3. DESIGN APPROACH

The Basket Bully is a basketball-returning device that boosts the safety and recreation of basketball. Using position-tracking sensors, the system alters the return angle of the ball. This method allows for the Basket Bully to rotate towards the player so that the ball is released in their direction. The product sits on the ground underneath the basketball goal's rim with its own net that extends upward to allow both misses and makes to be returned to the user. By returning the ball directly to the player, the Basket Bully reduces the chance of the ball bouncing into a busy street. A game feature is also available which includes multiple game modes that track the player's successful shots. Overall, the Basket Bully allows at-home basketball players to have a more convenient, safe, and enjoyable basketball experience.

3.1 Design Options

The Basket Bully design team considered two distinctive design options when planning the approach. The first option was a return system that attached to the backboard and/or pole of the basketball goal. This solution had one major problem: basketball goals are available in a variety of shapes and sizes. Trying to make a universal product that could attach to a goal of unknown proportions was deemed impractical for the scope of the project. The second option was a return system that would catch the ball after a goal was made, and then return it to the user. This option was chosen to maximize the universality of the product for the consumer, while also keeping set-up time at a minimum.

3.1.1 Design Option 1

Initially, the design was an attachable device that would be fitted on a basketball hoop with sensors that would detect the location of a player and rotate towards them. When a shot was successfully made, the ball would roll towards their location from an angled scoop underneath the hoop. By being up above the user, it would be out of the way, reducing the risk of objects obstructing the system or from player collisions during use. This design was rejected as compatibility between the variety of different potential hoop and pole designs proved too complex. There was also concern that when attached to some goals the overall system would be too front-heavy and too structurally unstable for use.

3.1.2 Design Option 2

The second iteration of the design is an on-the-ground return system. This approach involves an apparatus that houses the returner alongside a large netting system that funnels the ball inside. Sensors outside that detect the location of the player change the angle of the scoop so the ball then rolls toward their location on the court. By keeping the device sturdy on the ground, the team solved the concern of making the design universally function on multiple different hoops. This device is also much easier to move inside to protect against strong weather conditions, such as storms or hail.

There are some drawbacks to this approach, mainly in the integration of the game subsystem. While in the first approach the team was able to hardwire the game features together with the rest of the system, for this design the components had to be separated. This alteration was a manageable change to the design of the project and did not change the complexity too drastically. There was also the concern that the device is physically in the way for the movement of the players, but with the inclusion of the large netting it was determined that players do not need to be near the goal. With these drawbacks considered and compared to the first design option, the team determined that design option 2 was the most efficient solution.

3.2 System Overview

Fig. 3-1, the Basket Bully system has three primary inputs: power, motion, and the basketball entering the hoop. The main output is the basketball being returned to the player. Fig. 3-2 shows more details about each subsystem and their connections to the microcontroller and other subsystems.

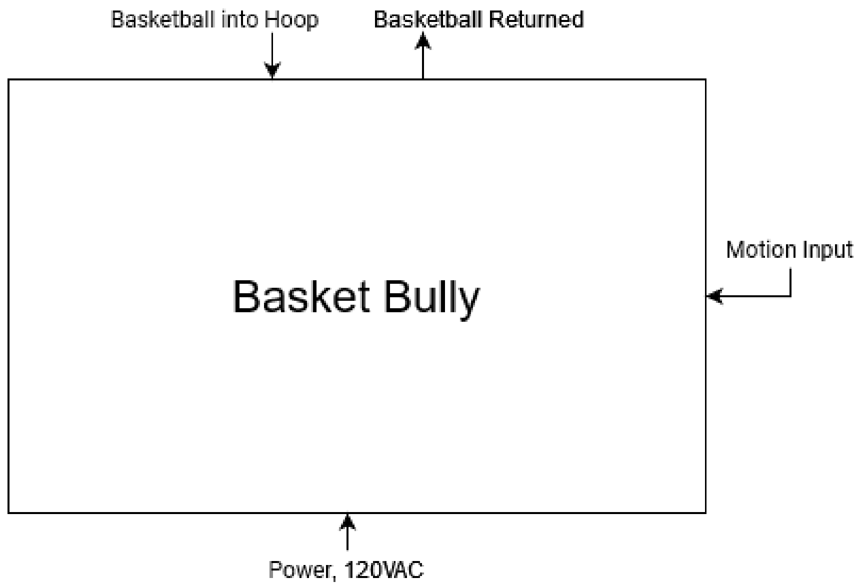

Fig. 3-1: Basket Bully System at a Glance (Level 0)

