

The Unreasonable Effectiveness of Deep Learning

Deep Learning — Unit 1

Dr. Jon Krohn

`jon@untapt.com`

Slides available at `jonkrohn.com/talks`

October 20th, 2018

- 1 Name
- 2 Relevant background, e.g., programming, stats, machine learning
- 3 Interest in Deep Learning
- 4 What you'd like to take away from this course

Introduction

Course
Survey

Introductory
Intermediate
Advanced

TF
Playground

Hardware

Software

Shallow Net

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Introduction

Course
Survey

Introductory
Intermediate
Advanced

TF
Playground

Hardware

Software

Shallow Net

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Outline

Introduction

Course Survey

Introductory

Intermediate

Advanced

TF

Playground

Hardware

Software

Shallow Net

1 An Introduction to Neural Networks and Deep Learning

2 Course Survey

Introductory Units (1-3)

Intermediate Units (4-6)

Advanced Units (7-10)

3 Interactive Visualization of an Artificial Neural Network

4 Hardware Options for DL

5 TensorFlow Jupyter Notebooks within a Docker Container

6 A Shallow Artificial Neural Network

Outline

Introduction

Course
Survey

Introductory
Intermediate
Advanced

TF
Playground

Hardware

Software

Shallow Net

1 An Introduction to Neural Networks and Deep Learning

2 Course Survey

Introductory Units (1-3)

Intermediate Units (4-6)

Advanced Units (7-10)

3 Interactive Visualization of an Artificial Neural Network

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5 TensorFlow Jupyter Notebooks within a Docker Container

6 A Shallow Artificial Neural Network

Introduction

Course
SurveyIntroductory
Intermediate
AdvancedTF
Playground

Hardware

Software

Shallow Net

1 An Introduction to Neural Networks and Deep Learning

2 Course Survey

Introductory Units (1-3)

Intermediate Units (4-6)

Advanced Units (7-10)

3 Interactive Visualization of an Artificial Neural Network

4 Hardware Options for DL

5 TensorFlow Jupyter Notebooks within a Docker Container

6 A Shallow Artificial Neural Network

Introduction

Course
SurveyIntroductory
Intermediate
AdvancedTF
Playground

Hardware

Software

Shallow Net

- 1 An Introduction to Neural Networks and Deep Learning
- 2 Course Survey
 - Introductory Units (1-3)
 - Intermediate Units (4-6)
 - Advanced Units (7-10)
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- 5 TensorFlow Jupyter Notebooks within a Docker Container
- 6 A Shallow Artificial Neural Network

Introduction

Course
SurveyIntroductory
Intermediate
AdvancedTF
Playground

Hardware

Software

Shallow Net

- 1 An Introduction to Neural Networks and Deep Learning
- 2 Course Survey
 - Introductory Units (1-3)
 - Intermediate Units (4-6)
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Introduction

Course
SurveyIntroductory
Intermediate
AdvancedTF
Playground

Hardware

Software

Shallow Net

- 1 An Introduction to Neural Networks and Deep Learning
- 2 Course Survey
 - Introductory Units (1-3)
 - Intermediate Units (4-6)
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Introduction

Course
SurveyIntroductory
Intermediate
AdvancedTF
Playground

Hardware

Software

Shallow Net

- 1 An Introduction to Neural Networks and Deep Learning
- 2 Course Survey
 - Introductory Units (1-3)
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- 6 A Shallow Artificial Neural Network

Introduction

Course
Survey

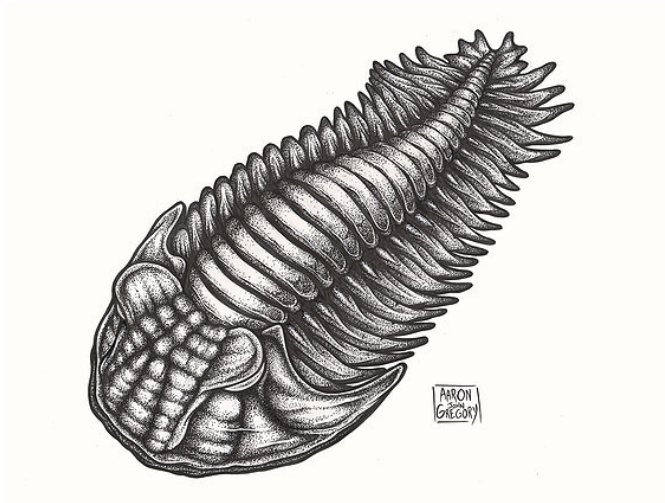
Introductory
Intermediate
Advanced

TF
Playground

Hardware

Software

Shallow Net



Introduction

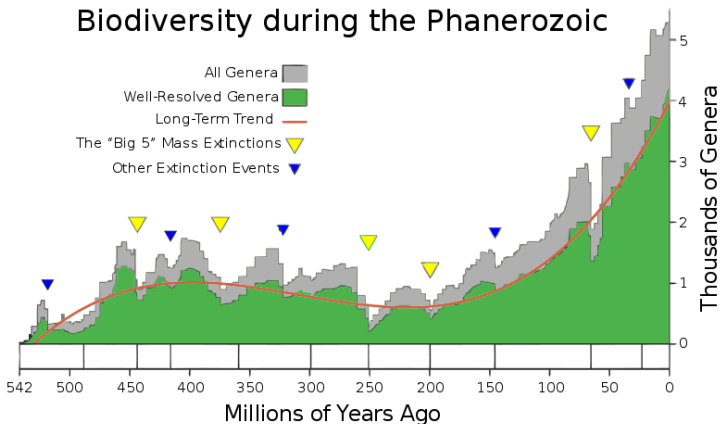
Course
SurveyIntroductory
Intermediate
AdvancedTF
Playground

Hardware

Software

Shallow Net

Biodiversity during the Phanerozoic



Hubel & Wiesel (1959)

