# DEEP LEARNING FOR SELF DRIVING CARS

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# OVERVIEW

- Self Driving Car and its Motivation
- Challenges
- Literature
- Model Description
- Experimental Setup
- Results
- Demo

# WHY SELF DRIVING?

- Emulation of human driver behavior
- Industrial revolution: Intel, BMW, Lyft, Volvo, Audi, Nvidia, Tesla, Uber, Ford, etc.
- Self driving car companies claim that:
  - Safer streets
  - More efficient
  - Save time and tailoring traffic and save fuel
  - Space saving
  - Enhance human productivity
  - Improved mobility for children, elderly and disabled people

# CHALLENGES

- Safety
- Obstacles
- Weather
- Driving rules
- Unexpected events
- Complex decisions
  - The Trolley  problem
- Cost

# LITERATURE REVIEW


- Bojarski, Mariusz, et al. "End to end learning for self-driving cars." *arXiv preprint arXiv:1604.07316* (2016).
- Greenblatt, Nathan A. "Self-driving cars and the law." *IEEE Spectrum* 53.2 (2016): 46-51.
- Bajracharya, Max, et al. "Autonomous off-road navigation with end-to-end learning for the LAGR program." *Journal of Field Robotics* 26.1 (2009): 3-25.
- Hee Lee, Gim, Friedrich Faundorfer, and Marc Pollefeys. "Motion estimation for self-driving cars with a generalized camera." *Proceedings of the IEEE Conference on Computer Vision and Pattern Recognition*. 2013.
- Pomerleau, Dean A. "Alvinn: An autonomous land vehicle in a neural network." *Advances in neural information processing systems*. 1989.

