北京交通大學

Deep Learning Based Motion Planning For Autonomous Vehicle Using Spatiotemporal LSTM Network

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Contents

Self Introduction

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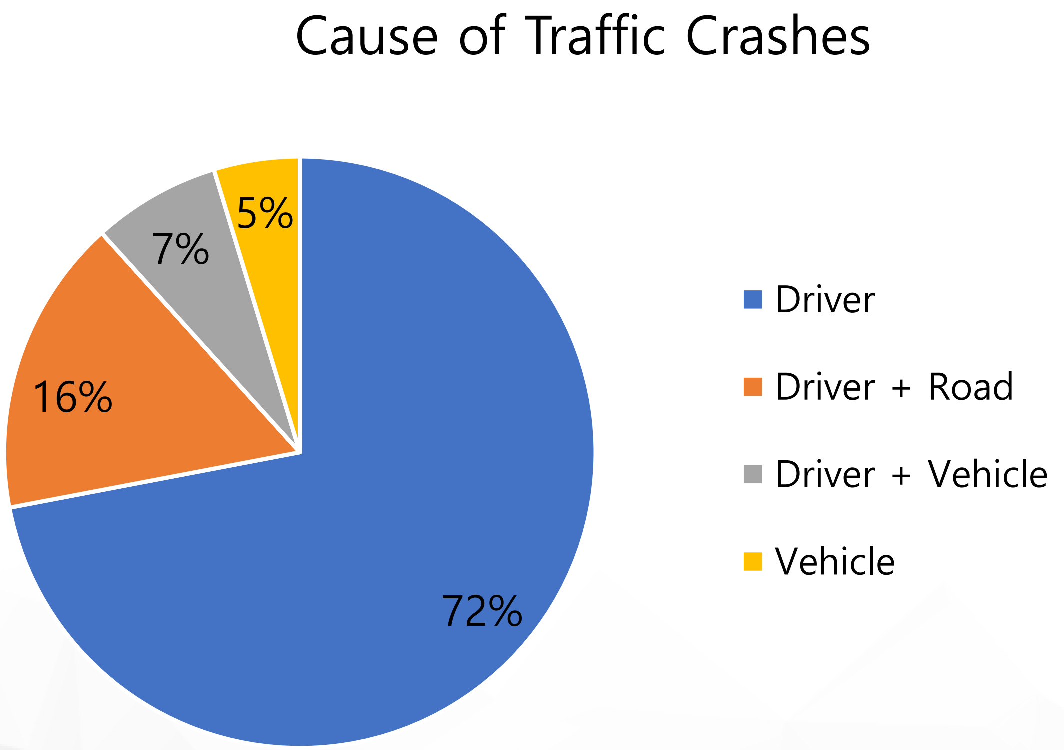
Autonomous Driving & Vehicle Infrastructure Cooperative Systems(VICS)

Project Intro.

Motivation

- About 1.25 million people die each year as a result of road traffic crashes
- Without sustained action, road traffic crashes are predicted to become the seventh leading cause of death by 2030



Background

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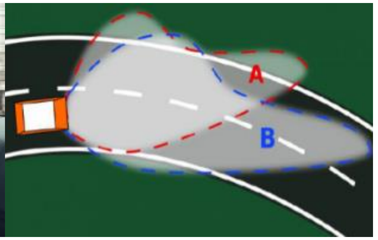
ITS is essentially a multi-variable complex system with human-vehicle coupling

Human2Vehicle



Driving Behavior | Path Planning

Vehicle2Vehicle

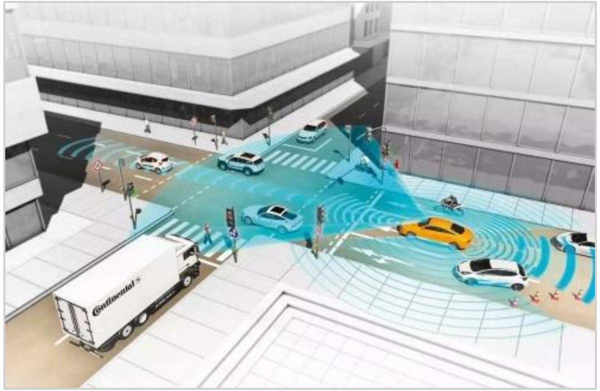
Car-following | Lane change

Vehicle2Road

Interwoven road | Intersection

H-V-R Coupling

Human
↕
Vehicle
↕
Road



Extrinsic Features of Traffic System

- Path planning
- Motion planning
- Motion control
- Road Capacity
- Service Level

