Game Feeder Cam

Richard Kelly, Anthony Crosby, Joseph Torres Rosario, Daniel Guzman

Dept. of Electrical Engineering and Computer Science, University of Central Florida, Orlando, Florida, 32816-2450 (12 point Times font)

***Abstract* — This paper presents the design methodology utilized to realize circuitry that implements safety standards for a 5 gallon hunting feeder. The necessary standards for the aforementioned project fall into several categories: (1) Solar Power Supply System; (2) Wild Live Activity Monitoring; (3) Recording Environmental Data and Scheduled Feeding Patterns. This paper also presents the methodology to realize a software integrations of the components as well as a mobile application.**

***Index Terms* — Event Detection, Motion Detection, Solar system, Camera, Sensors, Software, Mobile communication.**

I. INTRODUCTION

Before the hunting season begins, many sportsmen spend time out on their hunting property scouting for possible game activity in preparation for the upcoming season. This process of scouting eliminates inactive areas of the property ensuring better odds that the placement of ground blind or tree stand in that area will produce an opportunity for a kill. The typical sportsmen scouting technique involves providing feed to attract game to an area and a way to document game activity in the area. Usually this will require a game feeder and a carefully positioned game camera to document activity along with time of day. During the duration of this equipment being on the lease, the sportsmen must keep batteries replenished, replace feed and check cameras for activity using a picture viewer. The Game Feeder Cam system should allow for a more user friendly experience.

II. SYSTEM COMPONENTS

The system is best presented in terms of it individual subsystems. These are the physical modules that are interfaced to create the final product. This section will introduce each of these modules.

A block diagram of the components that will be used can be seen below in figure 1.

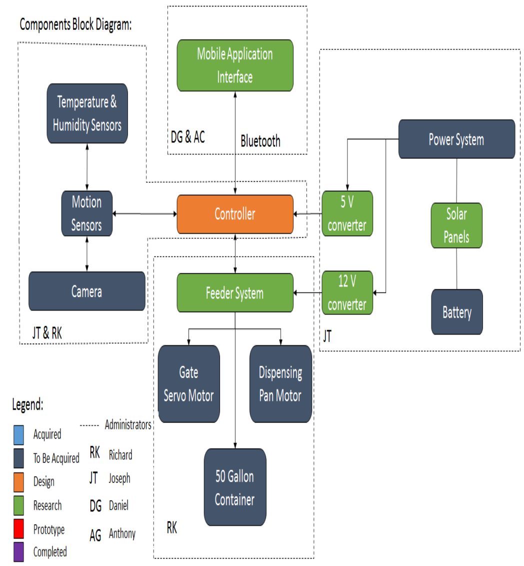
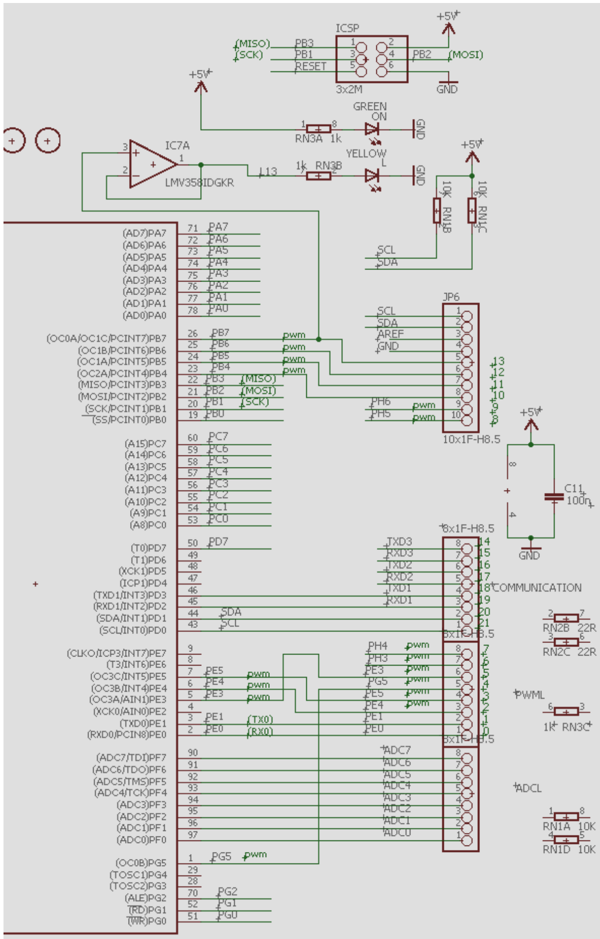


