Lockheed Martin DOMINANCE Challenge: Land Mine

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***Abstract* — The goal of this paper is to present the design methodology to create a stationary land mine that can detect, track, and autonomously disrupt Unmanned Aerial Vehicles (UAVs). This paper goes into the design detail of each hardware component that was used to create a fully functional mine as well as the software approach that was taken to train the detection, tracking, and autonomous portion of the mine.**

***Index Terms* — Launcher, Autonomous, Land Mine, Unmanned Aerial Vehicles (UAVs).**

I. Introduction

Lockheed Martin sponsored the Drone Mine Obstacle Avoidance (DOMINANCE) to challenge a group of students to develop a stationary mine system capable of detecting, tracking, and autonomously disrupting UAVs that are navigating a stochastically placed obstacle course. The obstacle course includes hoops, single pylons, double pylons, an acoustic waypoint, as well as the stationary land mine in which the UAV will have to autonomously navigate.

All involved teams will have to display the target type, identification confidence, range to target, and time of arrival in a GUI box displayed on a land station wirelessly linked to the UAV or Mine nearby. No teams are allowed to use YOLO based deep learning object detectors within the computer vision aspect of the project. Points will be awarded to drone teams that complete certain objectives, however the land mine evaluation hinges solely on the system's ability to target and disable a drone from play. The competition will be conducted within an indoor laboratory space with GPS denied navigation and observed by a panel of Lockheed Martin employees and advisors.

The mine system is required to demonstrate four operational features: Auto-Detection, Auto-Tracking, Auto-Disruption, and an Electronic Stop (E-Stop). To meet this challenge, the system will employ the latest computer vision deep learning algorithms along with fused range information from a stereo camera to achieve high accuracy detection and localization in three-dimensional space, multi-class classification capability, automatic target tracking, and kill capabilities with a custom net-based kinetic takedown system.

Detections will be computed from a state-of-the-art Faster R-CNN deep learning architecture based on a convolutional neural network (CNN) backend. Classification will be exclusively handled by CNNs due to their intelligent handling of feature extraction from known data through supervised learning and nonlinear mapping to class decisions.

Tracking will be accomplished through an optical flow tracker that can capitalize on the object detector's outputs and compute likely positions of identified targets across space and time. The stereo camera allows for both visual, and range to target tracking based on a computed point-cloud of object ranges within the cameras' fields of view. A primary objective of the project will be to evaluate the performance of a fully integrated computer vision system and the ability to deploy deep neural networks in an embedded systems environment with Nvidia's Jetson Nano Developer Kit. The Python programming language will be utilized along with multiple packages like OpenCV, TensorFlow, and advanced optimization libraries such as Nvidia's TensorRT and cuDNN to achieve computer vision and deep learning hardware acceleration.

Developing a robust game theory is also crucial to effectively disabling target drones. In order to counter possible retaliation, the mine team explored a multitude of disruption and camouflaging techniques. Dummy systems i.e. pop up targets, countermeasures for enemy projectiles, cybersecurity attacks and adversarial sensor exploitation will also be explored. The mine will be equipped with a projectile netting system that utilizes visual servoing allowing for vision-based robotic controls for aiming, targeting, disabling, and retrieving adversarial drones once they enter the mine's defined blast radius.

The goal is to create an Automatic Protection System (APS) able to intelligently decide whether a projectile should be fired based on the target classification and spatial position. The computer vision solution will be able to distinguish between drones and non-drones to be able to correctly and safety make autonomous targeting decisions outside of and within the effective range. The focus will be on portability, autonomy, detection accuracy, and kill capabilities. Finally, the safety features like a ground station laptop that will log image data sent directly from the mine through a video datalink as well as an E-stop kill switch to cut power to the system from a distance will be implemented within the final design to ensure the system meets safety needs. During competition, the mine will have three opportunities to compete in 10-minute rounds in which the team will be unable to repair the mine during round play and cannot have any human-in-the-loop cued functions to effectively disable the target and prove success.

II. System Components

This section introduces each system component that was used to develop the stationary land mine system. The system components were either purchased or custom designed and fabricated to meet the systems requirements.

