deep learning architectures & software

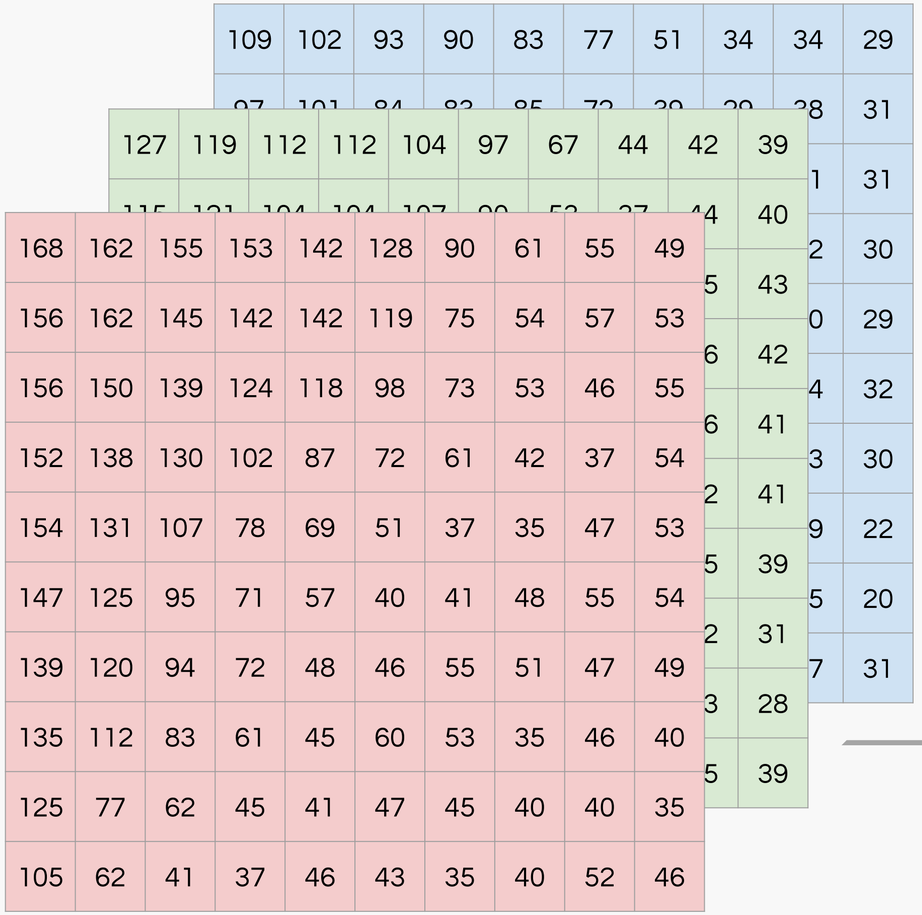
learning to **see**

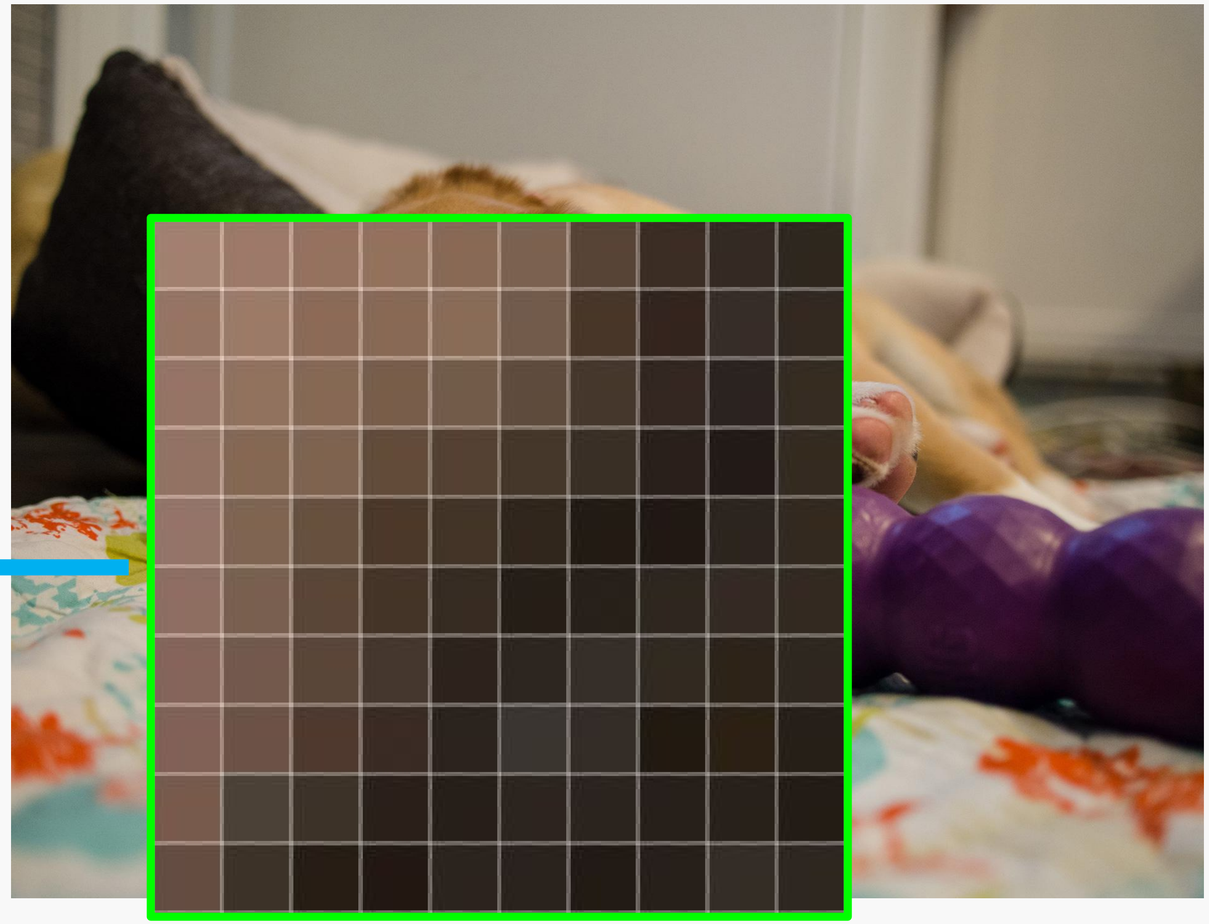
computer vision

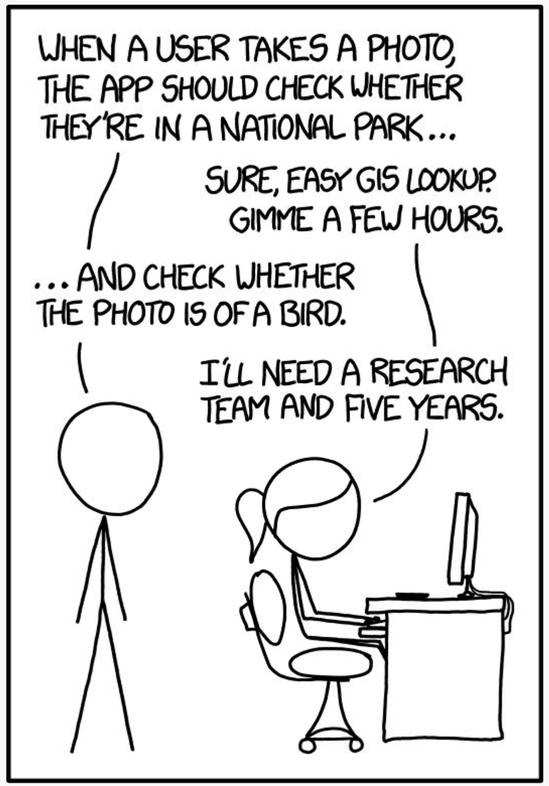
Why is this so **difficult** !?

What a computer “sees”

What we see







IN CS, IT CAN BE HARD TO EXPLAIN THE DIFFERENCE BETWEEN THE EASY AND THE VIRTUALLY IMPOSSIBLE.

