APPLICATIONS OF CNNs

SELF DRIVING CARS & OBJECT DETECTION API

SPEAKER

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Introduction

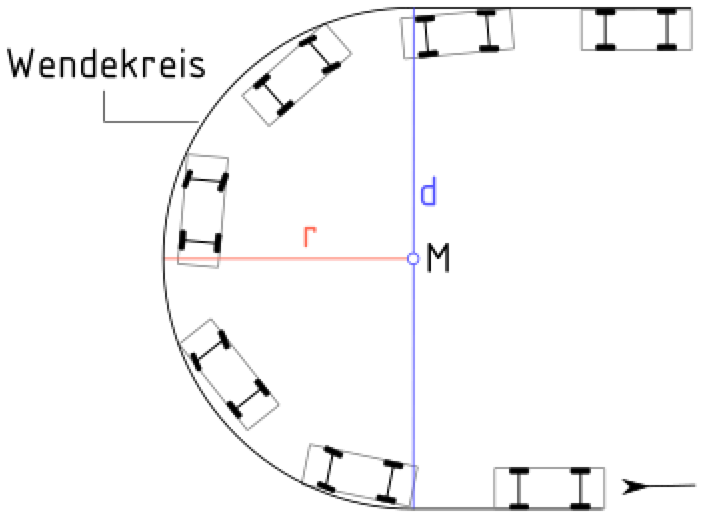
- A convolutional neural network (CNN) to map raw pixels from a single front-facing camera directly to steering commands.
- This end-to-end approach proved surprisingly powerful.
- With minimum training data from humans the system learns to drive in traffic on local roads with or without lane markings and on highways.
- It also operates in areas with unclear visual guidance such as in parking lots and on unpaved roads.

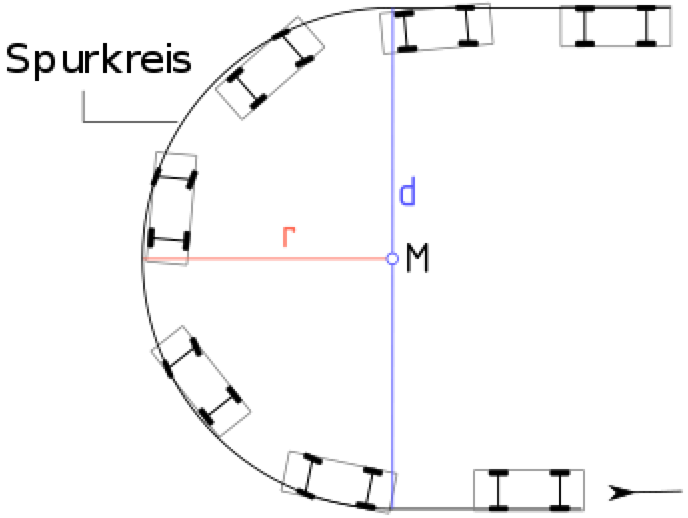
Introduction

- The system automatically learns internal representations of the necessary processing steps such as detecting useful road features with only the human steering angle as the training signal.
- Never explicitly trained it to detect, for example, the outline of roads.
- Used an NVIDIA DevBox and Torch 7 for training and an NVIDIA DRIVETM PX self-driving car computer also running Torch 7 for determining where to drive.
- The system operates at 30 frames per second (FPS).

Label

- In order to make our system independent of the car geometry, we represent the steering command
- as 1/r where r is the turning radius in meters. We use 1/r instead of r to prevent a singularity
- when driving straight (the turning radius for driving straight is infinity) 1/r smoothly transitions through zero from left turns (negative values) to right turns (positive values).





Features

- Training data contains single images sampled from the video, paired with the corresponding steering command (1/r).
- Training with data from only the human driver is not sufficient.
- The network must learn how to recover from mistakes. Otherwise the car will slowly drift off the road.
- The training data is therefore augmented with additional images that show the car in different shifts from the center of the lane and rotations from the direction of the road.

