Ben Fernandez, Kyle Rood, Suraj Shah

10/22/19

## AmberVision

### **Project Descriptions**

**Ben Fernandez**

As the world of data moves from mere gigabytes to exabytes of data points, there is a rising importance of making sense of this data. That is the primary goal of artificial intelligence and within that, Computer Vision focuses on images as a data type to see what can be pulled out and put together from images. This subfield has grown rapidly and can be seen through innovations like self-driving cars, facial recognition software, robotics, and many more. In parallel, the amount of images on the Internet is rapidly rising and adding to the data pool to be tapped into. In recognizing the current state of deep learning models as well as the increased access to images, our team looks to affect the community with this technology. We see an opportunity to assist families, the public, and governing bodies like law enforcement in Amber Alert searches. Taken from the official website itself, “The AMBER Alert™ Program is a voluntary partnership between law-enforcement agencies, broadcasters, transportation agencies, and the wireless industry, to activate an urgent bulletin in the most serious child-abduction cases. The goal of an AMBER Alert is to instantly galvanize the entire community to assist in the search for and the safe recovery of the child.” (DOJ, 2019) An AMBER alert usually consists of a description of the child-abduction case including the last location seen and suspect vehicle. Using state-of-the-art object detection models, we look to help identify those vehicles using a network of traffic cameras and in doing so, contribute to the goal of AMBER Alerts in search and recovery of the child. The team is seeking funding for this specific venture that has the chance to change the lives of many. With funding received, our team can increase the resources for development and server computation in order to get a product to market in a shorter time frame.

Many approaches have been taken in deep learning to detect cars and other vehicles in images and as we plan to use those existing architectures, we are aware of the technical challenges that will come with refitting these models for the data and images we are analyzing. Most traffic cameras from initial research are not of the highest resolution and the images, as a result, will be harder to analyze. On top of this, most existing models tackle one output of detection while our goal is to combine different outputs for one object. For example, we would aim to detect a red sedan in the image or video feed which could result in multiple detection models being used on one image. Initial research has led us to look into current models like YOLOv3 (Redmon, 2018) for real-time object detection but fitting this model on traffic camera feeds is not trivial. Acquiring data will also be a challenge as we are looking for live data in proximity to Washington DC. Our initial research has led us to DDOT’s Washington DC traffic cameras which as stated earlier are not high resolution and have low frames per second. In addition to building/using detection models and acquiring data, our goal is to surface the information in a useful and effective way. This means creating a frontend for our data and analysis to be displayed which will require development in data engineering and user experience. Altogether, the technical challenges encompass in acquiring valuable data, building/using effective and accurate object detection models, and creating a frontend for users to view the analysis. This full-stack approach will not be an easy feat but we are confident and inspired to help do work towards this specific need. Ultimately, we see the future of AI more as augmented intelligence rather than artificial intelligence as we aim to help people using the technology that exists today.

**Kyle Rood**

Computer Vision is an important subset of Machine Learning and can be leveraged to analyze massive amounts of data in seconds. Slow data analysis is often a bottleneck for completing many tasks, and one place we think we can help this bottleneck is with the AMBER Alert™ system for missing children. AMBER Alert™ is a partnership between law enforcement, wireless carriers, and broadcast companies to notify as many people as possible if a child is missing. (Office of Justice Programs, 1996) We are looking for investors in our tool, AmberVision, which will ensure law enforcement finds the person they are looking for instantaneously.

We will be making use of Washington, D.C.’s traffic camera network to answer the question: can we find a car (down to the color, size, and location in time and space) given a large array of cameras? Using a deep learning approach, we will create models to identify cars, and then classify those cars into color and sizing categories. The problem with traffic cameras is they are pretty low resolution, so getting an accurate identification of the type of car is very difficult. We may need to experiment with some deep learning techniques (such as transfer learning or combinations of networks) to sort this problem out.