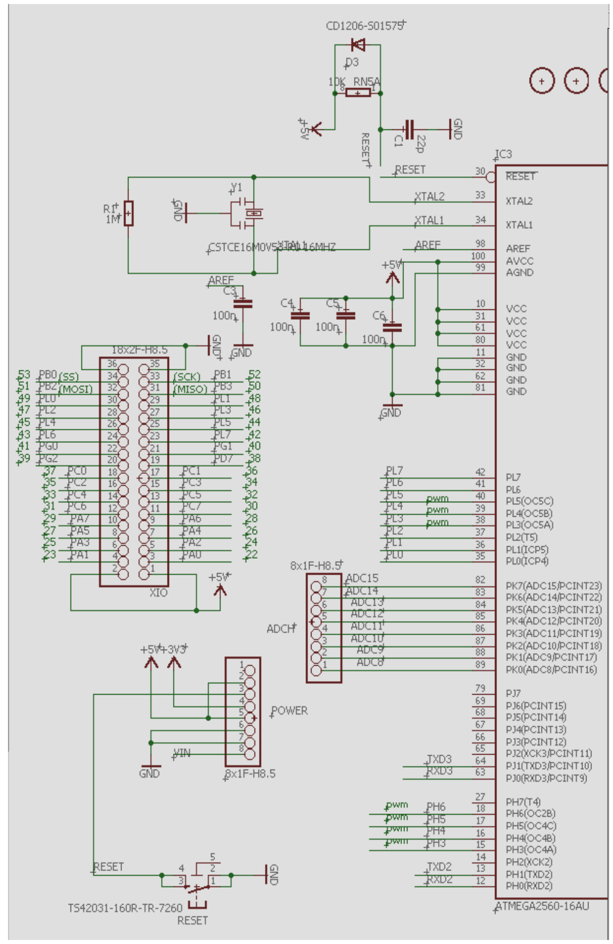
Figure 1. Components block diagram

A. Microcontroller

The heart of the project is an Arduino Mega2560 microcontroller in our design due to the fact that it has more RX and TX pins than the Arduino Uno, which was the original microcontroller that we anticipated using. The Arduino Mega uses the Atmega2560 processor to drive the software of the design. When trying to incorporate the camera unit, the Bluetooth module, the GSM/GPS module, and the barometric temperature and pressure sensor, the Arduino Uno did not have enough RX and TX pins to facilitate all of these components. We decided to use the Arduino Mega2560 microcontroller instead because of its increased connectivity and the increased functionality found in the Mega2560. It has a much higher Flash memory, SRAM, and EEPROM along with four UARTs versus one with the Uno. Overall the Mega2560 was much better suited to integrated assembly and the intended needs for the feeder system. The designed that was implemented is shown below in two schematics. The first one is the left side of the MCU design and the second image will be the right side. The MCU was designed to keep compatibility with the Arduino IDE. This will make it easier to continue programming and using all of the open source libraries to integrate the final product.



