Auto Sports

February 10th, 2016

Dr. Andrew Rawicz
Schol of Engineering Science
Simon Fraser University
Burnaby, British Columbia
V5A 1S6

Re: ENSC 440W Functional Specification for the SmartPitcher

Dear Dr. Rawicz:

Attached is the Functional Specification document for the SmartPitcher. We intend to design and build an advanced pitching system which will provide motion and distance tracking during an athlete's practice. In brief, the purpose of the system is to assist athlete to efficiently receive the ball at the desired location.

The purpose of this document is to present an overview of functional specification of SmartPitcher along with all the requirements needed for the design of this product. The functional specification provides proof-of-concept, detailed system overview, variety of system requirements, and proposed test plan. The proposed design will be created in respect to the functional specifications which will ensure that all the requirements are met at the end of test cycle.

The Auto Sports team consists of five engineering science students with various engineering backgrounds: Youjung Kim – Computer Engineering, Sion Park – Electronics Engineering Jeff Yoo – Systems Engineering, Joel Kim – Systems Engineering, and Sana Fereshteh – Systems Engineering. If you have any questions or concerns about the functional specifications, please feel free to contact us at youjungk@sfu.ca.

Sincerely,

Youjung Kim

Enclosure: Functional Specification for SmartPitcher

Functional Specification for SmartPitcher

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EXECUTIVE SUMMARY

Today's world greatly depends on technology to increase efficiency. Even in sports, modern coaches/trainers encourage athletes to train efficiently over just a tough grind. The recent advancements in technology have helped athletes improve the way that they train dramatically. Currently many athletes and trainers depend on technology to help them train more efficiently. In sport such as baseball, using a pitching machine in baseball gives excellent opportunities to efficiently improve the athletes' skill sets without much of labour input from trainers. Thus, many trainers like to take advantage of a pitching machine to maximize the athletes' improvement during practice time.

Our proposed project is to design and build an automatic pitching machine that will increase efficiency of an athlete's practice without much input of labour from the trainers. The development of the SmartPitcher will be divided into three following stages:

Stage 1 – Integration:

- Integrate all the required sensors to microcontroller
- Add motor shield to the microcontroller to control motor speed
- Add Bluetooth extension to Arduino
- Use color tracking software to monitor movement

Stage 2 – Building:

- Build a physical platform that support all the required parts
- Assemble the parts developed in Stage 1 with two wheels

Stage 3 – Testing:

- Test the prototype in indoor/outdoor environments

At end of the first stage, we will be obtaining proof-of-concept from developing main functionalities of SmartPitcher. The second stage of development, we build a working prototype with all the developed parts from the first which will be used in final stage. In the final stage we will be testing our prototype in variety of environments.

Table of Contents

List of Figures and Tables

Glossary

API	Application Programming Interface
DC	Direct Current
USB	Universal Serial Bus: A cable for connection, communication, and power supply between computers and external device.
IDE	Integrated Development Environment
Controller	Arduino Microcontroller, Bluetooth transceiver, battery, power supply, LED, LCD, motor shield, and its enclosure.
Mobile Application	Software application called, “ArduDroid,” supported by Android: A simple 2-way Bluetooth-based Android Controller for Arduino UNO.
Linear Gear	Stationary gear, powered by Servo Motor, and linear gear racks use rotation to transmit torque to push the ball to the spinning wheel.
Arduino LCD	Liquid-Crystal-Display: produces image and desired information regarding to the motor speed and the distant measurement.
Motor Driver	Type of current amplifier to take a low current control signal to produce higher-current signal in order to drive a motor.
Ultrasonic	A device emits high frequency sound wave that measures the distance between the device and an object.
Bluetooth	Short range wireless (connectionless) interconnection of a mobile device to the receiver mounted on microprocessor to receive a signal.
Loading	A design part where the ball and the linear gear encounter.
Camera	Webcam that is compatible to a laptop and Roborealm.
Wheel	Stationary 6 inch diameter of two spinning wheels engulfs a ball to shoot.

