Project Stage 2

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2.1 Research + Data Collection

2.1.1 Business Customers

- **What problem will your Computer Vision solution solve, and for whom?**

The traffic signal prioritizer plans to create a safer environment for pedestrians at crosswalks and create a more efficient traffic light system. Currently traffic signals use algorithms created by statistically analyzing common traffic patterns. Our Computer Vision solution aims to use cameras to see real time changes in both automotive and pedestrian traffic and adapt accordingly.

- **What value will it provide them? What are their pain points?**

Currently the pain points for traffic light systems is the cost associated with retiming the lights and unnecessary wait times for motorists. Unnecessary wait times at traffic lights contributes to several negative side effects including: greater fuel consumption, frustrated motorists, and more air pollution. Optimization of traffic signals using Computer Vision could potentially save the government hundreds of thousands of dollars which in turn would save taxpayers' money.

Source: https://pdfs.semanticscholar.org/055e/c1a092e9f007e24714aa2f92cda2da0de728.pdf

- **How big is the potential market?**

The Department of Transportation would be in charge of adopting and implementing this solution. Since traffic signals are instrumental to the flow of traffic in most countries, the potential market would be any country with a developed road system.

- **Do other similar solutions exist?**

One of the largest already existing solutions is Surtrac Smart Traffic Signals which was developed at Carnegie Mellon University. It has already been implemented in Quincy, MA and Portland, ME. This solution optimizes travel for pedestrians, bicycles, transit, and connected autonomous vehicles.

Source: https://www.rapidflowtech.com/

- **Would your business have any competitors? Who are they? How are they doing?**

The aforementioned company, Surtrac, would probably be the biggest competitor with this product as it is already an established company that has their solution implemented in several cities. However the existence of this company shows that there is currently a need for a solution like this.

- **How are potential customers dealing with these issues now?**

Currently the most reliable traffic signal detection systems in place are timers for big cities and induction loops for suburbs. Induction loops are the most common sensors used, and they are essentially coils embedded on the surface of the road that detect changes in the magnetic field surrounding the coils.

Source: http://www.automatesystems.co.uk/how-traffic-light-sensors-work/

- **How much would customers be willing to pay for your product?**

Traffic signal wait times must be optimized annually in order for the signals to change properly. According to the US Department of Transportation, optimizing already connected traffic signals costs about $300 to $400 per signal and optimizing new signals costs $760 to $2,700. Over forty cities in California retimed 1,535 signals in 1995 at a cost of 2 million dollars. Due to this, the Department of Transportation will more than likely be willing to pay large amounts of money for a better solution that does not require costly manual retiming each year.

Source: https://www.fhwa.dot.gov/publications/publicroads/02janfeb/timing.cfm

2.1.2 Academic Literature Review

PAPER 1

Paper Source: https://www.scirp.org/journal/PaperInformation.aspx?PaperID=78431

- **What makes this paper relevant?**

This paper describes the implementation of a smart traffic controller using real-image processing. It aims to achieve this by using Computer Vision and Image Processing techniques. The various methods explained in the paper can be helpful for us while creating a smart traffic light system of our own. The author also discusses different methods (such as motion detection, usage of lasers on both sides of the road), and how are they not an ideal choice.

Going through this paper helped us get an overview about what strategies might be helpful and which specific areas we need to target while coming up with a solution of our own. It can help us understand the image processing techniques to count the number of vehicles on the road, estimate its density and then use the outputs to control the traffic.

- **What are their results and how did they achieve the results?**

According to the author, the proposed model can calculate the cars and the traffic density with an accuracy of up to 90%. It is also relatively cheaper than the alternatives which use sensors to detect the traffic density. The author has described two different approaches to count the vehicles.

The first method is by using the video as an input. This video is separated into frames, converted from RGB to gray and then to binary. On these frames, foreground detector is applied in order to mark the differences between 2 different frames. The resulting frames are then enhanced by reducing and eliminating the noise. This is achieved by ignoring the pixels below a certain threshold.

The second method uses image processing to count the vehicles. In this method, the input image is converted to an RGB image. Vehicles are then identified by marking their edges. The paper describes Canny Edge Detection technique to achieve this.

The author then detects vehicles in motion and then tracking them by specifically marking the boundary around the detected vehicles. This is used to count the number of vehicles on each side, and then accordingly provide the input to the traffic lights.

- **What is different about these approaches?**

One of the standout points about this paper was that it also explained how the selected techniques were better than the alternatives. Algorithm selection for vehicle detection was one such case. Techniques like frame difference method and optical flow methods could also be used to carry out that operation, but were rejected due to their computational complexity and sensitivity to noise.

PAPER 2

Paper Source: https://ieeexplore.ieee.org/abstract/document/7868350

- **What makes this paper relevant?**

This paper introduces the concept of reducing the wait time of vehicles and increasing the running time of traffic lights with the help of Image Recognition and Scheduling Algorithms. It begins by computing Optimal Time at every intersection determined by number of cars at each node. Detection of cars using CV Detection Algorithm by counting the number of cars by subtracting the background, Light Intensity varying Image Recognition Algorithm which takes the image of empty background to use it for subtraction every 6 hours to determine the rate of change and intensity. Finally sending the signal to the traffic light. Similar idea is also proposed wherein all types of vehicles are detected using object detection (Mask RCNN or YOLO) followed by implementing a Deep Learning Algorithm for Scheduling Traffic signals

- **What are their results and how did they achieve the results?**

For Fixed 180s running time, four road cross junction takes 720s to complete a cycle. For every car generated using MATLAB it takes 180s at each node (wait-time) followed by 540s of constant wait time for each cycle.