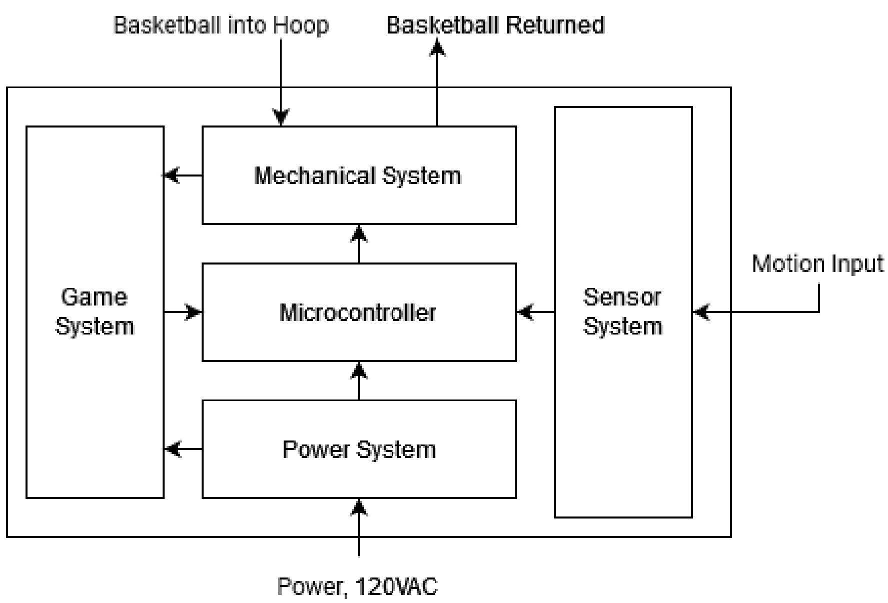

Fig. 3-2: Basket Bully Functionality (Level 1)

The six sensors receive motion input in the form of positional data from the environment and relay this information to the Arduino Uno. Based on this data, the Arduino calculates the return angle of the basketball and sends this data to the motor. The motor rotates to the proper angle and returns the basketball to the user. The game system keeps record of shot accuracy and includes multiple separate modes such as shot frenzy and three-point shootout.

3.2.1 Microcontroller

The selection of an appropriate microcontroller is a pivotal decision in the design process of the Basket Bully. Several microcontrollers were evaluated based on their performance characteristics and compatibility with the project design. The final choice of the Arduino Uno Rev 3 was made based on its compatibility in terms of operating voltage, the minimum price, and its number of pins. Table 3-1 details each product considered and their specifications.

Table 3-1: Microcontroller Options

Product	Operating Voltage	Number of Pins	Price
Requirements	5V	10	$50
Arduino Mega 2560 R3 [1]	5V	54	$48.40
Raspberry Pi Zero W [2]	5V	40	$16.00
Arduino Uno R3 [3]	5V	14	$27.60

The Arduino Uno Rev 3 is the best choice for the Basket Bully for multiple reasons. Among the Arduino boards considered, the Uno is the least expensive option available with the minimum number of necessary input and output pins. The Raspberry Pi Zero W also fits these specifications; however, the extensive documentation for Arduino projects along with the Uno's compatibility with a wide range of sensors make the Arduino Uno Rev 3 the obvious choice. Fig. 3-3 below shows the top view of the Arduino Uno Rev 3.

Fig. 3-3: Arduino Uno Rev 3 [4]

The 14 digital input/output pins are at the top of the board. The power and ground pins are near the bottom of the board. The board receives power in the port at the bottom left.

3.3 Subsystems

The Basket Bully consists of four subsystems: mechanical, sensors, game, and power. The sensors subsystem takes in positional tracking data using motion sensors and sends this data to the mechanical subsystem. Using this data as input, the mechanical subsystem physically rotates the return mechanism towards the user. The user can also take advantage of the game subsystem, which provides multiple arcade-style games from which the user can choose to play. Each of the aforementioned subsystems is powered by the power subsystem, which is also capable of simple plug-and-play charging using a standard wall outlet.

3.3.1 Mechanical

The mechanical subsystem fulfills multiple specific requirements, such as the ability to rotate 180 degrees using a small motor, catch the basketball, and return it to the user. While the initial plan considered a servo motor versus a stepper motor, the decision to use a servo motor was made, primarily due to concerns about the stepper motor's suitability in rotation and attainability from distributors. The servo motor uses feedback from the sensors system to move to the next location, which better fits the design of the Basket Bully.

The team searched for a motor with an operating voltage of ~5 volts. Most motors have multiple options of voltage power based on which battery is used. These options usually range from 4.8 volts to 7 volts of power consumption [5]; however, some motors can go beyond 7 volts. The team considered three different motors, but the Injora Radio Controlled (RC) digital servo motor was selected due to its price per unit and its voltage options being compatible with the battery and Arduino selected. The Injora 540 brushed motor 80T was not selected due to its input voltage being 7.4 V, which is incompatible with the battery selected [6]. The Zoskay high torque cordless servo motor was not selected because its potential torque power threatens to overpower the physical casing of the ramp and poses the problem of breaking the casing of the return system.

Table 3-2 contains several hardware options and their specifications.

Table 3-2: Motor Options

Product	Input Voltage	Torque	Rotation	Size
Requirements	4.8V < v < 7V	10 kg – 30 kg	180 degrees	< 15 cm
INJORA RC Digital Servo Motor [7]	4.8V – 6V	11.2 kg – 14 kg	180 degrees	40x20x28.8 mm
INJORA 540 Brushed Motor 13T [6]	7.4V	13 kg – 15 kg	180 degrees	36x12x3.17 mm
ZOSKAY High Torque Coreless Servo Motor [8]	5V – 7.4V	29 kg – 35 kg	180 – 270 degrees	40x20x38.5 mm

The component chosen is better suited to the needs of the system due to its voltage options being compatible with the battery chosen and its torque power being within the bounds of not risking the physical casing of the system. Fig. 3-4 below shows the Injora servo motor that was selected to fulfill the rotation requirement of this subsystem.

Fig. 3-4: INJORA RC Digital Servo Motor [7]

Fig. 3-4 shows the chosen servo motor which is 40 mm in length, so it is well within the size constraints of the project and fits easily inside the casing of the main system [7].

3.3.2 Sensor

The key function of the sensor subsystem is to detect the player's position on the court and relay this information in the form of an angle to the mechanical subsystem. A few different methods of position detection have been considered: a local positioning system (LPS), camera detection, and simple motion sensing.