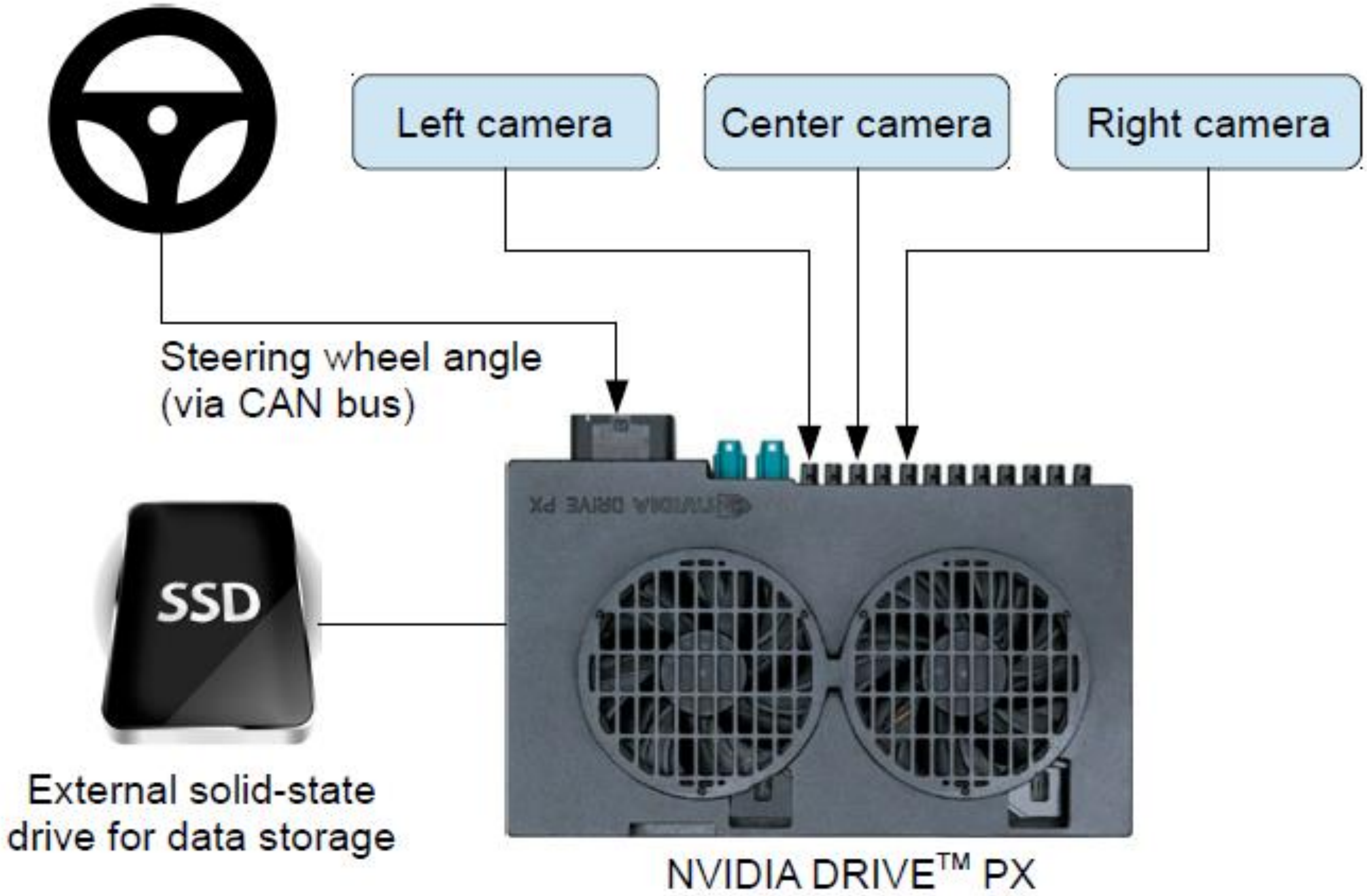
