**Embedded Approach to Vision Based Traffic Controlling & Monitoring System**

**Introduction**

* A centralized system that gathers and sends live video feed to a central server from thousands of devices across the country, runs neural networks on them and transmits results back to each individual node for traffic control **would require high power, high bandwidth connectivity** to each of those thousands of traffic lights.
* Instead, a fully localized device that processes the live feed on board and controls traffic signals would have the following problems. After manufacturing thousands of such devices and implementing, it would be impossible to update the system or get any data from the devices for centralized monitoring.
* Hence, we propose an alternative approach: an embedded system that processes the live video feed on board and controls the traffic lights, and also sends processed data through low bandwidth links for centralized monitoring. The central server can get full video feeds through high bandwidth links to a small subset of such devices and train neural networks adaptively (in the server). The trained weights, control signals, firmware updates or any other data can be slowly transmitted to all the devices in the network, so the country-wide system learns as a whole.

**Previous Work and Implementations**

Vision based traffic control is a thoroughly researched area and there are various approaches designed and implemented so far. Most use basic image processing or a neural network running on the server. Ours could be the first-in-the world embedded approach with a neural network running on the edge-device.

1. IEEE 2018

An abstract paper on Deep Reinforcement Learning techniques for adaptive traffic light control data from different sensors and vehicular networks. Not an edge-device solution. We could use this as the basis for our adaptive learning network.

1. Thailand (2009)

Basic image processing techniques (edge information) is used to extract foreground objects and they are tracked by Lukas-Kanade optical flow algorithm. They report traffic data to the public server.

1. India (2014)

Basic image processing (contour lines in grayscale image) running on a generic computer (Raspberry Pi) is used to calculate vehicle density on each side of a junction and change signal time accordingly.

1. India (2017)

This paper uses the same system as above with added functionality of RFID based monitoring.

1. 2011: Basic techniques (morphological operations and dynamic background subtraction) on generic device
2. Another research uses basic techniques to extract data and a small neural network to learn from that.
3. Fuzzy logic based system on FPGA at edge device

**Our Solution in Detail**

* Our product will be a low cost, low power edge oriented IOT device placed on traffic lights.
* We will demonstrate a prototype device that houses a low cost ($69) FPGA board. If needed, it can be made into a super cheap ASIC chip at mass manufacturing.
* The device will process the video stream on board (hardware accelerated neural network) at minimum power and give results like the crowd density, jaywalking frequency...etc
* Using that data, it will adjust the traffic signal times
* We will try to implement a localized algorithm for synchronization of signal lights. If not possible, we'll go with a centralised solution.
* It will also send those processed data (not images) to a central server for traffic monitoring via a low bandwidth
* Few of the devices will be connected to the server via high speed communication links. They will send the full feed and their processed results to the server
* The server will adaptively train neural networks with that data.
* The new neural network weights (and architectures?) can be slowly transmitted to all the devices via slow links over the time, so the whole country wide traffic network learns better over the time.

**Scope of Our Project**

Our team is highly talented in digital architecture design and neural network implementations. IOT implementation is not our field of expertise. We would be able to make a product prototype with robust neural networks running on FPGA, sending processed data (and full stream if necessary) and an algorithm to synchronize the traffic lights. But we might not be able to deliver a scalable IOT system ready to be implemented across the country at large scale.

However, as mentioned in the introduction, a localized + IOT based system would be the ideal solution to this problem. We feel, development of a scalable IOT architecture is a FYP in its own. Therefore, we would be grateful if you accept the idea of our system and let us develop the embedded side of it. The IOT architecture may be developed by a different group or by future groups as you mentioned in the mail.

The deliverables would be:

* One or more conference papers on accelerating this kind of DNNs on FPGA hardware, statistical methods used for analysis and the system as a whole.
* A small, power efficient FPGA running a modified version of state-of-the art neural network to asses traffic situations on-board and sending the data to an online platform for statistical analysis.
* A finalized product prototype, with 3D printed enclosure (mouldable design) with PCBs printed in China

**References:**

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2. <https://ieeexplore.ieee.org/document/5137245>
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