Pedestrian Detection via Thermal Imaging
And
The Hummingbird Field Light Attack Aircraft
(Technical Paper)

The Intersection of Engineering and Safety Regulation
(STS Paper)

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Sander Abraham
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Technical Project Team Members:
Pedestrian Detection:
Navya Annapareddy
Emir Sahin

Aircraft Design:
Lori Abed
Justice Allen
Eli Kidd
Marcus Dozier
Landry Myers
D'Michael Thompson

On my honor as a University Student, I have neither given nor received unauthorized aid on this assignment as defined by the Honor Guidelines for Thesis-Related Assignments

Signature ____ Date __________
Sander Abraham

Approved ____ Date __________
Tariq Iqbal, Department of Systems and Information Engineering

Approved ____ Date __________
Jesse Quinlan, Department of Mechanical and Aerospace Engineering

Approved ____ Date __________
Bryn Seabrook, Department of Engineering and Society

Introduction

In modern engineering, development is rapid and changes well before regulations do. Laws and policies are often made reactionary to different advancements. Regulations are important to ensuring the public interest is kept in mind and safety continues to be a high priority. However, since technologies are leaping ahead, engineers are increasingly given the role of balancing ethics and public interest in their work. The governmental regulatory bodies usually lack the resources to keep up with the cutting edge. Moreover, it is difficult to know how to regulate something without having the complete information, leading to vague policies or having in depth studies that require years of time wherein the technology in question has already been antiquated. This is particularly present in autonomous vehicles where the technology has a high learning curve for understanding, and changes are being made every day that the regulatory commission such as NHTSA are unable to keep up and have not made any significant relevant policy changes beyond guidance for engineers developing the cars. Engineers are thus given the role of having to balance the safety of the passengers and pedestrians while designing both the cars and the environment. To this end, Perrone Robotics is developing the usage of additional sensing in the form of thermal imaging to classify objects as humans vs. non-humans and change the car's behavior as a result. The other area of application is in aircraft design where these decisions are even more critical since there is a large public eye on aircraft development and therefore their failures too. This leads to the FAA having a role in ensuring public safety in their regulations.

Technical Topic 1:

Currently, autonomous vehicles use a combination of cameras, lidar and radar to detect objects, and conduct path planning (Burke, 2019). However, pedestrians and cyclists are hard to determine and from the car's perspective are no different than a box in terms of their possible actions. In reality, one would prefer that a car reacts differently when passing a pedestrian versus passing a random box. Moreover, at night the low levels of light make it harder to detect objects. Thus, Perrone Robotics asked the capstone team—Navya Annapareddy, Sander Abraham, and Emir Sahin with Professor Iqbal as an advisor—to develop a method to quickly and accurately identify pedestrians and cyclists in thermal videos. This will be accomplished through the development of a machine learning model that will train on existing public data, and then eventually tested in collaboration with Perrone Robotics with their facilities and testing platforms. Previous research has indicated that thermal imaging has the potential to help autonomous vehicles in non-sunny weather (Miethig et. al, 2020). Previous uses of machine learning in autonomous vehicles include path planning to determine optimal routes (Rus, 2018). Thus, this project aims to add a new dimension of computer understanding of the environment by providing better detection of human elements.

The machine learning model will be a deep learning long short-term model (LSTM) that is itself made up of a convolutional neural network (CNN) model. The CNN will take in frames from the thermal camera video feed and identify what objects appear to be people or cyclists with a high degree of confidence. The CNN is made up of several layers sandwiched by the input and output layer. When a image is passed in, each layer applies a function to the input and gets an output, in this case a determination. This function is manipulated by weighting and bias which is the learning part. When the model is being trained, it is adjusting those weightings and biases to be as accurate as possible. Then that information is passed into the LSTM where the identifications over time can be aggregated to determine trends and intent determination. The LSTM differs from other machine learning approaches in that it stores information and eventually forgets it. The LSTM will store some information from what was previously passed, and used it to influence their outputs, eventually though that information will recede in value and then be forgotten to prevent lasting bias when the situation has changed. By utilizing both models, the system will be able to better identify objects and then determine the object's intent i.e. the direction of the path they are taking. The result of this capstone will be a paper to a major organization and an implementable system to Perrone that is readily able to connect to their vehicle operating system.

Technical Topic 2:

Modern warfare has drastically changed how what is used in combat. The old methods and principles no longer work since the environment and combatants have changed. Warfare is largely urban centric with a focus on ground combatants. This leads to a key air support role called close air support, meaning the aircraft stays near the ground and provides an overview of the situation from above while being ready at any point to provide attacking fire, missiles, or bombs. Current aircraft such as the recent F-35 is very versatile and could accomplish this role, however it costs a lot to operate the F-35 and they are limited in low altitude flying since they need to be going relatively fast to maintain control. The previous plane designed for this exact role was the Fairchild A-10 Warthog. It was first in service in 1977 and is still active today (Northrop Grumman, 2020). Obviously, it is an aged platform and the Airforce is looking to replace it. The AIAA 2021 Undergrad Team Aircraft Design RFP is focused on this area of interest (AIAA, 2020). The objective listed in the request for proposal (RFP) is as follows:

> The objective of the project is to design an affordable light attack aircraft that can operate from short, austere fields near the front lines to provide close air support to ground forces at short notice and complete some missions currently only feasible with attack helicopters.