Another one of our technical challenges is that our product needs to be fast. If the police want to see all the red midsize cars in the city right now, we do not have time to run through a very complex model. We will probably resort to using a single shot detection algorithm, like YOLO (You Only Look Once), or something similar. (Redmon, Farhadi, 2018). This type of algorithm is advantageous in comparison to other similar technologies, like RCNN. Other neural networks take thousands of evaluations to output a single class, but YOLO does this using one evaluation. (Redmon, Farhadi, 2018) This is key to doing real-time detection.

Though we will be using an already established model, another technical challenge will be getting data that we can fit the model. The first piece of data we will collect is the traffic camera footage around DC. We have set up an arrangement with TrafficLand for a student license to their traffic camera API. They sent us an NDA to protect their data, and we are simply waiting on a signature to start using these traffic cameras for real-time detection.

AmberVision is the main product we will be delivering, but our project will also create a very unique dataset as a byproduct. Uber has started releasing some of its driver data (UberMove), which contains GPS traces of their cars throughout New York City. AmberVision would essentially be collecting the same data using computer vision. We plan on storing the locations of all the cars we detect, at all timestamps, to keep a historical record of the visible traffic in the city. This would give very accurate historical traffic data, and could be used by DDOT or other researchers who are studying traffic in cities.

The last technical challenge will be translating our machine learning outputs into an intuitive and useful display for law enforcement. This tool will be a deployed web application that any law enforcement agency could log into and use. Translating the machine learning output to an easy to use interface will be challenging, but will be an extremely beneficial tool to all law enforcement agencies, and can be used in association with all sorts of crimes. AmberVision will help law enforcement deal with the swaths of information they are given to make quick decisions when time is of the essence. Investing in our product means investing in keeping our cities safe.

**Suraj Shah**

The AMBER Alert system is a messaging system that notifies the public of missing children and provides details about the abduction. This usually includes the car the victim was abducted in or the last article of clothing the victim wore. This model relies on text messages, which is the problem we want to extrapolate and improve upon. There are a clear purpose and target audience that will benefit from a significant improvement in the AMBER alert system including law enforcement agencies. As the trend continues to use technology to improve upon existing infrastructures and update outdated communication methods, we believe our product is innovative, usable, and beneficial as a tool for social good in the world. The goal we set ourselves to accomplish is to find a car, including details about the color, size, location, and timestamp information given a vicinity of traffic cameras in a city. Our purpose, as mentioned, is to provide a tool for the public good that can minimize the loss during emergencies and maximize the rate of finding victims (Kang, 2016). This realm of emergency situation detection has been addressed before, but no approach is currently been published to tackle amber alerts.

Our research and development phase has several steps, each of which will accomplish goals that bring us closer to the tool we will build. We will start by using the DDOT traffic camera data in Washington, DC. Since object detection has been a problem that many notable industries and researches have worked on, we believe using pre-existing models will help us identify a car in a traffic camera. However, we will have to face several technical difficulties including low-resolution cameras and the likelihood that a pre-existing model might not be completely transferable to the DDOT traffic camera network. Therefore, we will need to look into a combination of deep learning models such as YOLO (You Only Look Once) and Retinanet (Focal Loss Object Detection). Aside from the specifics of the models, we want to also collect our own data from a specific radius on the George Washington University campus. We want to limit our reliance on the DDOT traffic data so we will also look into other potential dataset collection methods. This includes setting up higher resolution cameras that can also provide more accurate information about the cars in the view. There will be technical difficulties with our data collection methods, especially with the dependency on the weather. We want to be able to collect data in which there are more objects in the cameras. This is based on weather, so there will be less in the view when it rains, snows, or becomes colder. To account for this challenge, we will combine the research and development phase of canned models with our own data collection. By combining these two parts, we will have adequate data to focus on the third part, the actual tool.

