Image Processing in Machine Learning

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SINGAPORE DATA SCIENCE CONSORTIUM

Anchored at NUS National University of Singapore | Computing

About SDSC

Anchored at NUS | Computing

Established

May 2017

Location

Anchored at NUS | Computing

Purpose

To deepen Singapore's existing strengths in data science and analytics

NATIONAL RESEARCH FOUNDATION
PRIME MINISTER'S OFFICE
SINGAPORE

NUS National University of Singapore

NANYANG TECHNOLOGICAL UNIVERSITY SINGAPORE

SMU SINGAPORE MANAGEMENT UNIVERSITY

A*STAR SINGAPORE Agency for Science, Technology and Research

Collaborative Research

SINGAPORE DATA SCIENCE CONSORTIUM

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NUS National University of Singapore

NANYANG TECHNOLOGICAL UNIVERSITY SINGAPORE

SMU SINGAPORE MANAGEMENT UNIVERSITY

Agency for Science, Technology and Research SINGAPORE

Institutes of Higher Learning & Research Institutes

Data Science

R E S E A R C H

Industry

- Education
- Environment
- Finance
- Economy
- Health
- Transport
- Infrastructure
- Technology
- Society
- Defense

- Facilitate industry adoption of the latest cutting-edge data science and analytics technologies to address real-world challenges
- Train our local pipeline of talents with deep data science capabilities

Introduction

- Computer Graphics
- Master of Science in
  Digital Media Technology, NTU
- Applied Research

Taken from NTU DMT
Module DM6103 Lecture slide

Research Interest

- Applied Research Techniques in Real-World Applications
- Deep & Machine Learning Techniques in
  - **Image Recognition**
  - Sentiment Analysis
  - Social Media Mining
- Human Gait Analysis using
  - Inertial Sensors
- Chatbots to collect Feedback

Contents

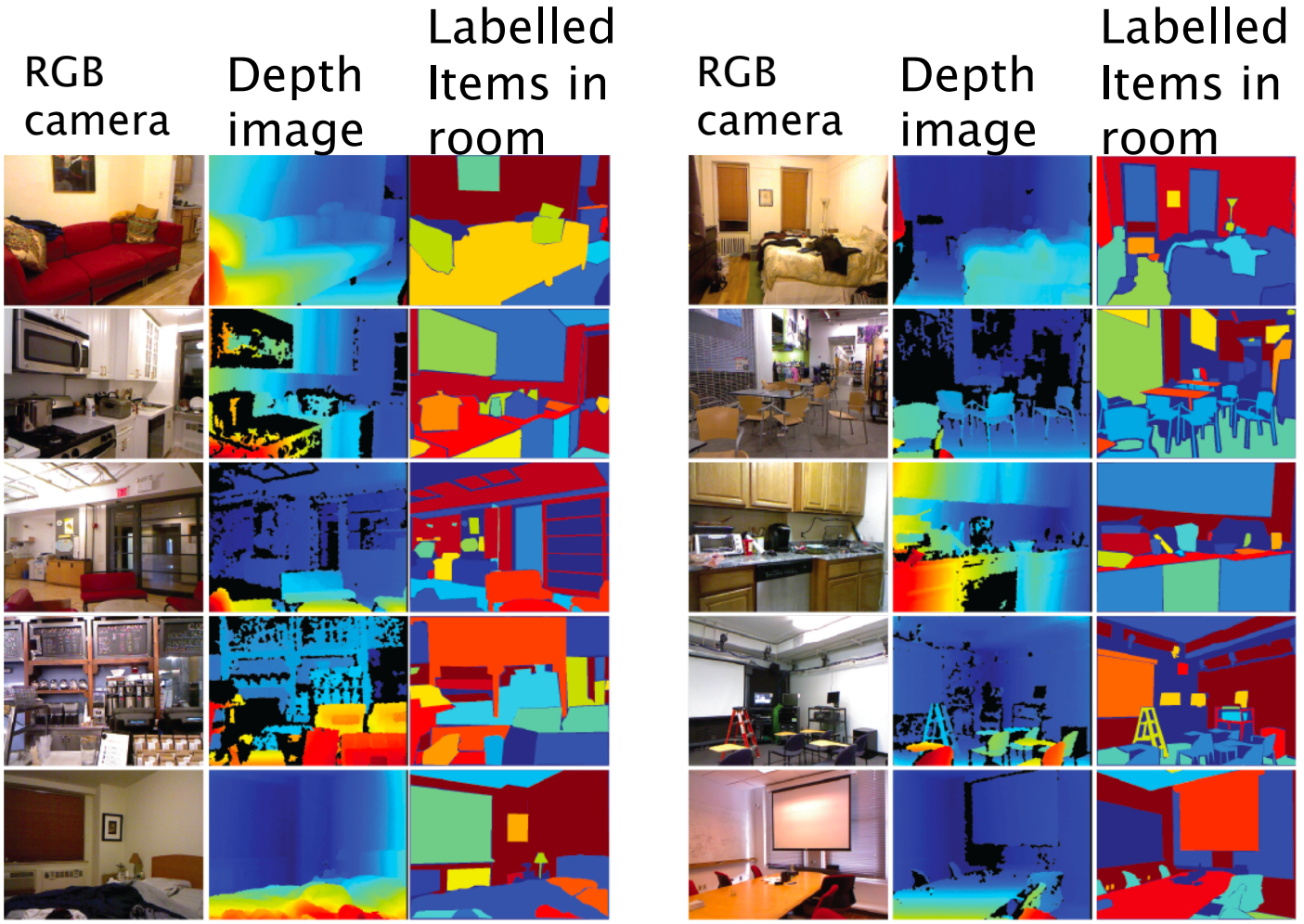
- Introduction
- Applications in Image Recognition
- Machine Learning vs Software Engineering
- Convolutional Neural Network
- Case Studies: Codes
- Conclusion