……

Traffic Efficiency

Autonomous Vehicle : a Crucial part of ITS

Related Works

Model Based : Pre-defined control strategies

Model Free : DL based Learning Process

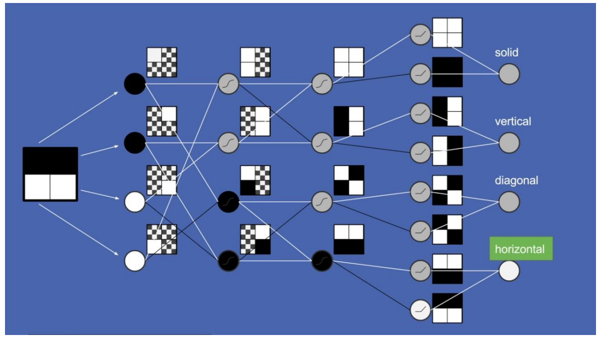
Imagination

Deep Learning: More adaptive to the complexity in real traffic scenarios

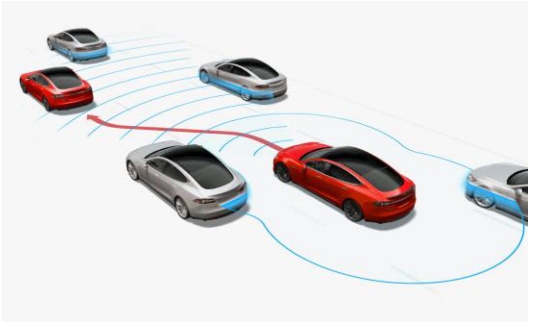
Project Overview

- **Input**: Human-level Control Through Deep Reinforcement Learning (Nature)
- **Algorithm**: Convolutional LSTM + 3D-CNN + FCNN
- **Output**: Motion planning (Steering angle)