Schematic 1. Left side of the PCB design



Schematic 2. Right side of the PCB design

The MCU PCB was designed to allow the Bluetooth module, GSM/GPS and SD card to plug directly into it vertically. All pins were ran to pins to allow future options, while the DC power option and USB programming options were removed. The overall board only retains a back-up power step down unit from the original prototyping board design. The new Mega2560 will come with factory settings and require a boot load from a programed development board to set the factory chip to development board settings. The actual programming will be done with an additional programed development board and write directly to memory address zero on the MCU. Writing to the MCU this way allows for other development boards to interact with it. Since the MCU is based of the Arduino software and uses the Atmega2560 processor, prototyping between the MCU and an Arduino Mega can be a simple process. In theory apart from the electrical components, all software that runs on the Arduino Mega our MCU should be able to process and execute.

B. Solar charging Power System

For the power system the Game Feeder uses a 50W polycrystalline solar panel that will charge a 12V lead acid battery. In order to protect the battery from over charging and prolong its life a solar charge controller was designed with a TI LM723 voltage regulator that switches a MJ1001 power transistor on when the battery is recharged.

The Game Feeder Cam's sub systems require at least three power regulators. The components for the voltage regulator of each subsystem have been determined by using the assistance of TI's Webench power design software. There will be a 5V source for the main control unit board, camera system and weather system, a 6V for the DC feed motor as well as a 3.7V source for battery port on the GSM/GPS.

C. Camera System

For the camera system design on the game feeder we will use one weatherproof TTL Serial JPEG Camera that is sold by adafruit.com. This camera has many features that can be customized depending on design needs. Some of the features include changing the picture size, motion detection, night vision, picture properties for example focus, etc. For our project the motion detection from the camera will not be used because this is not a full 360-degree sensor. To complete the camera system a microSD break out board will be used to store the pictures taken by the camera. The microcontroller chosen can take advantage of the extra storage that the SD card provides. This storage can be used for data logging or any other storage intensive tasks. For the purpose of the project it is great for storing pictures.

The camera will be mounted on a continuous motion servo motor that will move the camera between four different quadrants the servo motor's motion will be controlled by the MCU that will send pulse with modulated signals to the motor that will be determined by the motion sensor system. For instance if the sensor for quadrant number two detects any motion activity the MCU will send the assigned modulated signal for quadrant number two to the servo which will then rotate to the predetermined degree and consequently quadrant consequently rotating the camera into quadrant number two. Once the camera is in the correct diagram it will take the picture and send it to the MicroSD card module where it will be stored for retrieval later. All components for the camera system sit in a housing beneath the main feed housing making a junction PCB necessary to reduce the number of wires running up to the MCU PCB by tying all the power lines together. This PCB also incorporates a four hundred seventy microfarad capacitor for the servo and a voltage divider to step the MCU TX to camera RX voltage down to two point five volts, which is slightly below the cameras maximum input voltage of three point three volts for its RX line.

D. Feed Mechanism

The Game Feeder Cam will reuse the motor that was purchased in the feed system housing as well as the funnel and disc. Motor testing was conducted with a Keithley Triple Channel Power Supply using channel three set at six volts and five amps. The peak draw with disc simulated corn load was determined after using the highest initial reading during ten cold starts, meaning the motor was left to sit for one hour between starts, connected directed to the power supply. This this test was used in the selection of the of the N-channel MOSFET needed for the motor control PCB design.

Table 1 - DC Motor Amperage Testing

Test Performed	**Amperage Draw Average (Amps)**	**Amperage Draw Peak (Amps)**
Feed Disc Simulated Feed Load	3.704	4.901

E. Weather System

BMP180, Barometric, Pressure Temperature, and Altitude Sensor: This sensor is analog requiring the use of analog pin in number four which is for data and pin number five for the clock. It requires a three point three-volt power source and without an onboard regulator it will need a voltage regulator, to step down the voltage. The pressure sensing range is three hundred to eleven hundred hectopascals (hPa) from nine thousand to negative five hundred meters above sea level at up to zero point zero three hPa per one quarter meter resolution. The temperature sensor operates from negative forty to eighty five degrees Celsius but is plus or minus two degrees Celsius in accuracy. Because the temperature is not as accurate as the DHT22 sensor, the temperature readings from the BMP180 will not be polled. The BMP180 uses piezo-resistive technology to read the pressure and altitude.