1. Introduction

The SmartPitcher by Auto Sports is a full-fledged ball pitching performance with an advanced technology that increases the quality and efficiency of sport training. It is a cooperation of ball trigger mechanism and motion tracking system that is essential to eliminate the process of loading ball cartridge. The firmly affixed mobile device on a user's armband will interface with Bluetooth transmitter which will release a ball to the accelerated wheel, delivering the ball to where the user is standing. The first-perspective operating SmartPitcher is designed to bring easy, fast, reliable, and safe access for athletes to have convenience but expeditious exercise. The detailed requirements for the SmartPitcher are documented below.

1.1 Scope

The scope of the specification is to explicitly describe the functional requirements and the features that are met by the design of SmartPitcher. The specification acts as an instruction manual of how the hardware mechanism drives and interfaces with software design. Although the quality of an exterior hardware design is flawless compare to our primary prototype, the specification covers all the requirements that meet the concept of SmartPitcher.

1.2 Intended Audience

This document will be used as a guideline or instruction manual for engineers. The functional specification will have detailed exposition of requirements and design mechanism that can be fetched in the future in case of any revision. Additionally, this documentation can be used by test engineers to view as foundational test plans based on SmartPitcher whether to use for similar types of project.

1.3 Classification

In this document, the following format will be representing functional requirements:

[R#-x]

where **#** is the number of certain functional requirement, and **x** indicates the priority of the functional requirement distinguished as follow:

a This requirement corresponds to only Proof-of-Concept system.
b This requirement corresponds to both Proof-of-Concept and Final Prototype system.
c This requirement corresponds to only Final Prototype system.

1.4 Design Approach

When we started designing our ball-pitching machine, we figured that the best way to address our multiple design criteria is to add components one by one and calculate the minimum required input to dissipate the power to move the ball during a desired amount of time. Our approach for designing this system is to note the basic requirements, add components one by one, and define every force interaction during our calculations.

1.5 Engineering Standards

We focused on the following engineering criteria to obtain a safe and sustainable design:

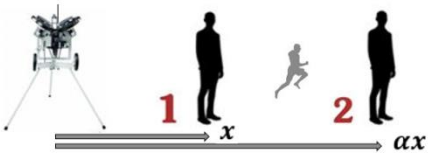
- The ability of the machine to aim the ball over a wide range of angles
- The ability to pitch the ball with the required maximum speed
- Stability of the whole machine specially when it is not mounted to a wall or ground

We first used kinematics to calculate to determine the angles that we wanted and then we determined the torque requirements to launch a ball at the desired speed. We performed force analysis to calculate the reaction forces that will happen within the machine and assessed its stability.

2. System Overview

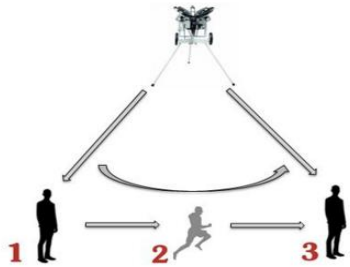
A high level diagram of the components of the SmartPitcher is shown below.

Motor Speed control



Sensors → Microcontroller with motor driver

Motion tracking system



Camera → Motion tracking software with servo motor

Loading mechanism

Bluetooth trigger → Linear gear with servo motor

Figure 1: High-level diagram of the SmartPitcher system

The SmartPitcher is designed to increase athlete's practice output. Figure 1 shows that the system is divided into three main parts which are: motor speed control, motion tracking system, and loading mechanism.

The main function of the motor speed control is to set how fast the wheel should be spinning according to the measurements from the distance sensor. The control uses ultrasonic range finder, Arduino Uno microcontroller, and motor driver. More specifically, the distance between the pitcher and an athlete will be measured by the range finger which will restrict the rotational speed of two wheels to ensure that the ball does not travel too far. The two wheels will be controlled simultaneously using Arduino microcontroller with dual Polulu motor driver.