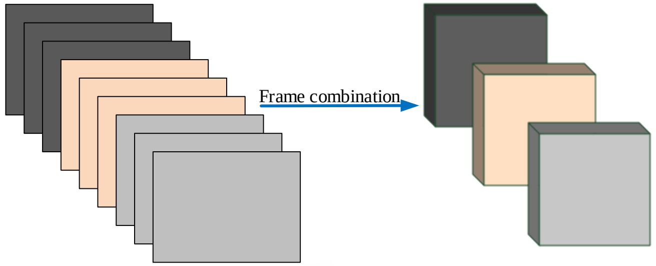
Camera Data



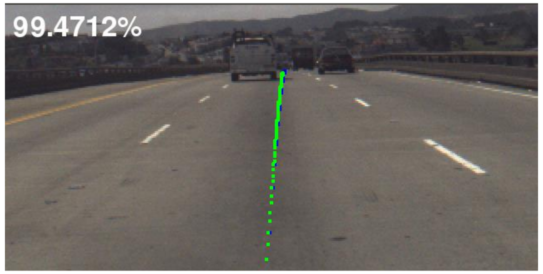
DL Algorithm



Motion Planning



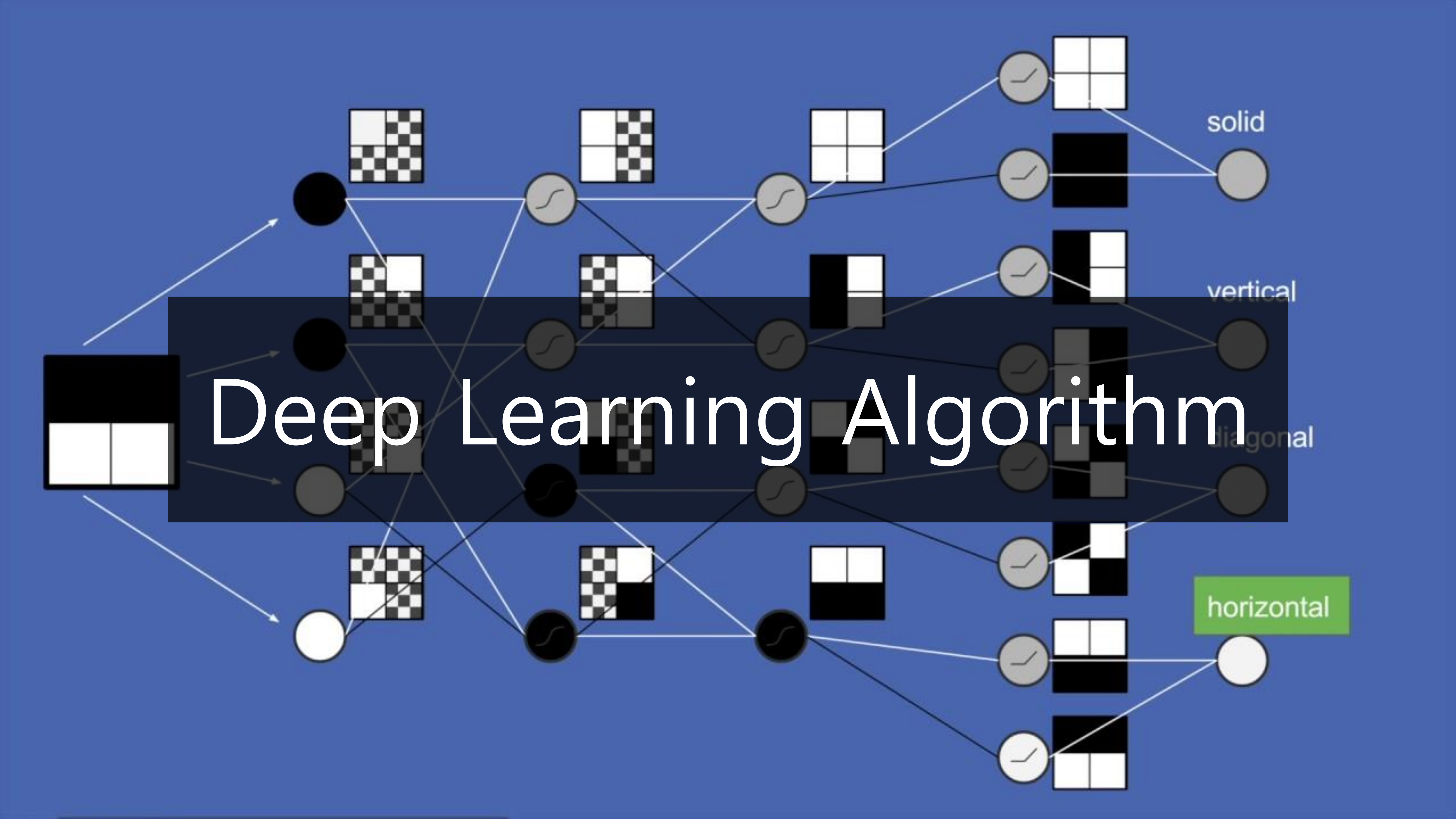
Preprocessing



Visualization

Raw image → Steering angle

Deep Learning Algorithm



Data Preprocessing

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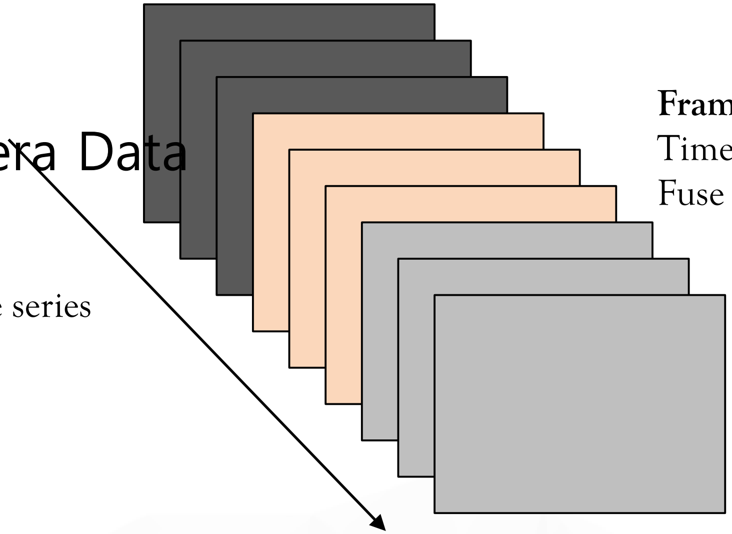
Raw image
Dim: 320*160*3