Introduction

Course
Survey

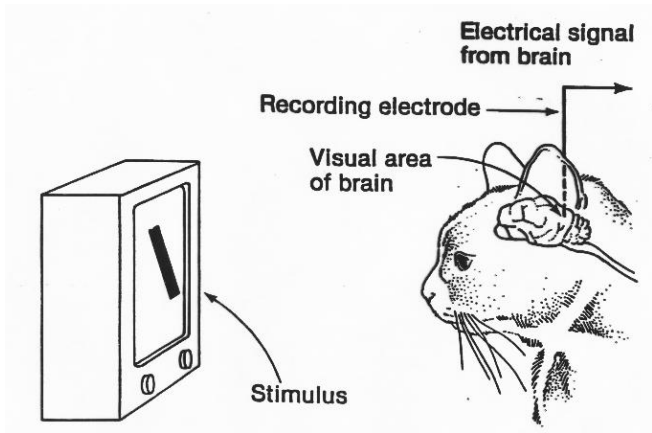
- Introductory
- Intermediate
- Advanced

TF
Playground

Hardware

Software

Shallow Net



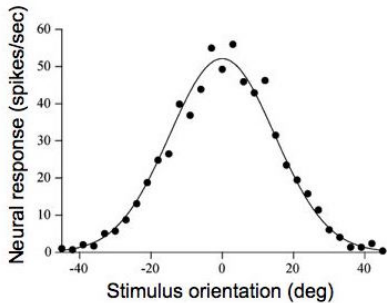
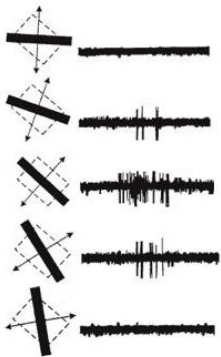
Introduction

Course
SurveyIntroductory
Intermediate
AdvancedTF
Playground

Hardware

Software

Shallow Net



Hubel & Wiesel, 1968

Introduction

Course
Survey

Introductory
Intermediate
Advanced

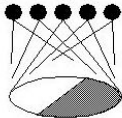
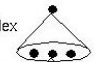
TF
Playground

Hardware

Software

Shallow Net

topographical mapping

hyper-complex
cells

complex cells



simple cells

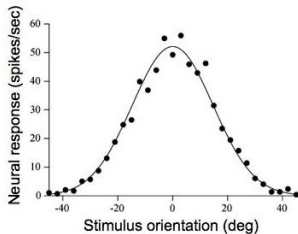
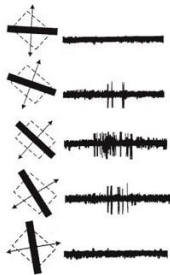


high level

mid level

low level

low level



Hubel & Wiesel, 1968

Introduction

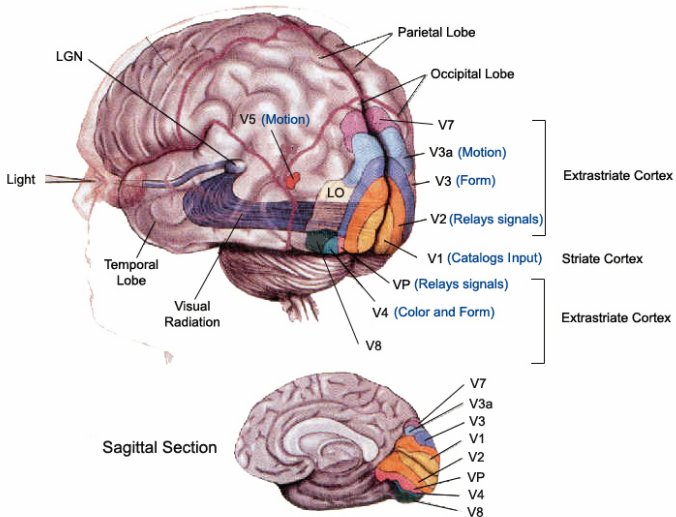
Course
SurveyIntroductory
Intermediate
AdvancedTF
Playground

Hardware

Software

Shallow Net

Visual Cortices



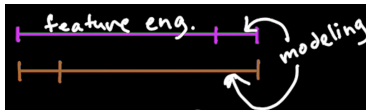
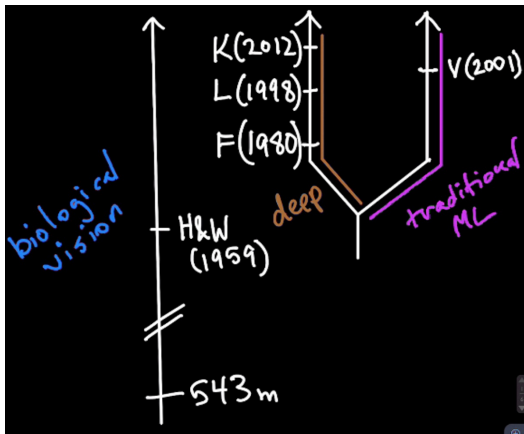
Introduction

Course
SurveyIntroductory
Intermediate
AdvancedTF
Playground

Hardware

Software

Shallow Net



Neocognitron

Fukushima (1980)

Introduction

Course Survey

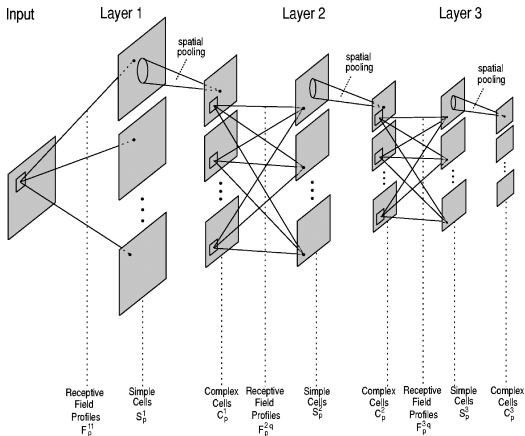
Introductory
Intermediate
Advanced

TF Playground

Hardware

Software

Shallow Net



Unit 1

Introduction

Course Survey

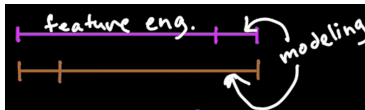
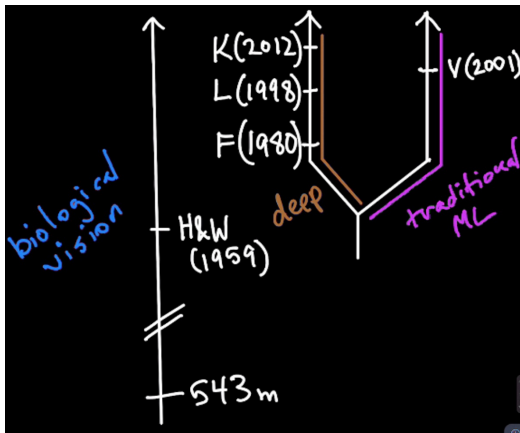
- Introductory
- Intermediate
- Advanced