The automatic motion tracking system consist of three main parts namely the camera capturing movement of an athlete real-time, the motion tracking software called Roborealm, as well as the servo motor with a mount which acts as a rotational platform of the pitcher, interfacing through Arduino to command the horizontal rotation in the range of 0 to 180 degrees. Software development of Roborealm will revolve around camera that captures a specific color which will trigger color code identification feature.

The loading mechanism of the ball requires a user to wirelessly trigger the servo motor through Arduino Bluetooth control which will determine the number of rotations in the linear gear. As a result the rotations in the linear gear will push the ball into the spinning two wheels. More specifically from a software perspective, the number of rotations can be determined by the set of APIs which are already pre-set in the mobile device application called Arduino Controls. In addition, all the important readings from sensors, microcontroller, and software will be displayed in a user-friendly fashion through Arduino LCD.

In conclusion, the final prototype of SmartPitcher will be assembled including three main functional parts: a tennis ball loader mount, Arduino and motor driver to control speed of two wheels which will determine the magnitude of ball's projectile, and Roborealm which will continuously monitor the movement of the user through color identification feature.

3. System Requirements

This section lists the general requirements applicable to the SmartPitcher.

3.1 General Requirements

[R3.1.1-b] The SmartPitcher shall be controlled by a microcontroller, and a motion tracking software.

[R3.1.2-b] The SmartPitcher shall remain stagnant along with other parts when completely turned off.

[R3.1.3-c] The SmartPitcher shall be mobile and easy to use.

[R3.1.4-c] The SmartPitcher shall be designed such that the initial cost in term of remodelling should not exceed $1000.

[R3.1.5-c] Each individual component of the SmartPitcher should be replaceable.

3.2 Physical Requirements

[R3.2.1-b] The SmarPitcher shall consist of a motor speed control with LCD display.

[R3.2.2-c] The SmartPitcher's motor power supply shall be rechargeable.

[R3.2.3-c] The final prototype shall be assembled so that the length and width does not exceed 50 cm.

[R3.2.4-c] The design/size of the SmartPitcher shall be adjustable according to specific market needs.

3.3 Electrical Requirements

[R3.3.1-a] A USB cable feed from a laptop will be used to power the camera, and the microcontroller.

[R3.3.2-b] The 12 V DC power supply will be used to power two wheels those are attached to two DC motors.

[R3.3.3-c] The troubleshooting of the electrical disorder shall be easily fixed by user.

3.4 Environmental Requirements

[R3.4.1-b] The SmartPitcher shall operate in temperature range of 5 ºC to 30 ºC.

[R3.4.2-b] The SmartPitcher shall operate in both outdoor and indoor.

[R3.4.3-b] The SmartPitcher shall be used in standard dry conditions.

[R3.4.4-b] The SmartPitcher shall have minimal noise while operating.

3.5 Design Standards

[R3.5.1-c] The device should comply with the CSA standards.

[R3.5.2-c] The Bluetooth transceiver module shall follow the IEEE 802.15 standards due to the wireless communications between Arduino Bluetooth Control application and the SmartPitcher [1].

[R3.5.3-c] The machine should be compliant with ISO/TR 20183:2015 in regards to "Sports and other recreational facilities and equipment -- Injury and safety definitions [2]."

[R3.5.4-c] The ball's spinning rate, which is fired from the pitching machine, shall comply to Section 5.2.1 of ASTM F1890 – 11 [3].

[R3.5.5-c] Servo motor which is utilized for the rotations of the SmartPitcher shall conform to IEC60034, rotating electrical machinery [4].

3.6 Reliability and Durability

[R3.6.1-b] All the components are safe to use under normal operating conditions.
[R3.6.2-c] The SmartPitcher shall require one person to maintain and operate.
[R3.6.3-c] The system shall be serviceable by trained technicians.
[R3.6.4-b] All components that requires a power source should not be exposed to moisture.
[R3.6.5-b] The delay time between loading the ball and firing to ball should be no longer than 5 seconds.