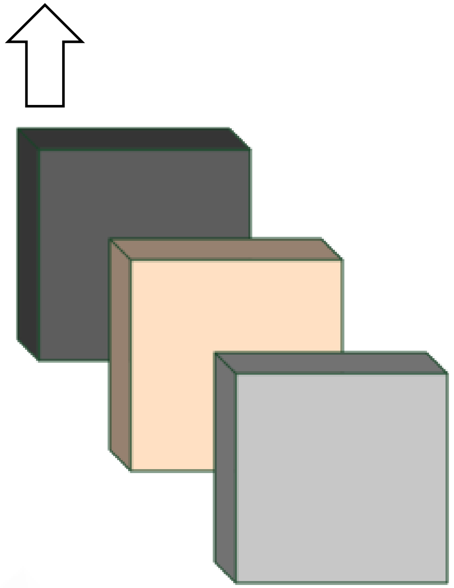
Multi-frame data
Dim: 320*160*3*3

Camera Data



Time series

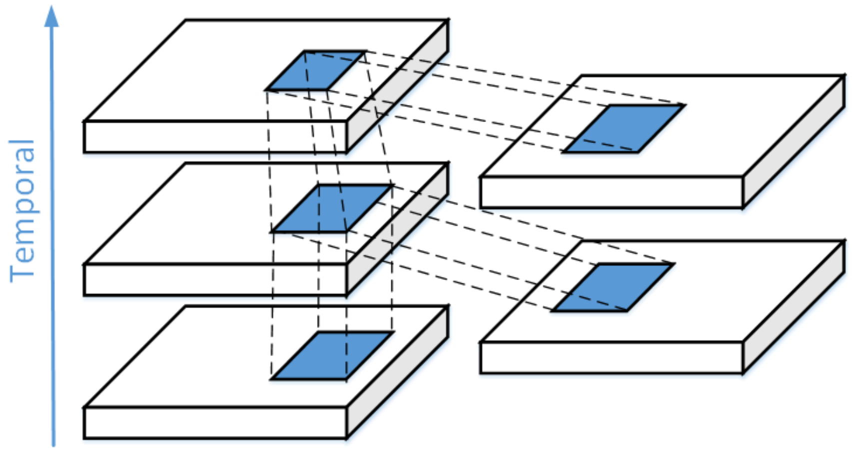
Frame Combination:
Time based 3 continuous frames
Fuse into a higher dimensional data format



Single frame image → Time based visual data

Convolutional LSTM

- Conv-LSTM :
  - Based on multi-frame picture segments
  - Use batch normalization between two layers



$$i_t = \sigma(W_{xi} * X_t + W_{hi} * H_{t-1} + W_{ci} \circ C_{t-1} + b_i)$$
$$f_t = \sigma(W_{xf} * X_t + W_{hf} * H_{t-1} + W_{cf} \circ C_{t-1} + b_f)$$
$$C_t = f_t + i_t \circ tanh(W_{xc} * X_t + W_{hc} * H_{t-1} + b_c)$$
$$o_t = \sigma(W_{xo} * X_t + W_{ho} * H_{t-1} + W_{co} \circ C_t + b_o)$$
$$H_t = o_t \circ tanh(C_t)$$

i_t: Input gate at time t

f_t: Forget gate at time t

C_t: LSTM cell at time t

o_t : Out put gate at time t

H_t: Hidden gate at time t

Extracting the temporal hidden feature information

3D-CNN

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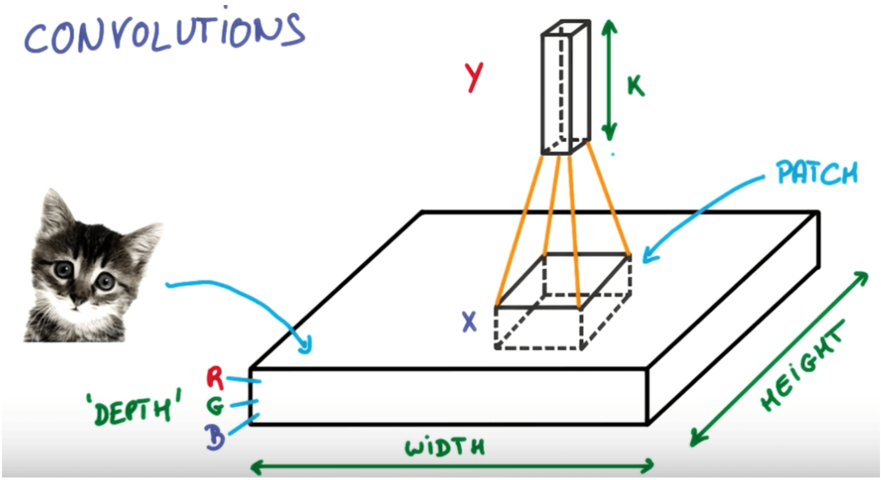
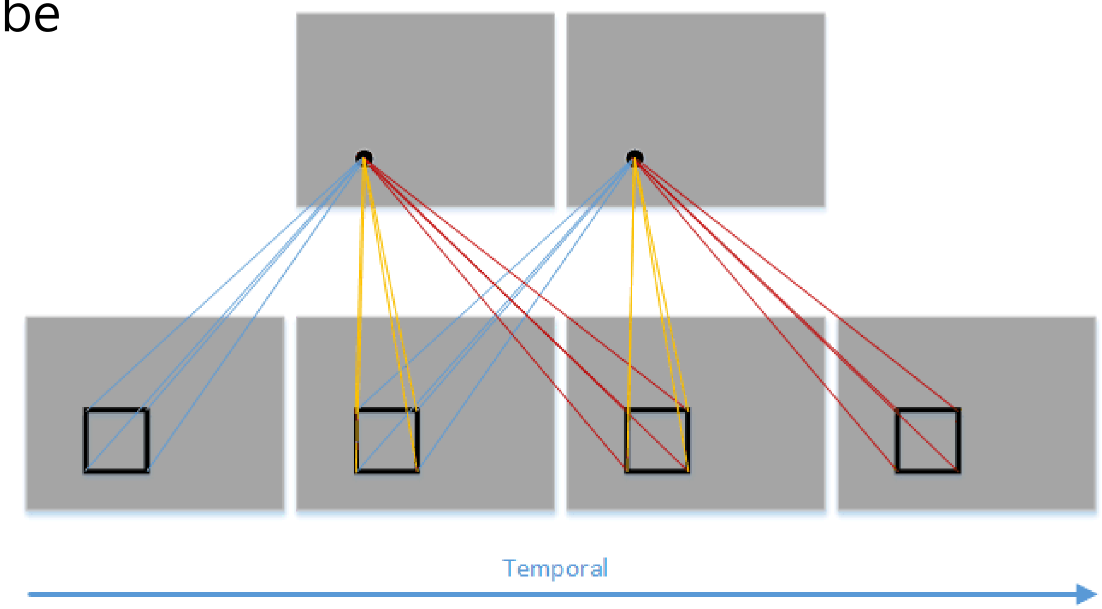
- 3D-CNN :
  - Build a cube by stacking multiple consecutive frames
  - Use the 3D convolution kernel in the cube