TF Playground

Hardware

Software

Shallow Net



MNIST Digits & LeNet-5

LeCun, Boutou, Bengio & Haffner (1998)



PROC. OF THE IEEE, NOVEMBER 1998

7

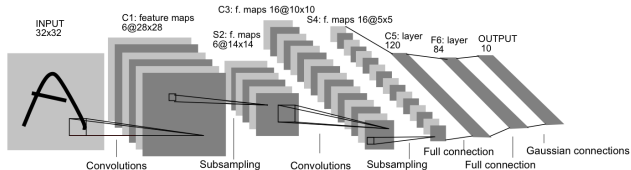


Fig. 2. Architecture of LeNet-5, a Convolutional Neural Network, here for digits recognition. Each plane is a feature map, i.e. a set of units whose weights are constrained to be identical.

Introduction

Course
SurveyIntroductory
Intermediate
AdvancedTF
Playground

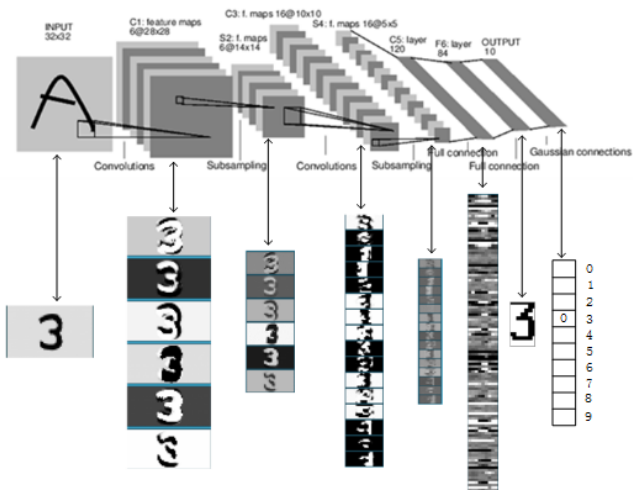
Hardware

Software

Shallow Net

LeNet-5

LeCun, Boutou, Bengio & Haffner (1998)



Introduction

Course
SurveyIntroductory
Intermediate
AdvancedTF
Playground

Hardware

Software

Shallow Net

Unit 1

Introduction

Course Survey

Introductory
Intermediate
Advanced

TF Playground

Hardware

Software

Shallow Net



Introduction

Course Survey

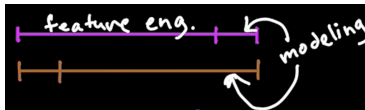
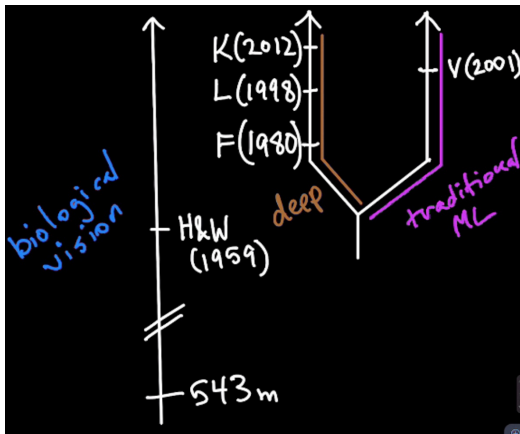
- Introductory
- Intermediate
- Advanced

TF Playground

Hardware

Software

Shallow Net



Viola & Jones (2001)

Introduction

Course
Survey

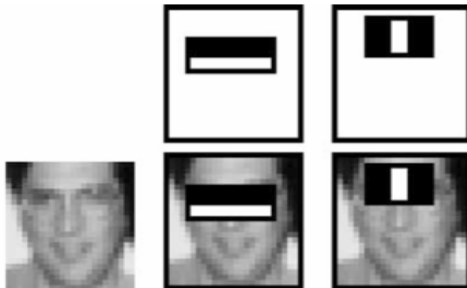
Introductory
Intermediate
Advanced

TF
Playground

Hardware

Software

Shallow Net



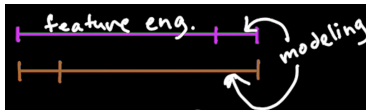
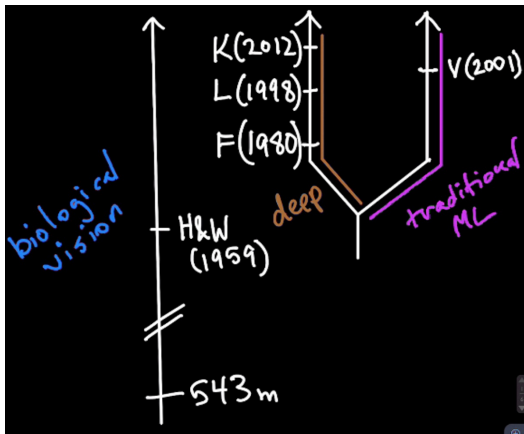
Introduction

Course
SurveyIntroductory
Intermediate
AdvancedTF
Playground

Hardware

Software

Shallow Net



ImageNet

Fei-Fei Li et al. (2009), 14m images, 22k categories

Introduction

Course
SurveyIntroductory
Intermediate
AdvancedTF
Playground

Hardware

Software

Shallow Net



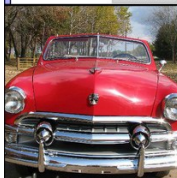
mite

container ship

motor scooter

leopard

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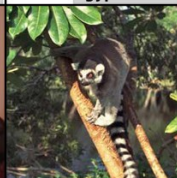
grille



mushroom



cherry



Madagascar cat

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ImageNet Classification Error