Applications in Image Recognition

How do you recognise your closest pal?

Image taken from
https://www.nap.edu/read/11577/chapter/3

How do you recognise a picture of a room is actually yours?

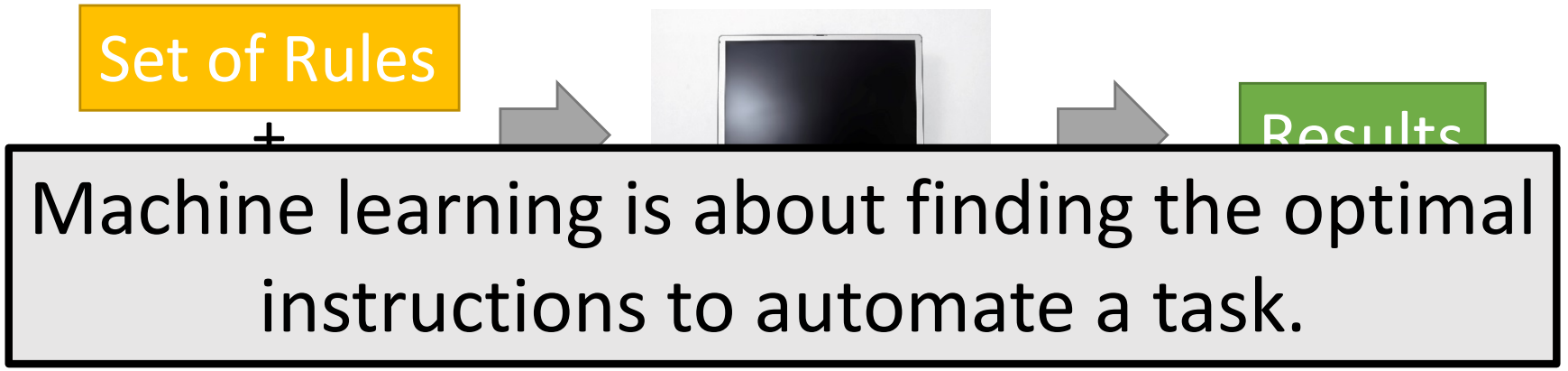


Images taken from
https://cs.nyu.edu/~silberman/datasets/nyu_depth_v1.html

Machine Learning vs Software Engineering

Machine learning vs Software engineering

- Traditional programming (rule-based)