3.7 Safety Requirements

[R3.7.1-c] There shall be no uncovered sharp edges or corners in the SmartPitcher
[R3.7.2-b] The SmartPitcher shall be used with extra care in high humid conditions.
[R3.7.3-b] User shall always wear necessary protective gear when using the machine.
[R3.7.4-b] Avoid overcrowding practice environment, if possible, minimize the risk of unpredicted accidents.
[R3.7.5-c] All the electronic components shall be enclosed in an appropriate casing.
[R3.7.6-c] The machine casing and packaging shall display all necessary warnings.

3.8 Performance Requirements

[R3.8.1-a] The operating range of the SmartPitcher is 0 to 6m using the measurements from range finder.
[R3.8.2-a] The operating range of the SmartPitcher is 0 to 10m using the pre-set speeds.
[R3.8.3-c] The system shall deliver sensor feedback for active data within 500 milliseconds.
[R3.8.4-c] The battery life of the SmartPitcher shall depend on rechargeable power supply used to power the motor.

3.9 Mechanical Requirements

[R3.9.1-c] The prototype of the SmartPitcher shall be able to load the tennis balls individually when triggered by the user.

[R3.9.2-c] The mount platform of SmartPitcher shall be able to handle 40 lbs of weight.

[R3.9.3-c] The mount platform of SmartPitcher should be able to horizontally rotate 180 degrees.

[R3.9.4-b] The surface friction of two spinning wheels shall provide enough friction to accelerate the ball at desired speeds.

[R3.9.5-b] The SmartPitcher shall be able to fire the ball repeatedly.

4. Microcontroller, Transceiver, Motor Driver, and Sensor Requirements

Microcontroller is a small computer on a single integrated circuit which consists of wide variety of feature, such as process core and programmable input/output system which will be utilized for the manipulation of 2 DC motors, used for spinning two pitching machine wheels [5].

Motor driver is a circuit design that is going to govern and restrict the revolution speed of high-powered DC motors and spinning wheels.

Transceiver contains two special features, transmitter and receiver, which will be connected to the microcontroller and will detect the Bluetooth signal response received from the user.

Lastly, sensor will be utilized as the range finder which precisely measures the distance between the user and the SmartPitcher.

4.1 Microcontroller Requirements

[R4.1.1-c] The microcontroller shall be powered by DC power supply of 12V [6].

[R4.1.2-b] The microcontroller should be and connected to a user's laptop via USB, in order to execute the codes written within Arduino IDE.

[R4.1.3-c] Recommended input voltage for the operations of the microcontroller board shall be between 6 and 20V [6].

[R4.1.4-c] The operation voltage of the board shall be 5V [6].

[R4.1.5-c] At least 4 digital I/O pins should be available in order to manipulate 2 digital Servo motors.

[R4.1.6-c] The microcontroller shall support C/C++ programming.

4.2 Motor Driver Requirements

[R4.2.1-b] The amount of voltage range to operate the motor driver shall be from 5.5 to 24 V and shall deliver 12 A (30 A peak) per motor [7].

[R4.2.2-b] The motor driver shall manipulate and restrict two DC motors with input signals.

[R4.2.3-c] Cooling fan should be attached above the motor driver to avoid overheating caused due to continuous manipulation of spinning motor.

4.3 Transceiver Requirements

[R4.3.1-b] Power Input of the transceiver should be between 3.6V and 6V DC [8].

[R4.3.2-b] The voltage of Bluetooth Transceiver should be able support 5V, since the ideal operating voltage of the microcontroller for the SmartPitcher development is 5V [8].

[R4.3.3-c] The component should be utilized as a wireless transceiver, and the coverable range shall be from 1 to 10 metres [8].

4.4 Sensor Requirements

[R4.4.1-b] The Ultrasonic Range Finder shall be able to track user's location simultaneously rotating with the platform.

[R4.4.2-b] The Ultrasonic Range Finder should be able to sense objects within 0 - 6 m.

[R4.4.3-c] The Ultrasonic Range Finder shall be tracking the user constantly as soon as the machine is turned on.