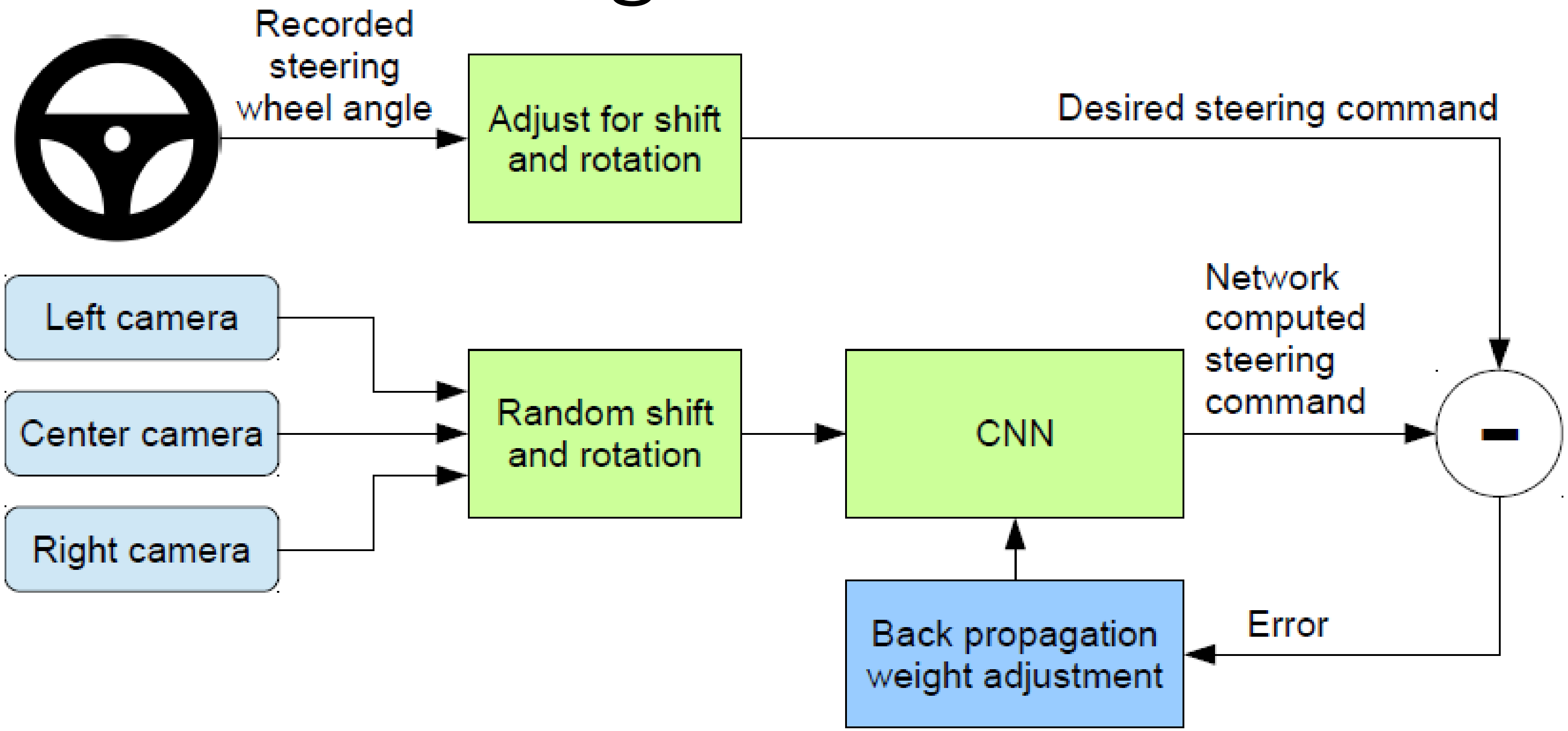