- Machine Learning

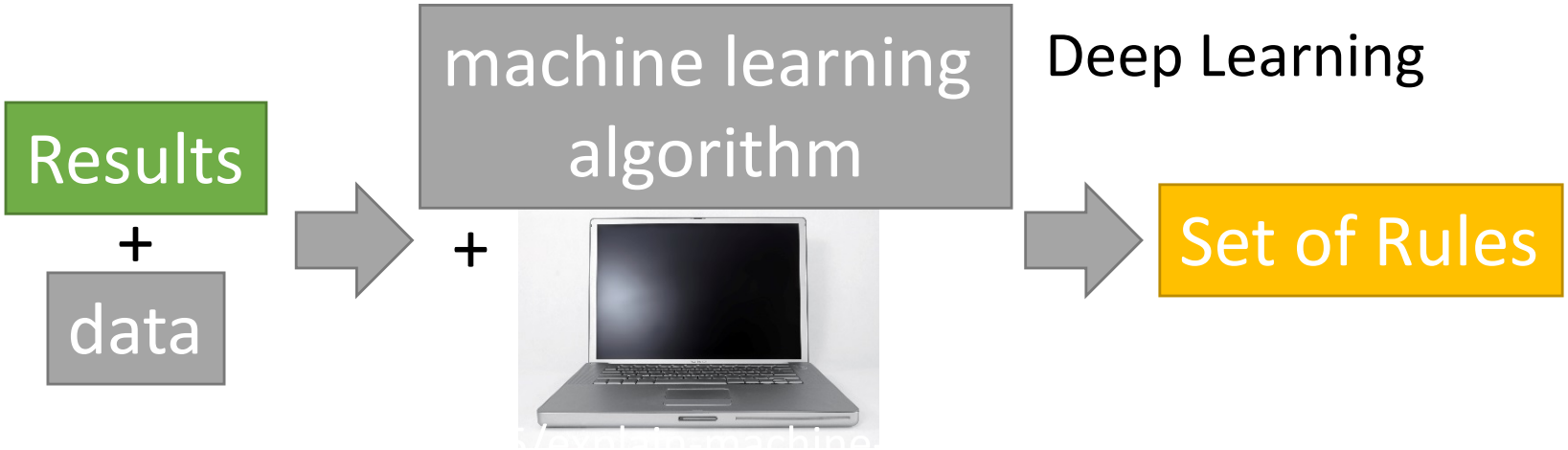
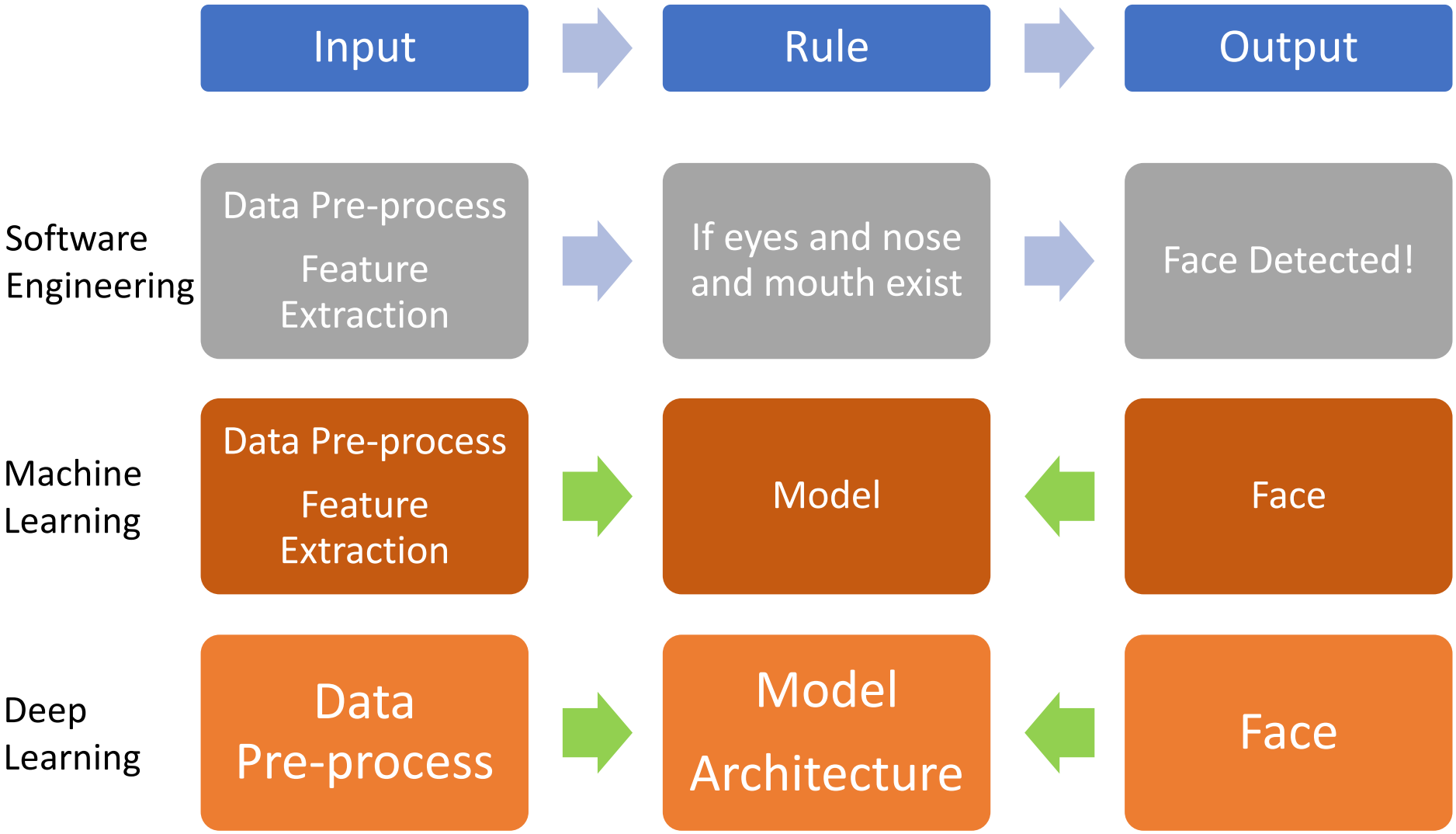


