Self-Targeting Autonomous Turret System

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***Abstract* — "STATS" is a joint effort project comprised of two electrical engineering students and two computer engineering students who integrated computer programming and electronic hardware skills in order to create a working self-targeting autonomous turret system. STATS is a lightweight, mobile and self-contained turret that can be placed in a large room or outdoors to be used for defending an area from potential intruders without the need of a human for controller purposes. Using the Processing IDE open source libraries, the tracking method used by the turret is processed and implemented to quickly identify and fire upon all moving objects in the field of view.**

***Index Terms* — Electronic circuits, breadboard circuits, receivers, radio transmitters, video equipment.**

I. INTRODUCTION

The motivation for this project, at its core, is developing a defense system that has real world implementations using the most current technology. Because of the group being divided between two students in the field of electrical engineering and two in computer engineering, it was important to choose a project idea containing an even portion of both hardware and software. The STATS project was able to fulfill this requirement as it contains tracking software, PCB designs and power management. STATS combines these skills together to create a system capable of defending an area. The project focuses heavily on computer programming, wireless data transfer and digital signal processing.

II. OVERVIEW

STATS functions by way of a linear signal path. The Windows tablet receives a live video feed via a wireless camera through the use of a local Wi-Fi signal. From here, the tracking software will locate the video stream. The images are then processed by the tracking program to check for pixel differentiation between frames. If differences are found, the software will pinpoint this location and send the coordinates to the onboard PCB located behind the turret. The PCB will process these coordinates to send pulse width modulation signals. The PWMs are used to control a set of servo motors that aim and fire the mounted airsoft rifle at the selected moving target(s). Two modes of operation are available for the user to implement with the system. The autonomous mode tracks and fires upon targets automatically without the need for an operator to adjust tracking positioning. The manual mode requires an operator to function properly. The user will be able to have full control of the system via the wireless tablet. By using the user interface for the tracking software, precision movement of the servos is possible. Taking advantage of touchscreen technology, the user simply has to press onscreen where the airsoft gun should aim and fire. The tablet will then process and send the position to the PCB. From here, the correct pulse will be sent to each individual servo to complete the positioning sequence.

III. SYSTEM REQUIREMENTS

The primary goal of the project is to develop a fully functional prototype which allows any user to quickly grasp the fundamental controls. The user interface is intuitive and simple in design. The project design is a completely wireless system from the video camera to the tablet and from the tablet to the processor. Because of the project being centered on a defense turret system, aesthetics are also important. It was agreed upon to have the physical design be militaristic in nature and look intimidating. The project, however, was not without boundaries. Secondary goals include budget and quality, which go hand in hand. Working with limited funds, the goal was to achieve optimal performance capabilities of the system using components that would keep the project budget within bounds.

The hardware requirements for this project include the following:

- Hit ratio of 20% or greater for manual mode. Automated is 10%.
- Robust design that can withstand the effects of high torque servos.
- Portable and lightweight with the capability for battery power.
- Agile and responsive (The servos must be fast enough to react to a moving target).

Software requirements for this project include:

- Tracking a moving target at speeds up to 3 meters/sec.
- Tracking priority on multiple targets.
- Responsive (<500ms reaction time for complete wireless system).

- Ability to switch between manual and autonomous tracking modes.
- Intuitive User Interface.
- Lightweight and efficient code to optimize the tablet's processor.

IV. MECHANICAL DESIGN

The mechanical design of this project consists of a base platform that houses the PCB, servo motors and power system. The base will also be the mounting point of the weapon system, video system, and will also serve as a resting place for the tablet when it is not in use. The frame contains a large surface area to distribute weight evenly to avoid wobble from the torque of the servo motors.

A. Weapon Armature

As shown in Figure 1 the turret armature will house the airsoft weapon as well as the required pan, tilt, and trigger servo motors. All three of the servo motors are controlled by the PCB's Atmega-328 microcontroller and give the turret a minimum of 90 degrees rotation in all directions and a minimum of 45 degrees for the trigger pull.