Figure 1: High-level view of the data collection system.

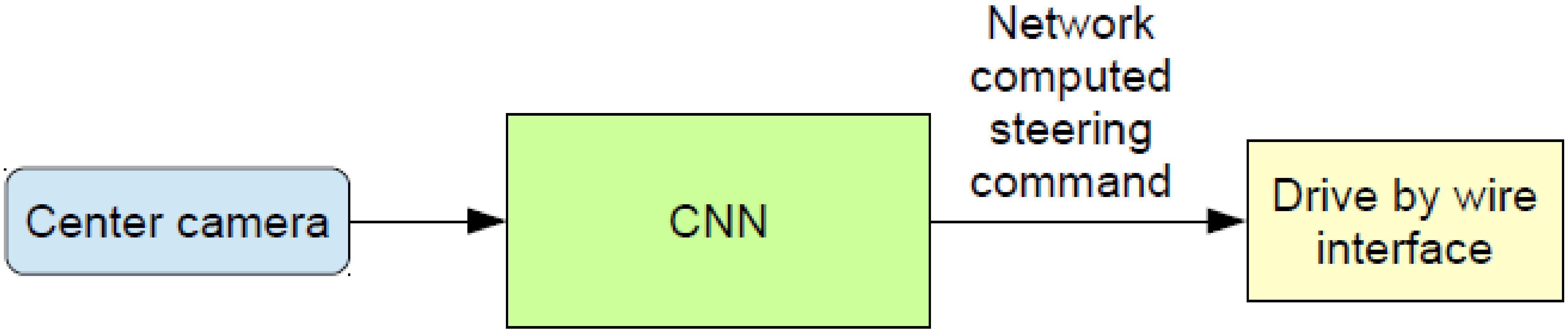
Augmentation



- Images for two specific off-center shifts can be obtained from the left and the right camera.
- Additional shifts between the cameras and all rotations are simulated by viewpoint transformation of the image from the nearest camera.

Testing

- Once trained, the network can generate steering from the video images of a single center camera.



Data Collection

- Training data was collected by driving on a wide variety of roads and in a diverse set of lighting and weather conditions.
- Most road data was collected in central New Jersey, although highway data was also collected from Illinois, Michigan, Pennsylvania, and New York
- Other road types include two-lane roads (with and without lane markings), residential roads with parked cars, tunnels, and unpaved roads.
- Data was collected in clear, cloudy, foggy, snowy, and rainy weather, both day and night. In some instances, the sun was low in the sky, resulting in glare reflecting from the road surface and scattering from the windshield
- about 72 hours of driving data was collected.

Network Architecture

- Trained the weights of our network to minimize the mean squared error between the steering command output by the network and the command of either the human driver, or the adjusted steering command for off-center and rotated images