2D-CNN



3D-CNN

Capturing the temporal and spatial features of time based image stream

Final DL Model

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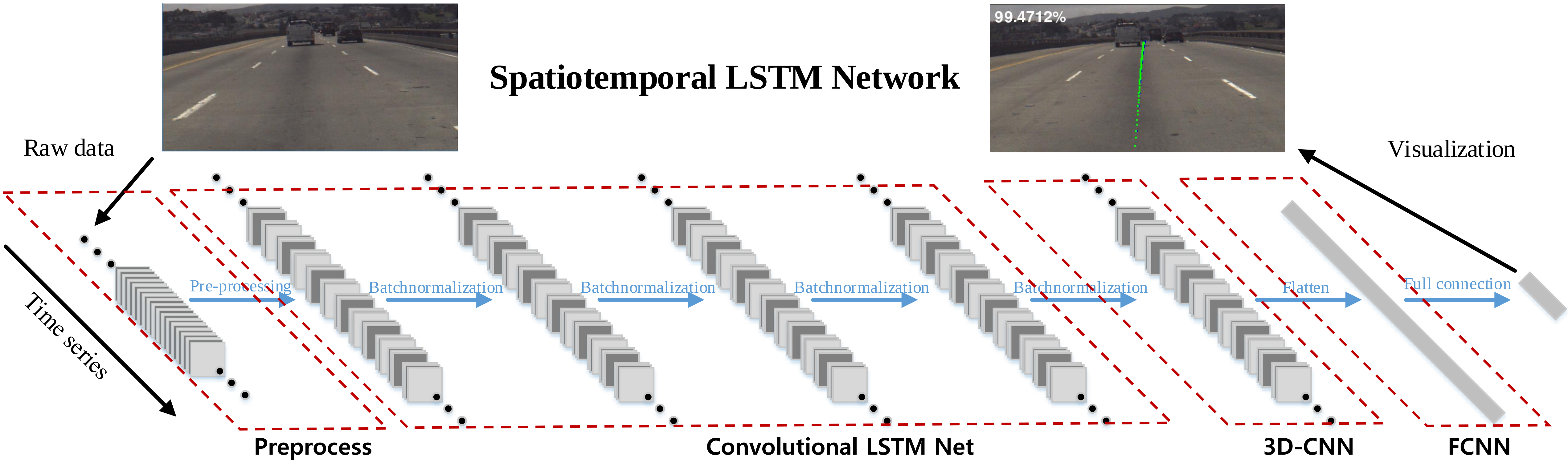


Activation Function

$$LeakyReLU = \begin{cases} -0.2 * x, x < 0 \\ x, x \le 0 \end{cases}$$

Loss Function

$$MSE(x,y) = \frac{1}{n_{samples}} \sum_{i=0}^{n_{samples}-1} (x_i - y_i)^2$$

Learning the data from both spatial and temporal dimensions

Experiment

- Experimental platform : ubuntu16.04LTS + Tensorflow + Keras

ubuntu + TensorFlow + Keras + Inter i7-6700 CPU @ 3.4GHz
32 GB RAM
NVIDIA GTX 980 GPU