[R4.4.4-b] The Ultrasonic Range Finder shall send the distance data to Arduino at the moment touch device is triggered to calculate the speed.

5. Software Requirements

The software and the Smartphone application integrated in our product development are all from the 3rd party. While Arduino IDE is utilized for the manipulation of motor speed, Roborealm and Arduino Bluetooth Control app is used for tracking the motion of user in real-time and sending Bluetooth signal to load and shoot the ball.

5.1 Arduino IDE Requirements

[R5.1.1-c] The version of Arduino IDE shall be the most recent version, 1.6.7 in this case.

[R5.1.2-b] C/C++ programming language shall be utilized for the coding, since they are most commonly used language when programming in the Arduino IDE [9].

[R5.1.3-b] The codes written in and executed by Arduino IDE should calculate the distance between the SmartPitcher and the user.

[R5.1.4-b] The codes also should execute the feature that DC motors' speed change depending on the distance between the athlete and the machine.

[R5.1.5-b] Arduino IDE program should be integrated with the microcontroller via the USB in order to allow the user to monitor the speed and distance of a ball travelled as well as monitoring live feedback from the SmartPitcher.

[R5.1.6-c] Libraries for Servo motor and Roborealm must initialize before interfacing with Arduino microprocessor in order to communicate.

5.2 Roborealm Requirements

[R5.2.1-c] Color code identification is one of the quickest and easiest method to track objects from one image frame to the next.

[R5.2.2-c] Use RGBFilter of Roborealm to remove all the other objects except assigned colour.

[R5.2.3-c] Add the Center of Gravity graphical overlay to set the size of the object.

[R5.2.4-b] Mean-filter can be used to reduce the error of capturing the assigned colour from the background. Mean-filter blurs the image to remove exterior assigned colours.

[R5.2.5-b] VBScript can be used to provide the image process statics and map toward the servo motor.

[R5.2.6-c] SSC Servo controller needs to be installed in order to run the servo Motor, interfacing with Roborealm.

5.3 Arduino Bluetooth Control app Requirements

[R5.3.1-b] The application should be compatible with wide variety of different android-based smartphones.

[R5.3.2-b] The application shall be installed automatically once the user downloaded the app from the Google Play Store.

[R5.3.3-c] Arduino Bluetooth Control app should also be integrated with wireless Bluetooth transceiver, so that the SmartPitcher can initialize loading and firing the ball. when the user sends the Bluetooth signal by touching the button on the smart phone screen.

[R5.3.4-b] The location of user who attached the smart phone in his/her forearm with the application already installed should be within 10 metre of the SmartPicher due to the range limit of ultrasonic range finder.

[R5.3.5-c] The button appearing within smart phone app screen shall occupy at least 80% of screen to avoid any mis-clicks during the practice.

6. System Test Plans

In order to verify that all the functions within SmartPitcher are operating properly and precisely, various types of testing within software, mechanical, and final prototype sections are going to be performed. The following table, Table 1, indicates the detailed schedule of our company's testing plan.

Table 1: Timeline Schedule throughout the Term

MONTHS	JANUARY			FEBRUARY				MARCH					APRIL	
WEEKS	2nd	3rd	4th	1st	2nd	3rd	4th	1st	2nd	3rd	4th	5th	1st	2nd
PHASE														
Research														
Design														
Development														
Integration														
Testing														
Parts order/Purchase														
Electronics/Hardware														
Mechanical														
Software														
DELIVERABLE														
Functional Spec														
Design Overview														
Written Progress														
Test Plans														
Presentation														

6.1 SOFTWARE TESTING

Software Testing will be performed from the beginning of development to the end of integration phase. During the development phase, three types of software testing will be conducted, since there exists three essential parts, motor speed control, motion tracking system, and loading mechanism, to create the SmartPitcher.