Figure 1 – Turret Armature

The design of the armature is the most important task for the mechanical side of the project. In order to have the servo motors function efficiently and position themselves accordingly, weight and measurements need to be taken with accuracy. The final build for the turret armature is a combination of custom and preassembled parts. The framework is comprised of precision aluminum pieces and rigid ABS plastic. To limit the amount of strain on the servo motors while providing maximum torque, the pan and tilt servos are mounted directly on top of each other at the upper portion of the vertical aluminum arm. In addition, two clamps are positioned and held in place with four bolts to secure the airsoft gun from readjusting under continuous movement. By bringing the clamps close to the vertical aluminum arm, the servos are able to pan and tilt with ease under full load of an airsoft gun. To fire the airsoft gun, the trigger servo is mounted to the clamp opposite of the positioning servos. The trigger servo contains a hub shaft with a cam piece enabling the trigger to be pushed back on command.

B. Hardware Housing

The housing for the entire project is represented in Figure 2 shown below. The requirement for the housing is to develop a lightweight frame with versatility in mind. To follow through with this concept, a hollow frame with ample surface area is constructed. Depending on the location for setup, legs or stakes can be fixed to the frame for balance.

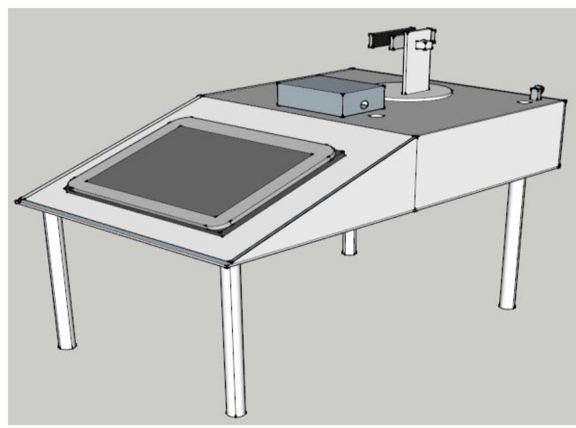

Figure 2 – Hardware Housing

The housing is built using wood and is fitted with a hinged door on the front in order to access the electronics housed inside for repair or replacement. The innards offer enough room for future modifications as a viable option. The use of wood was chosen because of cost and ease of use when compared to that of metal. It is determined that a wood housing would supply enough rigidity for the servos to move without affecting the rest of the system.

V. ELECTRICAL HARDWARE

The hardware block diagram below in Figure 3 shows the basic functionality and flow of this system. The diagram represents the linear flow of transmission from camera to tablet to PCB. The Windows tablet will act as the midpoint between image processing and PWM signals for the servo operations.

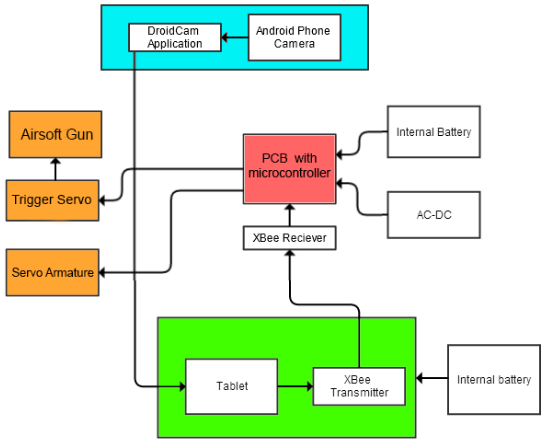

Figure 3 - Hardware Block Diagram

The video feed is sent from the camera and is processed in the tracking software. The software then communicates with the microcontroller on the PCB via XBee. The microcontroller will then send PWM signals to the servo motors. From the standpoint of the tablet, the video feed from the camera is used as part of the user interface and gives the user a first person view of everything that the turret can see.

