ECE 445

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Project Proposal

Automated NBA Game Clock Stopper

Team Number: 36

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Problem

Within the last two minutes of an NBA game, the game clock is supposed to stop immediately after each made shot. Currently, this process is done manually with a game clock operator that stops the clock once they see that a shot has been made. However, as viewers, we have seen delays in this manual stopping of the clock due to human reaction speed. An accurate stoppage of the clock is crucial for close games as every tenth of a second is enough time for another possession, which can influence the outcome of the game.

Solution

We are proposing the development of a system that will track when the ball goes through the hoop and send a signal to a receiver that stops the game clock. In a game, athletes are trying to block shots, make layups from right below the basket, and fight for rebounds. Thus, we present a 3 sensor system that will minimize the potential for inaccurate clock stoppage due to these situations.

One sensor, an optical sensor, would be placed right above the rim and behind the glass to determine whether the basketball is between the backboard and the part of the rim furthest away from the backboard. Another sensor, an ultrasonic sensor, is located at the bottom of the rim-backboard junction. This sensor's primary function would be to make sure that the ball is in the net. The third sensor will be a camera that will be used to detect the color that is passing which will in turn tell us if the object being passed through both sensors is a basketball. The two sensors will connect to the PCB and the camera will be connected to a Raspberry Pi which will then be connected to the PCB. Our PCB will then determine if the clock needs to be stopped and send an appropriate signal to stop the clock when a shot is made.

Visual Aid

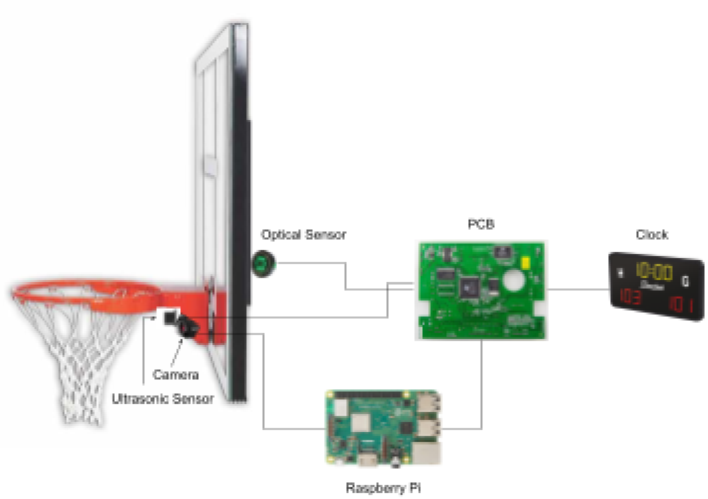

Figure 1. Visual aid of proposed system.

High-level requirements list

- The system should be able to detect the difference between a basketball and a human hand
- The system should successfully stop the clock during layups and dunks, but not during blocked shots and rebounds.
- The stop signal should be sent within 0.3 sec of the made shot to be considered an improvement compared to human reaction time.