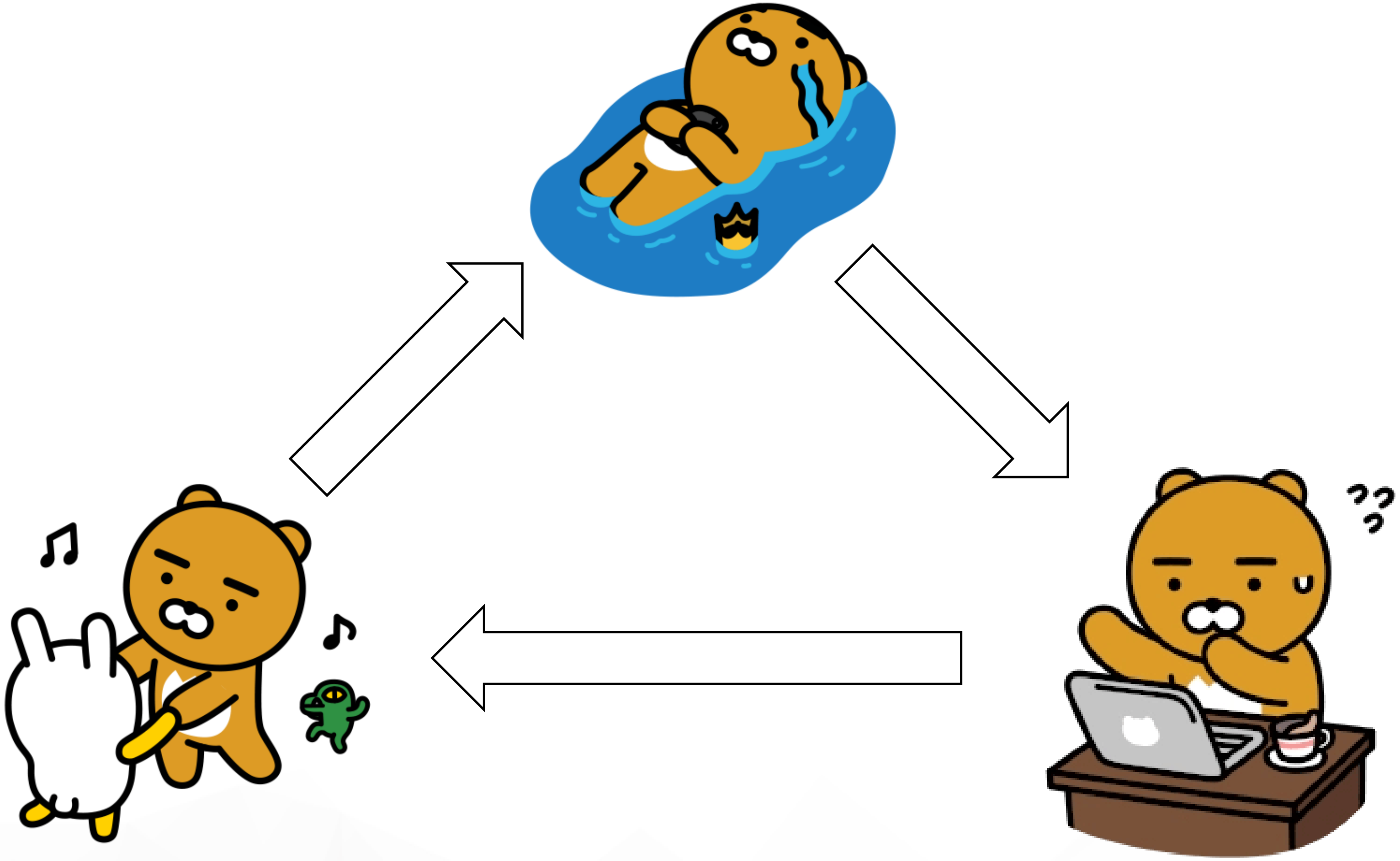
- Database : Comma-ai Dataset

comma.ai

Dataset content:

- **80GB** data
- Raw **image** data and vehicle **actual state** data
- Collected from the **vehicle-based sensors** respectively