ILSVRC: 1.4m, 1k object classes

Introduction

Course
Survey

Introductory
Intermediate
Advanced

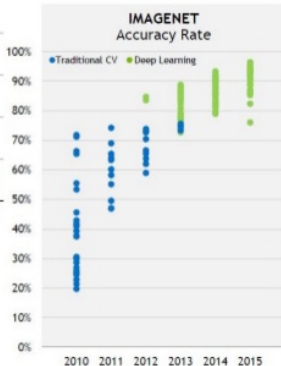
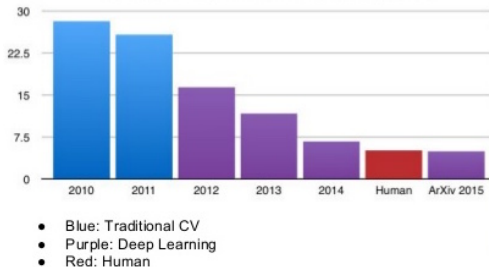
TF
Playground

Hardware

Software

Shallow Net

ILSVRC top-5 error on ImageNet



AlexNet

Krizhevsky, Sutskever & Hinton (2012)

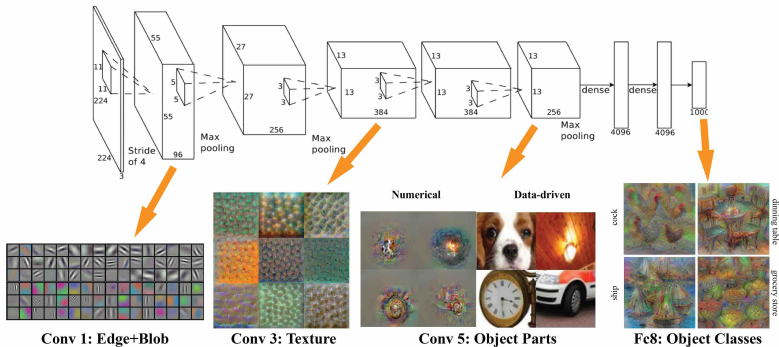
Introduction

Course
SurveyIntroductory
Intermediate
AdvancedTF
Playground

Hardware

Software

Shallow Net



Unit 1

Introduction

Course Survey

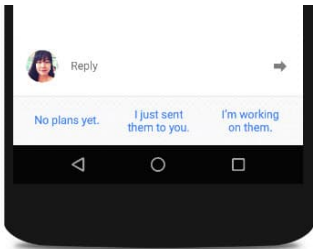
- Introductory
- Intermediate
- Advanced

TF Playground

Hardware

Software

Shallow Net



Unit 1

Introduction

Course Survey

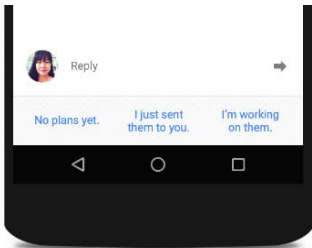
- Introductory
- Intermediate
- Advanced

TF Playground

Hardware

Software

Shallow Net



Unit 1

Introduction

Course Survey

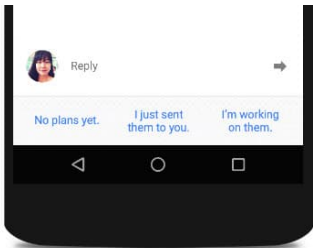
- Introductory
- Intermediate
- Advanced

TF Playground

Hardware

Software

Shallow Net



Outline

Introduction

Course Survey

Introductory

Intermediate

Advanced

TF

Playground

Hardware

Software

Shallow Net

- 1 An Introduction to Neural Networks and Deep Learning
- 2 Course Survey**
 - Introductory Units (1-3)
 - Intermediate Units (4-6)
 - Advanced Units (7-10)
- 3 Interactive Visualization of an Artificial Neural Network
- 4 Hardware Options for DL
- 5 TensorFlow Jupyter Notebooks within a Docker Container
- 6 A Shallow Artificial Neural Network

← → ↻ nycdatascience.com/courses/deep-learning/

Syllabus

Unit 1: The Unreasonable Effectiveness of Deep Learning

- An Introduction to Neural Networks and Deep Learning
- Course Survey
- Interactive Visualization of an Artificial Neural Network
- Hardware Options for Deep Learning, including How to Build a Deep Learning Server
- Running a TensorFlow Jupyter Notebook within a Docker Container
- A Shallow Artificial Neural Network

Unit 2: How Deep Learning Works

- Essential Theory I: Neural Units
- Interactive Visualization of Neural Units
- Essential Theory II: Cost Functions, Gradient Descent, and Backpropagation
- Interactive Visualization of a Deep Neural Network
- An Intermediate Neural Network
- Data Sets for Deep Learning
- **Your Deep Learning Project: Ideating**

Unit 3: Building and Training a Deep Learning Network

Outline

Introduction

Course
Survey

Introductory
Intermediate
Advanced

TF
Playground

Hardware

Software

Shallow Net

1 An Introduction to Neural Networks and Deep Learning

2 **Course Survey**

Introductory Units (1-3)

Intermediate Units (4-6)

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3 Interactive Visualization of an Artificial Neural Network

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The Unreasonable Effectiveness of Deep Learning

Unit 1: right now!

