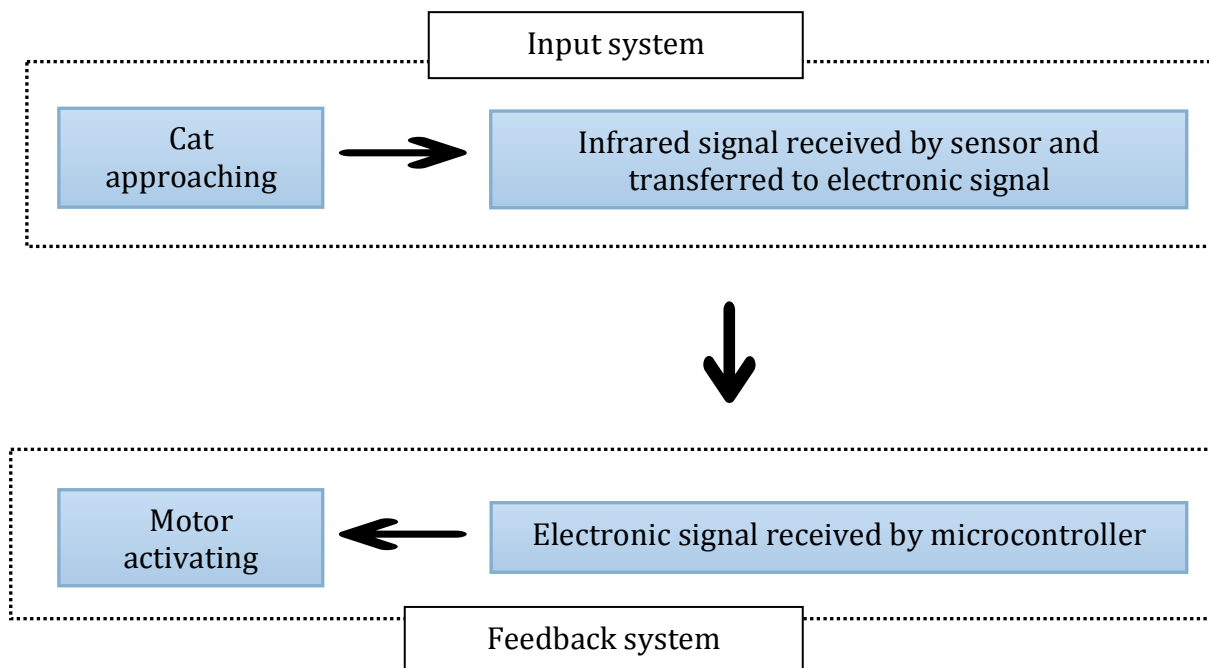


Figure 1: System Specification

The microcontroller would determine if the ball should turning, moving forward or moving backward here is some possible situations that may happened when the cat approaching:

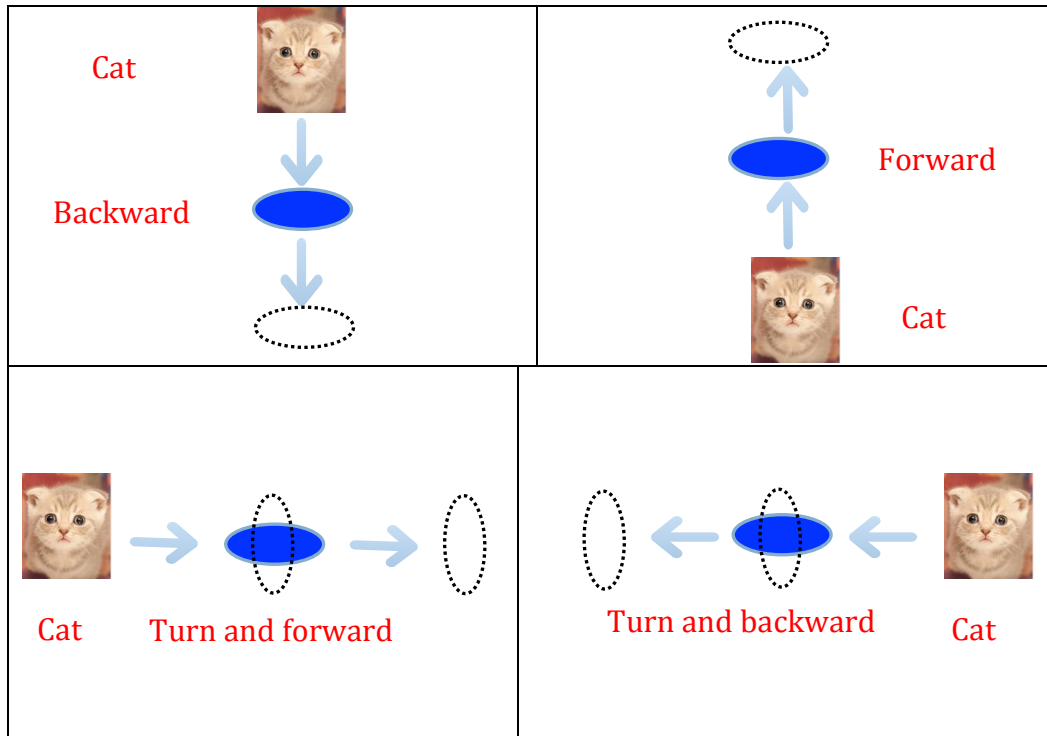


Figure 2: Motion Specification

2.2. General Requirements

[R1-II] The toy has an idle state and all adjustable parts are locked.

[R2-III] The retail price of the toy be should be under CDN\$100.

2.3. Physical Requirements

[R3-I] The length should not exceed 30cm.

[R4-II] The diameter shall be no more than 15cm.

[R5-II] The toy is supposed to look similar to regular toy ball for cats.

[R6-III] The weight of the toy should not exceed 2kg.

[R7-III] The toy should sealed sufficiency in order to prevent water damaging the inner electronic parts.

2.4. Electrical Requirements

- [R8-II] Batteries should be eligible to use as power supply.
- [R9-II] Battery life will be no less than 3 hours.
- [R10-II] The toy shall enter into sleeping mode if no cats approaching.
- [R11-II] Inner electronic signal need to be easily tested and debugged.
- [R12-III] Total circuit responds time should be less then 5 second.
- [R13-III] Battery should be easily recharged with external charger or replace.

2.5. Mechanical Requirements

- [R14-II] All parts inside should be intact with each other.
- [R15-II] The moving speed of the toy ball will be no less than 15cm/s and shall not exceed 30cm/s.

2.6. Environmental Requirements

- [R16-I] The toy can operate normally in room temperature (from 0°C to 40°C).
- [R17-II] The toy will operate normally in the humidity rage of 0% to 90%.
- [R18-II] The toy should be operated on the clean floor with less sticky substance.
- [R19-II] Noise produced by the balls should be minimized and do not exceed 40dB.

2.7. Standards

- [R20-III] The toy should conform to CCPSA standards.^[1]
- [R21-III] The toy should conform to CPSC standards.^[2]
- [R22-III] The toy is supposed to meet the requirement of CSA requirement CSA-ISO C22.2 No. 149-1972.^[3]

2.8. Reliability and Durability

- [R23-II] The toy should prevent interference from potential signals created by home appliance.
- [R24-II] Cats' physical interference should be minimized on the motion of the toy ball.
- [R25-II] The toy should be serviceable for at least 7 hours with perfect condition.
- [R26-III] The MTBF of the toy shall be more than 10000 hours

2.9. Safety Requirements

- [R27-II] The toy is not supposed to have and sharp edges that might hurt the cast or humans.
- [R28-II] The toy shall not be hot to touch.
- [R29-III] The toy should be resistant to flame.
- [R30-III] The electronic shock should be minimized.

2.10. Performance Requirement

- [R31-II] The toy will respond to any movement approaching within a range of 50 cm.
- [R32-II] The toy will indicate as on after 1 second of any movement approaching.

2.11. Usability Requirements

- [R33-II] The toy should move in the opposite direction of the cat.
- [R34-II] The speed of the ball should adjust correctly within the range of 15cm/s to 30cm/s.
- [R35-III] The structure of the ball should be easily cleanable by users after long time usage.