A. Image Processor

The image processor control will run image detection algorithms that utilize heavy image processing techniques. Not only must it be able to process large amounts of data but must also be able to process this data rather quickly since the design must function as a real-time system to be successful in its task. It will also need to be able to handle Wi-Fi communications via an external Wi-Fi module to complete tasks such as emergency stops and display live camera feeds to an external peripheral such as a nearby laptop.

The Jetson Nano was ultimately chosen because it had all of the specs that were required for the given task without being overly powerful. The price was reasonable as well.

B. Secondary Controller

A secondary controller will be utilized in the system to easily communicate with the primary control system and handle any functions divvied out to it. This controller will mainly read sensor information and process the data from the primary controller to handle turret motion as well as trigger the net launching mechanism. Because of the low amount of processing power required here, it would be possible to use a basic MCU implementation in this case. This secondary controller will also be integrated into the PCB design.

The ATMEL ATMega328 was chosen as the secondary controller ultimately because the price and the device specs meeting the processing requirements. Also, this chip can be incorporated into the PCB design easily as this chip has been used by enthusiast for years therefore resources are readily available for integrating this processor within the complete system.

C. Chassis Material

Being that this design will be comprised of multiple electrical components and the goal is to ensure the mine fully contained, it is imperative that the design includes a custom chassis that houses all parts in a compact fashion. This will not only help with the portability of the design but will also help with the overall presentation and in ensuring that the device is compact and stays within the sizing constraints of 1.5ft x 1.5ft x 1.5ft.

Due to exterior constraints such as time and readily available materials, MDF wood was used to develop the primary form of the chassis. The added weight of utilizing wood versus a PLC or equivalent 3D printable material allows for more stability at the base of the chassis design.

D. Camera Module

The most crucial factor in ensuring a successful mission for the overall design is being able to properly identify and track the enemy target; an autonomous drone. It is very imperative that the design features a highly accurate and consistent set of “eyes” for the primary sensor as a way to locate the object in open space.

The camera solution that fits this application best is the Intel RealSense D415 Depth module. This module not only provided the image quality, wide FOV, and frame rate that is required but will also measure depth without the need for any extra algorithm or hardware development. The price point is a major consideration, taking approximately 20% of the final design budget, but the added features and ease of configuration and usability ultimately make this the best and most reliable option for meeting the design requirements.

E. Disruption Devivce

The disruption devices within consideration included systems to disrupt the sensors of the target, systems to capture the target, systems to disguise the mine from the target, as well as systems to attract the target to enter the defined blast radius for the mine. All of these methods were discussed at length before dedicating the time into research as many ideas led to a customer constraint that would void the idea entirely.

After a thorough examination of different disruption tactics, developing a homemade net launcher would be the primary disruption device. It would be the easiest to develop and had one of the highest effective kill confidences. The mine would be placed on the obstacle course right underneath a scoring objective for the drone to ensure the target would enter the blast radius. The mine would then detect and track any drones flying over or through the scoring objective; entering the blast radius and make calculations when to fire the disruption device. This design would be heavily reliant on the software and computer vision aspect of the system.

F. Stepper Motors

The DOMINANCE mine functions using a turret-like motion therefore it is imperative that this motion is easily controllable and quite precise.

The option selected was the Nema 17 bipolar stepper motors to control the mine turret movements. This was selected due to the much lower current draw to torque ratio which not only the system will consume less power increasing total efficiency, but also that the options in selecting a compatible motor driver are not limited due to a specialty motor. Another factor that strongly swayed this decision was the weight. Even though this motor features less torque than some of the other explored options, the decreased weight of this motor implies there will be less of a strain on said motor required to supply horizontal motion to the mine body.

G. Motor Driver

An adequate motor driver is necessary to not only assist in supplying power to the motor via an external power source but will also aid in controlling the motor itself from signals received from the secondary controller.

After analysis of the motor drivers in question, it became readily apparent that the Big Easy Driver was a much better option for this component. It is controllable by 5V logic and can take an input voltage that is well within the bounds of what the design requires. The aspect that makes this driver stand out from the rest, however, is the 1.4-1.7A+ Amperage rating per phase. This will allow for control of virtually any motor that we would select for this application.