Although LPS is very accurate and a good fit for the project's needs, it requires multiple beacons to be placed in the surrounding area to triangulate the position of the user. Since a primary engineering requirement of the Basket Bully is low set-up time, the team deemed it necessary to keep the product as a singular unit, thus avoiding the LPS approach.

Camera detection is a viable option for ascertaining the position of a person in a specific and consistent environment; however, a requirement of the Basket Bully system is its universal usability. The product is required to operate in a range of 20°F to 130°F, 0 to 31 mph winds, and in any number of locations across the world. A camera system requires consistent lighting and environmental factors that cannot be guaranteed within the project's constraints.

The chosen approach for the sensor subsystem was simple motion sensing. The purpose of detecting the player's position is solely to return the basketball in their direction, so receiving input in the form of only motion is enough to satisfy the subsystem's requirements.

The sensors subsystem uses six passive infrared (PIR) motion sensors to split the 180° return radius into sections of 30° using blockers between each sensor. This method allows the system to be accurate up to the three-point line with a margin of error of approximately five feet.

When choosing the PIR sensor, the main considerations were its compatibility with the Arduino Uno microcontroller, its accuracy up to the distance of a high school three-point line (19.75 feet), and a cost lower than $10 [9]. Table 3-3 lists the sensors considered along with the requirements for each category.

Table 3-3: Sensor Options

Product	Input Voltage	Output Voltage	Accuracy	Cost
Requirements	5 V	3-5 V	19.75 ft	$10
HC-SR501 [10]	5-20 V	3.3 V	22.966 ft	$2.40
HC-SR602 [11]	3.3-15.5 V	3.3 V	16.404 ft	$8.63
HC-SR505 [12]	4.5-20 V	3.3 V	9.84 ft	$1.13

Among the components considered, the HC-SR501 was chosen because it meets all the requirements and there is extensive documentation online proving its compatibility with the project's needs. Fig. 3-5 shows the front-view and rear-view of the sensor along with the pins' location on the board. The HC-SR501 also has sensitivity and off-time control. These features offer additional flexibility in the design of the subsystem.

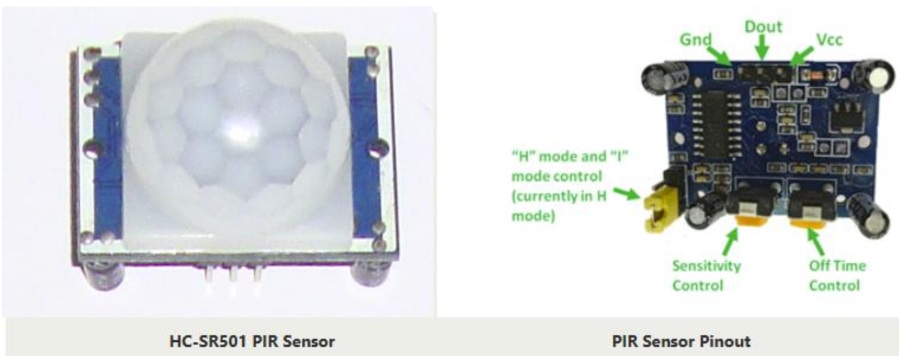

Fig. 3-5: HC-SR501 PIR Sensor [10]

Fig. 3-6 indicates the software process flow of the sensor subsystem. A sketch file runs on the Arduino Uno when it powers on. This program loops constantly, reading the six separate digital input pins connected to the HC-SR501 PIR sensors.

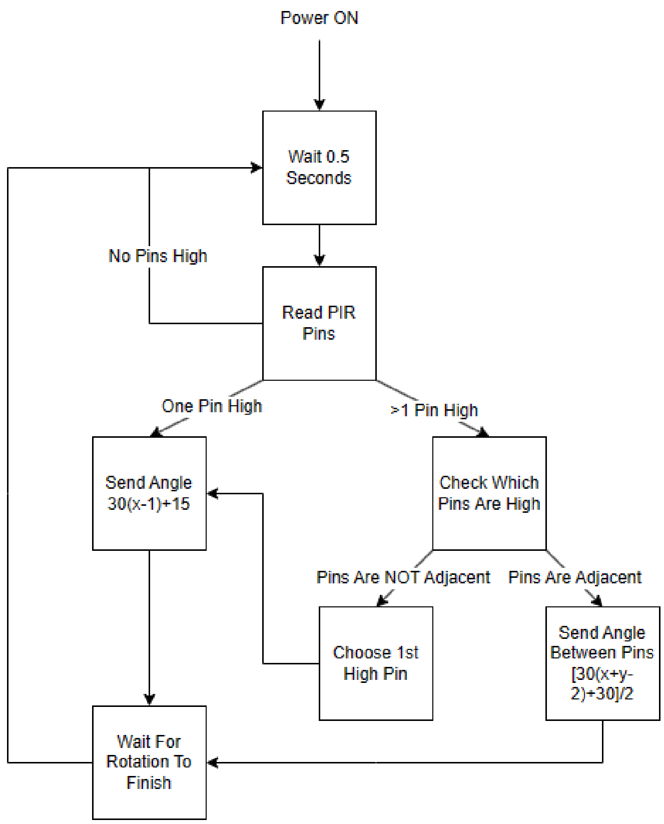

Fig. 3-6: Sensor Software Diagram

When the Arduino reads the digital pins, there are three separate cases possible: zero, one, or more than one of the sensors are detecting motion. The first case is simple and only requires the program to loop back to the initial case of waiting to sense motion again. The second case calculates the return angle using the formula $y = 30(x-1) + 15$. The x symbolizes which sensor is active and the resulting angle is the center of the conical section of that sensor's area. The complexity of the program increases drastically when more than one of the pins is high. First, the program checks if the pins are adjacent to one another (i.e., someone is standing perfectly between two sections). If this adjacency case is true, then the program returns the angle between the two sensors, otherwise the program reverts to the return angle of the first high pin.