Image Recognition Process



Convolutional Neural Network

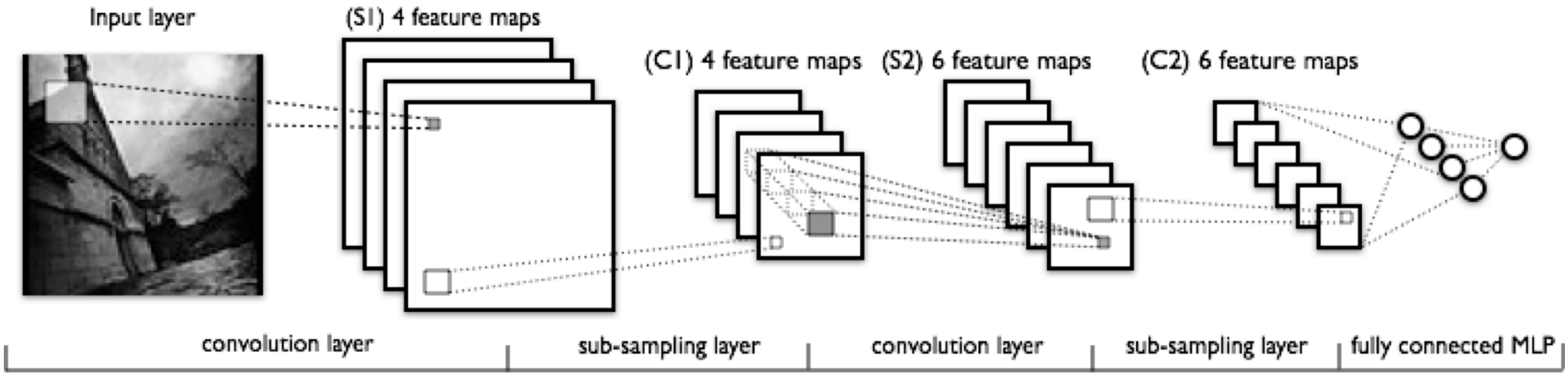


Image taken from:
https://deeplearning4j.org/convolutionalnetwork

Image Data Representation

- Images are represented as tensors

Scalar
0 dim

7

Vector
1 dim

7	8	9

Matrix
2 dim

7	8	9
1	2	3
4	5	6

Cube
3 dim

7	8	9
1	2	3
4	5	6

Tensor
4 dim
(width,
height,
depth)

7, (0,0,0)	8, (0,0,0)	9, (0,0,0)
1, (0,0,0)	2, (0,0,0)	3, (0,0,0)
4, (0,0,0)	5, (0,0,0)	6, (0,0,0)

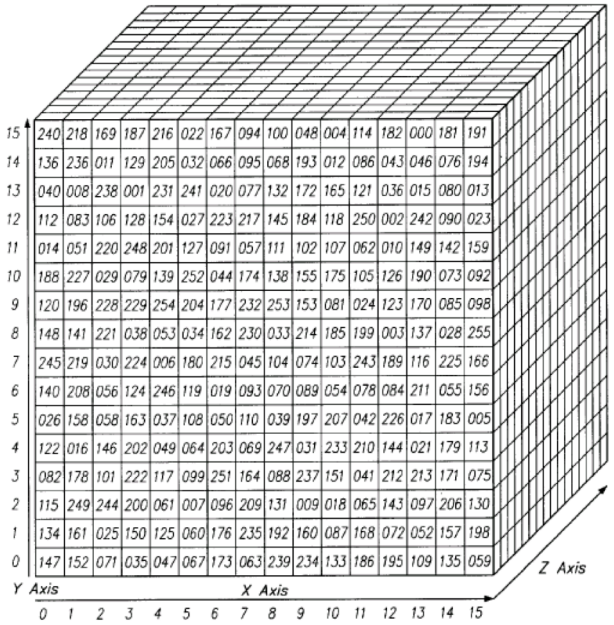
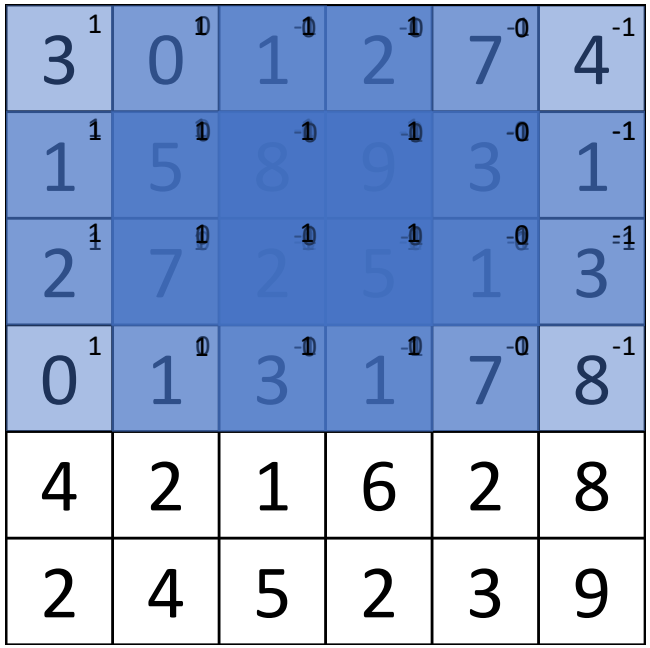