H. Wireless Fidelity (Wi-Fi) Module

A Wi-Fi module is necessary to connect a router or internet access point to the mine device in a wireless manner. Data such as confidence, classification, and time of arrival captured from the land mine will be set to the ground station (laptop) in real time.

The Wi-Fi modulator chosen would be the COMFAST CF-WU810N. The overall cost per technology and ease of use were the primary reasons as well as the fact that it met the necessary bandwidth requirement to set up live video feed (6 Mbps). The NVIDA Jetson Nano supports USB 3.0 and 2.0 which also allows for a “plug and play” design.

I. Router

To connect the ground station and land mine on a wide local area network (WLAN), a router is needed for the mine to send live video feed as well as metadata back to the land station. The Lockheed Martin Test Facility will not provide any internet connection so figuring out how to pass data packets back and forth without an internet connection is necessary.

The router chosen would be the Linksys E2500 due to it being the cheapest option. It met the minimum requirement of supporting the COMFAST CF-WU810N as well as setting up the WLAN between the ground station and mine.

III. SYSTEM CONCEPT

To fully understand the entire system, this section will outline the overall system design, hardware design, and software design.

A. Overall System Block Diagram

Developing an overall block diagram early in the designing process allows for the crucial components to be defined as well as assigned between each team member. Delegating these tasks not only allows for efficiency for completing the system, but also allows members to be held accountable for doing their part. While defining the main components, research into these general subsystems can begin to allow for further hardware and software details to be defined by the respected team members. This overall block diagram also provides a general system flow to show how to integrate all of the necessary subsystems together via power and signal flow to achieve a complete final system.

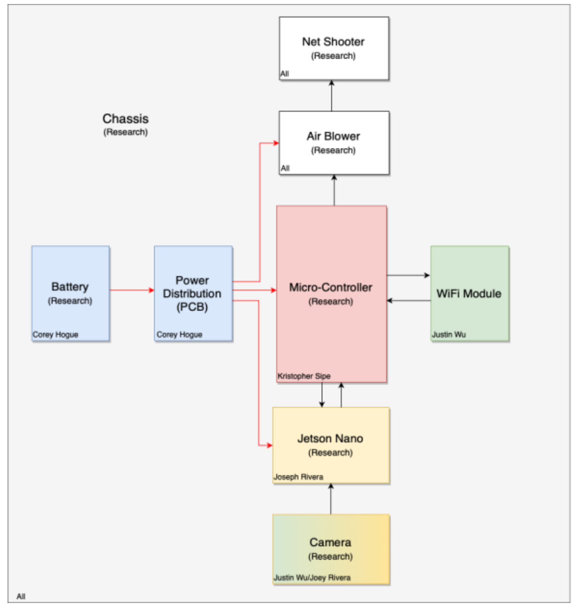

Figure 1: Overall system block diagram showing major components and primary development lead.

The block diagram shown in Figure 1 represents the crucial components necessary for the DOMINANCE mine to detect, track, and disable the UAV with the given proximity. The red arrows represent power flowing through the system. The black arrows represent the signal communication that will pass from component to component. The responsibilities of each member of the team are also represented in the diagram.

B. Hardware Flowchart

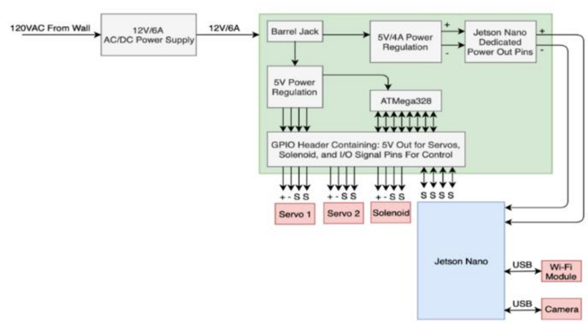

Figure 2. Complete hardware flowchart shows the electronic components on the PCB as well as the peripherals connected.

We first pass 120VAC wall power into a 12V/6A AC/DC Power supply. This will convert AC power to DC power and help create a steady 12V 6A supply that will later be used to power the PCB. On the PCB, a barrel jack will accept this power from the external supply and will distribute this power to all of the system hardware allowing for a single wall outlet to be utilized for the entire system. On the PCB, there will be voltage regulation to step down the 12V input to 5V in order to power the Jetson Nano, ATMEGA328, and GPIO headers.