Introduction

Course Survey

Introductory

Intermediate

Advanced

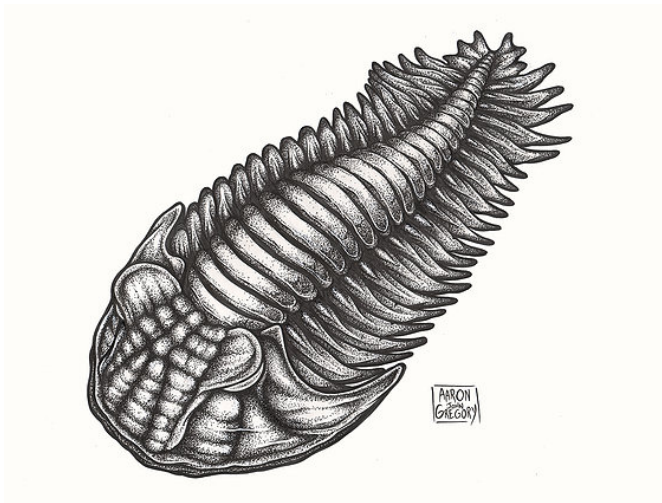
TF

Playground

Hardware

Software

Shallow Net



Hardware Options for DL

Introduction

Course
Survey

Introductory

Intermediate

Advanced

TF
Playground

Hardware

Software

Shallow Net



Jupyter Notebooks

+ Docker + Nvidia GPU + TensorFlow

Introduction

Course
Survey

Introductory

Intermediate

Advanced

TF
Playground

Hardware

Software

Shallow Net

A Shallow Neural Network

Introduction

Course
Survey

Introductory

Intermediate

Advanced

TF
Playground

Hardware

Software

Shallow Net



How Deep Learning Works

Unit 2: This Afternoon



Introduction

Course

Survey

Introductory

Intermediate

Advanced

TF

Playground

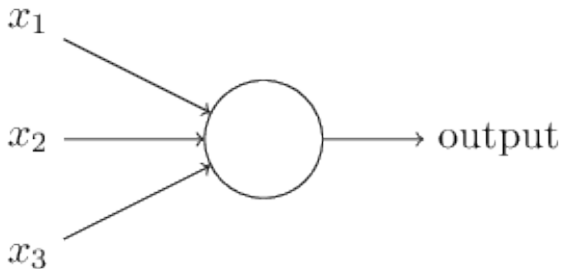
Hardware

Software

Shallow Net

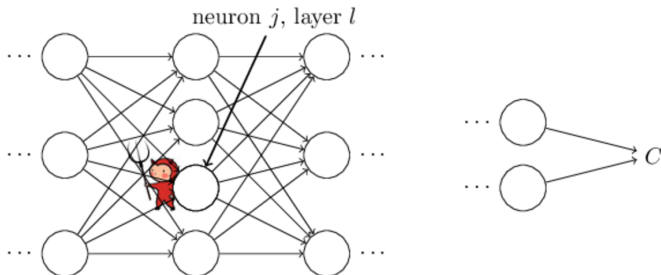
Essential Theory I

Neural Units

[Introduction](#)[Course Survey](#)[Introductory](#)[Intermediate](#)[Advanced](#)[TF](#)[Playground](#)[Hardware](#)[Software](#)[Shallow Net](#)

Essential Theory II

Cost Functions, Gradient Descent, and Backpropagation



An Intermediate Neural Network

Introduction

Course
Survey

Introductory
Intermediate
Advanced

TF
Playground

Hardware

Software

Shallow Net

[intermediate notebook]

Data Sets for Deep Learning

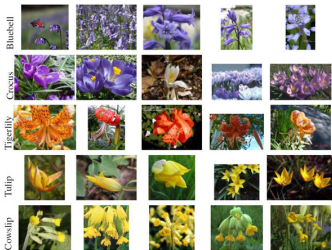
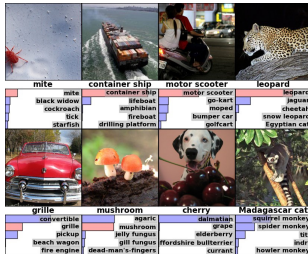
Introduction

Course
SurveyIntroductory
Intermediate
AdvancedTF
Playground

Hardware

Software

Shallow Net



Dataset	Classes	Train Samples
AG's News	4	120,000
Sogou News	5	450,000
DBpedia	14	560,000
Yelp Review Polarity	2	560,000
Yelp Review Full	5	650,000
Yahoo! Answers	10	1,400,000
Amazon Review Full	5	3,000,000
Amazon Review Polarity	2	3,600,000

Data Sets for Deep Learning

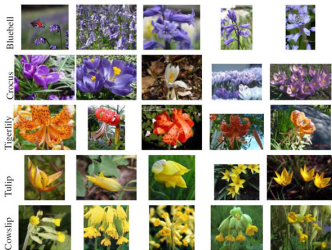
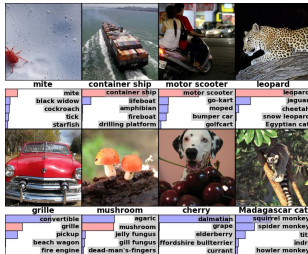
Introduction

Course
SurveyIntroductory
Intermediate
AdvancedTF
Playground

Hardware

Software

Shallow Net



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Data Sets for Deep Learning

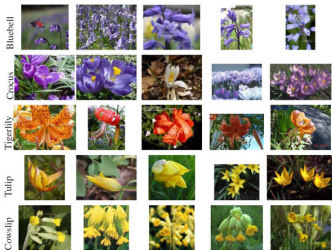
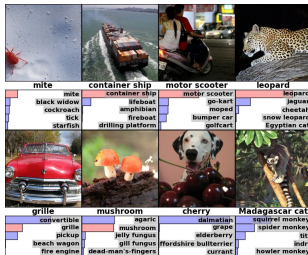
Introduction

Course
SurveyIntroductory
Intermediate
AdvancedTF
Playground

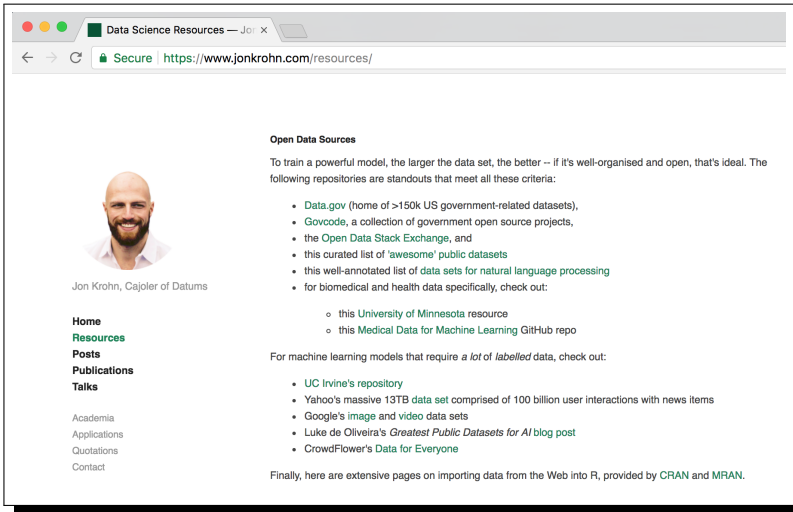
Hardware

Software

Shallow Net




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Amazon Review Full	5	3,000,000
Amazon Review Polarity	2	3,600,000



