System Design for Vision Based Traffic Sensing & Control

GROUP 6

Number of content slides: 20

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EXTERNAL STAKEHOLDERS

- A part of the nationwide ITS (Intelligent Transportation System) Project
- In collaboration with RDA and Transportation Engineering Division, Dept. of Civil Engineering, UoM
- Funded by World Bank

Problem Statement

- Traffic lights in Sri Lanka work on preset, static timing
- Blind to dynamic changes in traffic flow, hence increases congestion
- In such conditions, traffic policemen are deployed

Existing Solutions

1. **Induction Loops [13]**
   - Ideal for sparse traffic
   - Difficult to install, not ideal for motorbikes

2. **Microwave Radars [13]**
   - Ideal for sparse traffic

3. **Wireless sensor networks [14]**
   - Needs transmitters and centralized stations
   - False positives

4. **Existing vision-based systems**
   - Expensive processing hardware [9][3]

Edge Solutions: Research

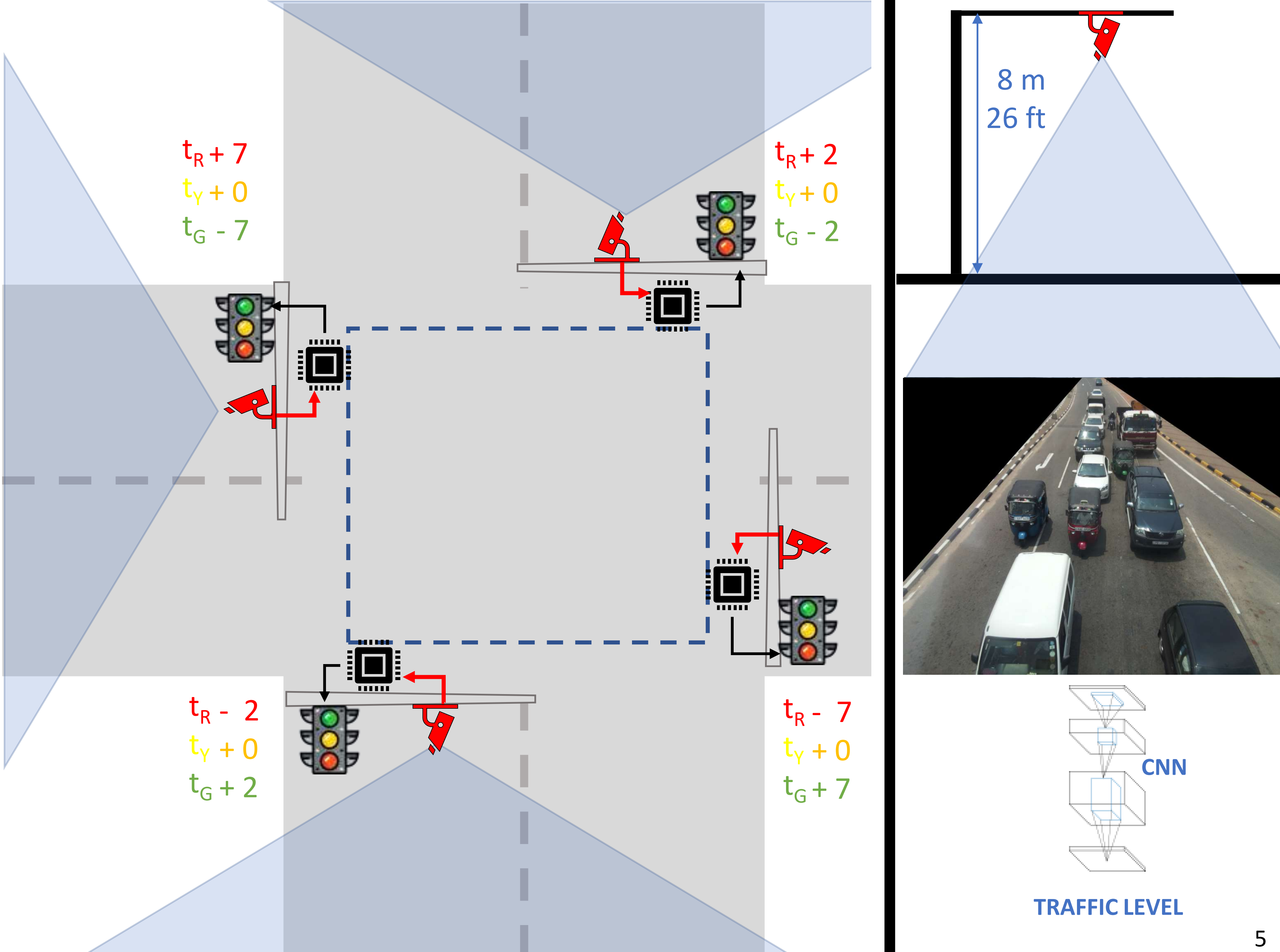
- Developing countries [1] [7]
- Need for cost effective, scalable solution
- Attempts using:
  - Raspberry Pi
  - Basic image processing techniques to detect traffic level [12]