Block Diagram

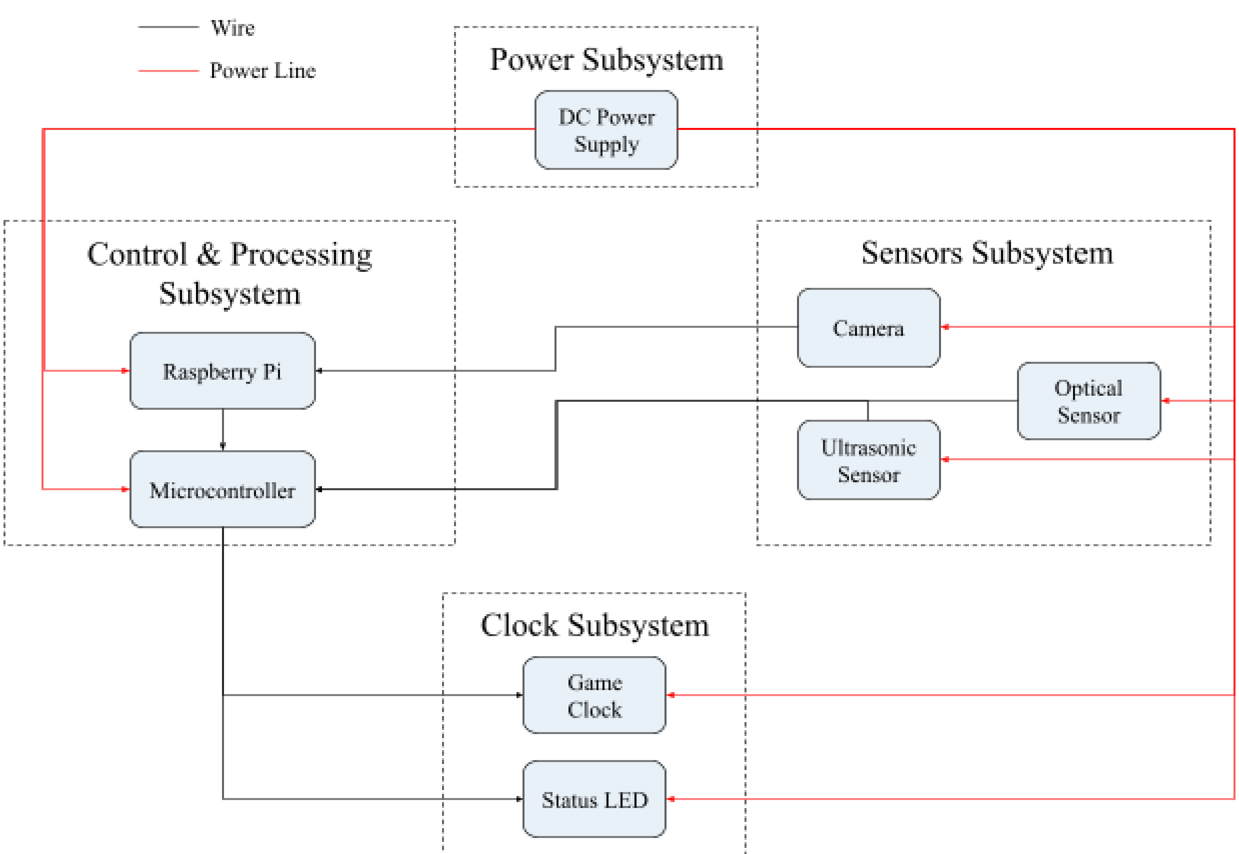

Figure 2. Block diagram breakdown of subsystems.

Subsystem Overview

The power subsystem is responsible for delivering power to every component of the system, including the Raspberry Pi, microcontroller, game clock, status LED, camera/color sensor, ultrasonic sensor, and optical sensor. As such, it connects to each of the other subsystems to provide power to their components as indicated by the red arrows in the block diagram. We plan to use a 12V DC power supply with the potential addition of some voltage divider circuits to power these components.

The clock subsystem consists of the game clock and a status LED. The game clock receives power from the power subsystem and information from the microcontroller in the control & processing subsystem. The microcontroller tells the game clock when to stop. The status LED gets similar information to the game clock, but is used to test the output from the microcontroller in case the communication between the microcontroller and the game clock doesn't work as intended.

The sensor subsystem contains the camera, optical sensor, and ultrasonic sensor. The sensors are powered by the DC power supply in the power subsystem. The output of these sensors will act as the input for our control and processing subsystem. The signals from these sensors will be used to determine a made shot and as a result trigger the sequence to stop the clock.

The control and processing subsystem contains the microcontroller and Raspberry Pi both being powered from the lithium ion battery that is a part of the power subsystem. The Raspberry Pi will be used as a secondary processing unit for the camera that is from the sensor subsystem. The Raspberry Pi along with the optical sensor and ultrasonic sensor from the sensor subsystem will connect to the microcontroller. The microcontroller will ultimately determine if a shot is made and send a signal to the clock subsystem to stop the clock and light up the status LED.

Subsystem Requirements

Power Subsystem

DC Power Supply - The power supply, with a built-in voltage regulator, will be connected to a wall outlet and have 12V of available voltage for all components of the system. Voltage divider circuits can be used to provide less voltage to some components based on the requirements listed on their datasheets. This power supply should be able to supply between 1 and 300 mA to the rest of the system continuously. We expect to build multiple voltage divider circuits to convert the 12V DC supply into 3V and 5V supplies for our sensors. Without the power supply, the overall system will not be able to communicate the necessary electrical signals.