8,294,400 pixel values

241	180	147	221	72	77	23	83	213	183	52	94	214	196	138	105	201	17	57	58	165	32	23	251	220	64	30	187	40	136	59	246	123	183	198	246	78	138
72	226	245	255	23	224	45	148	81	27	91	67	40	253	148	33	119	72	116	235	253	194	147	30	221	125	254	37	28	156	179	58	210	7	15	156	110	22
205	89	66	59	240	8	136	217	230	137	143	231	48	5	84	39	191	4	215	18	117	247	136	57	91	13	238	42	121	137	79	243	244	12	73	148	176	164
166	99	103	55	78	67	100	113	55	210	165	5	178	137	181	90	160	91	176	189	133	220	1	68	16	162	236	78	7	70	91	229	96	187	101	29	147	244
141	162	42	237	251	136	18	12	244	248	195	173	212	49	241	18	88	176	255	178	201	2	10	3	148	163	72	106	193	223	57	27	152	174	101	243	180	160
241	110	64	173	84	226	145	211	133	107	82	227	100	193	19	91	131	50	244	208	197	136	249	97	158	178	243	95	57	84	195	150	33	2	205	166	199	72
139	220	33	171	29	48	141	34	104	3	45	96	147	252	29	179	52	39	11	157	234	143	237	174	142	93	6	44	131	242	143	87	80	137	62	172	202	83
202	95	31	222	75	243	234	205	234	237	197	199	171	221	195	191	248	226	144	30	211	9	35	41	214	160	82	19	186	207	26	198	209	167	108	211	176	35
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39	93	21	91	77	60	141	52	42	98	223	232	132	242	238	16	114	221	31	228	181	30	238	57	112	251	238	13	100	96	200	208	208	120	148	245	101	55
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94	228	28	92	162	54	90	254	135	5	223	240	253	33	39	78	224	210	254	104	163	75	251	9	234	164	151	98	148	216	98	85	110	251	142	92	190	158
98	76	23	203	91	180	230	128	44	117	58	243	75	151	187	115	208	105	57	69	184	159	41	231	18	53	38	255	96	153	129	92	231	84	147	231	159	160
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229	160	104	41	7	172	218	184	217	126	2	22	98	134	191	91	53	40	154	80	93	76	19	127	235	70	3	89	211	65	142	144	199	119	254	10	255	161

1920

1440

convolutional neural networks

Take advantage of **structure** or **spatial** characteristics inherent in your **data**

```
I hear and I forget;
I see and I remember;
I do and I understand
```

TRANSLATION INVARIANCE

dog

classification example

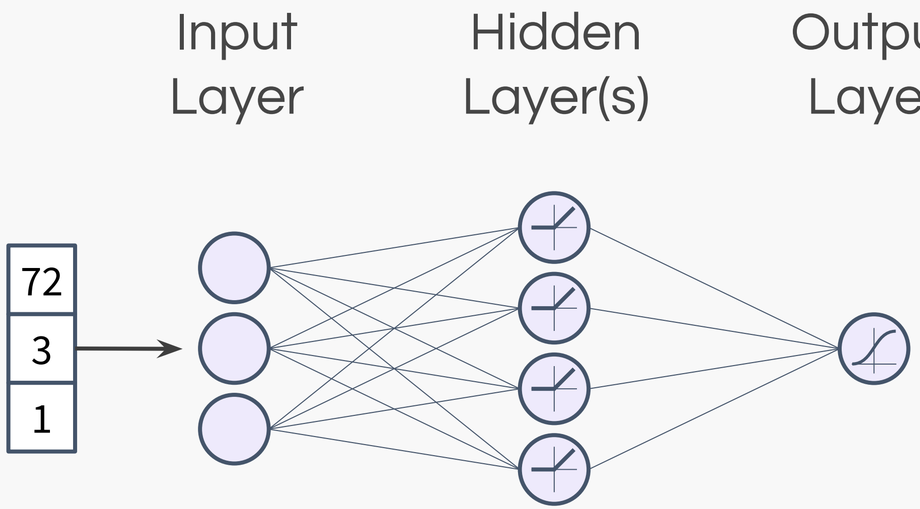
Translation Invariance

Rotation/Viewpoint Invariance

Size Invariance

Illumination Invariance

ConvNets can **vastly** reduce the **number** of **parameters** in the network



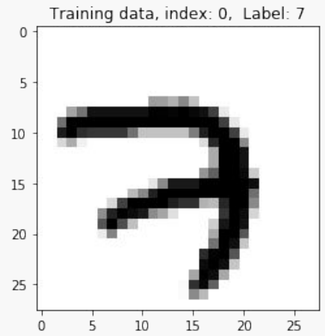
12 Weights + **4** Weights = **16** Weights