Our Solution

A low cost System on Chip (SOC) design, that

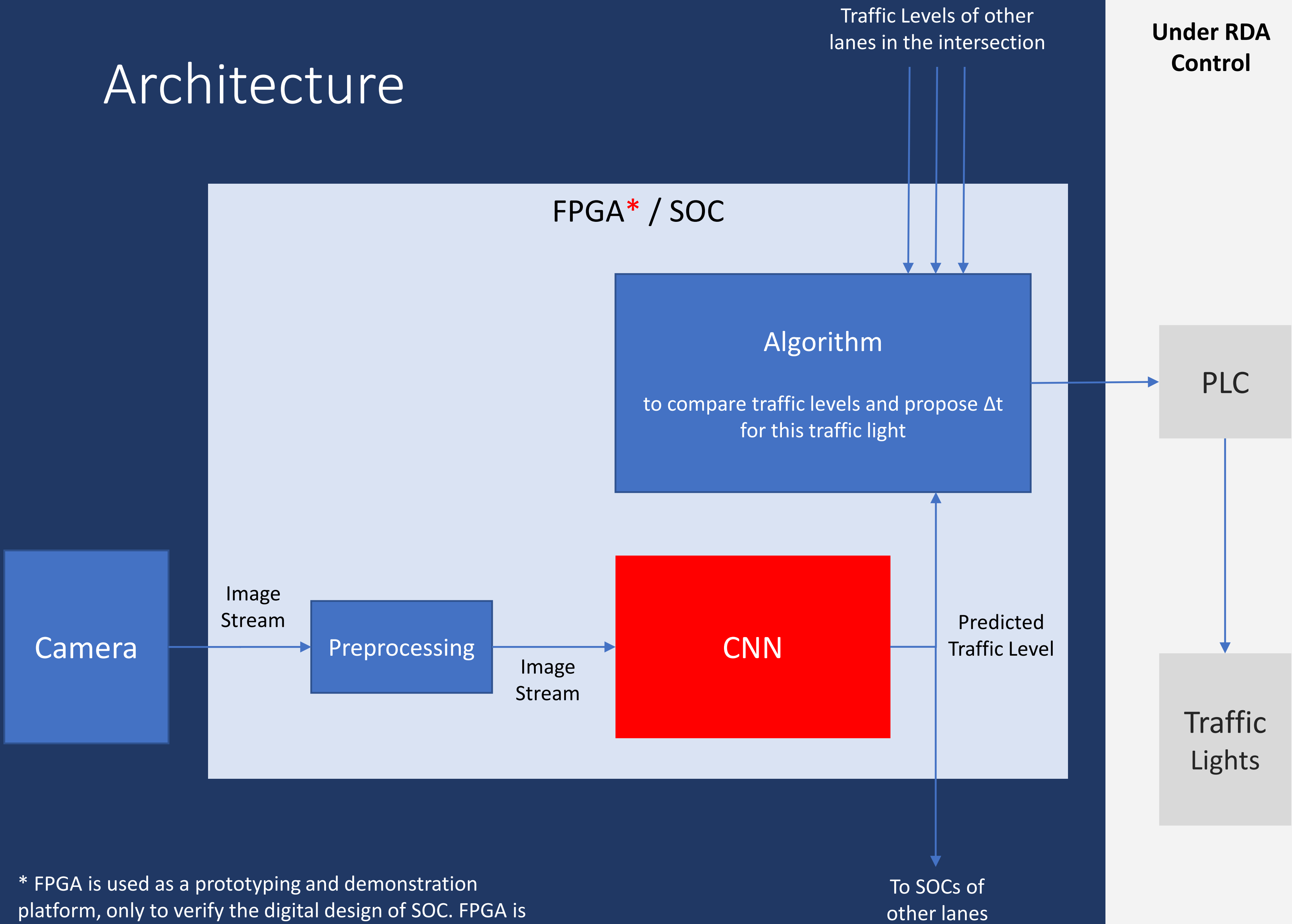
- Collects video feed
- Processes the feed locally **at edge**
- Deduces traffic level
- Suggests a **change in time** (Δt) to the traffic lights