Data Science Resources — Jon x

Secure | <https://www.jonkrohn.com/resources/>


Jon Krohn, Cajoler of Datums

Home
Resources
Posts
Publications
Talks

Academia
Applications
Quotations
Contact

Open Data Sources

To train a powerful model, the larger the data set, the better -- if it's well-organised and open, that's ideal. The following repositories are standouts that meet all these criteria:

- [Data.gov](#) (home of >150k US government-related datasets),
- [Govcode](#), a collection of government open source projects,
- the [Open Data Stack Exchange](#), and
- this curated list of 'awesome' [public datasets](#)
- this well-annotated list of [data sets for natural language processing](#)
- for biomedical and health data specifically, check out:
 - this [University of Minnesota](#) resource
 - this [Medical Data for Machine Learning](#) GitHub repo

For machine learning models that require a *lot* of *labelled* data, check out:

- [UC Irvine's repository](#)
- Yahoo's massive 13TB [data set](#) comprised of 100 billion user interactions with news items
- Google's [image](#) and [video](#) data sets
- Luke de Oliveira's [Greatest Public Datasets for AI](#) blog post
- CrowdFlower's [Data for Everyone](#)

Finally, here are extensive pages on importing data from the Web into R, provided by [CRAN](#) and [MRAN](#).

Your Deep Learning Project I

Ideating

Introduction

Course
Survey

Introductory

Intermediate

Advanced

TF
Playground

Hardware

Software

Shallow Net



Building & Training a Deep Network

Unit 3: March 10th AM

Introduction

Course
Survey

Introductory

Intermediate

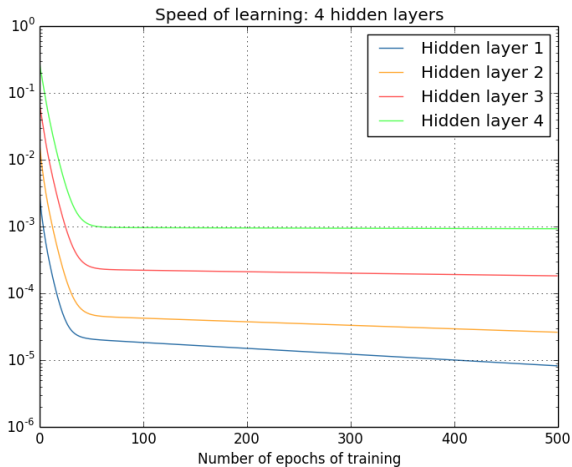
Advanced

TF
Playground

Hardware

Software

Shallow Net



Essential Theory III

Weight Initialization and Mini-Batches

[neurons notebook]

Essential Theory IV

Unstable Gradients and Avoiding Overfitting

Introduction

Course
Survey

Introductory

Intermediate

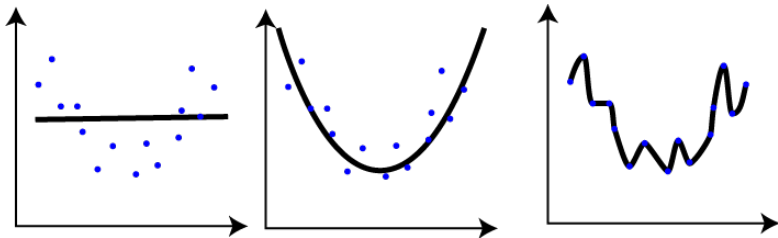
Advanced

TF
Playground

Hardware

Software

Shallow Net



A Deep Neural Network

Introduction

Course
Survey

Introductory

Intermediate

Advanced

TF
Playground

Hardware

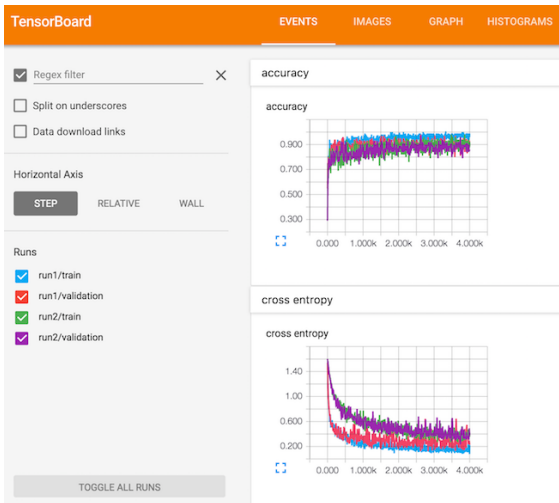
Software

Shallow Net

[deep notebook]

TensorBoard

and the Interpretation of Model Outputs



Introduction

Course
Survey

Introductory

Intermediate

Advanced

TF
Playground

Hardware

Software

Shallow Net

① An Introduction to Neural Networks and Deep Learning

② **Course Survey**

Introductory Units (1-3)

Intermediate Units (4-6)

Advanced Units (7-10)