Regarding our key deliverable and our minimum viable product (MVP), we want to design a frontend website that has a 2D mapping of the filtered cars in the traffic camera radius with their last scene location on this map. This visualization will allow law enforcement to quickly find all cars related to a specific AMBER alert and allow them to focus on the important part, finding the victim. We believe this tool will be exceptionally useful, not only for this specific application but its overall multidisciplinary tool for society, which is why the funding is necessary to develop this idea into a product. In the end, our project would not be a proof of concept or an idea that has potential, but a full-fledged tool that can be used for various applications, not just for the AMBER Alert system.

**Similar Projects**

While researching the project, it is evident that there are similar projects and studies that have been conducted before regarding improving the current emergency alert system as a whole. One of the most notable research papers written on this topic is from Byungseok Kang with the paper *A Deep-Learning-Based Emergency Alert System*. This paper focuses on improving emergency alert systems using deep learning models and minimizing the loss of victims that occurs during these emergencies. This paper is a good start to the Amber Alert project, but it differs with regard to its goal. Whereas the goal of AmberVision is to solely focus on Amber Alerts, Kang and their team’s deep learning model approach is a holistic solution to a general problem. Therefore, our project differs from the emergency alert system project because our primary purpose is to improve the amber alert system. Furthermore, our project is different because Kang’s approach uses Convolutional Neural Networks whereas we are using transfer learning which is a different method to get more accurate results based on a variety of deep learning models, not just one single model.

The other project that exists is a paper from Jason Kurniawan that has similar ideas to our project, titled Traffic *Congestion Detection: Learning from CCTV Monitoring Images Using Convolutional Neural Network*. This paper presents a novel approach to traffic congestion using computer vision models with traffic cameras. Essentially, Kurniawan and his team use image classification techniques, specifically convolutional neural networks, to provide a method to detect a buildup of traffic using CCTV data. An important aspect to note about their project is that Kurniawan limits the use of image preprocessing steps because the images are quite small from the traffic cameras. Furthermore, there is a simple binary classification, which means that the output gives the result of whether traffic *exists* or *does not exist*. Our project does not focus on alleviating traffic in cities, but certain aspects of Kurniawan’s paper are important for us to understand how we can work out problems we will encounter with our Amber alert system. For example, we plan to have significantly more data processing on the CCTV data because we need to detect more than the number of cars in a frame. Since our project focuses on finding cars and their respective sizes and colors, we will need to use advanced preprocessing that can account for sunlight reflections and other uncontrollable aspects that can miscolor a car based on its image. Furthermore, based on the results and accuracy of their classification system for a binary problem, we want to use transfer learning because we are not just checking whether there is traffic or there is not. Transfer learning will help with better accuracy by combining multiple models that each will solve a very specific part of this car classification problem.

The overall impact that our project has is its novelty as mentioned with the few examples that exist that have been published in this realm. It is evident that there is no current research paper or study done that uses traffic cameras to solve the focused goal of detecting cars in CCTV cameras based on Amber Alert data. However, it helps that there are projects that have used some machine learning and deep learning models on traffic cameras because that can help us avoid potential problems later down the road. These projects are not necessarily our competitors because we are in different spectrums of the problems we are trying to solve. Rather, our product is novel and can use certain implementation ideas that these projects succeeded at and failed with so that we can accurately develop a pipeline from data collection to the frontend web application.

### **Target Audience**

We want to deliver a usable product at the end of this project. We aim to have a multidisciplinary tool that can be used by many, but our primary audience is law enforcement in this country and specifically for our pilot, the Washington DC police department. As the product goals allude, AmberVision is designed to help with active AMBER Alerts, but we see larger reaching applications with this tool as well. With the AMBER Alerts, we see this as a tool that takes in the latest inputs of current AMBER Alerts and with our tool, law enforcement can track cars that are in the AMBER Alerts. We see this tool being primarily used by law enforcement because of the specificity of the project and the need for an improved version that can help law enforcement scrape through thousands of images using smarter technology that exists currently.