for optimal traffic flow at a junction



$t_R + 7$
$t_Y + 0$
$t_G - 7$
$t_R + 2$
$t_Y + 0$
$t_G - 2$
$t_R - 2$
$t_Y + 0$
$t_G + 2$
$t_R - 7$
$t_Y + 0$
$t_G + 7$
8 m
26 ft
CNN
TRAFFIC LEVEL

Architecture



Under RDA Control

* FPGA is used as a prototyping and demonstration platform, only to verify the digital design of SOC. FPGA is not proposed to be used in the final product

Advantages,

Uniqueness

&

National Importance

- Low cost solution
- Localized – No optic fibers or monitoring centers
- Easily implementable
- Scalable
- Unique, ideal solution for a developing country
- First steps in implementing an ITS in Sri Lanka

Objectives

- Deduce traffic level from video feed
  - Design morphological operations or choose suitable CNN and modify
  - Fine Tuning
- Hardware Implementation
  - FPGA for prototyping and verification
  - Test real time prediction accuracy in prototype
  - Algorithm to propose Δt
  - By comparing traffic levels in different lanes of a junction

Key Deliverables

- SOC (with neural network)
  - as FPGA based prototype
- Algorithm to propose Δt
  - closed loop demonstration in VISSIM simulator

Optional Deliverables

- ASIC fabrication files
- Real world demonstration (with RDA permission)

Scope

Data Collection

- Image feed from 2,3 junctions
- Different conditions
- Labeled dataset

Neural Network Design

- Modify an existing CNN[16]
- Fine-tune training
- Robust to day, night, twilight and rain.