The entire process is divided into 5 steps, 1. Optimal Time Computation, 2. Car detection with Computer Vision, 3. Light Intensity Algorithm, 4. Image Processing and Network Settings, 5. Configuration of every traffic node.

Initially they calculate the optimal time for the entire wait-time and running-time of cars and traffic signals at each node in an intersection respectively which would act as the base case where we need to reduce the values achieved in the base case. Secondly, They use subtraction method to identify the cars in the video footage that is they snap images of the background in every 6 hours in order to identify change in background and during every intersection, they subtract the image resulting in an empty space for cars. Thirdly, to make the detection more efficient, an algorithm is devised which increases the intensity thereby making the detection more powerful. Image is then processed on the server and the network settings for the traffic signals are given as an input to the server. Finally, the output from the server is fed as an input (as a configuration file) for every traffic node.

- **What is different about these approaches?**

It uses Image Recognition by subtracting the background by capturing an image of the background for every 6 hours. Using this to count the number of cars in the vicinity and then generate a scheduling algorithm for traffic light, followed by analysis of each car’s wait-time per node and then for each cycle. The entire process takes place on a single network - single server, identification involves predefined threshold and requires larger computational power. Since traffic signals consist of solar cells, it improves efficiency as well.

PAPER 3

Paper Source: https://arxiv.org/pdf/1703.05868.pdf

- **What makes this paper relevant?**

This paper is about estimating traffic density using webcam videos with low frame rate as a dataset. Traffic density is nothing but the number of vehicles per unit length of road. The dataset has low resolution videos with high occlusion and large perspective. This system works by selecting region and counts the number of vehicles in the selected region. Further calculates density of traffic by dividing the number of vehicles by length of region.

- **What are their results and how did they achieve the results?**

This system uses two different approaches to calculate the traffic density, one is optimization and other one is deep learning based. In both of them instead of calculating number of vehicles individually, system uses mapping of the dense image feature into vehicle density. Mapping of dense image feature is accomplished using two methods: rank constrained regression and fully convolutional network. Rank constrained regression uses way of learning weights of different blocks to embed road geometry for different image blocks and reduces the camera perspective induced error. Fully convolutional network does the same using residual learning framework.

- **What is different about these approaches?**

    This approach is just for estimating the traffic density. But we can use this calculated traffic density to prioritize the signals.

PAPER 4

Paper Source:
https://www.academia.edu/7883103/Computer_Vision_Application_Real_Time_Smart_Traffic_Light

- **What makes this paper relevant?**

This paper introduces the concept of developing intelligent traffic light which can capture the no of vehicles and pedestrians. Which matches exactly with our idea of prioritizing traffic signals for emergency vehicles and pedestrians using computer vision. This paper has proposed solution for counting number of pedestrians, number of vehicles and determining the situation of crossing area and considering all these factors change the colour of the traffic light signal. Which helps to reduce the pedestrian- vehicle conflict.

- **What are their results and how did they achieve the results?**

This system uses two cameras one for pedestrians and other one is for vehicles. Each of the camera connected with Matrox Meteor capture card having resolution of 320×240 pixels. This system has two levels, the first level is to process the captured images and identify the moving object. Second level is to provide information like position and trajectory by analysing movements to the system. Using the provided information system will take the required decisions. System is using a kalman filter to track moving objects. This whole system is being tested at the Royal Automobile Club of spain.

- **What is different about these approaches?**

  This approach is just for reducing vehicles-pedestrians conflicts. It doesn't consider the cases of emergency vehicles.

2.1.3 Open Source

- **What open source code is available that are relevant to your topic?**

There are several open source code repositories available for AI traffic light simulators, however there are not many for projects using Computer Vision that are similar to ours. Most open source code available is for object detection for autonomous vehicles. The open source code will be useful for help with programming the traffic light controllers, however we will need to combine tutorials for other Computer Vision based object detection in order to complete our project.

Sources:

1. https://github.com/SmartTrafficIntersection/SmartTrafficIntersection
2. https://github.com/samuelyu2002/pedestrian-traffic-lights
3. https://medium.com/machine-learning-world/tutorial-making-road-traffic-counting-app-based-on-computer-vision-and-opencv-166937911660
4. https://www.pyimagesearch.com/2015/11/09/pedestrian-detection-opencv/

- **What data is available for testing and/or training algorithms?**

There are several labelled datasets available on the websites on the sources below. The datasets in the first set include labelled sections of video that include abnormalities such as: cars stopping after the stop line, people crossing the road away from the zebra crossing, jay walking, and cars entering the pedestrian area. There are also unlabeled data sets that can be created from live youtube videos of intersections.

Sources:

1. https://sites.google.com/site/vjagan/home/action_datasets
2. https://youtu.be/1EiC9bvVGnk

- **Is labeled data available? How much? How is the data licensed? Is it under copyright protection?**

A majority of the data sets in the links posted above state that they should not be used commercially but can be used for research and that the associated paper for the dataset needs to be cited as well.

2.1.4 Industry Solutions

- **What companies are solving similar problems to yours?**

The Surtrac company listed above is solving the same problem using Computer Vision.

- **It can be tough to tell exactly how proprietary solutions work, but what can you find on the internet?**

The paper posted by the students at Carnegie Mellon that created Surtrac is available online. However their code is marked as proprietary so they do not give much insight into how exactly the code is written.

Source:
https://www.cmu.edu/epp/people/faculty/course-reports/SURTRAC%20Final%20Report.pdf

- **Are there available talks, documentation, or other resources from their engineering teams?**

The Surtrac team has several available podcasts, news interviews, and case studies on their traffic signal prioritizing product and how it has increased productivity in urban areas. The content is all available on their blog page.

Source: https://www.rapidflowtech.com/blog