DHT22 temperature-humidity sensor: Using a capacitive humidity sensor and thermistor temperature sensor the DHT22 uses three to five volts to operate and a max two and a half milliamp draw. The humidity sensor reads zero to one hundred percent humidity with two to five percent accuracy while the temperature sensor detects temperatures from negative forty to eighty degrees Celsius with plus or minus on half a percent accuracy. A simple PCB schematic was designed with a pull-up ten thousand ohm resistor for the DHT22 also needed was two female headers for the two weather sensors to plug in and screw terminals for data out and power in>

F. Bluetooth Module

The Bluetooth module that we have decided on is the JY-MCU HC-06 slave module. This simple class two Bluetooth module has four pins: RXD, TXD, GND, and VCC. The supported baud rates for this module range between 9600 to 115200. This are the limits of the module while using it with a serial connection. Since this is used for wireless transfer the faster the transmission rate the more errors can happen. For the purposes of this project most of the testing has been done using the module at 9600. It has an operating VCC voltage of three point three volts and to the RXD pin a level conversion must be made in order to achieve this voltage. This is done by connecting a two point two kilo-ohm resistor to GND, a one kilo-ohm resistor to the Mega2560 MCU, and connecting the RXD pin of the Bluetooth module in between these resistors to create a voltage divider. This will give the RXD pin the correct voltage for operation.

G. GSM and GPS Modules

The GFC will use text notifications to notify the user of certain events that happen. A GSM module is used to achieve this functionality. The FONA 808 from Adafruit is the cellular and GPS modules used in our design. This module incorporates cellular connectivity and GPS into one integrated component. The Adafruit FONA 808 GSM module cost forty-nine dollars and ninety-five cents plus the cost of purchasing the external antennas and 2G SIM card. A passive GPS antenna and a GSM/cellular quad-band antenna were needed for connectivity of this GSM module. These will allow text notification capability as well as GPS location services. With quad-band functionality, this module can connect onto any GSM network with a 2G SIM card. This makes our product design versatile for many areas. The module also includes GPRS data, which can later be used to expand the functionality and features of the GFC. The module operates with an input voltage range of three point four to four point four volts with very low power consumption. This module works specifically well with the chosen Arduino based microcontroller.

III. GFC FEEDER STAND

The GFC feeder stand consists of a fifty-five gallon drum, drum stand, and all component housings. The component housings break down into the solar panel, power system, and main feed system.

A. Drum Stand

The drum stand was built from the ground up out of angle, tube, square, sheet, and expanded steel. The four legs are five feet long thick wall tube steel which fit into four leg mounts made of angle and sheet steel. The ladder is constructed of square thick wall steel with a piece of angle steel on the top designed to fit in the lip made using two pieces of angle steel on the front platform of the stand. The floor and uprights of the stand are angle steel with expanded steel floor to stand on and sheet steel sides. The roof is framed from angle steel and filled in with sheet steel.

B. Housings

The solar panel housing is on the roof of the feeder stand allowing maximum sunlight collection. The wires will be run down the inside of the angle steel upright via a hole drilled in the corner of the roof.

The power system housing is a fifty caliber plastic ammunition container which is designed to be waterproof and as added safety will sit partially under the stands roof. The battery, charge control PCB and all power step down units PCB's will be installed in this box and wires run out of a hole in the bottom to prevent water damage.

The main housing consists of the feeder, weather, and camera system housing. The feeder housing is a store bought feeder housing stripped of all internal components except the DC motor. Removing the components inside allowed enough room for the MCU PCB to be installed inside as well as the motor control PCB. Careful measures were taken to reduce the effects of noise interference due to the DC motor. The camera system housing is a repurposed GoPro container fixed to the bottom of the feeder housing with brass hinges and a brass clip to allow access into the container for maintenance. As for the weather system housing it was built from a three way electrical junction box with PVC attached. The bottom leg of the box has an endcap with a hole to allow the wires to run out, while the sides have forty-five degree elbows with metal screens to allow air to pass through, but prevent bugs and rain from entering.