Scope

Hardware Implementation

- Specialized design
- Prototyped on FPGA
- ASIC conversion, if time permits

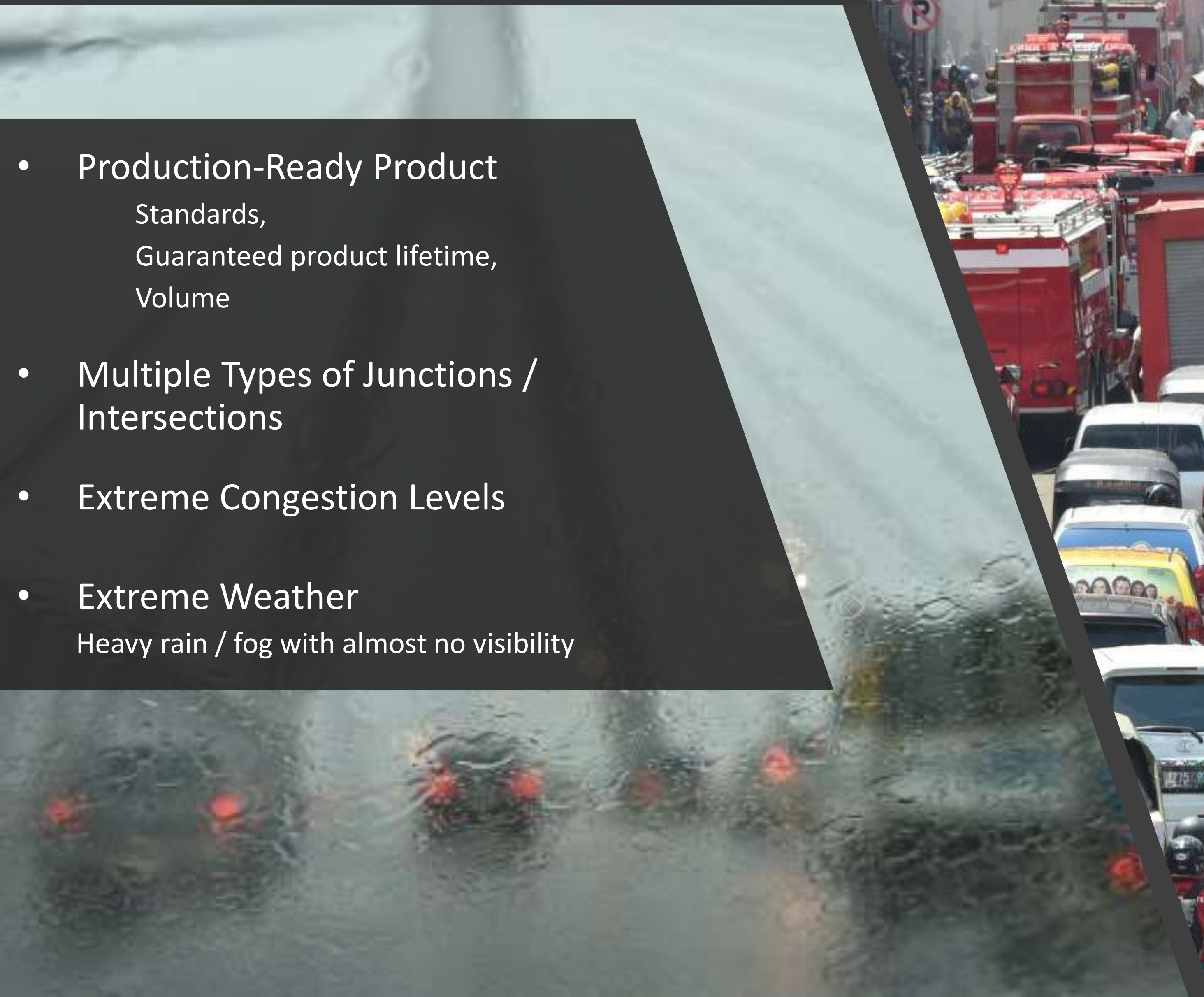
Algorithm

- Input : traffic levels in all lanes of the junction
- Output : Change in static time ($\Delta t \neq 0$)
- Four way intersections only
- low confidence → static timing ($\Delta t = 0$)
- Tested an demonstrated in VISSIM