A. Camera

Many camera systems were researched and tested including wired web cameras and wireless IP cameras. There were a number of issues involved in implementing these options; most of all was the budget. Most wireless camera options would cost over $100.00 dollars which makes up approximately one-fifth of the allotted budget. Because of this, the group decided to approach the camera issue from an entirely different direction. Instead of focusing on testing and implementing a consumer-end camera system, a camera application is utilized in the final design. Using an existing Android application called DroidCam, the app can be downloaded to any Android phone or tablet being used as the camera. Additionally, a Windows version of DroidCam is downloaded and installed to the tablet. This creates drivers which allows for the JMyron library and Processing IDE to pick up the live video feed. Without these drivers, this application would not be compatible with the software. This was the reason for initially allocating research to find a suitable camera system. DroidCam is a great alternative to traditional IP camera because of the versatility of the setup. Using this app, any phone or tablet running Android can be compatible with the system. DroidCam functions similar to an IP camera. The phone or tablet used as the camera will pick up the static IP from the Windows tablet used for tracking. From here, the app is able to send wireless video directly to the tablet through the use of a Wi-Fi connection. Other options are available, such as Bluetooth, but will not meet the range requirements for the project. With the use of an application over purchasing a wireless camera, this method costs the group nothing and has sufficient capabilities for the intended purpose. The wireless method originally planned for video transmission was involving XBee Wi-Fi modules to receive video footage from a wireless camera system and transmit directly to the tablet. This would have cost over $250.00 dollars for the XBee alone. Therefore, strictly due to cost this idea was not implemented and the free software with the android phone was used instead.

B. Tablet

The tablet is the core component of the project design. It is the main computational source for the programming and the only interface the user will have with the turret system. Many options were looked at when deciding on a suitable tablet. There are three major tablet options on the market today: Apple, Android, and Windows. Apple applications are programmed in Objective-C language. The group has no experience with Objective-C so this option was not considered. Android is mainly programmed in Java with XML used for the layout of the app's interface. With the programmers of the group already having worked with and created Android apps for both classroom and hobby projects, creating an Android app would cut down on the learning curve significantly. Windows programs can be done in a variety of languages including C, C++, and Java.

Another consideration is not only experience, but processing power. The tablet that is employed in our project will be used for manual override control and for the object detection and tracking algorithm calculations. This was taken into consideration when deciding the tablet for the project. Had the group decided to use an Android or Apple tablet, the processing power needed for the object detection and tracking calculations would not have been met.

After much consideration the group decided that the available Windows tablets on the market were in the correct price range and had the most processing power for the money. The information on the chosen tablet is shown below in Figure 4. The group decided that the Dell Venue 8 Pro was ideal for this project. It is equipped with a powerful processor and is running the full version of Windows 8.1 operating system. This corresponds to less issues when transferring any code written on our home computers directly to the tablet, and would allow for changes more easily due to the compatibility.

The main downside of this choice of tablet is having only one micro USB port to work with. More expensive Windows tablets come with additional ports, but are not within the price range. Therefore, a micro USB right angle adapter is used to support the XBee dongle and streamline the tablet.

Screen Size	8 in
Screen Resolution	1280 x 800
Weight	0.86 lbs
Processor	2GHz Intel Atom Z2580
RAM	2 GB
Operating System	Windows 8.1 – 32 bit
USB Port	Micro USB - one
Price	$275

Figure 4 – Dell Venue 8 Pro [1]

C. Wireless Communications

One of the standout features of the turret is its ability to fully interface wirelessly in both manual and autonomous mode. In order to meet the project requirements, the system must be controlled from a set distance and the user must be able to fire upon targets from a safe location. This requires a completely wireless system. The option that was chosen by the group was the XBee 802.15.4 wireless modules. These modules are able to be connected directly to the PCB with the use of headers. Under testing, the transmission speed between modules and the servo motors functioned accordingly and to specifications.

Another reason XBee was chosen is the sleep mode that occurs when the module is not in use. This allows for greater battery savings. With the receiver module connected to the PCB board, the transmitter will be connected to an XBee Explorer Dongle. This allows for direct connection to the tablet through the USB port. These devices are used in this project to wirelessly send control signals from the tablet directly to the microcontroller. From here, servo control can be maintained from a distance of up to 15 meters away reliably. The receiver end is mounted directly to the custom made PCB and connects to the microcontroller. Through extensive testing, this method has proven to be the most effective wireless communications protocol that could have been used for this project without exceeding the budget any more than needed.