IV. SYSTEM INTEGRATION

The individual components described in section II have been integrated and interfaced into the final product. This section will describe the integration of these various components.

A. Hardware Integration

The hardware integration of these components will be accomplished through the Microcontroller. Each of the components, the DC motor, and the Servo motor will use the Digital and Analog pins of the Microcontroller to communicate with the system. When the system is powered on, each of the components will be initialized and connectivity confirmed. The system will then reach its idle state. At this time Bluetooth connectivity is ready and can be established if so desired by the user.. The Android application will send commands to the microcontroller to be carried out. The functionality of the various components and the motor systems will be tested using this Android application. Once the system is confirmed to be working correctly, it will operate the camera system cycle and the feeding cycle using the chosen parameters without requiring any extra input from the user. This is made possible through automating the component and servo motor functions to be triggered by the PIR sensors. The DC motor feeder system will be initiated automatically once the chosen time of day arrives.

B. Software Integration

This automated system is accomplished through integrating the code of each component to cooperate together in a single system environment. This software is written in the C/C++ programming language and tested in the Arduino IDE. A diagram is shown below in figure 2 to show all of the software tasks that need to be accomplished.

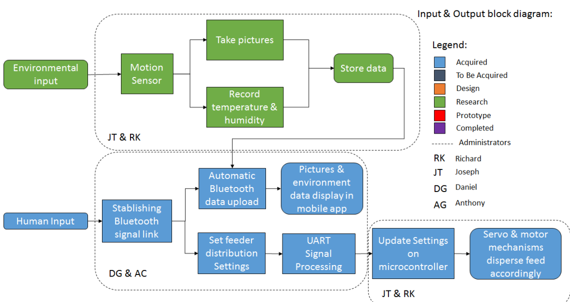


Figure 2. Software block diagram

The system will initialize all of the components before a Bluetooth connection can be established or proceeding to the motion detection sequence. The PIR motion detection cycle along with the camera system cycle and the feeder motor cycle are completely automated and will continuously carry out functions based on the initial settings. The Bluetooth functionality is a state that will be carried out only when initiated by the Android application. The Android application, when within range, will connect to the system and the user will have the options to change the feeder DC motor settings, check the DC motor function, check camera functionality, and manage the pictures stored on the SD card. Management of the stored information includes viewing the pictures and readings taken by the sensors both in thumbnail and full screen format, downloading pictures and readings to the Android device, and deleting unnecessary pictures and readings from the system.