3.3.2 Game

The game subsystem is required to detect a shot's accuracy. This knowledge is acquired using a pressure sensor in the net, which is activated upon a basketball entering the hoop. An Arduino Nano is required to process the data from the pressure sensor. The Nano connects to a Bluetooth module which communicates with the main system via an identical module on the Arduino Uno Rev 3. This wireless communication allows the Nano and pressure sensor to be placed in the basketball net instead of wired directly to the Uno.

Table 3-4 below shows other microcontroller options that were ruled out. The microcontroller needs at least 3 inputs, so the pressure sensor and Bluetooth module are powered and controlled properly. Using another Arduino board allows for seamless data transfer between the game subsystem and the main system. The availability of analog input is necessary for the pressure sensor's ability to measure a wide range of forces, which allows for a more better detection of accurate basketball shots.

Table 3-4: Game Microcontroller Options

Product	Available input pins	Cost	Make	Analog input availability	Size
Requirements	> 3	< $30	Arduino	Yes	Smallest available
Arduino Nano V3.0 [13]	19	$20	Arduino	Yes	18x45mm
Arduino Uno Rev3 [3]	26	$27	Arduino	Yes	68x53mm
Arduino Mega 2560 R3 [1]	70	$48	Arduino	Yes	101x53mm

The Arduino Nano V3.0 (shown in Fig. 3-7) takes in data from a pressure sensor and translates it to a missed or made basketball shot. The pressure sensor is wired into an analog pin allowing for a variety of values to be read instead of just a high or low signal. The Nano sends data for shots made to the Uno which stores the program needed to execute a game of the user's choice.

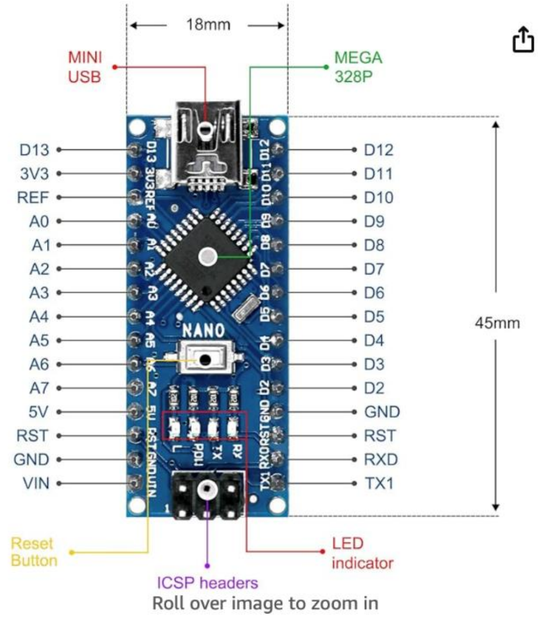

Fig. 3-7: Arduino Nano V3.0 [13]

Table 3-5 below shows the pressure sensors that went into consideration. The pressure sensor needed to be slim and waterproof since it operates in an outdoor setting. The sensor also needed to be able to sense a range of values instead of just a high or low signal to accurately measure a made shot. Force is a key factor as there is a potential of direct impact from a basketball to the sensor. Newton's Second Law of Motion states that force equals mass times acceleration. The mass of a standard basketball is 0.62 kilograms and the acceleration due to gravity is ~10 meters/second^2 [14]. Therefore, the maximum force of a basketball in the downward direction is ~6.23 Newtons, which is equal to 6230 grams.

Table 3-5: Pressure Sensor Options

Product	Width	Analog	Weight Tolerance (grams)	Waterproof
Requirements	< 20mm	Yes	> 6230g	Yes
Thin Film Pressure Sensor SF15-130 [15]	13mm	Yes	10,000g	Yes
Thin Film Pressure Sensor ZD10-100 [16]	10mm	Yes	500g	Yes
GY-291 ADXL345 3-Axis Accelerometer [17]	16mm	Yes	16g	No

The obvious choice of pressure sensor was the Thin Film Pressure Sensor SF15-130 as shown in Fig. 3-8 below. It was the only option that could tolerate enough weight and had a small enough width which would allow for the sensor to go along a basketball net line and not cover up holes. An accelerometer was considered due to its valuable ability to sense the direction of its movement. This would prevent any false positives that would normally happen if a user were to hit the net in an upward direction. Hitting the net in such a way is rare and the accelerometer did not meet major requirements, so it was not chosen.

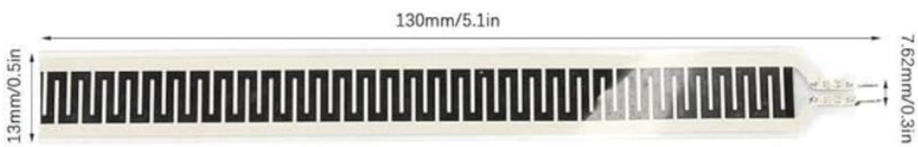

Fig. 3-8: Thin Film Pressure Sensor SF15-130 [15]

Table 3-6 shows each Bluetooth module that was considered. There are few differences in standard Bluetooth modules, but one difference that mattered for this project was the ability of a module to be in either slave or master mode. This way one module can send, and one module can receive.