Image taken from:
https://deeplearning4j.org/convolutionalnetwork

Vertical edge detection



3	0	1	2	7	4
1	5	8	9	3	1
2	7	2	5	1	3
0	1	3	1	7	8
4	2	1	6	2	8
2	4	5	2	3	9

*

1	0	-1
1	0	-1
1	0	-1

=

-5	-4	0	8
-10	-2	2	3
0	-2	-4	-7
-3	-2	-3	-16

n x n * f x f = n-f+1 x n-f+1

From Andrew Ng Deep Learning Specialization (Coursera)

Vertical edge detection

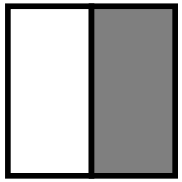
10	10	10	0	0	0
10	10	10	0	0	0
10	10	10	0	0	0
10	10	10	0	0	0
10	10	10	0	0	0
10	10	10	0	0	0

*

1	0	-1
1	0	-1
1	0	-1

=

0	30	30	0
0	30	30	0
0	30	30	0
0	30	30	0



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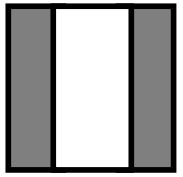


From Andrew Ng Deep Learning Specialization (Coursera)

Other Image Process techniques

- Padding – to include pixels at the edge of an image

n x n * f x f = n+2p-f+1 x n+2p-f+1

n+2p-f+1 = n

- Strided Convolution – filters take n steps instead of one

2	3	7	4	6	2	9
6	6	9	8	7	4	3
3	4	8	3	8	9	7
7	8	3	6	6	3	4
4	2	1	8	3	4	6
3	2	4	1	9	8	3
0	1	3	9	2	1	4

*

3	4	4
1	0	2
-1	0	3

=

From Andrew Ng Deep Learning Specialization (Coursera)

Summary of convolutions

$n \times n$ image $\quad$ $f \times f$ filter

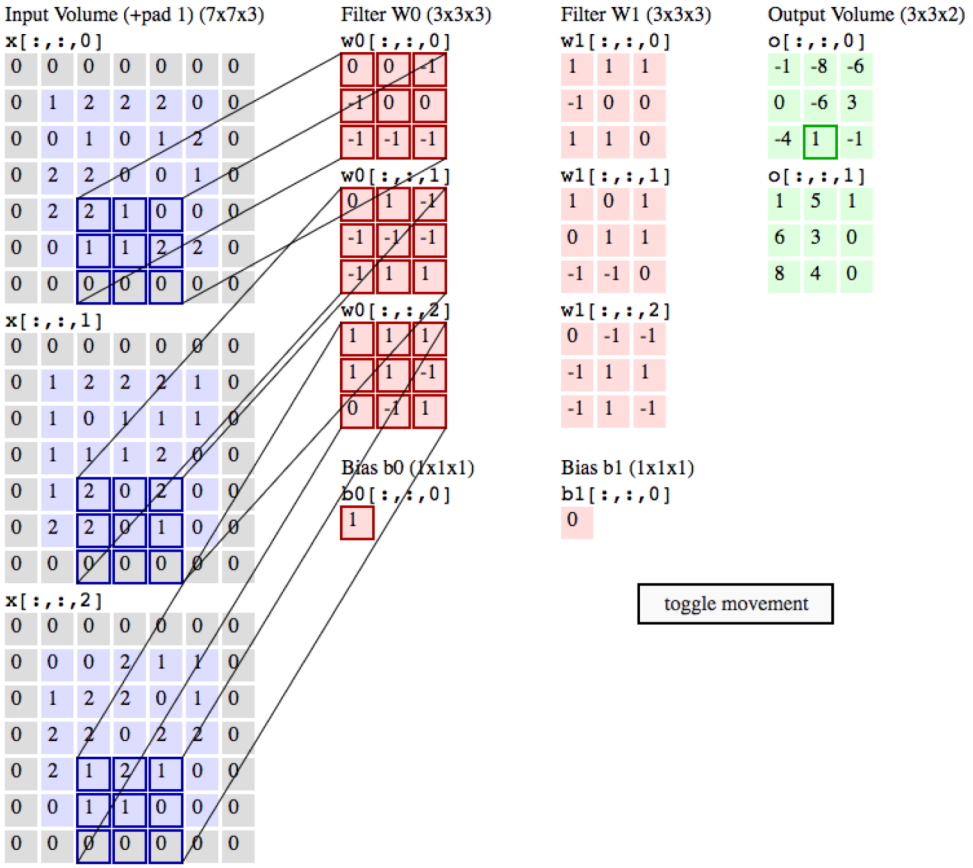
padding p $\quad$ stride s

$$\left\lfloor \frac{n+2p-f}{s} + 1 \right\rfloor \times \left\lfloor \frac{n+2p-f}{s} + 1 \right\rfloor$$