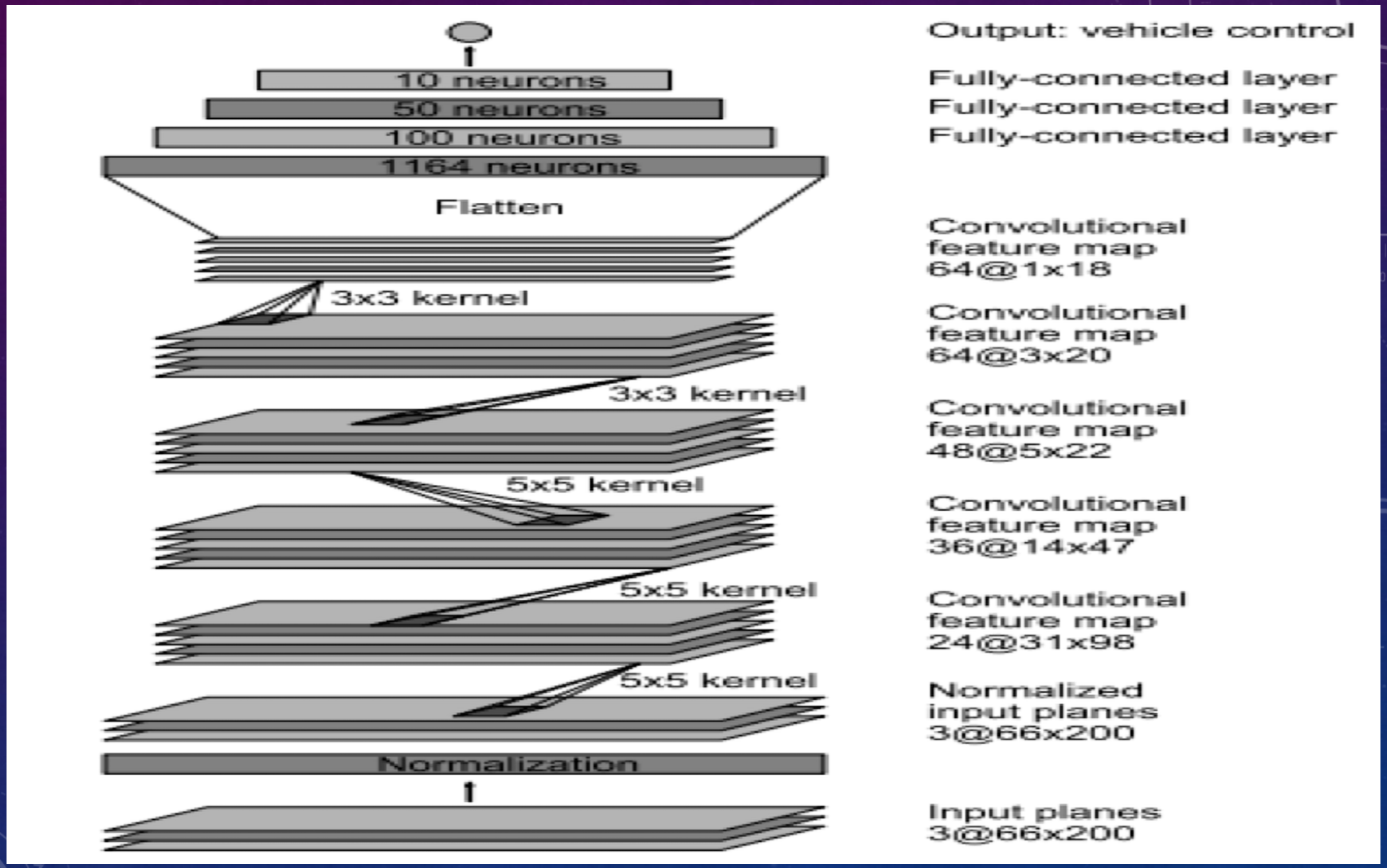
# THE TECH

- Problem statement:
  - Design a deep learning framework for self driving car
  - Implementation of “End to End learning for self driving cars” by Nvidia
- A convolutional neural network with 9 layers, 250 thousand parameters
- Three steps to self driving
  - Data generation
  - Training
  - Evaluation

# DATA GENERATION

- Udacity's simulator for self driving cars
- Generates a csv file with following features:
  - 3 sets of images (from center, left and right camera on vehicle)
  - Steering angle
  - Speed
  - Throttle
  - Brake

# THE NETWORK


Output: vehicle control
10 neurons
50 neurons
100 neurons
1164 neurons
Fully-connected layer
Fully-connected layer
Fully-connected layer
Flatten
Convolutional feature map 64@1x18
3x3 kernel
Convolutional feature map 64@3x20
3x3 kernel
Convolutional feature map 48@5x22
5x5 kernel
Convolutional feature map 36@14x47
5x5 kernel
Convolutional feature map 24@31x98
5x5 kernel
Normalized input planes 3@66x200
Normalization
Input planes 3@66x200

# TESTING & EXPERIMENTATION

- Autonomous mode on Udacity's simulator
- Evaluation metric: Time, the network could follow the road
- Experimentation:
  - Max Pooling
  - Dropout tuning
  - Learning rate
  - Number of convolution layers
- Libraries: Keras, PIL, numpy, sklearn, pandas, socketio, eventlet, flask, etc.

# RESULTS

| Model | Time |
|---|---|
| Model in paper | 6 min |
| Dropout : 0.5 | 1 min 24 sec |
| Dropout : 0.7 | 1 min 1 sec |
| Learning rate: 10e-5 | 1 min 23 sec |
| Learning rate: 10e-3 | 23 sec |
| 4 layer model | 2 min 30 sec |
| Dropout : 0.3 | 50sec |
| MaxPooling after 1 layer | 30 sec |
| MaxPooling after  2 layer | 12 min 2 sec |
| MaxPooling after all layers | >20 min |

# FUTURE WORK

- Improve accuracy
- Train model with real data
- Extend model for the following:
  - Tuning with different activation functions
  - Different weather conditions
  - Lane changing
  - Obstacle detection
  - Driver safety

# REFERENCES


- Bojarski, Mariusz, et al. "End to end learning for self-driving cars." *arXiv preprint arXiv:1604.07316* (2016)
- https://github.com/udacity/self-driving-car-sim
- http://selfdrivingcars.mit.edu/


QUESTIONS