Progress of Experiment Making



Experiment & Result

Result & Visualization

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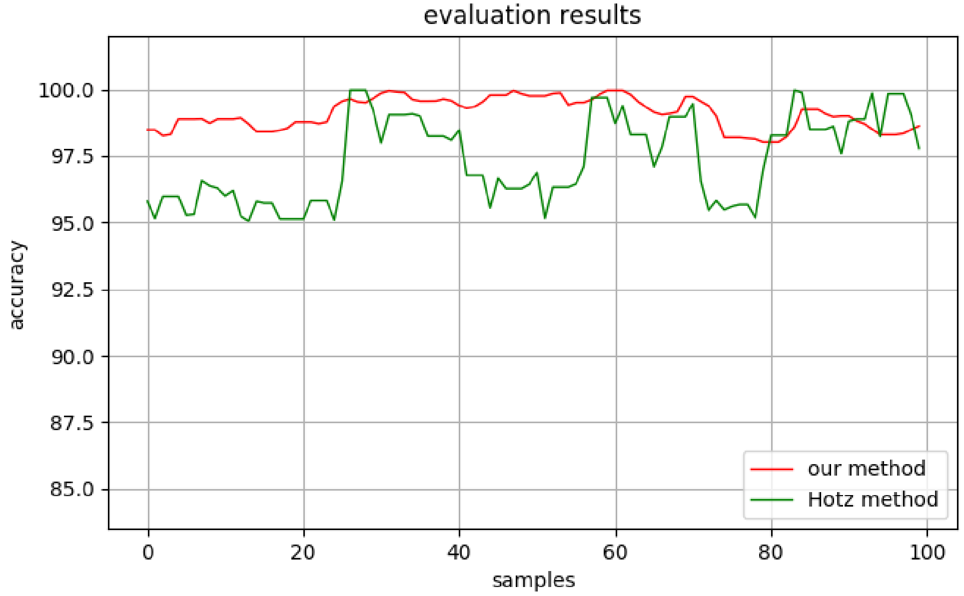
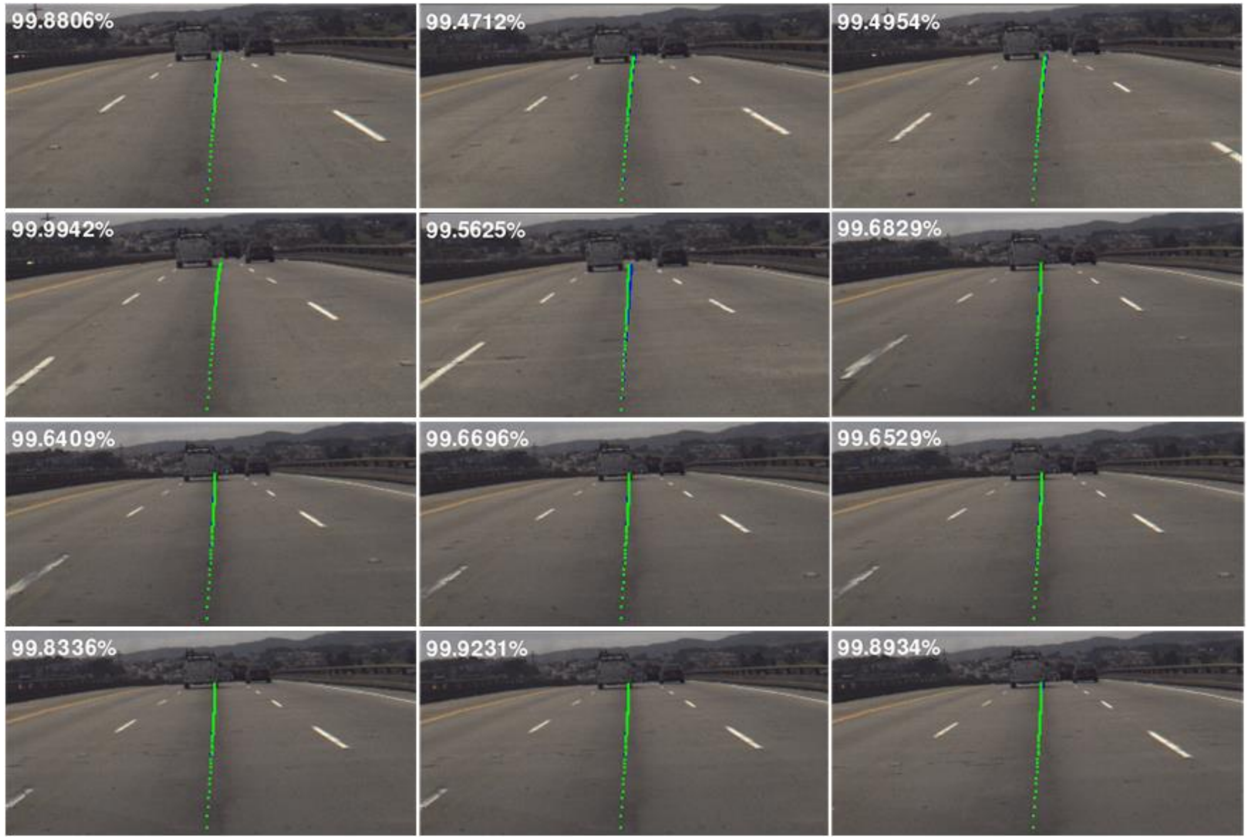
Contrast experimental results



- **Our method**: high accurate and stable
- **Hotz's method**: Can achieve the high accuracy sometime but with higher fluctuation