2.12. Luxury Functions

- [R36-III] The toy can enter into a sleep mode to save energy if no movement approach for a long time.
- [R37-III] The toy can be reactivated from the sleep mode upon new movements.
- [R38-III] The toy can be painted to look like a mouse to raise the interest of cats.

2.13. Sustainability

- [R39-III] Use Ni-MH rechargeable batteries for long time usage and low-cost battery recycle.
- [R40-III] The recyclable plastic which is polyethylene terephthalate (PETE) is needed to make the outer shells to control the total weight.^[4]

3. Shell

3.1. General Requirements

- [R41-II] The shell should have an outer structure of an ellipse.
- [R42-II] The shell is should be able to contain all the parts of the ball.

3.2. Physical Requirements

- [R43-II] The radius of the shell shall not exceed 15 cm and the length shall not exceed 30 cm.
- [R44-II] The total weight of the shell should not exceed 150 g.
- [R45-III] The surface of the shell should be smooth.

4. Motion Sensors^[5]

4.1 General Requirements

- [R46-II] The motion sensors shall be only used to detect motion from pets/humanoids, excluding the interference of surroundings motion when the toy is rotating.
- [R47-II] The sensitivity range of the motion sensors shall be at least 2m.
- [R48-II] The detection range of the motion sensors shall be above a 110° cone.
- [R49-II] The voltage supply for the motion sensors shall be 5V ideally, which can be easily gained from the microcontroller's 5V regulator.
- [R50-II] The motion sensors shall have a delay (2 - 4 seconds) to provide steady detection signal to microcontroller.

4.2 Physical Requirements

- [R51-II] The motion sensors shall be as small as possible.
- [R52-III] The motion sensors shall be mounted on the surface of the toy.
- [R53-III] The motion sensors shall be mounted as few as possible without blind detection spots on the ground plane.

5. Offset Weights and Motors^[6]

Offset weight motors are design for rotating the toy. The function of using offset weight motors is to change the central mass of toy to make it rotate.

5.1 General Requirements

- [R54-II] The speed of motors shall be 1200 or 2400 RPM, which could control the rotating position easily by programming the microcontroller.
- [R55-II] The shaft of motors shall be lockable when power is off for setting the offset weight back to the original position.
- [R56-II] The motors shall have enough torque to load the offset weight.
- [R57-II] The voltage of motors shall not exceed 12V due to the selection of motor and power supply.
- [R58-II] The offset weights shall be semicircular to change the central mass of ellipsoid toy.
- [R59-III] The offset weights shall be heavy enough to rotate the ellipsoid toy.
- [R60-III] The toy shall rotate forward or backward when two offset weight motors run in the same direction and rotate angle when motors run in opposite directions.

5.2 Physical Requirements

- [R61-II] The diameter of the semicircular offset weight shall be between 3 - 4cm.
- [R62-II] The thickness of offset weights shall be about 4mm.
- [R63-II] The motors shall be mounted to the vertical axis of symmetry.

6. Microcontroller^[7] and Motor Drivers^[8]

Microcontroller is a small computer on a single integrated circuit, which contains a processor core, memory, and programmable input/output. Microcontroller is designed for embedded applications, which is used in automatically controlled products and devices.

Motor driver is a circuit design that serves to govern some predetermined manner performance of electric motors. Motors typically require voltages or currents that exceed what can be provided by the analog signal. The motor driver provides the interface between the signal processing circuitry and the motor.

6.1 General Requirements

- [R64-II]** The microcontroller shall be small enough to fit in the toy, and low cost.
- [R65-II]** The microcontroller shall have at least 8 I/O pins, which 4 pins are used to acknowledge the detection input signal from motion sensors and other 4 pins are used to transmit output signal to motor driver.
- [R66-II]** The motor drivers shall control two motors with input signals.
- [R67-II]** The motor drivers shall provide functions for starting and stopping the motor, and selecting forward or reverse rotation.
- [R68-II]** The voltage supply of motor driver shall be 5V ideally, which could be gained from the microcontroller voltage regulator.
- [R69-II]** The voltage load and current limit of motor driver shall fit the requirements of the two offset weight motors.

6.2 Physical Requirements

- [R70-II]** The microcontroller and motor drivers shall be connected and soldered in PCB board for reducing wire connection and optimizing the layout of the circuit.
- [R71-III]** The PCB board shall be mounted between two offset weight motors.