AmberVision would be extremely helpful to any member of law enforcement, and we hope to implement our system in every major city in America. We hope to deploy this technology nationally within large precincts and build out the network of cameras to enable large scale Amber Alert search. Onboarding multiple police departments inherently improves the product because the data gathered is interoperable and can be used by multiple departments to aid and inform their own searches. Training law enforcement to use the tool would be relatively straightforward because our design will be planned to be inherently user-friendly. Our goal is to have a filtering system that can search for cars of any color and size similar to a *Google* search. We also see an expansion of this tool to other cities because traffic cameras do not solely exist in the District of Columbia, but all over the United States and even the world. Therefore, by implementing a successful tool that the Metropolitan Police Department could use, it can serve as a valuable benchmark for other significant law enforcement agencies to use our software for their own city’s needs.

Regarding our plan for a potential path of profitability, by working with established government bodies, AmberVision will use a licensing model that will charge per licensed user. This license needs to be renewed every year and will be specialized for each department user. The initial market is limited to law enforcement as we acknowledge the associated risk with our product and want to keep the product focused on its value proposition for Amber Alerts. The benefit of working with law enforcement is the level of network effect that exists within this industry; if one department finds the tool useful, then that customer story will drive other customers to our platform. Expanding upon our business model, our goal is not for explosive growth, but continuous usage of our system. By focusing on a subscription-based model and entering markets and cities that we can see potential use, we can control our market share and the relative growth that we can handle. For example, we will start with the DC police department and based on the success of this market, move to similar interest markets, such as Boston and Newark. By charging for each user, our product will be limited relative to users, but this is a factor we are taking into consideration because of the sensitivity of the data we will be handling. Since traffic cameras have various privacy laws based on the information of the images, we aim to only focus on the consumers that we know are legally allowed to access this data, such as law enforcement agencies. We also see this tool as a future implementation for government agencies such as the FBI and CIA that want to track other aspects of traffic cameras such as suspected bystanders or other criminal requests or activities. By establishing a strong reputation with government bodies, AmberVision aims to gain the credibility to keep onboarding potential consumers and customers for the platform.

### **Societal and global impact**

In a world of big data, we are not making full use of the information that we are collecting. Washington D.C. has hundreds of traffic cameras that are constantly collecting data, but none of this is being used. People are using big data for financial or statistical purposes, so why is our law enforcement groups not using the same sorts of strategies for cracking down on crime? We are building an application to bridge the gap between constant, usable information, and the people who can use this information to do the most good. According to the FBI’s National Crime Information Center (NCIC), there are over 400,000 entries for missing children. With AmberVision, we aim to continue lowering this number by helping enable robust searches through the network of cameras that exist on the road. By using the traffic camera data, we will have access to important information that is not stored anywhere. For example, we will focus on storing timestamp data as well as last updated images, which is extremely important with tracking specific instances in a night. Currently, the traffic cameras around DC are just live streaming the video feed, but there is no storage of the actual data, for various reasons, whether it be storage costs or lack of technological capabilities. We aim to fill this void by storing valuable data that can help law enforcement.

Furthermore, AmberVision will absolutely need regulation. Collecting people’s data unknowingly is always a slippery slope, so we will try to prevent the wrong people from accessing our tool. A member of a lab we all work in created a computer vision-based application for law enforcement, which helped them to track down human trafficking victims using minimal images taken in hotel rooms. Human traffickers could potentially use the tool to improve their techniques, but since it is firmly in the hands of law enforcement agencies, the technology is not being used for the wrong reasons. We will need to work with law enforcement to figure out the best way for this process to work. By using a subscription-based model based on each user, as mentioned previously, we aim to limit the number of users, so that we have control over who accesses the data and who can see the data.

Additionally, AmberVision could potentially be used to track people in a city. Our tool is constantly creating a map of all of the visible cars in the city, which could help somebody malicious find out the whereabouts of anybody in the city. AmberVision can be interpreted as a “big brother” application, which is why we will take extensive measures to make sure this data is protected.

This would be a problem if only one child was going missing, but sadly, thousands of kids are abducted every year, and many are never found. Any international city with traffic cameras throughout the city could use this technology. We cannot entirely solve this problem since not all kids are taken in cars, but AmberVision will be able to at least start to combat this problem better than we have in the past.