The Jetson Nano and ATMEGA328 will use the dedicated power in/out pins to connect to the PCB. The GPIO headers will be used to connect the stepper motors, solenoid, and any other input/output pins. The Jetson Nano will have the Wi-Fi module and camera peripherals connected to it via USB to allow inputs for processing as well as wireless transmission abilities to the home base. When information is captured from the target drone, it is then passed from the Nano to the ATMEGA328 which in return will activate the stepper motors and triggering solenoid to effectively capture the target.

C. *Software Flowchart*

This section will outline the software flow for both the NVIDIA Jetson Nano that handles the computer vision and neural network computation, and the ATMEL ATMEGA328 which handles the motor and triggering control.

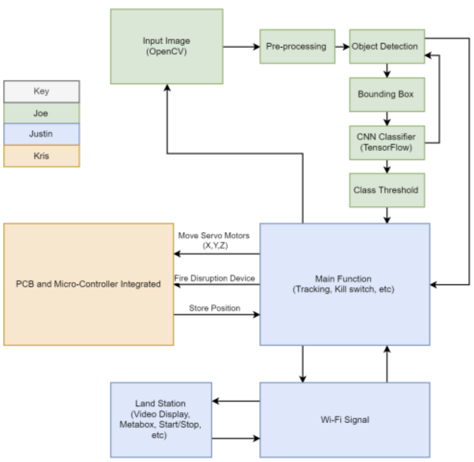

Figure 3. Software Flowchart for the Jetson Nano

Figure 3 outlines the software block diagram for the Jetson Nano. We first take in a live video feed from the camera that will be pre-processed (normalized, filtered, etc.) using OpenCV in Python. After video processing, TensorFlow will be used to detect any objects in the frame and a bounding box and a classifier will be placed on the object displayed on the GUI interface. A confidence percentage as well as class will also be placed on each object detected. Depending on the object, the main function will send a signal over to the PCB to move the motor or fire at the target. If no objects are detected, it will loop through the object detection until it finds a target within the frame. Live video will be sent to the land station as a video is captured.

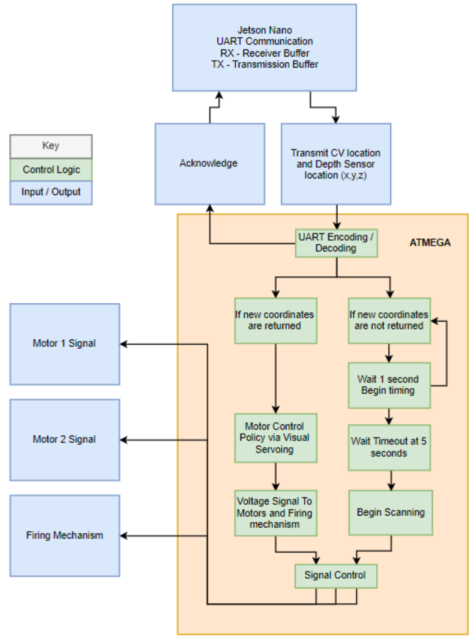

Figure 4. Software Flowchart for the ATMEGA328

The ATMEGA software flowchart is referenced in figure 4. The process begins by starting to receive and decoding the UART signals. Based on if a new coordinate is returned, the motors proceed to adjust left, right, up, and down to match the detection location to the center of the frame.

Logic is incorporated to aim the net launcher in front of the current location of the detection location. If the z coordinate is under 3 feet confirming the target is within the blast radius, then the firing mechanism will be enabled. The interception of the drone should happen as far from the system as possible in order to account for the deployment delay of the net.

If new coordinates are not received, the system will transition into a scanning state where it can structurally look for new targets. Both the visual servoing and scanning states output control signals to the two motors and firing mechanism.

IV. Hardware Details

Each of the major system components outlined in section II, with the exception of the router, will now be explained in technical detail.