D. Microcontroller

The microcontroller chosen for this project is the Atmel ATmega328. This microcontroller has been around for a significant number of years and there is a large amount of online support that can be utilized to help control the turret device. These microcontrollers are also plentiful, easy to find online and inexpensive. These features let the group purchase multiples in case one gets damaged or fails for any reason. The ATmega328 provides an adequate amount of resources in terms of I/O pins, clock speed, and is equipped with enough memory to support the functions of this project. Although the memory can be expanded, the provided memory will be sufficient. The microcontroller was chosen for the fact that it is the form, fit and function equivalent to the microcontroller found on the Arduino development board that was used during the testing phase of this project. This helps reduce the difficulties of transitioning from a development board to the custom PCB designed by the group. This also allows for the use of the open source Arduino libraries and functions to be used on the final design. This step is crucial for eliminating troubleshooting for the coding of the servo and tracking controls.

The ATmega328's key specifications include an 8-bit RISC based architecture and 32 KBytes flash. An interesting ability of the ATmega328 is its ability to achieve 1 MIPS per MHz. This allows for a good tradeoff between power, cost, and performance. Serial communication is also taken advantage of including a USART port. Figure 5 below shows the statistics for the ATmega328P microcontroller. Figure 6 illustrates the microcontroller schematic, along with all the required components to insure maximized performance. The Arduino boot loader is used to upload the STATS motor controller program to the ATmega328. The Mega328 is boot loaded and programmed by removing the chip from and into the dip socket. Pins 14, 15, 16 will be used to send PWM signals to the motors to create servo movement.

Operating Voltage	1.8 – 5.5 V
DC Current per I/O	40mA
FRAM	32KB
SRAM	2KB
EEPROM	1KB
I/O Pins	14
Analog Input Pins	6
Clock Speed	16 MHz

Figure 5 – ATmega328 Specifications [2]

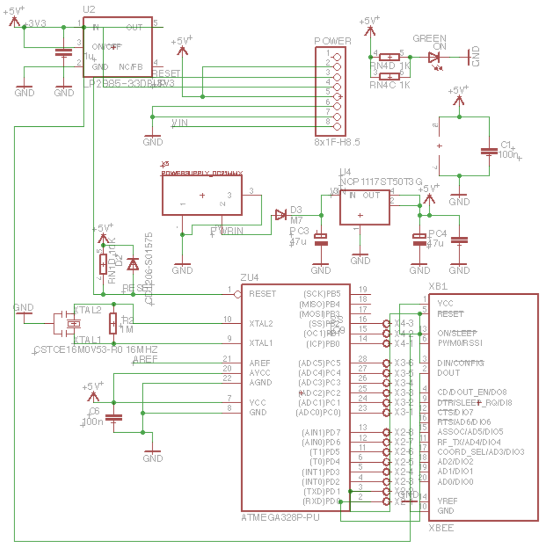

Figure 6 – PCB Schematic

E. Servo Motors

Extensive research was allocated in deciding upon the correct servo and/or actuator for the STATS project. Because of the large role servos have in the overall function of the system, price points were set higher. An actuator for the trigger was an initial idea, but could not be included in final design due to integration drawbacks. The servos chosen for directional control were the digital Hitec HS-5685MH high torque servos from servocity.com. Digital servos were chosen over analog for their faster response times and great performance out of the box with minimal to no programming needed. These Hitec servo motors are able to run on 4.8V to 7.4V. At 6 volts, the servo motors are capable 157 oz-in of power, which is close to 10lbs per inch. At 7.4 volts, the servos can produce upwards of 179 oz-in of torque, or over 11 pounds per inch. Because of the HS-5685MH having its motor optimized to run off of a 7.4 V two-cell Lithium Polymer batter, it was in the best interest to take advantage of the extra torque the servo could produce and design a power system with 7.4 volt batterie. In addition to torque, the motor is rated at a speed of 0.20 seconds per 60 degree turn. The servo features include up to a 180 degree turn radius, a neutral point, and multidirectional control. Two HS-5685MH servo motors were integrated into the armature design; one for horizontal movement and another for vertical movement. The pan servo was set at 180 degree rotation and the tilt servo at 90 degree rotation. This ensures that both servos will never reach their full rotation and hit the lock point. Since the twin HS-5685MH would be taking the brunt of force from swinging a 4 pound or heavier airsoft gun, servo splines and mounting options become crucial. Fortunately, the HS-5685MH comes standard with metal gears and servocity.com offers an extensive range of further mounting devices. To complete the integration of the pan and tilt servos, the motors were mounted to an exoskeleton frame (servoblocks) to reduce stress on the servos.