Visualization Results



Spatiotemporal LSTM Network : Get more accurate and stable results

Result Video

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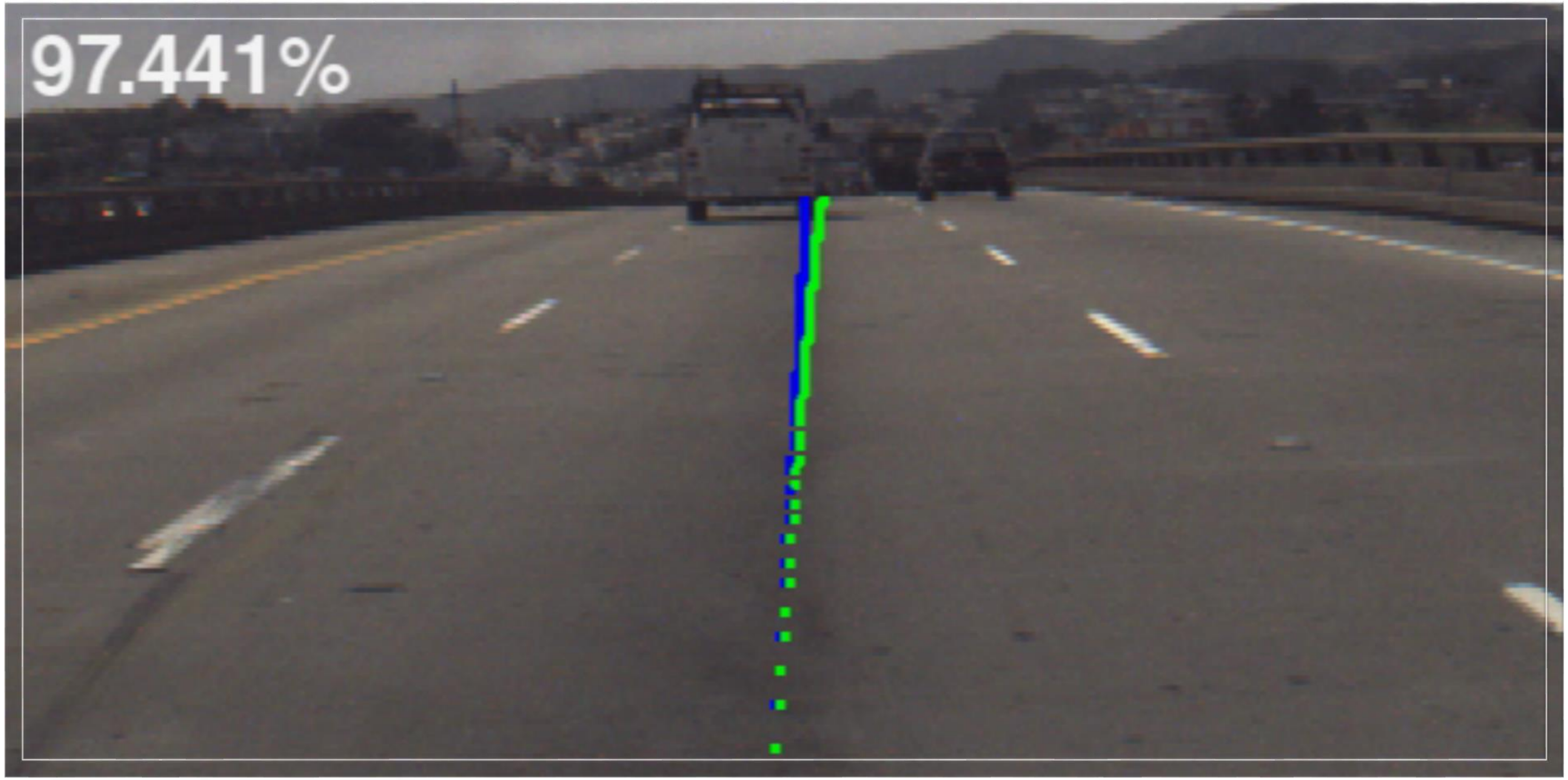

Conclusion

- It can drive vehicle!! But not smart at all scenario
- The Spatiotemporal LSTM Network has the ability to learn the data from both spatial and temporal dimensions.
  - Spatial: more precise results in motion output
  - Temporal: more stable motion in complex scenario
- Changing layers and parameters can cause much better result
  - Need more 3D-CNN layer, more FCNN layer!
  - More training time!!

After This Project...

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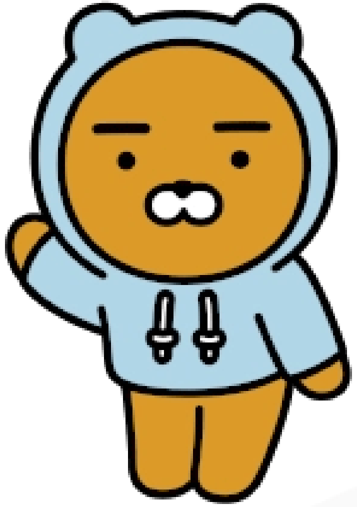
- Training the algorithm with a better computer in lab!
- Read and implement more papers to reinforce my DL algorithm
- Training and testing algorithms with more dataset
- Compare the results in different sensor data
  - Lidar + Image
  - Only Image
  - Only Lidar
- Implement in a real vehicle?



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THANK YOU !

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