③ Interactive Visualization of an Artificial Neural Network

④ Hardware Options for DL

⑤ TensorFlow Jupyter Notebooks within a Docker Container

⑥ A Shallow Artificial Neural Network

Machine Vision

Unit 4: March 10th PM



Introduction

Course
Survey

Introductory

Intermediate

Advanced

TF
Playground

Hardware

Software

Shallow Net

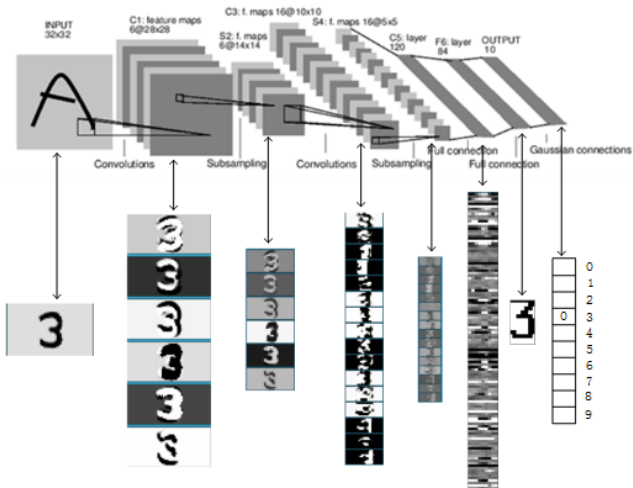
Intro to ConvNets

for Visual Recognition

[deepvis]

LeNet-5

Classic ConvNet Architecture I



[notebook]

Introduction

Course
SurveyIntroductory
Intermediate
AdvancedTF
Playground

Hardware

Software

Shallow Net

Transfer Learning

Introduction

Course
Survey

Introductory

Intermediate

Advanced

TF
Playground

Hardware

Software

Shallow Net



mite

container ship

motor scooter

leopard

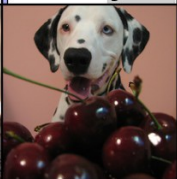
mite	container ship	motor scooter	leopard
mite	lifeboat	go-kart	leopard
black widow	amphibian	moped	jaguar
cockroach	fireboat	bumper car	cheetah
tick	drilling platform	golfcart	snow leopard
starfish			Egyptian cat



grille



mushroom



cherry



Madagascar cat

grille	mushroom	cherry	Madagascar cat
convertible	agaric	dalmatian	squirrel monkey
grille	mushroom	grape	spider monkey
pickup	jelly fungus	elderberry	titi
beach wagon	gill fungus	ffordshire bullterrier	indri
fire engine	dead-man's-fingers	currant	howler monkey

Your Deep Learning Project II

Formulating

Introduction

Course
Survey

Introductory

Intermediate

Advanced

TF
Playground

Hardware

Software

Shallow Net



Natural Language Processing

Units 5 & 6: March 17th

Introduction

Course
Survey

Introductory

Intermediate

Advanced

TF
Playground

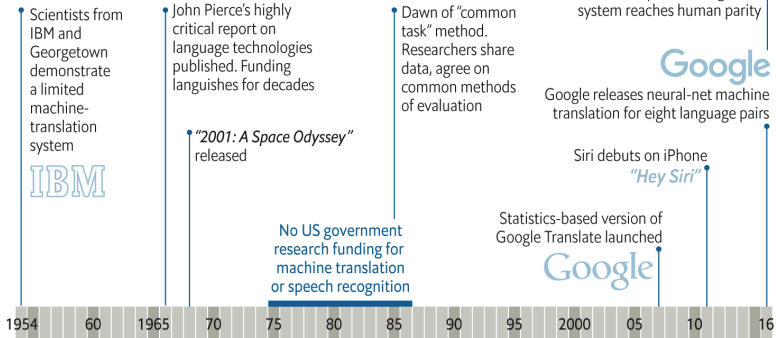
Hardware

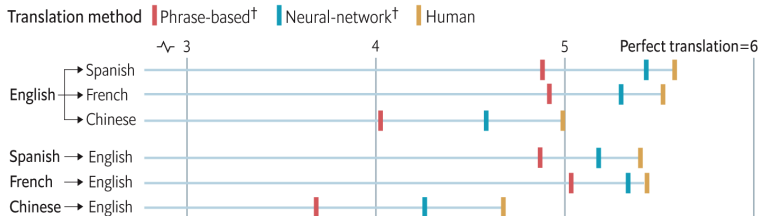
Software

Shallow Net



A history of language technologies





Sunspring

Introduction

Course
Survey

Introductory

Intermediate

Advanced

TF
Playground

Hardware

Software

Shallow Net



Sunspring

Introduction

Course
Survey

Introductory

Intermediate

Advanced

TF

Playground

Hardware

Software

Shallow Net

TNT. GRIP

We see H pull a book from a shelf, flip through it while speaking, and then put it back.

H

In a future with mass unemployment, young people are forced to sell blood. That's the first thing I can do.

H2

You should see the boys and shut up. I was the one who was going to be a hundred years old.

H

I saw him again. The way you were sent to me... that was a big honest idea. I am not a bright light.

C

Well, I have to go to the skull. I don't know.

He picks up a light screen and fights the security forces of the particles of a transmission on his face.

H

(continuing)
What do you mean?

C

(smiling)
I don't know anything about any of this.

H

(to Hank, taking his eyes from his mouth)
Then what?

H2

There's no answer.

C

(frowning)
We're going to see the money.

H

(reading)
"All right," you can't tell me that."

steps back. coffee is still going through.

C

I was coming to that thing because you were so peppy.

H

I don't know. I don't know what you're talking about.

C

That's right.

H

So what are you doing?

H2

I don't want to be honest with you.

He looks at him for a moment, then smiles at him.

H

You don't have to be a doctor.

H2

I am not sure. I don't know what you're talking about.

H

I want to see you too.

H2

What do you mean?

H

I'm sorry, but I'm sure you wouldn't even touch me.

H2

I don't know what you're talking about.

H

The principle is completely contrived for the same time.

H2

(smiling)
It was all about you to be true.

H

You didn't even see the movie with the rest of the team.

H2

I don't know.

H

I don't care.

H2

I know that it's a consequence. Whatever you want to know about the presence of the story, I'm a little bit of a boy on the floor.

H

I don't know. I just have to ask you to explain to me what you say.

H2

What do you mean?

H

Because I don't know what you're talking about.

H2

That was all the time.

H

I know that.

H2

I don't know.

H

(angry)
It would be a good time. I think I could have been my life.

He starts to shake.

H (CONT'D)

It may never be forgiven, but that is just too bad. I have to leave, but I'm not free of the world.

Yes. Perhaps I should take it from here. I'm not going to do something.