The most difficult portion of mechanical work for STATS was the integration of the trigger servo. Because of limited space for the design of a finger trigger system, custom parts were needed to complete the final design. The electrical specifications of the trigger servo did not need to compete with the specifications of the directional servos. The only real use of the servo is its ability to pull a trigger with up to 2lbs of force and come in a small form factor. Using servocity.com as a reference, an appropriate servo would be the Hitec HS-5485HB. This servo runs off of a lower voltage than its parent HS-5685MH. Therefore power supply design will be designed accordingly. This servo motor comes in the standard size and the positioning servos, but is still small enough to work in the space allocated. At 6V, this servo is able to produce over 5 pounds of force with its karbonite gears. Metal gears are not necessary for this application, and karbonite gears come at a lesser price. To have the trigger pull back, the HS-5485HB will turn a minimum of 45 degrees. The servo will be fitted with a custom hub shaft from servocity.com. The end of the shaft will contain a cam piece comprised of ABS plastic which will contact the trigger. Many mounting options were considered for the trigger application, but this design is the most feasible and efficient.

The Figure 7 below shows the specifications for the positioning and trigger servos.

	HS-5685MH	**HS-5485HB**
Operating Voltage	4.8V – 7.4V	4.8V – 6V
Pulse Vpp	3-5 Vpp	3-5 Vpp
Max Speed (6V)	-	0.17sec/60°
Max Speed (7.4V)	0.17sec/60°	-
Max Torque (6V)	-	89 oz-in
Max Torque (7.4V)	179 oz-in	-
Max Current Drain	3A	500mA
Gear Type	Metal Gear	Karbonite Gear

Figure 7 – Servo Motor Specifications [3]

F. Power Supply

The power supply design provides the turret with all the correct amounts of power in each location. Two separate power supplies are created, each for a separate specified application. The high current draining servo motors will utilize a 7.4V KingMax 1000mAH battery with a maximum discharge current 25C. This battery will be used to provide the manufacturer recommended voltage. The 7.4V KingMax battery will be connected in parallel to provide equal voltage to both pan and tilt servos. Since the servos will not encounter lock or stall during operation, the rated current discharge is acceptable for the system. One 7.4V LiPo battery proved sufficient in testing. Therefore, a 7.4V battery for each servo is not needed. Though higher rated batteries may be used with the system, the battery chosen for the project held good price per performance. The secondary power system for the PCB will use a 9V battery. The ATMega328 requires 5V for normal operation. As illustrated in the schematic found earlier in Figure 8, an LM7805 regulates the output to a steady 5V, while the recommended input is 7V - 12V. With that said a 9V alkaline battery connected to the PCB using size N barrel jack is used. For mobility purposes mentioned earlier, the board can be run off of a battery or a standard wall outlet. If the system does need to be run from a wall outlet, the onboard 9V battery will perform this function. A 12V barrel jack adapter is used to connect to the motor controller PCB. All that will be required to perform this function is a 120V 60 Hz wall outlet.

G. PCB Design

Since printed circuit boards are part of the guidelines in Senior Design, a two layer PCB board was created and implemented using Eagle by Cadsoft. The free version provided by Cadsoft allows for the design of a board no larger than 4 x 3.2 inches. There will only be one major PCB for the design, with three major control units included on the board. The main control unit of the board will be the ATMega328, followed by the wireless mounts for the XBee module. It is estimated that the servo motors will draw approximately a maximum of 2 Amps when they are all working simultaneously. As for the PCB fabrication, it was determined that the two layer printed circuit board would be adequate and was ordered from 4PCB.com. Figure 8 illustrates the Eagle design of the PCB that was used. Screw in Wago terminal connectors are used to connect all input and output signals to the PCB. This will ensure a reliable and strong connection.