784
Input
Nodes

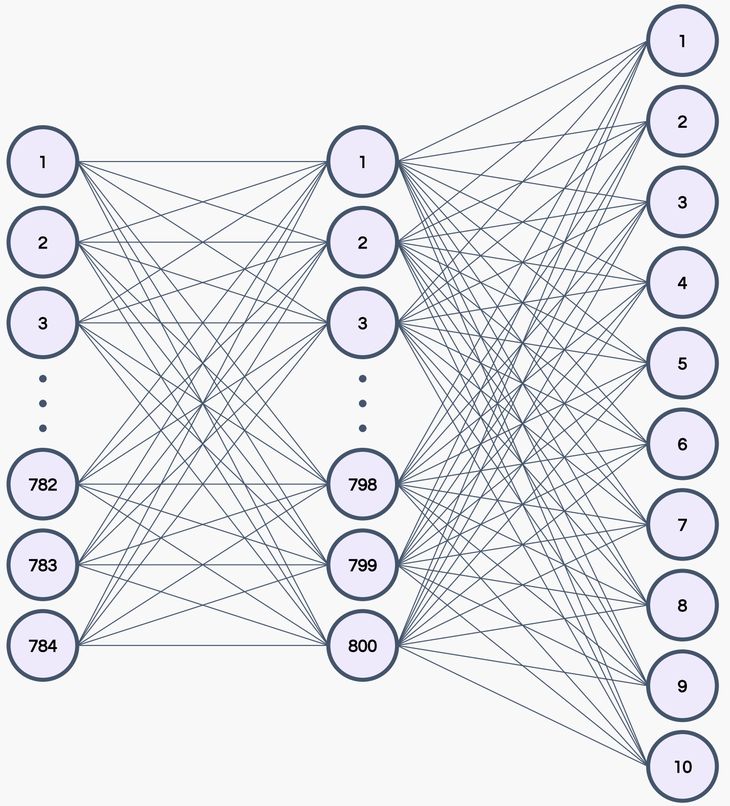
800
Hidden
Nodes

10
Output
Nodes

MNIST Dataset



28 x 28 x 1



627,200 Weights + **8,000** Weights = **635,200** Weights

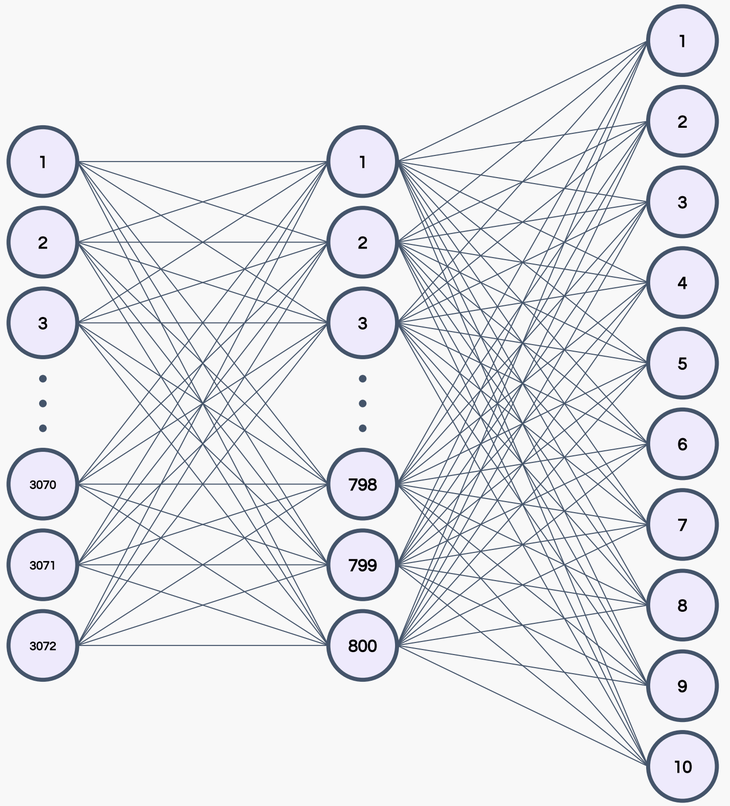
3,072
Input
Nodes

800
Hidden
Nodes

10
Output
Nodes

CIFAR-10 Dataset

32 x 32 x 3



2,457,600 Weights + **8,000** Weights = **2,465,600** Weights

Driving Dataset

455 x 256 x 3

349,440 Input Nodes

40 Hidden Nodes

1 Output Node

13,977,640

Weights

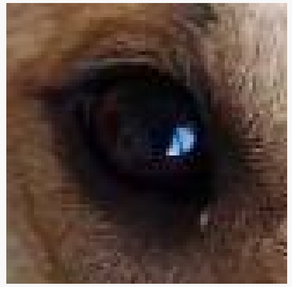
filters & weight sharing

inputs contain structure

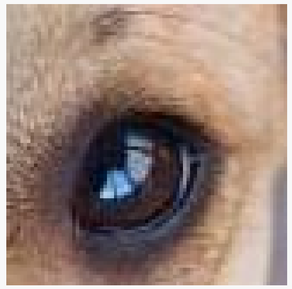
relative proximity matters

order matters

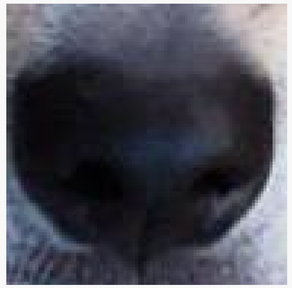
Classify this Image:



eye



eye



nose

fur

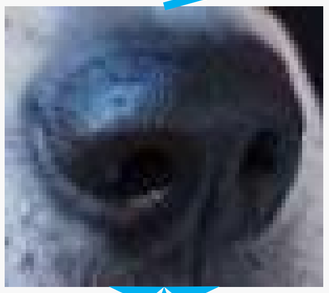
Going One Step Further

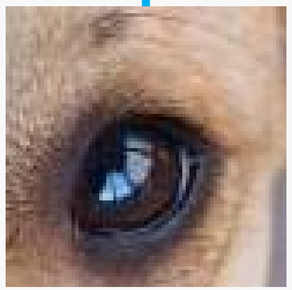
How do we know
what a nose is?

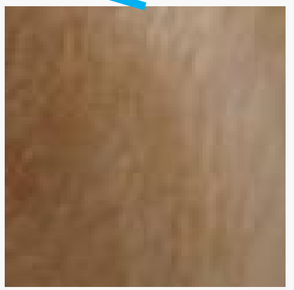
Final Layer

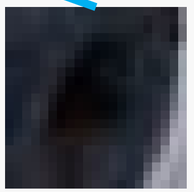
Layer 2

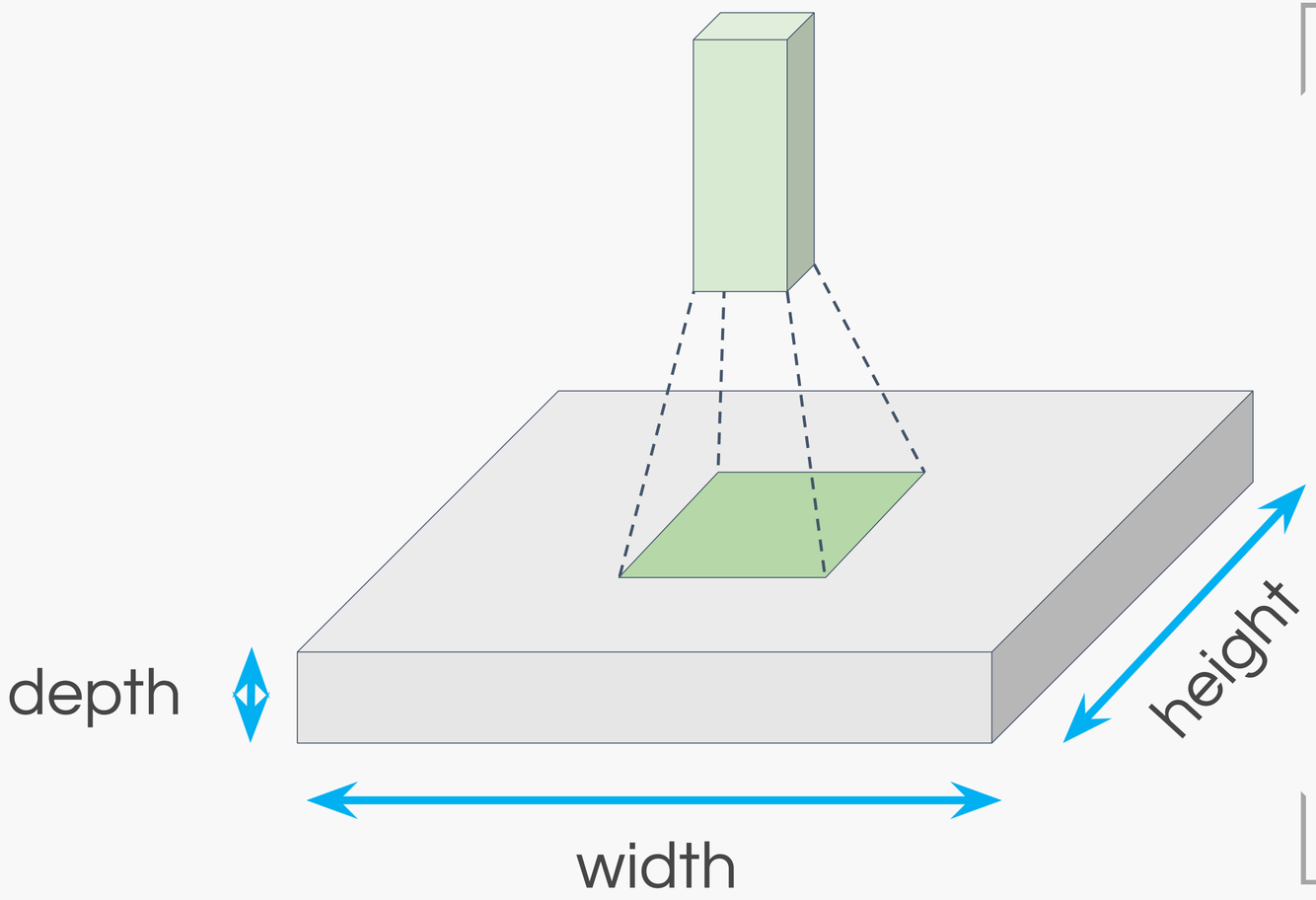
Layer 1



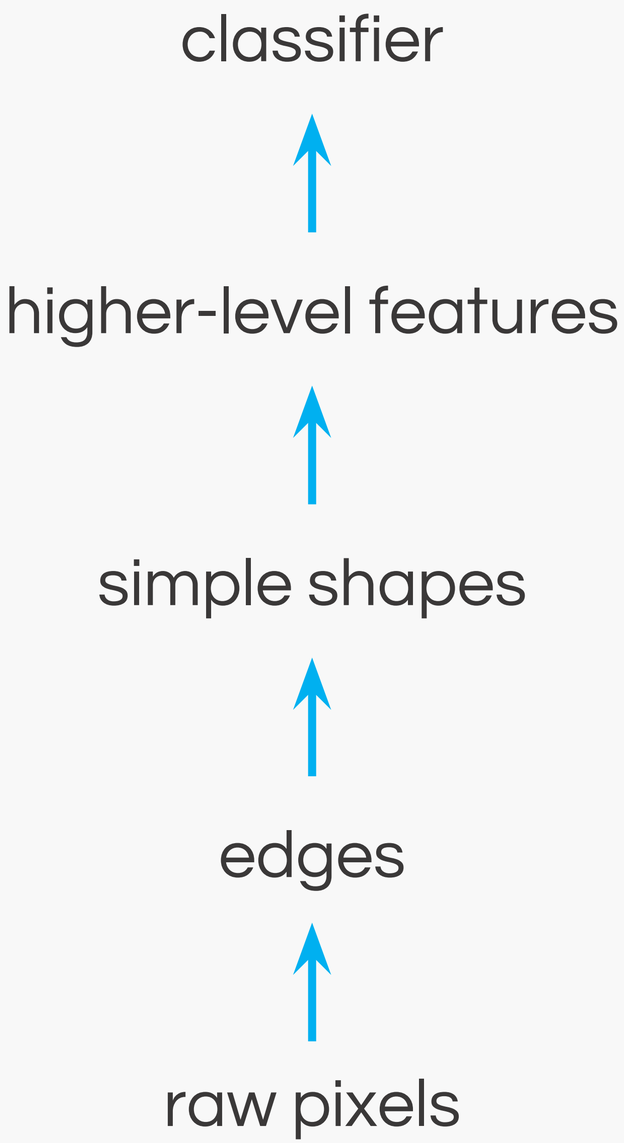






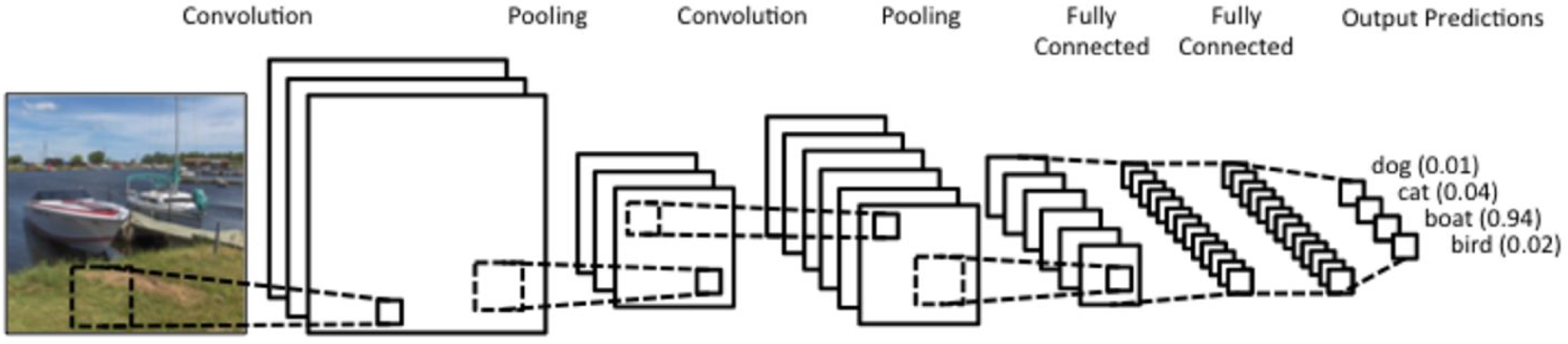


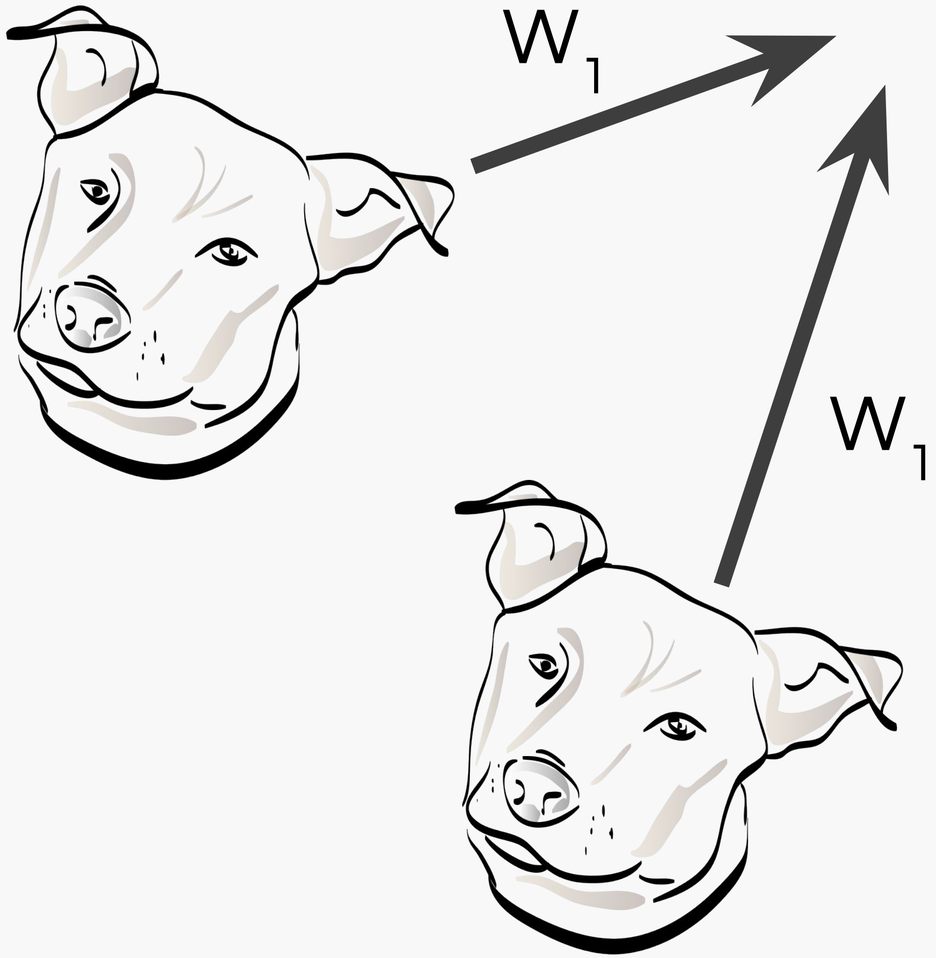
filters


classifier
higher-level features
simple shapes
edges
raw pixels

filters

Example CNN


Convolution
Pooling
Convolution
Pooling
Fully Connected
Fully Connected
Output Predictions
dog (0.01)
cat (0.04)
boat (0.94)
bird (0.02)



weight sharing

https://github.com/frankhinek/Meetup-ADL-17-Apr-10

README.md

Autopilot

Overview

In this project we have a modified implementation of the NVIDIA End-to-End Deep Learning for Self-Driving Cars self-driving car model and this paper. Our implementation is based on the python TensorFlow implementation by Sully Chen.

The project consists of a python-based training script and an inference implementation. A convolutional neural network (CNN) is trained to map raw pixels to steering commands. The image frames were captured by a dash-mounted video camera. At the end of the training, the model is saved. This saved model is then loaded by the inference implementation to evaluate what the model predicts for the steering commands.