Table 3-6: Bluetooth Module Options

Product	Send and Receive	Cost	Simple communication
Requirements	Yes	< $15	Yes
DSD TECH HC-05 Bluetooth Module [18]	Yes	$9.99	Yes
HiLetgo HM-10 Bluetooth Module [19]	Yes	$10.59	No
HiLetgo HC-06 Bluetooth Module [20]	No	$9.49	Yes

The DSD TECH HC-05 Bluetooth Module shown in Fig. 3-9 below was the best choice for a Bluetooth module. The HiLetgo HM-10 Bluetooth Module was almost chosen but uses encryption for data communication which is unnecessary for this project.

Fig. 3-9: DSD TECH HC-05 Bluetooth Module [18]

The Arduino Nano uses the Arduino IDE which allows for smooth communication between it and the Arduino Uno board. The flowchart below (Fig. 3-10) explains the general process of the game feature's software. A user may pick from two game modes depending on their preference. Each game mode has a given time where the user's made shots are tracked. Frenzy allows for shots from anywhere on the court while 3 Point Shoot off rotates incrementally to simulate a traditional NBA (National Basketball Association) 3-point contest [21].

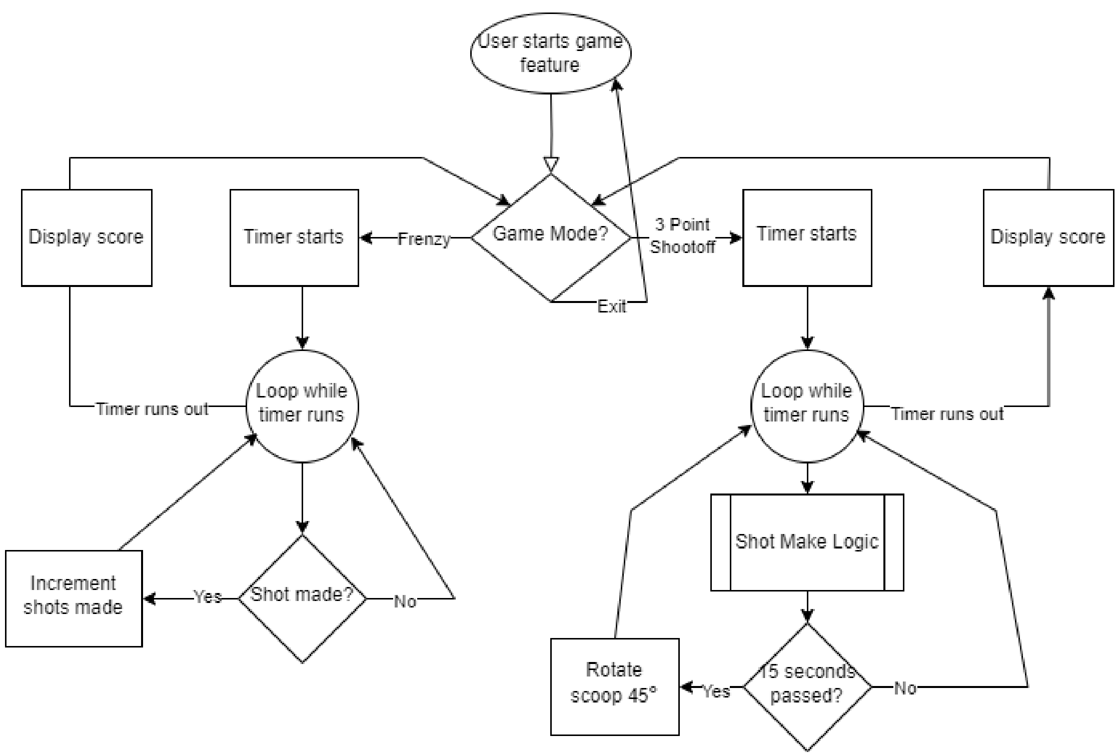

Fig. 3-10: Game Feature Flowchart

The software described in Fig. 3-10 is implemented on both the Arduino Uno and the Arduino Nano. The user starts the game of their choice by pressing a button attached to the returner. Once the timer has started for either game mode, the Nano sends notifications when shots are made to the Uno using the

Bluetooth modules which use UART data format for communication. The Uno executes the rest of the code described in the flowchart. The reasoning for this software flow is because the only data needed from the Nano is whether a shot is made or not. The less data to send over Bluetooth the better, as wired connections are more stable and efficient. When either game mode finishes, the user’s score is displayed on a screen on the returner.

3.3.3 Power

The power subsystem has been split into two separate parts. The first part powers the Arduino Nano used in the game subsystem, and the second part powers the Arduino Uno used in the main system. Table 3-7 lists the various products that were considered for the Arduino Uno’s power supply as well as the requirements the chosen product needed to meet. The battery life without recharging for each product was calculated by dividing the supplied current by the minimum required supplied current, 390mA.