C. Camera System Cycle

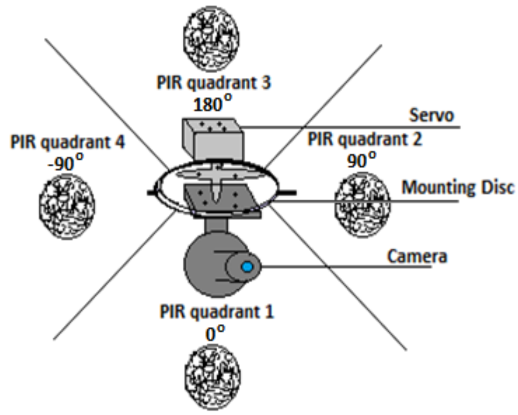


Figure 3. Camera System Quadrant Diagram

While the GFC is in the idle state the system will check for sensor readings during the camera cycle. The camera system cycle operates on a four quadrant detection system, the model that was chosen for the design can be seen above in Figure 3. The camera cycle will only continue if motion is detected by one of the PIR sensors. The system will then record which of the four PIR sensors has been triggered. First atmospheric data will be collected form the temperature and pressure sensor, then date and time will be recorded. The servo motor will then move to point the camera in the direction of the triggered sensor. This will only happen if the sensor that is triggered is not sensor one (default quadrant), in this case the servo will remain in its current position. With the camera positioned in the correct direction, the sequence continues. The camera and SD card will be initialized and a picture will be taken and stored in the SD card connected to the microcontroller. After the picture is stored, the data collected previously will also be stored to a text file using the same filename as the picture. Finally, a text notification will be sent to notify the user that motion was detected around the GFC. The servo motor is checked to be at the default position every time the camera cycle starts. A brief pause is implemented to the camera cycle if a picture was taken. This is to prevent many text notifications from being sent and to save storage space. This loop will automatically resume. After the cycle ends the microcontroller will return to the idle state to be available for a Bluetooth connection and to check if time for feeding has arrived. In Figure 4, there is a detailed flow diagram for the camera system.

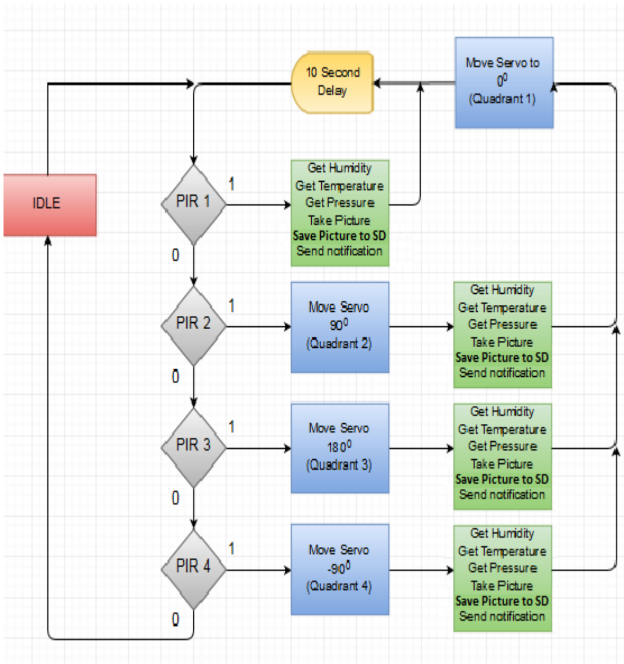


Figure 4. Camera System State Decision Diagram

D. Feeding System Cycle

The feeding system cycle operates with the settings given by the user. The DC motor operates on 3 speeds to determine the distance that the feed is disbursed, 3 durations to determine the amount of time that the feed is disbursed, and at 2 different times of day, all of which are entered by the user upon initializing the system. Once initialized to the correct settings, the microcontroller will obtain the time from the GPS and GSM module in continuous system loop. When the chosen time of day arrives, the DC motor system will disburse the corn feed based on the user preferences.

E. Command Based Communication

For testing purposes the software running on the microcontroller is being designed to activate certain features based on commands. This command based system will be checked for every loop that the microcontroller takes. At the middle of each loop it will check if any commands have been sent through the serial port. Commands can be sent by USB serial or using a Bluetooth module. For the GFC a Bluetooth module is already being used and serial commands can be sent and received via Bluetooth. The information sent and received is being interpreted by the Android application that will accompany the GFC. More information on the application will be found in the Mobile Application section below. A simple diagram is shown below figure 5, to illustrate the decision and flow system of the commands.