The key parameters just from the objective is: cost, weight, runway length and quality, and slow and low altitude flying. From this, and from the rest of the RFP, the team--Lori Abed, Sander Abraham, Justice Allen, Eli Kidd, Marcus Dozier, Landry Myers, and D'Michael Thompson with the guidance of Professor Quinlan—can use the aircraft design process and tools such as AeroVSP, to develop a design to meet the specifications of the RFP and ideally provide a competitive submission to the AIAA Student Design Competition.

STS Topic

As technology rapidly develops, engineers are more and more given the responsibility of deciding how much safety to incorporate in their designs. Ideally, the designs are as safe as possible, however, this comes at a tradeoff in cost and performance. So, engineers are put in the position of making moral decisions on what is safe enough. Typically, regulatory bodies are given this role of setting the bar for minimum safety, however, in modern development, a lot is changing in a short amount of time, and the regulatory agencies often do not have enough resources to keep up, thus leaving the job to the designers. This best evident in the recent Boeing

737 Max incidents and the development of autonomous vehicles. Currently for autonomous vehicles there are not any real laws or regulations. The relevant federal agency, the National Highway Traffic Safety Administration (NHTSA) has not released any rules beyond a voluntary guideline that does provide any real requirements but instead offers best practices while designing the system (NHTSA, 2020). It only provides recommendations and suggestions for industry's consideration and discussion" without a "compliance requirement or enforcement mechanism." A brief from the Federation of American Scientists given to Congress on the current regulatory space on autonomous vehicles highlights the disarray of any real requirements for safety in this system (R45985, 2020). They found several attempted bills at the federal level to construct laws for autonomous vehicles and the few but varied state laws that exist. For this technology to be best integrated it needs to be done with public safety in mind. There are also questions of who is responsible in the event of an accident. This is another area where engineering ethics is under scrutiny. The current legal framework does not have the foundation to handle any upcoming battles in this area (Brodsky, 2016). It is a largely an argument on if the manufacturer/designer is entirely responsible for safety or if the consumer is one who has to pay the insurance claims. Since no legal or regulatory bodies are taking stance or putting hard guidelines on the safety of this technology, engineers are left deciding how to navigate this space. There have already been two deaths involving autonomous vehicles and in both cases the car's developers were blamed, but no legislation followed through. Instead, in both locations, testing and development for self-driving cars was halted preventing a chance for oversight to be introduced and outside input into development.

Another area which has seen rapid technological change is in aircraft design. The Boeing 737 Max 8 incidents and subsequent groundings was also a result of ethics being withdrawn due to hurried development (Herkert, et. al, 2020). Boeing needed to update their 737 model since Airbus' competitor for a regional carrier jet, the A320 Neo, dominated the 737 in every metric. So, Boeing decided to rush out a design that had a bigger engine which, due to geometric constraints, made the aerodynamics difficult to manage. Boeing's solution was to build software that would force a false stability through the Maneuvering Characteristics Augmentation System (MCAS). Now, one would think that the FAA would catch and vet such a system, but since the FAA allows self-certification if the plane is deemed close to its previous model in performance and control characteristics (FAA, 2020). Once again, the responsibility falls back to the manufacturer and in thus the engineers to determine safety due to the lack of accountability and real oversight.

To analyze this system, Actor-Network Theory will be utilized. This will help demonstrate who and how decisions are made in the engineering design process. This will also highlight where regulatory input is or should be inputted. The benefits of this is that the network at a holistic level which is ideal since each element has equal value and the interactions are made obvious. The downside of this method is that intents are not modeled (Bruni, 2007).

The question being answered is: How does engineering design and ethics interact with regulations and therefore safety? I will be analyzing historical documents and government documents that focus on autonomous vehicles, the Boeing 737 incidents, engineering ethic, and regulatory bodies. This method is best since there are many documents that exist on these topics. There have been many government reports and research literature written on these exact topics.

Conclusion

From these projects there will be several deliverables. The Perrone Robotics Thermal Imaging project will produce a working system that can reliably identify humans and cyclists and pass that information seamlessly into the MaxOS from Perrone Robotics. We also expect to publish a paper on the results and methods used. For the Light Attack Aircraft design, we will be submitting a proposal to the AIAA Aircraft Design Student Competition. This proposal consists of geometric and characteristics details of the design as well as justifications for the design and the process used to get there. Lastly, from the STS project, I expect to have an analysis of change in the role of an engineer due to the increased demand for safety assessment. While I do not think a solution will be proposed, exposure of the issue could lead to actions taken by those in relevant regulatory positions to take action.

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