A. *Image Processor and Secondary Controller*

Being that this system is comprised of two controllers, it is imperative that both of them are able to communicate freely to one another and also that they are able to perform each of their tasks. To assure that the two controllers are able to communicate effectively, this design will be using a UART communications scheme between the two. In order to achieve this on the hardware side, this will involve linking the two together via RX and TX pins on each processor. The

Jetson Nano features a header which includes specialized lines for UART communications using a 3.3V TTL signal. The ATMEL ATMEGA328 features dedicated TX and RX lines that operate on a 5V TTL signal and are located on pin 1 and pin 0, respectively.

To ensure the communications are sound, the RX of the Jetson Nano will be connected to the TX of the ATMEGA328, and vice versa. A ground pin on the Jetson Nano will also be tied to the ATMEGA328's ground, ensuring that there is a common ground between the two sub-systems. Once this wiring is complete, and the software settings are set to equivalent levels in each system (baud rate, number of bits, parity) making the communications almost be ready for commencement.

The final step to ensure proper communication between these two controllers is to include logic-level shifters integrated between the two communication lines within the PCB. The ATMEGA328's UART scheme uses a 5V TTL signal, while the Jetson Nano utilizes 3.3V logic. These voltage level shifters ensure that communication between the two controllers will function as expected.

B. Chassis

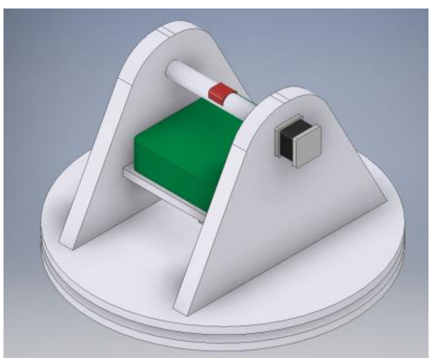

Figure 5. Software Flowchart for the Jetson Nano

The CO2 launcher will be mounted at the top of the chassis (marked in red) and the camera will be on the servo enabled mount. The camera will be able to move in the X, Y, and Z directions in order to help track any drones flying on the obstacle course. The Jetson Nano, PCB, and any other internal parts will be self-contained in the chassis.

The figure show where the processor will be housed in green, the point where the launching mechanism and camera will be mounted in red, and the positions of where the motors will be mounted for X, Y, Z controls.

C. Camera Module

The Intel RealSense D415 camera is interfaced with a USB 3.0 cable making the connections for this sensor to the Jetson Nano convenient as it features four USB 3.0 ports located directly on the carrier board. All that is required is to connect the male end from the Intel RealSense camera module to the female USB connector on the Jetson Nano carrier board, then configure the SDK to create a 3-D point cloud to give range information. Overlaying the detection location with the point cloud yields range to target and after recording temporally, the time of arrival can be calculated based on a simple velocity calculation for the target drone.

The power for the camera will also be drawn from this USB connection via the Jetson Nano, so no external power source will be required for the sensor. The camera will be mounted on top of the launching mechanism as such that the center of the image frame is pointing at the direction as to where the net will be launched.

D. Capturing Device

For the primary disruption device, a CO2 powered net launcher will be implemented on the mine. The net launcher is composed of three primary components: The CO2 canister adapter along with brass tubing, a valve that will trigger the device to fire, and the net deployment system. All three main components will be connected via brass piping of which will serve as pressure regulation for the propulsion system for the net.

Table I. Net Launcher Part List

Item	Description
15 Count Crossman 12 Gram CO2 Cartridges	CO2 Cartridges
Paintball Quick Change 12 Gram Co2 Adapter	CO2 Cartridge Adapter
6'x6' 1" Mesh Net	Net
10' 1/4" PVC Pipe	Net Deployment Tube
DERNORD Stainless-Steel Heavy-Duty Ball Valve	Mechanical Valve
Everbuilt 1/4" Brass 90* Elbow	Brass Piping Turns
Everbuilt 1/4" Brass 3" Straight	Straight Tubing
Everbuilt 1/2" to 1/2" Adapter	Couples CO2 to Elbow
Everbuilt 1/4" Coupler	Between Ball Valve and PVC

The main propulsion source for the new launcher is compressed carbon dioxide (CO2) in which can be readily purchased for a relatively low cost. For this application, it was decided to use single-use twelve-gram CO2 canisters with the respected adapter The disposable single-use canisters require the adapter to pierce the thin metal seal as well as adds a ½" threaded male coupler to allow further components to be added in unison with the adapter. The adapter allows for quick reloading as it only requires the user to unthread the piercing valve, place a new unopened CO2 cartridge in, and replace the piercing valve and tighten until the seal on the cartridge is pierced. The CO2 adapter will be connected to the other components via brass piping. Brass piping was chosen as it allows for 1000psi of working pressure of which is plenty of working pressure considering this application.