In order to manipulate the motor speed of the pitching machine, the most recent version of Arduino IDE (1.6.7) and the applications of C/C++ codes will be utilized [13]. Software testing of the codes written in Arduino IDE plays an important role in steps where the calculations of the distance between the user and the device are taking place, and the display of the calculated value correctly appears within Arduino LCD module.

The significance in software testing also takes place while creating the motion tracking system of the SmartPitcher with the computer/robotic vision analysis software called Roborealm [14]. The software possesses API feature that facilitates the image processing/analysis procedure and provides Windows-based GUI which can be experimented with wide variety of modules, including VBScript and Python [14]. This software and possibly Python codes will be used and tested to identify whether the machine can detect the precise movement of athlete and then rotates to the correct direction. Moreover, the codes which execute color identification feature will be included to detect the motions of athlete and his/her uniform for efficient analysis.

Lastly, the software testing with the use of pre-existing smartphone application, Arduino Bluetooth control that includes the Bluetooth triggering feature will be conducted to operate the successful ball loading mechanism. The application is utilized to trigger the ball to be fired once the athlete transmits, and the machine receives the Bluetooth signal. Moreover, it is also going to be tested to verify whether the ball is being shot accurately and immediately after receiving signal response from the user.

6.2 MECHANICAL TESTING

Mechanical Testing will be performed simultaneously with software testing and will take place from the beginning of development to the end of integration phase. SmartPitcher utilizes wide variety of mechanical components, such as sensors, motor driver, microcontroller, camera, motors, and linear gear. During the development phase, all the mechanical components will be integrated while conducting the software testing. Then, the testing and verifications of whether the mechanical components of SmartPitcher are functioning properly or not will be conducted until the end of integration phase. The following subcategories display the components that will be used and tested in motor speed control, motion tracking system, and loading mechanism section.

6.2.1 MOTOR SPEED CONTROL SYSTEM

Motor speed control system involves range finder, microcontroller, motor driver, two DC motors, and two spinning wheels for the SmartPitcher. The following functionalities from these components shall be tested once they are connected to the Arduino software, and the programming codes within Arduino IDE are executed.

- Range finder sensor measures and identifies the distance of either a dummy objector an individual that is placed up to the distance of 10 metre.
- Two DC motors are connected to the Arduino microcontroller in order to trigger two pitching machine wheels to spin.
- Depending the distance between the user and the SmartPitcher, Arduino microcontroller and motor driver either restricts or manipulates the rotation speed of spinning wheels, with the applications and executions of C/C++ codes from Arduino IDE.
- The first row of 20X2 Arduino LCD modules displays correct displacement (m) value between the SmartPitcher and the athlete while the second row shows accurate revolution speed of two spinning wheels (rpm).

6.2.2 MOTION TRACKING SYSTEM

The following features from camera and Servo motor will be tested while they are being operated and integrated with Roborealm.

- Camera detects the movement of athlete by receiving the information from Roborealm's real-time tracking system and the color code identification feature.
- After camera tracks the athlete's uniform color, servomotor facilities the rotation of the SmartPitcher up to 180°rangeand will point to the user at a predetermined speed.

6.2.3 BALL LOADING MECHANISM

One of the most special features of the SmartPitcher is the automatic ball loading mechanism which loads and fires the ball from the machine without the need of manpower. Once the user provides Bluetooth signal using the Arduino Bluetooth Control app, the Bluetooth transceiver attached within the Arduino microcontroller will trigger servo motor to rotate the linear gear which loads and fires the balls from the SmartPitcher. In order to build a flawless ball loading mechanism, following features from Bluetooth transceiver, linear gear, and servo motor must be tested.

- Bluetooth transceiver requests the microcontroller to load the ball after receiving the signal from the Arduino Bluetooth Control application.

- Another servo motor, added to the microcontroller, triggers a linear gear to perform the rotation for loading and shooting the balls to the user's location when the orders from the microcontroller are received.

6.3 FINAL PROTOTYPE TESTING

Final Prototype Testing of the SmartPitcher is planning to be performed during the final integration phase, which is taking place after the successful collaborations in each of software and mechanical components within motor speed control, motion tracking system, and loading mechanism parts.