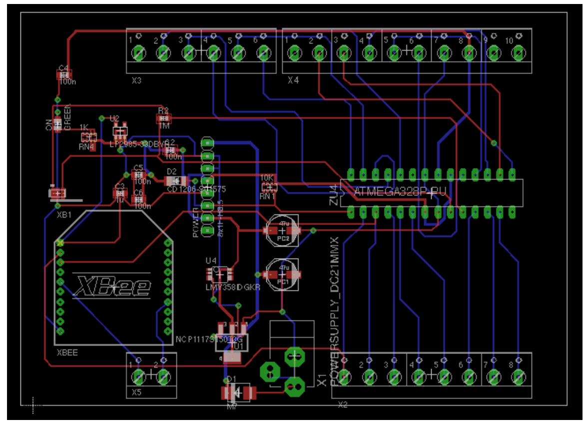

Figure 8 – PCB Design

Once the custom board is designed and received, all of the individual parts are then hand soldered on in order to save money and time. The board is then mounted in a clear plastic Lexan housing that resides on the top of the turret’s base so that any user can view its design. This also allows for the designers to quickly access the board for repair or adjustment in case of unforeseen problems. Another reason that the PCB is mounted on the top of the frame is for the wireless XBee modules to easily communicate without any extra obstacles to distort the signals.

VI. PROGRAMMING SOFTWARE

A. Tracking Software

The programming software used to create the tracking system for the turret is implemented using the Processing IDE. Processing was chosen because it allows the tracking software to be written in Java instead of the different variants of C that most other IDEs require. Since the two computer engineering students in the group had less experience in C than in Java, it was determined that the coding for the tracking and targeting software should be written in Java in order to avoid complications as much as possible. The Processing IDE also works well when run on the Windows tablet in conjunction with the Arduino IDE that was used to program the servo control; using the open source libraries available online.

The multiple libraries that will be used for this project are the “JMyron”, “BlobDetection”, and the serial communications library called “Processing.Serial”. When the user selects to run the Processing IDE, as well as the associated program files, the program must borrow heavily from the pre-defined libraries in order to function. The use of the JMyron library allows for the camera input to be easily utilized by the code and makes it easy to use multiple sources as the camera feed. Whether using a directly connected camera system or the wirelessly connected camera, as the one implemented in the final design, the JMyron library helps connect that video feed to the rest of the code and instructions.

In order to create the motion detection and the target tracking ability, a tracking algorithm is needed. Since it would take months of trial and error testing for the group to create a tracking algorithm from scratch, an open source algorithm is used. The choices came down to color based tracking, background subtraction and blob detection. Blob detection is the chosen tracking algorithm used for this turret project. By comparing pixels between frames and referencing a saved background image the system can determine where and when any pixels have changed. This is done at about 20 frames per second, which allows for fast reaction times from the turret. When these pixels are located a rough shape is drawn around the entirety of the object and that shape is used to find the center point of the moving object. This center point is then communicated to the PCB via the pin locations that the servo motors are on and the turret can then begin following the moving object as it navigates the field of view of the video sub system.

In order to track with some form of accuracy, a path prediction class is created to help determine the direction that the object is traveling and communicate this information with the servo controller. This class is used to effectively lead the target enough to account for changes in the objects direction as well as the time lag between shots fired and target hits. During testing, the servo motors are able to quickly adjust to directional changes in the target. This additional ability is crucial to making the weapon system accurate and reliable.

The main class has multiple tasks, mostly involving the calling of the other classes and loading them with information that is gathered from the video input. In the main class, the camera's field of view window size is set, the libraries needed to complete the tracking algorithms are imported, and it is where the bulk of the tracking instructions needed for the motion tracking are located. Though the main class is where the motion tracking algorithm will be doing most of its work, there will be a separate class needed for features like target path prediction.

Since this path prediction is a special ability of the turret system, a separate class will be needed to implement it. This path prediction class will be called by the main function after the blob detection library has been imported and called. In order for it to work, the X and Y coordinates must be compared in consecutive images. By comparing directional differences in the old position to the new position the program can predict that the next location will be in the direction that the object was traveling in the last two frames. This will allow the turret system to actively lead its target thus increasing accuracy by compensating for the time between firing and making contact with the target. The function can also use the amount of pixels that have changed between frames to determine how much acceleration the object has in order to send reactionary signals to the PCB.