Dependencies

Python Packages

- OpenCV 3.1.0
- Pillow 4.0.0
- SciPy 0.19.0
- TensorFlow 1.0.1

The commands below will be useful for those using Anaconda/Miniconda and pip to manage Python packages. If you use another method you will have to adapt the steps.

```
conda create -n autopilot python=3.5
source activate autopilot
export TF_BINARY_URL=https://storage.googleapis.com/tensorflow/mac/cpu/tensorflow-1.0.1-py3-none-any.whl
pip install --ignore-installed --upgrade $TF_BINARY_URL
pip install pillow==4.0.0
conda install -c menpo opencv3=3.1.0
conda install -c anaconda scipy=0.19.0
```

Note: Only tested with macOS 10.12.3 and Ubuntu 16.04.2 LTS.

Dataset

The driving_dataset.zip file contains 45,568 JPEG images of video frames that are used to train the model and the observed steering wheel angle readings. It is 2.2 GB compressed, so you'll want to be on fairly fast internet connection before starting the download.

- Download the driving dataset and unzip it into the repository folder.
- The path should be something like `/path/to/repo/Autopilot-TensorFlow/driving_dataset/`.

Usage

Train the Model Using the Prerecorded Training Dataset

The model needs to be trained with the prerecorded driving data. Training the model should create a `save` folder that will contain the saved model and checkpoint files. We will use the saved model for inference.

- `python train.py` to train the model
- To visualize the training performance using Tensorboard use `tensorboard --logdir logs`, then open http://0.0.0.0:6006/ in your web browser.

Evaluate the Model Using the Prerecorded Training Dataset

The `save` directory contains a model that was already trained using the JPEG and steering wheel readings dataset that you downloaded earlier. When run two windows will be launched displaying the video frames captured during the drive and the steering wheel angle predicted by the pre-trained model.

- `python run_dataset.py` to run the model on the dataset

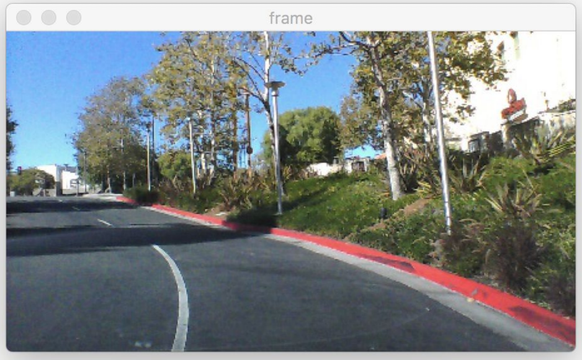
Evaluate the Model Using a Live Webcam Feed

If you have a dash-mounted video camera that is connected to your computer you can use `run.py` to evaluate the trained model using the captured frames to see what steering wheel positions it predicts. I have not tested this code that was forked from Sully Chen's repository, so you may need to make some modifications.

- `python run.py` to run the model on a live webcam feed

Credits

This repository was forked from SullyChen/Autopilot-TensorFlow, modified to support TensorFlow 1.0, and expanded with additional documentation. Full credit for the original code goes to Sully Chen. Additional code and comments from Tomi Malla's repository.



Code Example

Modified implementation of the NVIDIA self-driving car paper based on a TensorFlow implementation by Sully Chen.

Includes a pre-trained model you can run on a system without requiring GPUs to accelerate the training process.

Note: Only tested on Mac and Linux.

Deepen Your Understanding

Stanford CS 231 Notes

http://cs231n.github.io/convolutional-networks/

Brandon Rohrer Video

https://www.youtube.com/watch?v=FmpDIaiMIeA

Christopher Olah Writings

http://colah.github.io/posts/2014-07-Conv-Nets-Modular/

Sources & Credits

Slide No(s).	Source	Link
5	xkcd	http://bit.ly/xkcd-ml
7	LoggaWigler	http://bit.ly/2nAVQmP
8, 21	Leunert	http://bit.ly/2oUHmOV
9	Matt Krause	http://bit.ly/2p1lq4l
11	LeCun, Cortes, Burges	http://bit.ly/2o3x8YH
12	Krizhevsky, Nair, Hinton	http://bit.ly/2onUNFw
13, 22	Sully Chen	http://bit.ly/2p1mNjJ
20	Karpathy, Johnson	http://bit.ly/2oo4VhN
3-5, 15-17	Frank Hinek	http://bit.ly/linkedin-hinek