After combining these three sections, it is expected to proceed to the final prototype testing phase in order to ensure that all of them work simultaneously and verify other testing issues, related to entire systems, batteries, and stabilities.

The following steps below indicate the order of entire system testing procedure:

1. Stay at most 10 meters of range after the initiation of SmartPitcher.
2. Move around within 180° of range to identify whether the machine rotates to the correct direction at a predetermined speed.
3. Send the signal to the pitching machine by tapping the smartphone application attached on the forearm.
4. The ball is fired from SmartPitcher to individual.
5. Repeat the above steps for approximately an hour.

The following tests based on batteries and stabilities will be performed:

- Since the motor parts of the SmartPitcher are powered by power supplies, our product is expected to run approximately minimum an hour. This test will be conducted by operating the machine continuously for an hour during indoor/outdoor sports' practice.
- Stability testing is categorized by balance and temperature. Since, the stable balance of the SmartPitcher is essential while the two wheels are spinning. We can test the balance by constantly changing the position of the user, and check to see if there are certain positions that cause much stress on the machine. Since we are using power supplies to operate the motor and the microcontroller, we have to test if the temperature will cause overheating during the operation. This test will be conducted by continuously monitoring the rise of temperature, and comparing the corresponding value with the components' specification limits.
- Different values of voltage ranging from 1V to 12V, is going to be applied to the motors to obtain the optimum power supply value.

7. Safety and Sustainability Analysis

The purpose of the SmartPitcher is to safely improve athlete's practice output. Thus, the safety of our design is carefully considered to ensure that the pitching machine does not cause any unforeseen and unnecessary injury/accidents to the athletes. We will consider potential situations when user might be in danger, along with the system safety requirements that we have mentioned previously in section 3.7 in the document.

In regards to sustainability, the following standards were considered in our design:

Energy efficiency

- One factor that plays an important role in sustainability of our design is energy efficiency. We tried to find the best motor that gives us the same output power with less consumed energy.

Environmental capabilities

- Energy saving is not the only criteria that we considered in our part selection; we also wanted to avoid the need for frequent maintenance issues and unplanned downtime. Ball pitching machines tend to be used in outdoor activities so to design an efficient and sustainable machine we need to consider the environmental performance of the system.

Durability and Recyclability

- The selected parts, including the motor need to be made out of materials that not only are suitable for harsh weather conditions and rainy days but can also be recycled and reused.

Renewability

- Renewability is another form of reliability constrain that we try to address in our design, we are designing our system so that it is easy to replace the wearied and damaged parts easily and all the parts can be purchased form easy accessed renewable sources.

8. Conclusion

The in-depth analysis and details arranged within this document clearly and concisely provide the functional specifications of SmartPitcher. The document lists all the essential requirements for the product development with accurate priority labels which are determined based on the types of system class, such as proof-of-concept, final prototype, or both.

The entire system design of SmartPitcher consists of three major sections:

1) **Motion Speed Control**: Depending on the distance between SmartPitcher and the user that ultrasonic range finder identifies, the revolution speed of two spinning wheels varies. In addition, Arudino Microcontroller and Polulu motor driver with the applications of Arduino IDE programming codes play an essential role of maintaining and limiting rotation speed.

2) **Motion Tracking System**: Integration of Roborealm, camera, and servo motor automatically detects the movement of an athlete with the utilization of real-time tracking system and color identification feature.

3) **Ball Loading Mechanism**: Once the pitching machine's transceiver receives Bluetooth signal from the user who has tapped the phone attached within his/her forearm, linear gear assists the pitching machine to fire the ball to the user.

For each section, both software and mechanical testing will be performed in order to proceed to final prototype testing where the last check-up of entire systems including balance/temperature stabilities and batteries takes place. Even though the proof-of-concept and final prototype of SmartPitcher are currently under development, the completion of the pitching machine is expected to be accomplished by April 11, 2016.

Reference

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