7. Power Supply^[9]

The power supply of the toy is designed for providing electronic devices long lasting power and stable current.

7.1 General Requirements

- [R72-III] The power supply shall be separated, which one is 5V for the microcontroller and another is 9V or 12V for the offset weight motors.
- [R73-III] The power supply shall be a portable power solution that can be mounted inside the toy.
- [R74-III] The power supply shall guarantee long lasting power and reliable performance.
- [R75-III] The power supply shall be easily recharge or replace.

7.2 Physical Requirements

- [R76-III] The size of the power supply shall not exceed 6cm x 5cm x 3cm.
- [R77-III] The power supply shall be mounted in the vertical axis, making the total central mass of the toy downwards in a center location.

8. User Documentation

- [R78-III] The user manual shall include the logo of the company, a contact number and a potential website address
- [R79-III] User documentation shall be provided in English, French, Spanish, German, Traditional Chinese, Simplified Chinese, Japanese, and Korean to satisfy product language requirements for international markets.
- [R80-III] The user manual shall be written for an audience with minimal knowledge of electronics devices.
- [R81-III] User documentation shall include a website with general and technical support information and a user manual, both written in English.
- [R82-III] Warranty information will be included with the product.

9. System Test Plan

In order to get the best performance of Purrsuit, test scenarios must be conducted. Purrsuit's sensors receive input and pass the signals into the microcontroller and outputs to the motors. Therefore, it is very important to make sure the inputs and the outputs correspond. The following figure shows how the sensors and motors are positioned.

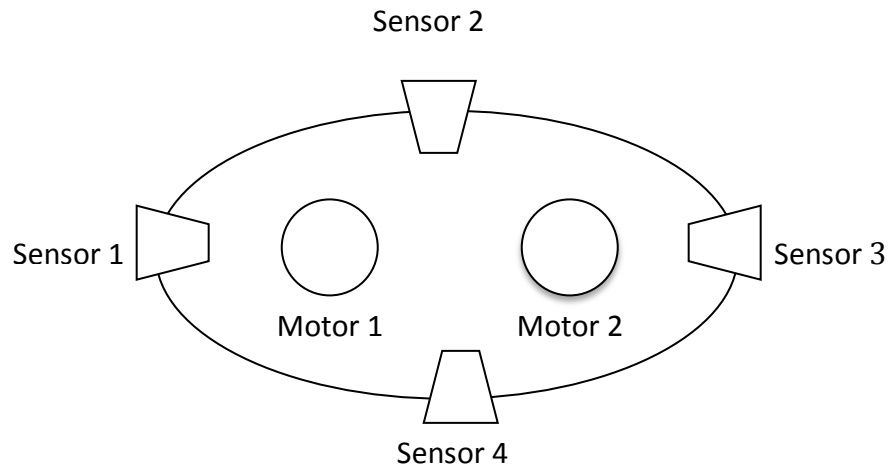


Figure 3: Sensors and Motors Positions

With this setting, we can construct the following test cases listed in the table below to test the outputs with each sensor input respectively.

Sensor	Output
0	No movement
1	Motor 1 will roll towards sensor 2 and motor 2 will roll in opposite directions for the toy to turn, then motor 2 will roll in the same direction of motor 1
2	Both motors roll towards sensor 4
3	Motor 2 will roll towards sensor 4 and motor 1 will roll in opposite directions for the toy to turn, then motor 1 will roll in the same direction of motor 2
4	Both motors roll towards sensor 2

Table 1: System test cases

10. Conclusion

This documentation provided the functional specification for each component of Purrsuit. Individual requirements for the shell, offset weights, sensors, and microcontrollers are included, as well as requirements for the overall system. Further, test plans are also provided to ensure the quality of the overall system. By following to the requirements in this document, CatStone is confident that Purrsuit will be designed to the highest of quality.

Among other electronic cat toys already available on the market, Purrsuit is unique and high-tech, but yet within a reasonable price range. The manufacturing cost of each unit is low and the materials used are environmental friendly, making it suitable for mass production. We hope Purrsuit will be a start of a new era in cat toys industry.

11. References

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