Table 3-7: Battery Options for the Arduino Uno

Product	Operating Voltage	Supplied Current	Battery Life Without Recharging	Charging Time
Requirements	≥ 5V	≥ 390mA	≥ 1.5 hours	Fastest Available
SPARKOLE Rechargeable Lithium-ion Battery [22]	12V	5200mAh	13 hours	3 – 6 hours
Talentcell Rechargeable Lithium-ion Battery Pack [23]	12V	3000mAh	7.5 hours	6 hours
Melasta Rechargeable Lithium-ion Battery Power Bank with Charger [24]	12V	5200mAh	13 hours	Not provided

The SPARKOLE Rechargeable Lithium-ion Battery (shown in Fig. 3-11) was chosen to power the Arduino Uno because it has the fastest charging time and longest battery life without charging. A charging time of 3 – 6 hours ensures the user does not have to wait too long to use the Basket Bully. The longer battery life allows users to play on the device for at least one play session without needing to stop and charge the battery. Since the battery did not come with a charging cable, one had to be purchased separately. The charging cable allows for the battery to be rechargeable via an outlet.

Fig. 3-11: SPARKOLE Rechargeable Lithium-ion Battery [22]

Table 3-8 lists the various products considered to power the Arduino Nano in the game system. The table also lists the requirements the chosen product must meet. The battery life without recharging, operating voltage, and price requirements are the same as the requirements for the Arduino Uno. The supplied current must be at least 30mA.

Table 3-8: Battery Options for the Arduino Nano

Product	Operating Voltage	Supplied Current	Battery Life Without Recharging	Charging Time
Requirements	≥ 5V	≥ 30mA	≥ 1.5 hours	Fastest Available
KILISTEELS Rechargeable AA Batteries [25]	6V	2000mAh	66.5 hours	1.5 hours
SPARKOLE Rechargeable Lithium-ion Battery [22]	12V	5200mAh	173 hours	3 – 6 hours
KBT Rechargeable Li-ion Battery [26]	12V	1200mAh	40 hours	Not provided

The SPARKOLE Rechargeable Lithium-ion Battery (shown in Fig. 3-9) was also chosen to power the Arduino Nano for similar reasons to the Arduino Uno. In this case, the SPARKOLE Rechargeable Lithium-ion Battery did not have the fastest charging time. While a faster charging time is preferable, the Kilisteels rechargeable AA batteries create a couple of extra problems for the user. Since a marketing requirement for the Basket Bully is convenience, creating extra problems for users is not worth choosing a power supply that charges faster.

3.4 Level 2 Prototype Design

The Basket Bully's subsystems are integrated into a two-part system with two goals in mind: low installation time and minimal take-down time. Fig. 3-12 helps visualize the main portion of the design.

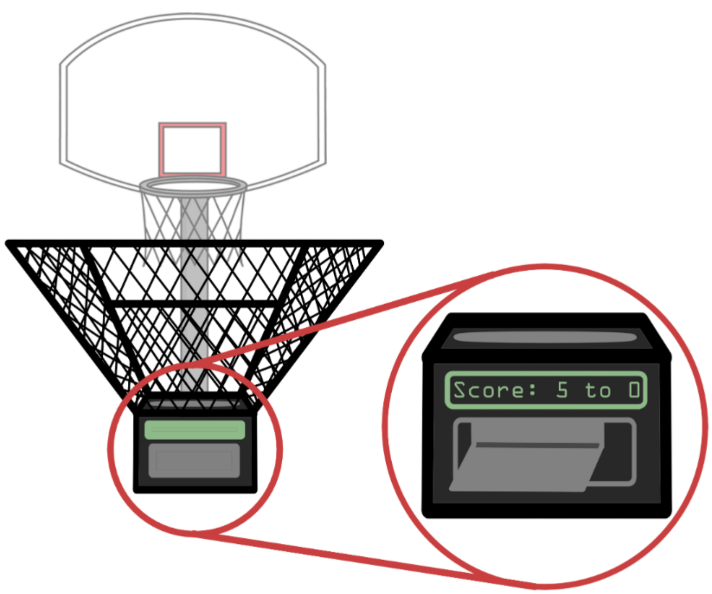

Fig. 3-12: Basket Bully Fully Integrated System

The mechanical return system, the Arduino Uno microcontroller, the PIR sensors, and the 12V battery all reside within the black box at the bottom of the design. The netting is connected to the box and protrudes upward towards the goal at a 30° angle. The game system and the other 12V battery are connected to the rim of the goal itself, allowing for the pressure sensor to detect accurate shots. The box is made of plywood, and the net structure uses PVC pipe and plastic netting. Plastic netting is lighter and cheaper than woven fabric netting which is why this design choice was made; furthermore, PVC pipe is lighter and more affordable compared to metal poles, which is why PVC pipes have been chosen.

3.4.1 Level 2 Diagram

Fig. 3-13 shows the interconnections between each subsystem and how they operate together to accomplish the goal of the product: to return a basketball to the user. Each of the subsystems is shown in the diagram along with its internal parts broken down into more detail.