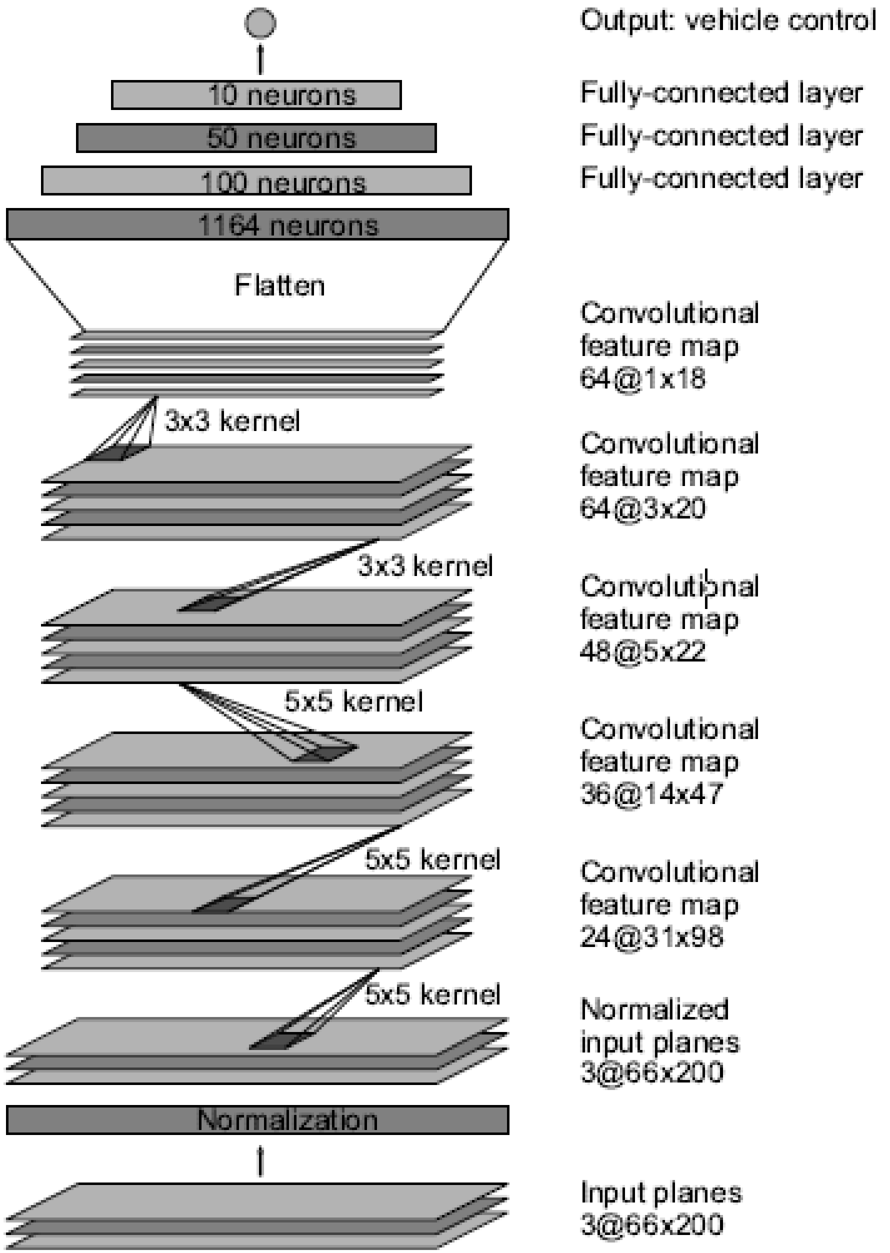
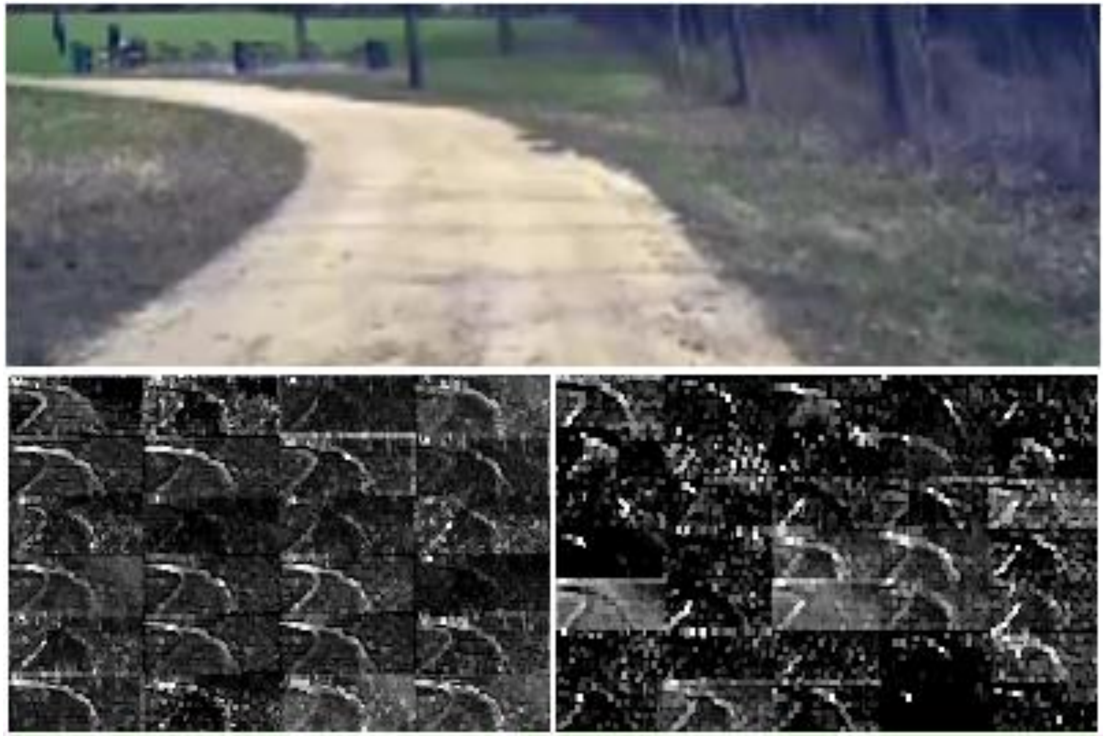
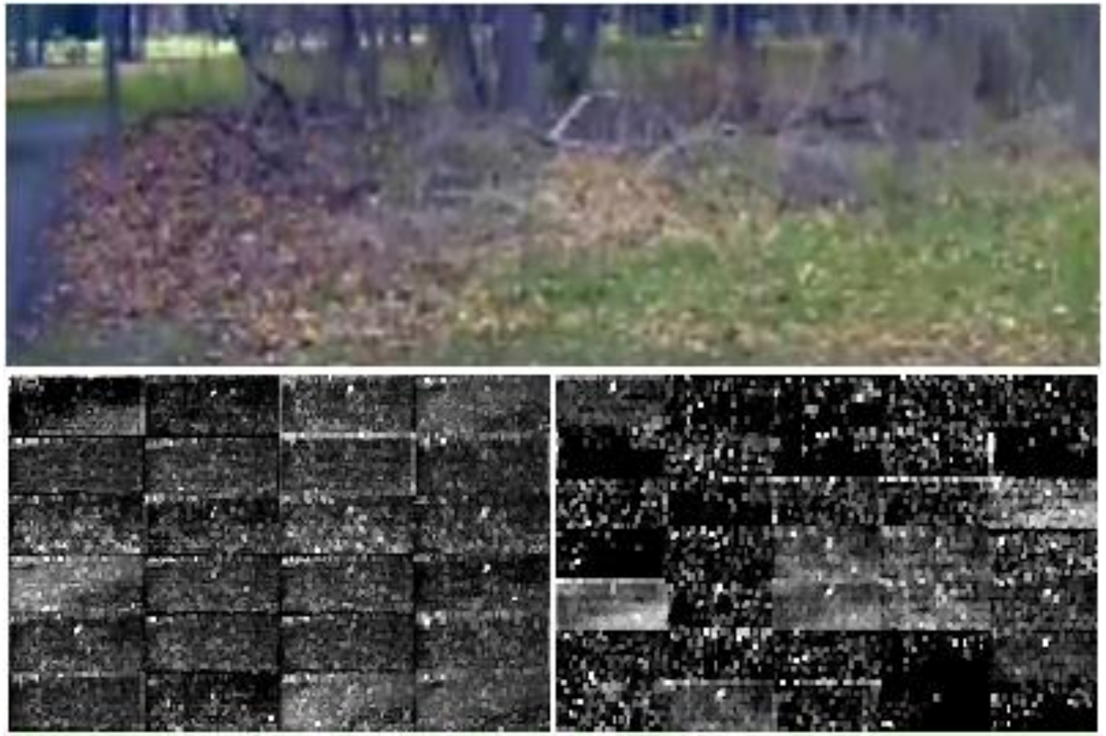


Figure 4: CNN architecture. The network has about 27 million connections and 250 thousand parameters.

Visualization of Internal CNN State

- This demonstrates that the CNN learned to detect useful road features on its own, i. e., with only the human steering angle as training signal. It was never explicitly trained it to detect the outlines of roads,





References

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