The intention of Amber is to be fully secure, so data can’t be removed, and easy enough that people without a technological degree can interface easily with the application. We want police officers to be able to use our tool as soon as they have access. A police officer who has received a report of a missing child would plug the description of the car into our interface (basic color and size of the car), then they select a certain radius for where the child may have gone missing. The officer would then be able to scrub through photos from different cameras in the area to find the car that most likely took the child. In our design, we are placing an emphasis on speed and ease of use, so that the user can get exactly the information they need in a timely manner. The police already do a similar sort of investigation when it comes to finding and tracking criminals, but our tool will help to automate this process.

Our platform will be based around the traffic cameras in Washington DC, but this could be used in cities all over the world. TrafficLand has an API that expands to other cities in America, and countless other cities have accessible traffic camera data. Amber Vision could be used seamlessly with other TrafficLand cameras, but it would only take a little tweaking to make Amber Vision work on any camera set. Not only is the tool generalizable in terms of the location of the cameras, but the tool is also generalizable to other crime reporting. People drive away from crime scenes all the time, and our tool would be able to find and track them. Amber Vision would not only help police with active Amber Alerts but could help them with all of their work. This is a powerful tool that could be applied to any city with traffic cameras.

**Technical Innovation**

Amber Vision is a combination of a database and API of images, machine learning algorithms, and a front end web application that is updated in real-time, and nobody else is doing this. Using a network of hundreds of traffic cameras, we will be able to identify where most of the cars in the city are at all times. This novel technology will help law enforcement to find criminals in moments, and moments are often enough to make a difference in high-density scenarios like Amber Alerts.

Primarily, the central piece of Amber Vision is the Database and API. The database contains all of our images as well as bounding boxes and classifications for the size and color of every car in every image. Our API will be set up so that our other pieces can push and pull directly from the database. Regarding machine learning, for AmberVision we decided to go with YOLO, one of the fastest machine learning algorithms available. YOLO (You Only Look Once) is a real-time detection algorithm used for classification in videos. It is optimized for speed, but the current version (YOLOv3) has accuracies of over 94% on the DarkNet Dataset. (Redmon, Joseph. 2018) This is an incredibly accurate and fast algorithm, which makes it perfect for vehicle detection. Despite its advantages, this model does have limitations when it comes to color and size. We will use this machine learning technique, and specifically, the deep learning portion of YOLOv3 to detect vehicles based on their size in real-time.

During our initial tests, running any car detection model on a video would produce shaky results in terms of the color and size evaluations. YOLOv3 can identify cars but is not particularly good at describing them. Using the pre-trained model as our basis, we will use transfer learning to add depth to the network. Using a TSNE classification approach, we can group all of our images into lower-dimensional space. By mapping these images (high dimensional vectors) into lower dimensional space we can help the computer distinguish classes from one another. This may also contain a “human in the loop” component, as we can use people to help weed out the images that are on the edge of two classes. A potential future application is using a small human validation aspect to help to automatically train our color algorithm. We may take a similar approach to our size calculation, but we need to do more research on this front.

In addition to the technical innovation in Machine Learning, Amber Vision uses state-of-the-art frontend web frameworks and protocols. Amber Vision is built off using Vue which is a component-based framework to enhance data manipulation and interaction on the client-side. The platform displays the most information for the user which is the camera image and detections as this is the main output of our product. With Vue, Amber Vision provides a minimal view but allows users to dive into the data and pull out additional resources if requested. These include additional data points for the camera and the detections as well as documentation to help navigate the website. Using Vue, Amber Vision delivers a user experience that enhances completing for the very important task of Amber Alert searching.

Finally, for the development aspect of Amber Vision, Vue is the right choice for speed and scale. The workflow to publish new content on the Vue web app is unprecedented in the frontend framework realm and allows for quick and large updates to the site in a quick time. The toolkit that accompanies Vue is comprehensive which means the user experience is not limited based on the Vue framework.