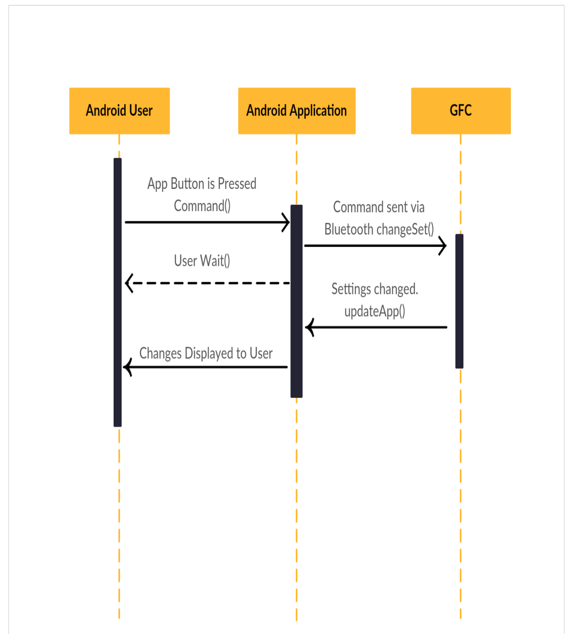


Figure 5. Command Based Activity Diagram

The user can send the GFC a command at any time while the GFC is operational. Even if the GFC is executing the camera cycle a command can still be registered and will be executed the next time the microcontroller checks for commands. For user simplicity a delay has been implemented to allow a specific time to input a command. This makes it easier and avoids confusion.

F. Final Complete Integration

In the section above each component of the GFC has been described in detail how each other will interact with the other. All of the components come together using hardware and software. Many of the components used specially those from Adafruit have their own software library that needed to be used in the final integration code of the project. As expected some of the software libraries had conflicts with others. During the final integration of the project all of the libraries are working together to run one integrated code.

In this final section a less detailed explanation of the GFC states will be explained. When the system is first turned on, many components are initialized and some do a quick test to ensure functionality. After completing initialization, the system starts its idle state. In the idle state the system runs in its low power mode, only checking for PIR sensor movements or a Bluetooth connection. It will also check the feeding time. From this state the system can change to the

Feeding, Camera, or Bluetooth connection. These states have been discussed above. In the Feeding and Bluetooth connected states the GFC will not look for sensor readings from the PIR sensors. This is designed in this manner so that the present function is not interrupted by outside movement. After these states end the GFC will return to idle and continue checking for sensor readings. Figure 6 shows a visual representation of the GFC Integration states.

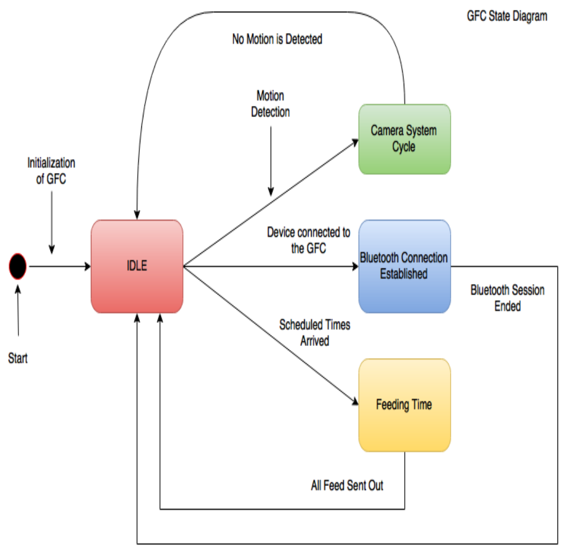


Figure 6. The GFC Integration state diagram

Above the different states can be seen and the flow each of them takes in the system.

V. Mobile Application

The Game Feeder Cam will be accompanied by a mobile application. The application will be used to control and changed some of the customizable settings that the GFC offers. The application will also feature a gallery style interface for displaying the pictures stored in the MCU's SD card. The idea behind an application is to provide the user with a new experience on managing their game feeder experience. In the following sections the application design will be discussed with greater detail.

A. Operating System

The application is being developed at this time for Google's mobile operating system, Android. The decision was made to develop the application for Android because it currently has more users and the developing criteria are less restrictive than developing for Apple's iOS mobile operating system. Currently the application will be compatible with most of the Android devices in the market, starting with Android version 4.0.3 or Ice Cream Sandwich. Android is based of the widely used Linux operating system. Android applications are written mainly in the Java programming language. This was also one of the reasons why the team chose to develop with Android. The team has more with Java. Other languages that can be used include C and C++, but these are not recommended. There are many tools available that can be used to develop Android applications and an example of them will be discussed in the next section.