From Andrew Ng Deep Learning Specialization (Coursera)

Convolutional Neural Networks

- Image related applications
- https://deeplearning4j.org/convolutionalnetwork



Case Study 1: Recognizing Handwritten Digits

- MNIST dataset
- Codes

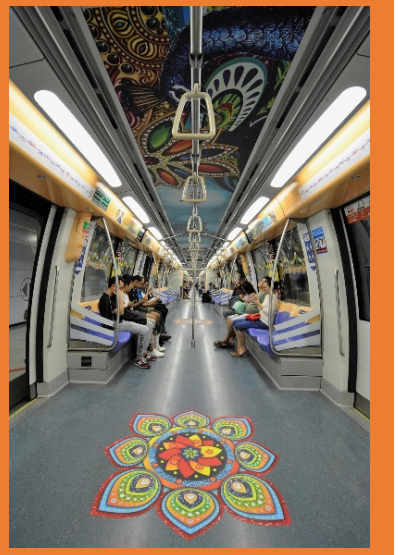
https://machinelearningmastery.com/handwritten-digit-recognition-using-convolutional-neural-networks-python-keras/

Case Study 2: Recognizing Traffic Signs

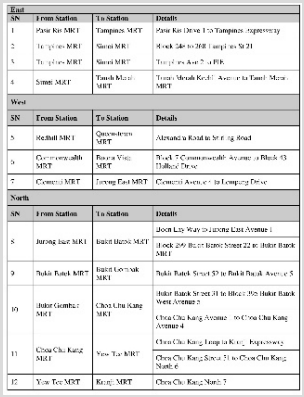
- https://towardsdatascience.com/recognizing-traffic-signs-with-over-98-accuracy-using-deep-learning-86737aedc2ab

Case Study 2:
Identifying MRT Relevant images

1 – relevant



0 – irrelevant



East			
SN	From Station	To Station	Details
1	Pasir Ris MRT	Tampines MRT	Pasir Ris Drive 1 to Tampines Expressway
2	Tampines MRT	Simei MRT	Block 2A to 20B Tampines St 21
3	Tampines MRT	Simei MRT	Tampines Ave 5 to PIE
4	Simei MRT	Tanah Merah MRT	Tanah Merah Kechil Avenue to Tanah Merah MRT
West			
SN	From Station	To Station	Details
5	Redhill MRT	Queenstown MRT	Alexandra Road to Strathmore Road
6	Commonwealth MRT	Buona Vista MRT	Block 7 Commonwealth Avenue to Block 93 Dalkeith Drive
7	Clementi MRT	Jurong East MRT	Clementi Avenue 6 to Jurong Drive
North			
SN	From Station	To Station	Details
8	Jurong East MRT	Bukit Batok MRT	Boon Lay Way to Jurong East Avenue 1
9	Bukit Batok MRT	Bukit Gombak MRT	Block 269 Bukit Batok Street 22 to Bukit Batok MRT
10	Bukit Gombak MRT	Choa Chu Kang MRT	Bukit Batok Street 51 to Block 356 Bukit Batok West Avenue 8 Choa Chu Kang Avenue 7 to Choa Chu Kang Avenue 4
11	Choa Chu Kang MRT	Yew Tee MRT	Choa Chu Kang Loop to Kang Expressway Choa Chu Kang Street 51 to Choa Chu Kang North 6
12	Yew Tee MRT	Kranji MRT	Choa Chu Kang North 7

Identifying MRT Relevant images (2) InceptionV3 – an architecture of CNN

- Dataset

	total	0 - irrelevant	1 - relevant
Train	366	178	188
Valid	92	45	47
Test	115	56	59
Total images	573		