**Technical Feasibility**

This project has challenges, but overall we are confident that we will be able to construct a usable tool for our consumer base. We have a thorough plan to construct our product from a plan to a full-fledged application. Our first step in approaching the problem is using existing infrastructures. Since there are many machine learning models that are much better at car detection than a built-from-scratch machine learning model. Therefore, we aim to use some of these models and improve upon them by focusing on the preprocessing of the images we collect. Furthermore, we will use Trafficland’s API, which has the data we need. Rather than seek out traffic cameras that could potentially be subpar, by using TrafficLand, we will have access to a much higher quality dataset. Furthermore, we plan to use web frameworks such as Vue JS as a Javascript framework to allow us to display our results in a friendly user interface that will make it easier for our consumers to access the information they need. We are essentially putting the pieces together to make a product that is more useful than the sum of its parts. By combining various and separate entities that are each excellent in their own respective fields and combining them together, we will create a pipeline that is extremely good at classifying cars as well as high-quality traffic data. Therefore, we are extremely confident in our ability to create this tool because of the existing infrastructures and our ability to build upon existing tools to create a minimum viable product or MVP.

Furthermore, the team that is working on Amber Vision has great experience working with some of the existing architectures in the project as well as lots of experience overcoming hurdles by learning new techniques and technologies. As the backgrounds range from a machine learning experience to full-stack web development, these skill sets raise the technical feasibility percentage. These skill-sets also should not undermine the actual difficulty of the project; Amber Vision is tackling a tough problem for society as well as the evolving field of computer science. However, even with the technical difficulty, the team brings passion and experience to try, iterate, and develop Amber Vision.

One of the most difficult things will be getting Amber Vision to work with the level of latency that we are looking for. We want a live-updating website that is constantly downloading images, performing car identification and classification, and displaying the results to the user. This means constant communication between the machine learning algorithms, the front end framework, and our database. On top of constant communication, the user interface must be intuitive for those who have not worked with web interfaces as their main domain, so this must be addressed in the overall design of the system. The idea is that Amber Vision will run asynchronously, downloading images, performing classifications, and saving/pulling information from the database. This will require some coordination to prevent race conditions, but it is very doable. Once we have the information classified and stored in the database, we will be able to query for any time and location instantaneously, so all of the throughputs are done upfront. If this means we are only updating the main page every couple of seconds instead of every second that is acceptable because we are optimizing for the officers querying for older information. Officers could use it to find all of the cars in the city at that moment, but we think it is more likely that officers would be looking for people that had gone missing a few hours before. Either way, we will achieve the latency we are looking for with asynchronous threading and by saving our classifications.

**Cost, Risks, and Risk Mitigation**

This project has many moving parts, so it is important to set goals and milestones to make sure the project keeps moving. Our team’s goal for the end of the semester is to have a fully integrated product that we can show a baseline use case. We do not expect any part to be totally finished, but definitely some aspects of integration, but we hope to have a basic version of our “identification” algorithms (size and color) working by the end of the semester, as well as a full data pipeline to ingest and process images, and a front end to display of the data we are collecting.

Primarily, the primary risk of our project is the large amounts of data and the lack of consent to collect information on individual people. Taking images of their cars and logging the whereabouts of those cars in a database is likely a concern for most people. We are currently in a data revolution, and people are aware of how companies are using their data now more than ever. At Amber Vision, we plan on taking the extra precautions of how to handle this data and who we are going to be sharing this data with. As mentioned earlier and will be reiterated throughout the process of development, Amber Vision’s main customer is working with governing bodies who deal with Amber Alerts. Not only is the data we are collecting sensitive but also the data that we are receiving from these governing bodies, so we have to be careful with following privacy concerns.