B. IDE and Tools

The main tool for developing Android applications is using the integrated development environment (IDE) provided by Google called Android Studio. For the GFC application Android Studio is being used. Android Studio provides many templates that can be used to shape the application in the right direction. It is a full feature IDE based of the IntelliJ IDEA Java IDE. Android Studio also includes a visual designer that can used to design the graphical side of the application. The GFC application is being developed using these tools. Now that we have discussed the tools and operating environment of the GFC application the next section will cover the features that the application will provide.

C. Features and Settings

The GFC application is being designed with custom settings for the user in mind. First of all, the user should be able to check on the status of the feeder using the app. The application will provide an interface that can be used to send text commands to the GFC for testing. With the application the user will be able to change the feeding schedule, change motor speeds if necessary, and text notifications to be sent. Finally, the GFC will feature a gallery style interface to interact with the pictures stored in the SD card. This interface should allow the user to view the images in full screen and the conditions of when the picture was taken. In the current build of the application users will be able to browser through pictures. In the future updates saving these pictures and removing them from the SD card should be possible. The application provides a user friendly way to interact with the system without actually having to open the housing and physically connecting to the controller. This is a feature that would be appreciated since maintenance can be done without having to physically interact with the GFC.

VI. CONCLUSION

In conclusion, the overall project setup will utilize a weather system, feed system, camera system, communication system and power system. The weather system and communication system will provide the data to stamp on the picture file after the camera system records a picture. The communication system will also provide text messages notifications each time a picture is taken, and allow wireless mobile application programmability. The feed system will provide the bait to lure the animal's close enough to record on camera. All systems will integrate into the MCU where all information and commands will process. The power system consisting of solar panels, a charging system, a battery and step down units, which will power all components. The complete product satisfies the goals and requirements of the project. The final and main objective of the GFC is to have a Feeder System that can be easily customizable with the help of a companion mobile application. Customizable was the first idea and objective of the project and thanks to the integration and mobile application this goal has been met.

ACKNOWLEDGEMENT

Keith Kelly, an avid hunter of twenty years, gave input to the features that he would like to see to on the GFC as well as improvements to the features already offered. Mr. Kelly also gave insight to the average battery lifespan with and without solar panels which was between twenty to thirty days. Also mentioned was that if the GFC was to implement a greater camera area to identify the direction in which the picture was taken. The input was based on both hog and deer hunting experience.

Karl Clements, an electrical engineer at Mears Transportation donated his time and personal facilities for the construction of the GFC stand as well as feedback on design ideas and problems.

PERSONNEL

The GFC team consists of two computer engineers and two electrical engineers. At the first group meeting the members discussed the project and assigned responsibilities for each component of the project. Anthony and Daniel, computer engineering majors, will focus on software design of the project while Richard and Joseph will focus on electrical component design. All group members contributed to the project. Many sections needed to be worked on by more than one person due to the complexity. Each member helped each other with their parts as needed.

The component housings, feeder and feeder stand will be designed and assembled by Richard because of his knowledge and experience with game feeders and game cameras. Although the team will be dividing the project into parts to work on individually the project is interlaced so component decisions must be made in parallel to ensure proper compatibility.

Daniel Guzman is a Graduating Computer Engineer that plans to continue his education and pursue a Masters in Computer Engineering at the University of Central Florida. His main focus will be in Network Security and Artificial Intelligence.

Richard Kelly is a graduating Electrical Engineer. After graduation Richard will work at Lockheed Martin. Thanks to Richard the Game Feeder Cam system was designed and with the help of the team fully assembled.

Anthony Crosby is a graduating Computer Engineer that will be focusing on continuing his education with software and electrical components. His contribution to the project was to assemble and integrate code for the final system.

Joseph Torres Rosario is a graduating Electrical Engineer that will be focusing on future electrical designs. His contribution to the project was to develop and integrate the power system. This includes the solar powered charging system.

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