- Results

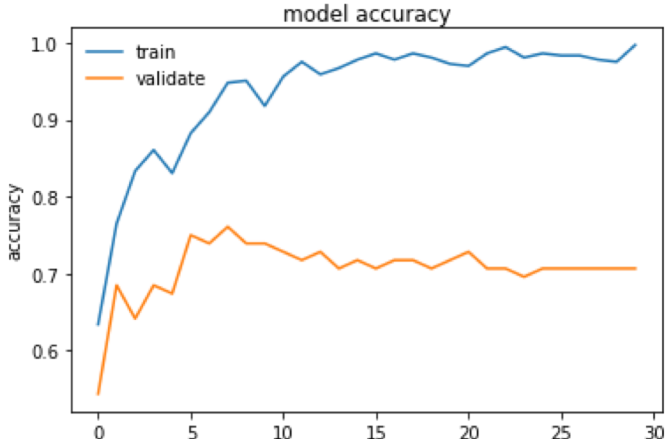
Test results

	precision	recall	f1score	support
0	0.82	0.75	0.79	56
1	0.78	0.85	0.81	59

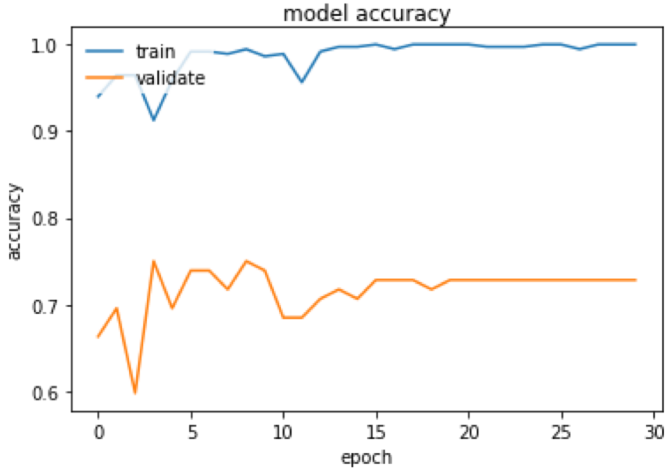
Confusion matrix		GT	
		1	0
Predicted	1	50	14
	0	9	42