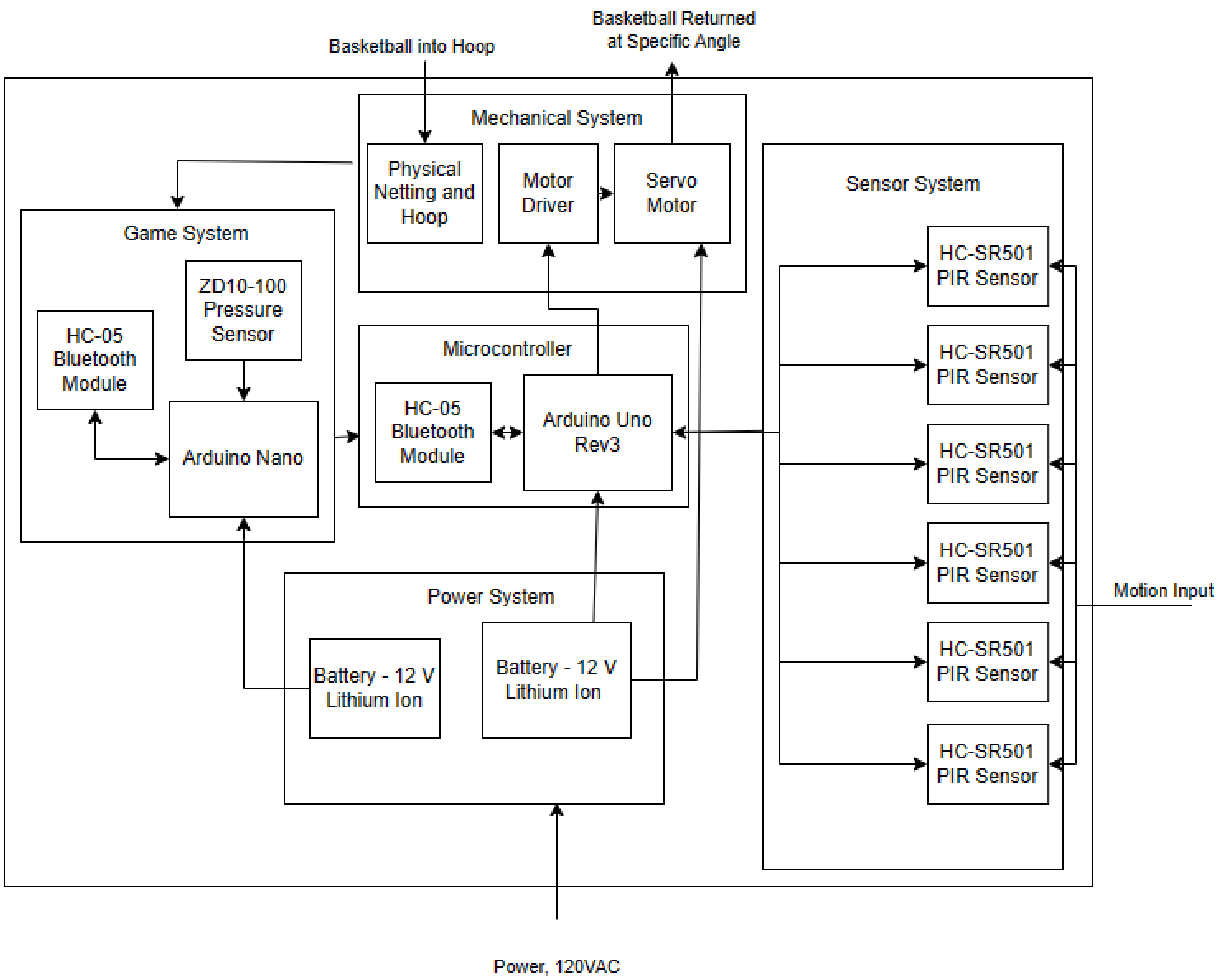

Fig. 3-13: Diagram for Basket Bully (Level 2)

A 12V lithium-ion battery supplies power directly to the Arduino Uno and the servo motor. Another 12V battery provides power to the game system. The batteries are charged using a wall outlet with an output of 120VAC. The six HC-SR501 PIR sensors get power directly from the Arduino Uno. The sensors receive motion input from the environment and relay that information to the Arduino Uno. The servo motor is controlled via a driver receiving input from the Arduino as a return angle. The basketball itself acts as an input to the overall system and is received by the netting/hoop of the mechanical system. Lastly, the game system uses a ZD10-100 pressure sensor to detect when a basketball shot enters the net. Information is relayed between the Arduino Uno and the game system's Arduino Nano via HC-05 Bluetooth modules. The system utilizes information from each subsystem to return the ball at a specific angle to the user's location on the court.

3.5 References

[1] "Arduino Mega 2560 Rev3," *Arduino.cc.* [Online]. Available: https://store-usa.arduino.cc/products/arduino-mega-2560-rev3. [Accessed Oct. 30, 2023].

[2] "Raspberry Pi Zero W," *Raspberrypi.com.* [Online]. Available: https://www.raspberrypi.com/products/raspberry-pi-zero-w. [Accessed Oct. 30, 2023].

[3] "Arduino Uno Rev3," *Arduino.cc.* [Online]. Available: https://store-usa.arduino.cc/products/arduino-uno-rev3. [Accessed Oct. 30, 2023].

[4] "Arduino Uno – Arduino Uno, Rev. 3, Atmega328, USB," *Reichelt.com*. [Online]. Available: https://www.reichelt.com/de/en/arduino-uno-rev-3-atmega328-usb-arduino-uno-p119045.html. [Accessed Nov. 2, 2023].

[5] "Servo Motor," *Sciencedirect.com*. [Online]. Available: https://www.sciencedirect.com/topics/computer-science/servo-motor. [Accessed Oct. 31, 2023].

[6] "INJORA 540 Waterproof Brushed Motor...," *Injora.com*, [Online]. Available: https://www.injora.com/products/540-brushed-motor-35t-45t-55t-for-1-10-rc-crawler. [Accessed Oct. 31, 2023].

[7] "INJORA INJS014 14KG…," *Injora.com*. [Online]. Available: https://www.injora.com/products/14kg-metal-gear-digital-core-servo-for-1-10-rc-car. [Accessed Oct. 31, 2023].

[8] "ZOSKAY 35kg High Torque Coreless Motor Servo...," *Amazon.com.* [Online]. Available: https://www.amazon.com/ZOSKAY-Coreless-Digital-Stainless-arduino/dp/B07SBYZ4G5 [Accessed Oct. 31, 2023].