Documentation

- For future improvement and implementation

Excluded from scope

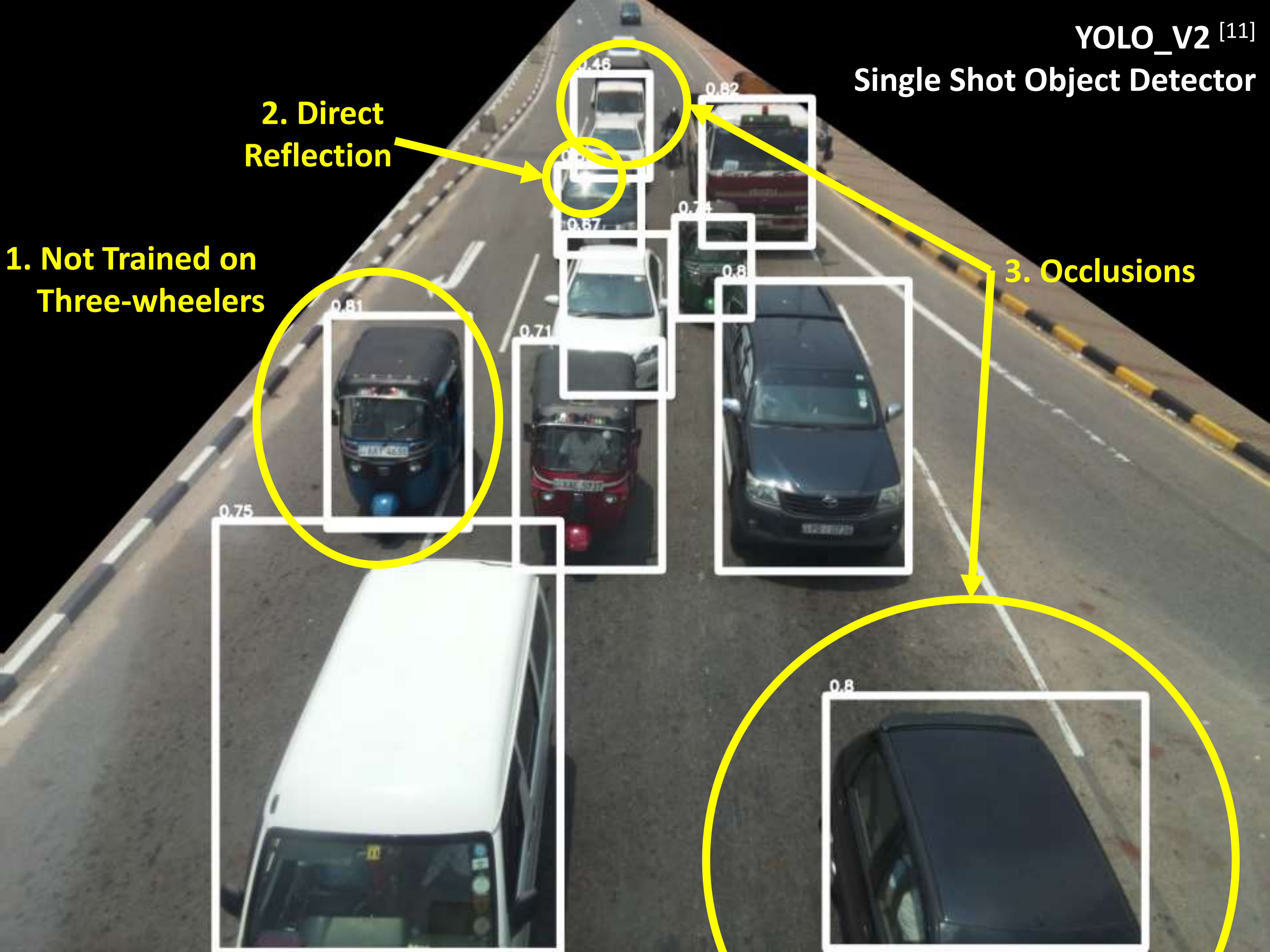


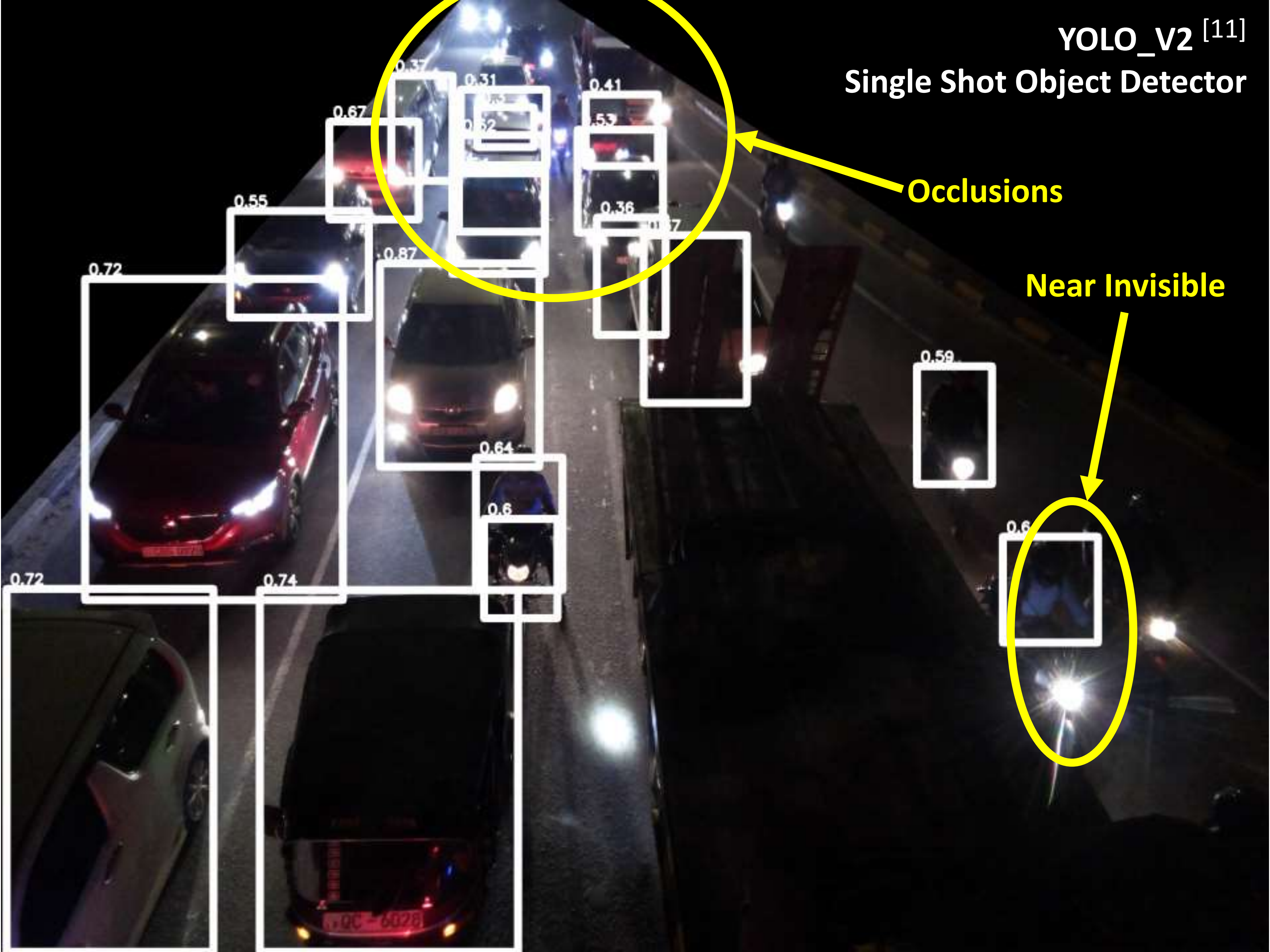
- Production-Ready Product
  - Standards,
  - Guaranteed product lifetime,
  - Volume
- Multiple Types of Junctions / Intersections
- Extreme Congestion Levels
- Extreme Weather
  Heavy rain / fog with almost no visibility