Upon researching, we found there is no legal problem with collecting this data. TrafficLand’s site is publicly accessible, but it is just giving us easy access to query for data through its API. The data is there and we are simply making use of it. Since we are using its data simply for the information the data provides, such as the image and the location information, there is no significant cause for legality issues. Furthermore, since our primary consumer market is the Metropolitan Police Department, we are only allowing access to our product with experts in the legal field. Another relevant point to make is that our tool is not collecting precise information about cars, but simply the image of the cars and timestamp and location. We are not classifying make, model, or license plate. Therefore, we are creating profiles and tracking people, but simply using a few basic categories (location, color, size) as metadata, and querying this basic data only when entirely necessary.

In addition, our team is dedicated to working with Law Enforcement to make sure that there is controlled access to our tool. A new professor in our team’s lab worked on a project called TraffickCam, which is a computer vision tool used to identify hotel rooms from minimal photos of human trafficking victims. Though it does not have the “big brother” feel of our collection of data, TraffickCam does show us that we can collaborate with law enforcement to create a safe system. This means we will also need to get security recommendations from law enforcement themselves, as they will have the best idea of the kinds of cyber threats facing their systems.

Also, to make our project more secure, our goal is to use a subscription-based model, so that we will be aware of all current users and limit the total number of users. By doing so, we will be able to control and constrain the security. Furthermore, we aim to keep our database internal and housed at The George Washington University’s internal servers. This will prevent any possible cloud services from accessing our information and only allow the creators of the product to access information if needed. Finally, we will encrypt our database information, such as the location history and timestamp data, so that if there is a leak or hack with the data, it will be meaningless without the actual image. We will use these steps to secure our information because we are aware of the potential privacy laws and the thin line we are walking regarding the data we are capturing and using.

Furthermore, the development monetary cost of this site will be very minimal if it costs anything. All of our infrastructures will be hosted online, from the database to the live server. The lab our team works in has access to two servers with excellent Graphics Processing Units that we have been given access to. This means we can do all of our training, testing, and deployment inside of this environment. Beyond that, we have been given a Student Account with the TrafficLand API. Since we told them it was a student project, Traffic Land is giving us access to the platform for free. The only cost which could potentially arise would be cloud computing services, but this is only if we are unable to set up our application on our local server for testing. Since our app is not going to be getting a lot of traffic any Cloud Framework that we use would not cost a lot.

Additionally, the development timeline will be the one in most flux as the project continues as there are many milestones that can prove to be more difficult than initially expected. This flux ties directly back to the technical innovation that comes with this project and the core technologies Amber Vision is built on. The approach we are taking is novel to Amber Alerts and is breaking new ground for traffic cameras and low-resolution camera images and data types. Although the server and data costs will be minimal, the machine learning aspect, as well as the intellectual property that comes with the product, will provide great value to the end-user. Amber Vision will be an embodiment of the model that rapid development and project timelines do not have to be high in cost to achieve a large goal which is what we want.

Finally, for the Javascript and HTML regarding the front end, a rough estimate of the total lines of code will be about 500 lines. Regarding the backend API structure, we estimate about 400 lines of code. The significant portion of the code will be housed in the machine learning, which will be more than 1200 lines of code at least.

### **Bibliography**

Kang, Byungseok. “A Deep-Learning-Based Emergency Alert System.” *ICT Express*, Elsevier, 21 May 2016, www.sciencedirect.com/science/article/pii/S2405959516300169.

Kurniawan, Jason. “Traffic Congestion Detection: Learning from CCTV Monitoring Images Using Convolutional Neural Network.” *Procedia Computer Science*, Elsevier, 21 Nov. 2018, www.sciencedirect.com/science/article/pii/S1877050918322397.

Office of Justice Programs. *AMBER Alert*. 1996. https://www.amberalert.gov/index.htm.

Redmon, Joseph, and Ali Farhadi. “YOLOv3: An Incremental Improvement.” ArcXiv, 87 Apr. 2018, https://pjreddie.com/media/files/papers/YOLOv3.pdf.

Scott, Katy. “Hotel Room Photos Could Stop Sex Traffickers.” *CNN*, Cable News Network, 20 Mar. 2017, www.cnn.com/2017/02/09/tech/traffickcam-sex-trafficking/index.html.