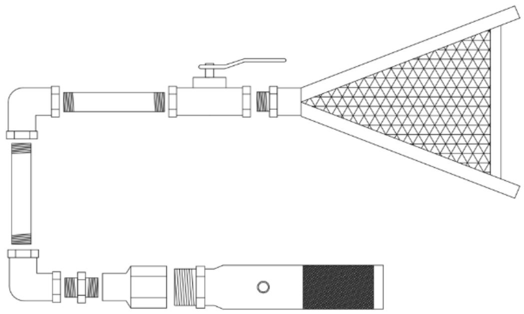

Figure 6. Net Launcher Schematic

The pressure within the system is fully dependent on the volume of the space occupied by the CO2. This results in the length of the tubing sections being the key variable for adjusting the pressure for deploying the net. The brass piping is also used to route the gas in a way such that the device can occupy the least amount of space possible to stay within the size limitations of the customer. By utilizing two 90 degree couplers, the size of the disruption device can be reduced to roughly half of the overall length while still maintaining all of the necessary components. Since all of these components are under great pressure once the 12g CO2 canister is punctured, Teflon tape will be used to guarantee a secure seal between all of the components. The quick-change 12g CO2 adapter, Crossman 12g canisters, and brass tubing and couplers are all used together to form the final system used for successfully propelling the net to capture the UAV.

To fire the launcher, the solenoid will receive a signal from the ATMega328 triggering the normally-closed valve to open and release the pressurized gas. This solenoid will require power to actuate the valve of which will be provided by the PCB terminal block outputs. Once the Jetson Nano detects the target with a high enough confidence to meet the threshold, the Nano will send a signal to the ATMega328 on the PCB to turn this pulse into the trigger command; sending a voltage to the solenoid to quickly open and reclose the valve. This triggering command will be a sudden, short pulse to ensure that the solenoid does not remain open any longer than needed so that temperatures of the system do not drop to any critical lows as well as ensuring the limited CO2 in the canister is not wasted.

The net deployment system that will deploy the net in a way that allows for maximum coverage. This part will be constructed using a PVC pipe that will be cut to make four, equal-length tubes that will all be aiming outward from one another for form four barrels. These four barrels will be joined with a ¼" brass coupler that will allow the net deployment system to be attached to the previously discussed triggering valves. Each of these four PVC barrels will be attached to one another via dowels and plexiglass to allow the net to be contained between the barrels. The net will have four small metal weights, one attached to each corner, which will be placed in each barrel to serve as the 'bullets' for the mine. When triggered, the pressurized gas will be released and dispersed within each barrel; propelling the weights outward from one another simultaneously. Since these weights are attached to the four corners of the net, this will deploy the net along with the weights. To ensure that the CO2 propels the weights efficiently, each weight must create a seal between it and the inner diameter of the barrel. This seal can simply be made by wrapping electrical tape around the weights; adding more layers as needed without creating too tight of a seal that would obstruct the weight from propulsion entirely. Having each of the barrels facing outward from one another ensures the proper expansion of the net to provide the largest deployment possible while also providing a space for the rest of the net to be held before being triggered.

Utilizing the largest net possible while also being able to deploy it successfully is a crucial component of the system. A 6'x6' net with a 1" mesh was chosen from *TheNetGunStore.com* as this completely encapsulates the given blast radius if fired directly vertical. The biggest concern is with the drag that the net will create upon deployment; making the net not travel the required distance to reach the target. This will be considered heavily when designing the piping lengths for pressure regulation to ensure there is enough pressure to propel the net as fast as possible to maximize the accuracy of the mine in case of a fast-moving target.

E. Stepper Motor and Motor Driver

The motion of the turret system is critical to mission success as this will control the accuracy in which the mine will be able to fire upon the target. Guaranteeing that the targeting is accurate will require input to the ATMega328 from the Jetson Nano to ensure the location of the firing mechanism is in line with the location of the target. The input from the Jetson Nano will be relayed to the ATMega328 via the UART communication scheme.