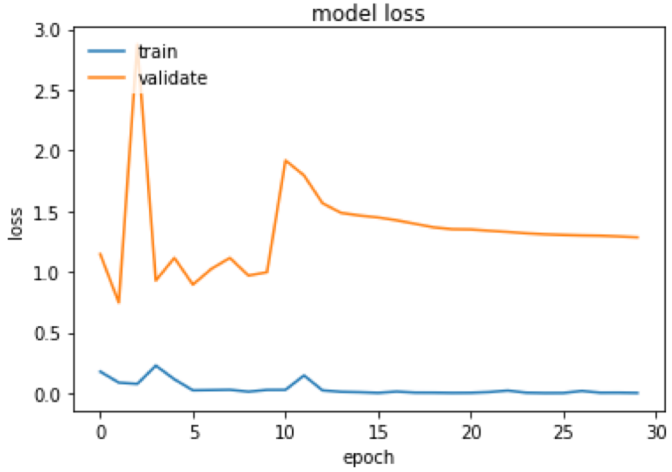
Results: Accuracy and loss charts

Run 1

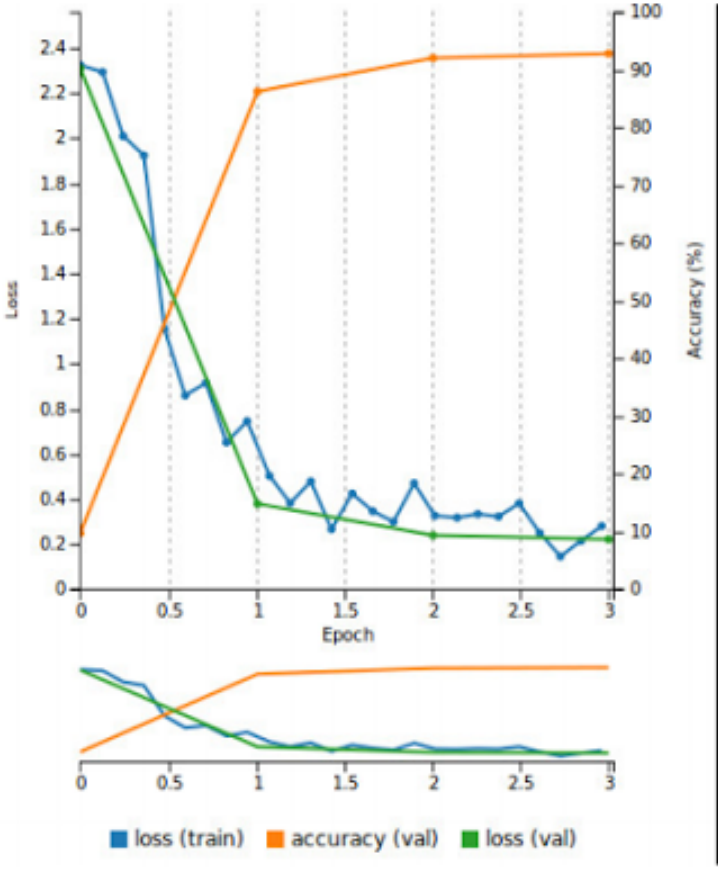


Run 2

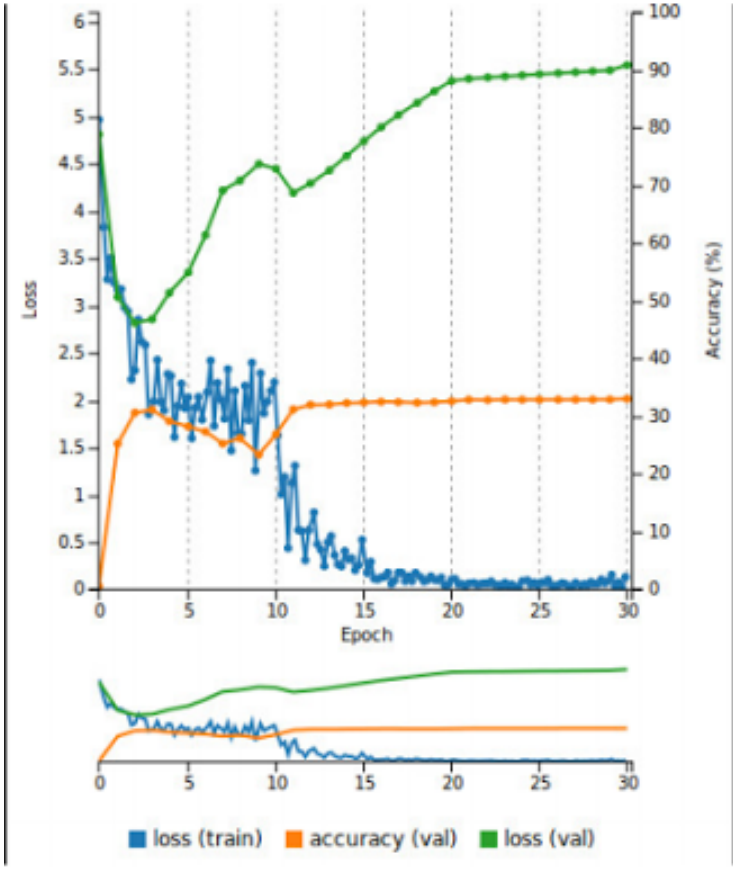




Different scenarios of accuracy and loss plots



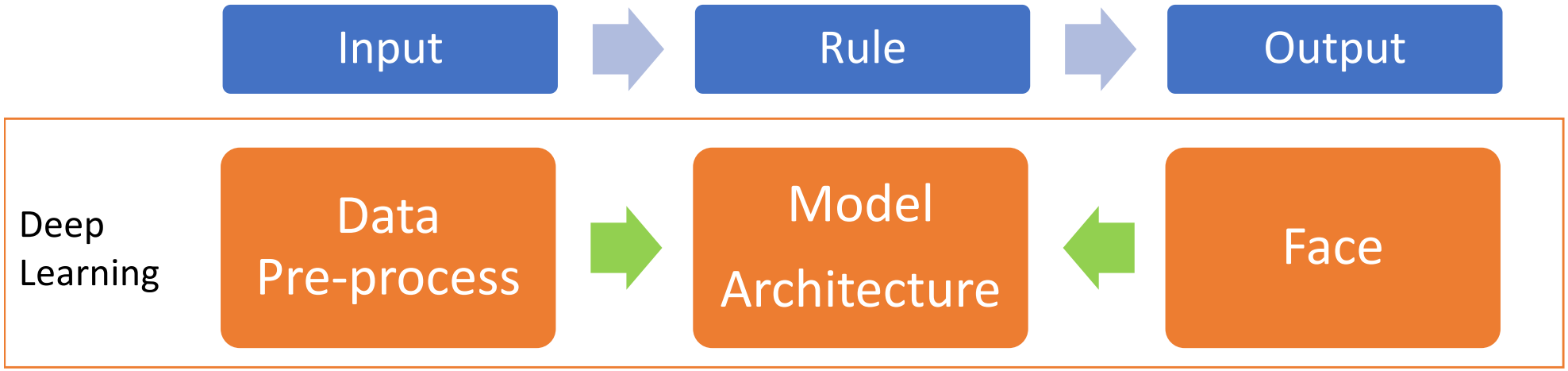
Well-behaved Network



Overfit Network

Yeager 2016 - Effective Visualizations for Training and Evaluating Deep Models

Deep Learning



- Automates feature extraction (edge detection, object recognition, etc)
- Design the architecture and number of layers
- Output labels
- Train the model

Conclusion

- Traditional Image Processing is essential to understand how images are stored and processed.

- Latest technology is to use Deep Learning techniques to process and recognize images through automation of feature extraction.

We are recruiting.

Interest?
Email: cherph@comp.nus.edu.sg

Website: http://sdsc.sg/

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