[9] M. Sanchez, "How Far Is The 3 Point Line In High School Basketball," *Saveourschoolsmarch.org*, Sept. 11, 2023. [Online]. Available: https://www.saveourschoolsmarch.org/high-school-3-point-line-distance. [Accessed Nov. 3, 2023].

[10] "HC-SR501 PIR Sensor," *Components101.com*, Jul. 18, 2021. [Online]. Available: https://components101.com/sensors/hc-sr501-pir-sensor. [Accessed: Oct. 30, 2023].

[11] A. Victor, "HC-SR602 Datasheet," *Sinoning.com,* Jun. 29, 2020. [Online]. Available: https://www.sinoning.com/hc-sr602-datasheet. [Accessed Oct. 30, 2023].

[12] "HC-SR505 PIR Motion Sensor Module," *Components101.com,* Nov. 25, 2018. [Online]. Available: https://components101.com/sensors/hc-sr505-pir-sensor-pinout-datasheet. [Accessed Oct. 30, 2023].

[13] "Arduino Nano," *Arduino.cc.* [Online]. Available: https://store-usa.arduino.cc/products/arduino-nano?selectedStore=us. [Accessed Oct. 30, 2023].

[14] J. Haefner, "Basketball Size Chart – Recommended for Kids & Adults," B*reakthroughbasketball.co.* [Online]. Available: https://www.breakthroughbasketball.com/basketballs/size-chart.html. [Accessed Nov. 3, 2023].

[15] "Thin Film Pressure Sensor Flex/Bend Sensor SF15-130…," *Amazon.com*. [Online]. Available: https://www.amazon.com/Pressure-SF15-130-Resistance-Type-Sensitive-Resistor/dp/B07PM64VN6. [Accessed Nov. 2, 2023].

[16] "Force Sensor,Resistance-Type Thin Film Pressure Sensor, 500g ZD10-100," *Amazon.com*. [Online]. Available: https://www.amazon.com/Force-Sensor-Resistance-type-Pressure-ZD10-100/dp/B07ZX8RPKX. [Accessed Nov. 2, 2023].

[17] "HiLetgo GY-291 ADXL345 3-Axis Digital Acceleration of Gravity Tilt Module for Arduino IIC/SPI Transmission : Industrial & Scientific," *Amazon.com*. [Online]. Available: https://www.amazon.com/HiLetgo-ADXL345-Digital-Acceleration-Transmission/dp/B01DLG4OU6. [Accessed Nov. 2, 2023].

[18] "DSD TECH HC-05 Bluetooth Serial Pass-through Module Wireless Serial Communication with Button for Arduino : Electronics," *Amazon.com*. [Online]. Available: https://www.amazon.com/DSD-TECH-HC-05-Pass-through-Communication/dp/B01G9KSAF6. [Accessed Nov. 2, 2023].

[19] "HiLetgo 2pcs CC2540 CC2541 AT-09 Serial Wireless Module BLE 4.0 Bluetooth Module Compatible HM-10 : Electronics," *Amazon.com.* [Online]. Available: https://www.amazon.com/HiLetgo-Bluetooth-Wireless-Compatible-Arduino/dp/B00WGPKZ8Y. [Accessed Nov. 2, 2023].

[20] "HiLetgo HC-06 RS232 4 Pin Wireless Bluetooth Serial RF Transceiver Module Bi-Directional Serial Channel Slave Mode for Arduino : Electronics," *Amazon.com.* [Online]. https://www.amazon.com/HiLetgo-Wireless-Bluetooth-Transceiver-Support/dp/B01CKW4FSI. [Accessed Nov. 2, 2023].

[21] J. May, "2023 NBA All-Star 3-Point Contest: Format and Rules Explained," *en.as.com*, Feb. 18, 2023. [Online]. Available: https://en.as.com/nba/2023-nba-all-star-3-point-contest-format-and-rules-explained-n/. [Accessed Nov. 3, 2023].

[22] "Sparkole 12V Battery Pack Rechargeable 5200mAh Lithium Ion …," *Amazon.com.* [Online]. Available: https://www.amazon.com/SPARKOLE-Rechargeable-Electronic-Portable-Interface/dp/B09GVD92JF. [Accessed Oct. 31, 2023].

[23] "Talentcell Rechargeable 12V 3000mAh Lithium ion …," *Amazon.com.* [Online]. Available: https://www.amazon.com/TalentCell-Rechargeable-3000mAh-Lithium-External/dp/B01M7Z9Z1N. [Accessed Nov. 2, 2023].

[24] "Melasta Rechargeable 12V 5200mAh Battery Pack …," *Amazon.com.* [Online]. Available: https://www.amazon.com/Melasta-5200mAh-Rechargeable-Security-Telescope/dp/B0C1BQ1L33. [Accessed Nov. 2, 2023].

[25] "Rechargeable AA Batteries …," *Amazon.com.* [Online]. Available: https://www.amazon.com/Rechargeable-AA-Batteries-Pc-1-5v-Lithum-Ion/dp/B0BDZ2QBYR. [Accessed Nov. 2, 2023].

[26] "KBT 3.7V 420mAh Li-Polymer …," *Amazon.com*. [Online]. Available: https://www.amazon.com/KBT-Battery%EF%BC%9A602040-Rechargeable-Lithium-ion-Replacement/dp/B0BDFYZF4H. [Accessed Nov. 3, 2023].