Following the input from the Jetson Nano, the ATMega328 will then be required to step the motor to the correct position to ensure that the target is in the engagement location. To achieve this, the ATMega will be connected to the Big Easy Motor Driver, which will in turn be connected to the Nema 17 Bipolar stepper motors. Since this design features two motors in order to support 3D targeting, two motor drivers and two motors will be required to accomplish this task [1].

To power the motors, a 12V power source will be connected to the VCC of the motor driver and the 12V power source's ground will be connected to the GND on the motor driver. The next step, after motor power is considered, is to connect the control lines from the ATMega328 to the motor driver's inputs. Since the motor selected for this design is bipolar in make, it will require four control lines per motor driver to stop them. Because of these digital pins 2, 3, 4, 5, 6, 7, and 8 will be tied to IN1, IN2, IN3, and IN4 on the first motor driver and the remaining to IN1, IN2, IN3, and IN4 on the second motor driver, respectively.

In order to create motion, the final step is to wire each motor driver to its motor in question. The first motor will be used to control yaw, and therefore will be connected to motor driver one. Here, the positive and negative terminals of each phase (A, A-, B, B-) must be connected to the motor drivers. Similarly, for the pitch control, the positive and negative terminals of each phase will be connected from motor driver 2 to motor 2.

With this configuration in place, the motors will be able to control the position of the net launcher in both the yaw and pitch rotation planes. This will, therefore, allow the three-dimensional targeting that is pivotal to this design and overall mission success.

F. *Wi-Fi Module*

This design requires a reliable Wi-Fi communication as a requirement of the system is to be able to display a live video feed to an external device. The requirements also extend to being able to disable/enable the system remotely, meaning that communications will need to travel both ways.

The integration of Wi-Fi communications is made simple in this system due to the Wi-Fi module that was chosen for this task. The COMFAST CF-WU810N that was selected for this application is perfect as it is simply a small USB dongle. It will be interfaced with the Jetson Nano by simply being inserted into a USB port on the carrier board. Once this is complete only software will be required to establish a reliable Wi-Fi connection with the external device.

G. *PCB*

The design will feature power routing and voltage step downs for distributing power throughout the system. Also, to be included in the PCB design is the female connection for the ATMega328 chip, which will also feature traces to screw connectors that will allow the motor drivers to be easily connected.

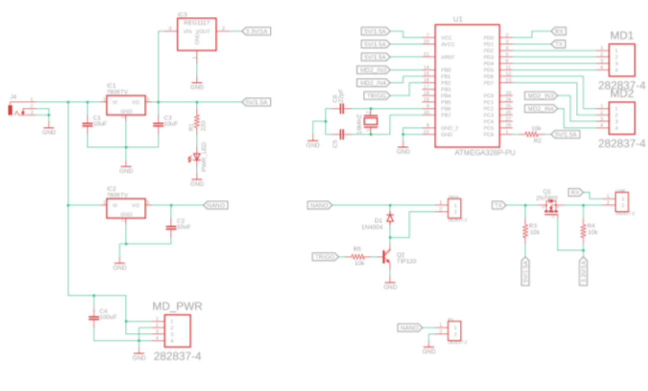

Figure 7. PCB Schematic

The PCB design features various terminal blocks to allow easy connections to all of the peripherals in regard to signals and power. Distributing power to all of this hardware via the PCB allows for the entire system to only need to rely on a single 120VAC wall outlet for power; increasing portability and ease of use. Signal connections are also made for the UART connections, triggering solenoid, and the motor drivers.

V. Software Details

This section will explain the software design in technical detail. References to section III will be made.

A. *Object Detection and Recognition*

Implementing a Faster R-CNN object detector with a transfer-learned MobileNet-v2 convolutional neural network backend provides intelligent bounding box nomination, and classification [2]. The network was trained in MATLAB with parameters and techniques specified in the technology comparison. The network is then exported into the ONNX file format and optimized for Nvidia GPUs with TensorRT and serialized. The engine is loaded in its optimized format in the main Python script that uses OpenCV to read image frames while applying image pre-processing and continues to pipe the detections down the computer vision pipeline.