In order for these calculations and tracking systems to be of any use, the tracking code must be in communication with the microcontroller. This is done through a small class that must be called by the main function as well. This class is called controlConnect and will be used to send the tracking information to the microcontroller, which will then send its resulting commands to the servo motors so that the turret may begin to move.

B. Arduino IDE

To program the custom-built microcontroller, the latest version of Arduino IDE is used. This open source IDE from the Arduino website is written in Java. By using the default environment, it makes writing code and uploading it to the board time efficient.

C. User Interface

The user interface was developed in the Processing program language and is a simple yet clear GUI displayed for the user. The first step in creating a user interface is creating windows that will house the commands, buttons, as well as the video feed from the camera. The main window is filled with the options for the users will be the lower layer of the UI. These options include a checkbox to alternate between manual and autonomous mode, along with buttons to reconnect the board to the software. A prewritten Java GUI library was used to assist in creating the button panes and image windows in the correct format. Next to this control window will sit a separate pane that will house the live video stream. While in autonomous mode, when the program detects a moving object crosshairs will move with the target. During the firing process while still in autonomous mode, a target box will appear to give the user a sense of what the program is shooting at. This is part of the blob detection tracking method. The crosshairs will be in the center position of this target box. In manual mode, when the user presses on the screen to shoot at an object, the crosshairs will move to that position and the turret will begin firing.

VII. CONCLUSION

The Self-Targeting Automated Turret System was chosen for this senior design project because it was an interesting and challenging project that would be a balanced split between computer programming and electronic hardware design. With the use of proven electronic parts, along with the most up to date programming methods, this system was built to the highest quality levels that budget would allow for. The electrical hardware used in this project was mostly custom designed including the printed circuit board and power system. The use of wireless communication technology via UCF's Wi-Fi system and the radio communications between the XBee wireless modules allow the user to have full control of the turret system from a safe and secure distance. The implementations of this design could be used as a security system for an interior or exterior perimeter or can simply be used for recreational or sporting enjoyment.

The tracking system created for this project allows for a fully autonomous turret that is self-sustaining with no user action is required. If user input is wanted, the manual targeting option can be used and the wireless tablet can then be the main controller of the weapon system. The manual mode is easily activated via a checkbox on the touch screen of the tablet, and allows for user specified targeting. The user interface found on the screen of the tablet was created to be as simple and straightforward as possible in order to avoid confusion and allow for anyone to instantaneously be able to control the entire system.

The turret system was also designed to be very portable and as lightweight as possible. This is why it was limited in size to fit onto most surfaces including tables, ledges, and even directly on the floor with restricted space. The square base is beneficial in keeping the system as stable as possible during firing and servo actuation which is highly important due to the camera system needing complete stability in order to maintain proper tracking abilities. Portability was also considered when designing the power system which is why the turret's PCB can be powered by a direct wall outlet connection as well as a rechargeable battery system that can be used whenever the system needs to be placed in a remote or outdoor location.

ACKNOWLEGEMENTS

The engineers of the "STATS" system would like to thank Boeing for their financial assistance which greatly helped in the funding for this project. Without their support, this project would not have reached its final potential. Also the group would like to thank Dr. Samuel Richie for his motivation and guidance during the course of this class.

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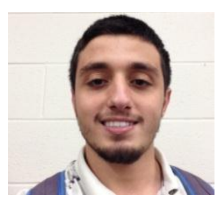
BIOGRAPHIES

Elso Caponi is a 25 year old senior graduating with a Bachelor of Science in Computer Engineering in August 2014 at the University of Central Florida. He enjoys debugging Java and C code and would like to be in a sales position within a computer engineering company directly after graduating.

Michael Lakus is a 22 year old senior graduating with a Bachelor of Science in Electrical Engineering in August 2014. His interests are in defense and integration work. He participated in the CWEP program with Lockheed Martin and plans on attending graduate school.



Ali Marar is a 20 year old senior graduating with a Bachelor of Science in Electrical Engineering in August 2014. His interests are in power and digital signal processing. He has a job lined up after he graduates with an electric utility company in his hometown of Jacksonville, FL.

Jonathan Thomas is a 22 year old senior graduating with a Bachelor of Science in Computer Engineering at the University of Central Florida in August 2014. He plans on attending graduate school at UCF and is pursuing to become a computer programmer.