RISK ANALYSIS

Analyzing technical feasibility


ACL
CABLES
ACL
CABLES
No.1
CABLES
IN SRI LANKA


YOLO_V2 [11]
Single Shot Object Detector
2. Direct Reflection
1. Not Trained on Three-wheelers
3. Occlusions
0.46
0.82
0.67
0.8
0.81
0.71
0.75
0.8


YOLO_V2 [11]
Single Shot Object Detector
Occlusions
Near Invisible

Risk Factors

Risk	Mitigation
State-of-the-art CNNs may perform poorly in real world	• Mostly robust [5], further improve by fine tuning • Extreme conditions → static ($\Delta t = 0$)
Accuracy - complexity trade-off	• 100% accuracy is not required • Traffic is a qualitative problem
Implementing Neural Networks in hardware is complicated	• Not building a GPU / TPU • Specific CNN on hardware is possible [2] [4] [6] [10] (eg: DAC)
Demonstrability of the project	• Closed loop VISSIM simulations [8] • Real world data on FPGA
Synchronizing the entire traffic network	Unsolved problem, even in developed countries (green wave)
ASIC conversion is complex and time consuming	Optional scope

Closed Loop Simulation

VISSIM: Industry Standard [15] Traffic Simulation Software

COM commands To change traffic lights

Traffic levels

Python / C++ script

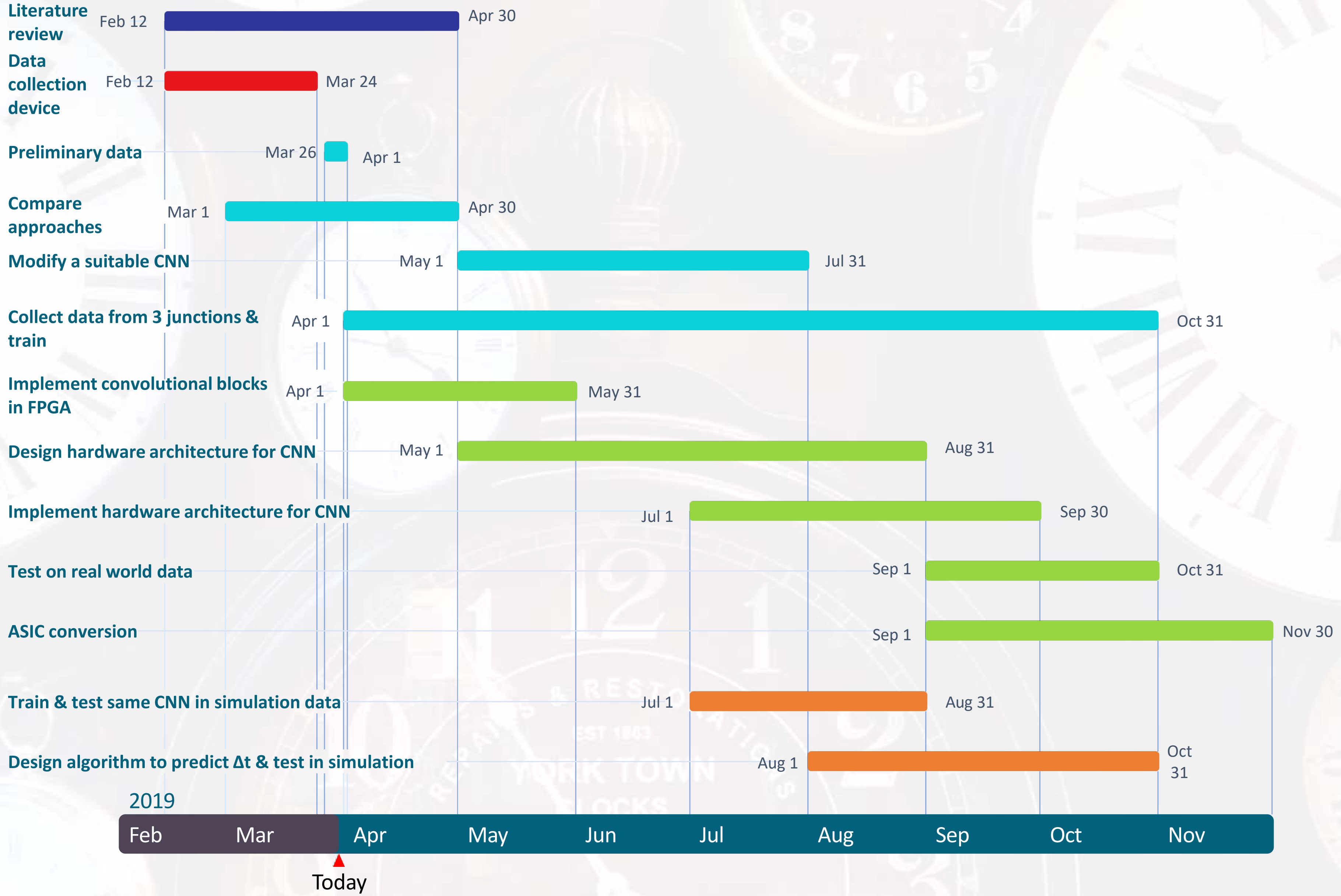
Algorithm
to propose Δt

Task Delegation

- Preliminary Tasks
- Traffic sensing
- Hardware Implementation
- Algorithm Design & Testing

Task	Abarajithan	Tehara	Rukshan	Chinthana
Literature review & analyzing alternate methods				
Building & testing data collection device				
Implementing device and collect preliminary data				
Compare different approaches				
Modify a suitable CNN				
Collect data from 3 junctions & train				
Implement convolution blocks in FPGA				
Design hardware architecture for CNN				
Implement hardware architecture for CNN				
ASIC conversion				
Test on real world data				
Train & test same CNN in simulation data				
Design algorithm to predict Δt and test in simulation				

Timeline



Literature review
Feb 12
Apr 30
Data collection device
Feb 12
Mar 24
Preliminary data
Mar 26
Apr 1
Compare approaches
Mar 1
Apr 30
Modify a suitable CNN
May 1
Jul 31
Collect data from 3 junctions & train
Apr 1
Oct 31
Implement convolutional blocks in FPGA
Apr 1
May 31
Design hardware architecture for CNN
May 1
Aug 31
Implement hardware architecture for CNN
Jul 1
Sep 30
Test on real world data
Sep 1
Oct 31
ASIC conversion
Sep 1
Nov 30
Train & test same CNN in simulation data
Jul 1
Aug 31
Design algorithm to predict Δt & test in simulation
Aug 1
Oct 31
2019
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Today

Resources & Budget

	Amount (Rs.)
Raspberry Pi 3 Model B (x2)	14, 000
Pi Camera (x2)	4, 000
FPGA Board (x4)	36, 500
FPGA Camera (x4)	14, 000
GPU Server (Estimated GCP computational cost)	25, 000
Material to build the data collection device	10, 000
Total Estimated Amount	103 500/=

Other Resources:

- ZYNQ Ultra 96 - available
- VISSIM research license - from Dept. of Civil Engineering
- Permissions from RDA and Traffic Police


Thank You

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