B. *Tracking*

Implementing a KCF tracker in python with OpenCV allows for temporal correlation between detections with a regressive bounding box. This helps to smooth detection locations over time and establish smooth tracks. KCF tracking should be easy to implement since OpenCV 3.1 has a built-in implementation. It will take in the processed (classified and bounded) frame and initiate the tracking around the bounding box [3].

C. *Turret Movement*

Once the target has been successfully located and tracking has commenced, it is imperative that the turret is able to move with the target and attempt to keep it located within the center of its line of sight (LOS).

To achieve this feat, the Jetson Nano will relay information about the target's exact position in a frame via a UART communication scheme. This transmission will be handled at a relatively low baud rate. The information sent will consist of the position of the target's bounding box center in relation to the center of the frame.

The information sent via UART from the Jetson Nano will inform the ATMega of how off-center the target is, in terms of angle in the yaw and pitch rotation planes. This angle will then be converted into an exact number of steps that the motor should take in order to center the target within the camera LOS. This will then be used to control the motor driver via the Arduino Stepper library, which will ensure the motors translate the targeting system to the correct position.

D. *Enabling Launch Sequence*

Being that UART communications already exist to relay the angle between the center of the bounding box and the center of the frame, the system will also be able to utilize this communication to relay when firing is necessary.

Since the requirement of the system is to not fire upon target unless it is in the target zone cylinder (3’ radius x 10’ height), the ATMega must know when the target has entered this range. The RealSense D415 will be able to locate this third position coordinate (depth) of the target via its included SDK libraries and stereo camera configuration. Once this depth is calculated it will then be sent, along with the angle information, to the ATMega328 chip. If this depth is appropriate, and within the required firing zone, then the ATMega will send a high signal to the solenoid. This will, in turn, cause the launching mechanism to be activated.

E. Interface

Figure 8. GUI interface

Simple bounding boxes can be overlaid onto the live camera feed, which is returned by the object detector. Class labels and class confidences are determined by the most confident class returned by the classifier, and range to target will be estimated by the range to the center of the detection boxes. These statistics will be incorporated in a simple GUI and saved to local storage on the microSD card in a data structure.

CONCLUSION

The DOMINANCE Landmine project not only challenged our knowledge but also developing an interdisciplinary team to achieve a common task. Tasked to develop a fully functioning disruption device with a list of specified engineering, there was a need to figure out how to design, research and develop the mine to meet or exceed these requirements. The overall goal of the design was to make an easy to use and effective disruption device while meeting the specified customer requirements, which we successfully accomplished.

ACKNOWLEDGMENT

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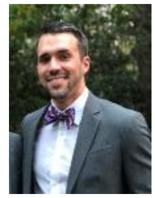
BIOGRAPHY



Corey Hogue is currently a Senior at the University of Central Florida and will receive his Bachelor of Science in Electrical Engineering in May of 2020. Currently, he is a Technology Designer at EXP. for the entertainment industry designing low-voltage systems for theme parks around the world.

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Kristopher Sipe is currently a senior at the University of Central Florida and will receive his Bachelor of Science in Computer Engineering in May of 2020. Currently he is interning with Lockheed Martin as a member of the College Work Experience Program but looks forward to beginning full time employment with EPS Corporation this Summer. There he will specialize in MCU hardware / software development.

Justin Wu is currently a senior at the University of Central Florida and will receive his Bachelor of Science in Computer Engineering in May of 2020. He plans to attend the University of Central Florida for his master’s degree in the field of Machine Learning. He is currently a System’s Engineer at Lockheed Martin looking to specialize in software engineering.

REFERENCES

[1] B. Schmalz, "schmalzhaus," [Online]. Available: http://www.schmalzhaus.com/BigEasyDriver/.

[2] E. Forson, "Towards Data Science," [Online]. Available: https://towardsdatascience.com/understanding-ssd-multibox-real-time-object-detection-in-deep-learning-495ef744fab#targetText=Single%20Shot%3A%20this%20means%20that.

[3] OpenCV, "OpenCV," [Online]. Available: https://docs.opencv.org/3.4/d2/dff/classcv_1_1TrackerKCF.html.