Sensor Subsystem

Optical Sensor - We will be using LTR-329ALS-01 optical sensor. The optical sensor will be used to determine that an object is above the rim. This will be the sensor that should be triggered first in the process of making a shot. The optical sensor is a 2.0 x 2.0 mm^2 sensor with a detection area of 0.32 x 0.29 mm^2. The optical sensor will require 2.4 V constantly. Without the optical sensor the sensor subsystem will fail as it will falsely trigger the clock to stop without knowing if the basketball came from above the rim.

Ultrasonic Sensor - We will be using the HC-SR04 ultrasonic ranging module. This will go underneath the rim and will be used to ensure that the ball passes through the net. This sensor provides a 2cm-400cm non-contact measurement function, with a ranging accuracy that can reach up to 3mm. Further, it has a measuring angle of 15 degrees. As such, this will have enough accuracy to detect a decrease in distance when the ball passes through the net. The sensor has four pins: 5V Supply, Trigger Pulse Input, Echo Pulse Output, 0V Ground. It requires 5.0 V and 15 mA to operate. Its dimensions are 45 x 25 x 15 mm.

Camera - We will use a Raspberry Pi 12.3MP high quality camera. This camera will be used to determine if the object being passed through the bottom of the rim is a basketball or a different object like a player's hand. This will be done by measuring the color that is passing through. The camera will require an extra 200-250 mA from the Raspberry Pi. We are considering replacing this component with a color sensor that will be more budget friendly and still serve as a sensor that can differentiate between a player's hand and the basketball.

Control & Processing Subsystem

Microcontroller - We plan to use an ATMega328p microcontroller soldered onto our PCB to process the output signals from the ultrasonic sensor, optical sensor and Raspberry Pi. The microcontroller will implement the required logic to convert these three signals into a signal that stops the game clock and turns on the status LED. One of the peripheral 8-bit timers/counters on the microcontroller can be used to make sure that the top and bottom sensors are triggered within the time span of a basketball going through a hoop to avoid false positives. The 16-bit peripheral timer/counter will be used as the game clock and its data will be sent to the game clock display. Without the microcontroller, we would not be able to appropriately send a single signal to stop the game clock, as we would have three separate signals from the sensors and Raspberry Pi. If we opt to use a color sensor in place of the camera, then the input to the microcontroller from the Raspberry Pi will be replaced with a signal directly from the color sensor and the logic will be changed to be compatible with the color sensor.

Raspberry Pi - The Raspberry Pi is used to process the data from the camera and detect the basketball color within the net. This ensures that the object that is detected in the net is a basketball rather than a human hand, which would trigger the ultrasonic sensor and could falsely indicate that a shot was made. If the basketball color is detected within the net, the Raspberry Pi will send a signal to the microcontroller, which will handle this signal in combination with the signal from the optical and ultrasonic sensors. If we opt to replace the camera with a color sensor, then we will remove the Raspberry Pi from the system and the output of the color sensor will be connected to the microcontroller.

Clock Subsystem

Game Clock - We will have a game clock display that will display the data from the clock on the microcontroller. The game clock will be a 40 pin LCD Display Module that is 50.80mm x 22.73mm x 2.20mm. The LCD display module will require 5V.

Status LED - The status LED will be used to indicate the stoppage of the clock. In the event that the sensors and control & processing subsystem work as intended, but the output signal of the microcontroller does not appear to stop the clock in a visible way, the status LED can indicate that the issue is with the communication between the signal output from the microcontroller and the stoppage of the 16-bit clock. Ideally, the entire system will work without the status LED and the LED will only be used for testing purposes. This LED should have a low forward voltage in accordance with the output voltages from the microcontroller.

Tolerance Analysis

We determine that a potential failure point of the system is the ultrasonic sensor being falsely triggered by the net. To combat this, we aim to position the ultrasonic sensor such that both the transmitter and receiver are not blocked by the net. Furthermore, the sensor will be close enough to the net such that the 15 degree projection is narrow enough to pass through the empty space. A conservatie estimate is that the net holes are 6 cm wide. A horizontal isosceles triangle with a base of 6 cm and a vertex angle of 15 degrees has a height of 8.97 inches. In the context of this project, this means that the ultrasonic sensor must be positioned within 8.97 inches of the middle of the farthest net hole, which is feasible based on the dimensions of a professional basketball hoop.

Ethics and Safety

- System should be consistent in time delay and accuracy for both hoops in a basketball court so that one team does not unfairly benefit.
- The same device has to have a consistent stopping time that way in any shot the time delay is the same.
- Should not disturb the flow of the shot.
- Adheres to NBA league regulations on equipment.