H

You can't afford to take this anywhere. It's not a dream. But I've got a good time to stay there.

C

Well, I think you can still be back on the table.

H

Man. It's a damn thing scared to say. Nothing is going to be a thing but I was the one that put on this rock with a child and then I left the other two.

He is standing in the stairs and sitting on the floor. He takes a seat on the counter and pulls the covers over to his back. He stares at it. He is on the phone. He holds the phone from the edge of the room and puts it in his mouth. He sees a black hole in the floor leading to the sea on the roof.

He comes up behind him to protect him. He is still standing next to him.

He looks through the door and the door closes. He looks at the bag from his backpack, and starts to cry.

T

Well, there's the situation with me and the light on the ship. The guy was trying to stop me. He was like a baby and he was gone. I was worried about him, but even if he would have done it all. He couldn't come any more. I didn't mean to be a virgin. I mean, he was weak. And I thought I'd change my mind. He was crazy to let it out. It was a long time ago. He was a little late. I was going to be a woman. I just wanted to tell you that I was much better than he did. I had to stop him and I couldn't even tell. I didn't want to hurt him. I'm sorry. I know I don't like him. I can go home and be on bed and I love him. So I can get him all the way one here and find the square and go to the game with him and she won't show up. Then I'll check it out. But I'm going to see his when he gets it. He looks up and he'll be through me out of his eyes. Then he said he'd go to bed with me.

Word Vectors

word2vec & Vector-Space Embedding

[vse 2000]

[word2viz]

Recurrent Neural Networks

GRUs and LSTMs

Introduction

Course

Survey

Introductory

Intermediate

Advanced

TF

Playground

Hardware

Software

Shallow Net

[BiLSTM notebook]

Advanced Architectures

Introduction

Course
Survey

Introductory

Intermediate

Advanced

TF
Playground

Hardware

Software

Shallow Net

[multi-ConvNet notebook]

Your Deep Learning Project III

Improving

Introduction

Course
Survey

Introductory

Intermediate

Advanced

TF
Playground

Hardware

Software

Shallow Net



Outline

Introduction

Course Survey

Introductory

Intermediate

Advanced

TF

Playground

Hardware

Software

Shallow Net

1 An Introduction to Neural Networks and Deep Learning

2 **Course Survey**

Introductory Units (1-3)

Intermediate Units (4-6)

Advanced Units (7-10)

3 Interactive Visualization of an Artificial Neural Network

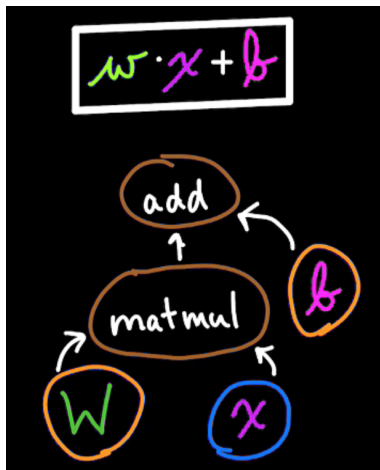
4 Hardware Options for DL

5 TensorFlow Jupyter Notebooks within a Docker Container

6 A Shallow Artificial Neural Network

TensorFlow

Unit 7 & 8: March 24th



Leading DL Libraries

A Comparison

Introduction

Course
Survey

Introductory

Intermediate

Advanced

TF
Playground

Hardware

Software

Shallow Net

	Caffe	Torch	Theano	TensorFlow
<i>language</i>	Python, C++	Lua, <u>PyTorch</u>	Python	Python, Java, C, Go
<i>pre-trained models</i>	Model Zoo	ModelZoo	Lasagne	Inception, others
<i>parallel GPUs: data</i>	Yes	Yes	Yes	Yes
<i>parallel GPUs: model</i>		Yes		Yes
<i>source code</i>	Readable	Readable		
<i>for RNNs</i>			Good	Best
<i>high-level APIs</i>			Keras	Keras, TFLearn

Neurons in TensorFlow

Introduction

Course
Survey

Introductory

Intermediate

Advanced

TF
Playground

Hardware

Software

Shallow Net

[LeNet-5 in TF]

Improving Model Performance

Introduction

Course
Survey

Introductory

Intermediate

Advanced

TF

Playground

Hardware

Software

Shallow Net

- 1 Xavier Glorot initialization
- 2 problem simplification
- 3 layer architecture
- 4 cost function
- 5 avoid overfitting
- 6 variable learning rate η
- 7 epochs
- 8 regularization parameters, e.g., λ
- 9 mini-batch size
- 10 grid-search automation

Improving Model Performance

Introduction

Course
SurveyIntroductory
Intermediate
AdvancedTF
Playground

Hardware

Software

Shallow Net

- 1 Xavier Glorot initialization
- 2 problem simplification
- 3 layer architecture
- 4 cost function
- 5 avoid overfitting
- 6 variable learning rate η
- 7 epochs
- 8 regularization parameters, e.g., λ
- 9 mini-batch size
- 10 grid-search automation

Improving Model Performance

Introduction

Course
SurveyIntroductory
Intermediate
AdvancedTF
Playground

Hardware

Software

Shallow Net

- 1 Xavier Glorot initialization
- 2 problem simplification
- 3 layer architecture
- 4 cost function
- 5 avoid overfitting
- 6 variable learning rate η
- 7 epochs
- 8 regularization parameters, e.g., λ
- 9 mini-batch size
- 10 grid-search automation

Improving Model Performance

Introduction

Course
SurveyIntroductory
Intermediate
AdvancedTF
Playground

Hardware

Software

Shallow Net

- 1 Xavier Glorot initialization
- 2 problem simplification
- 3 layer architecture
- 4 cost function
- 5 avoid overfitting
- 6 variable learning rate η
- 7 epochs
- 8 regularization parameters, e.g., λ
- 9 mini-batch size
- 10 grid-search automation

Improving Model Performance

Introduction

Course
Survey

Introductory
Intermediate
Advanced

TF
Playground

Hardware

Software

Shallow Net

- 1 Xavier Glorot initialization
- 2 problem simplification
- 3 layer architecture
- 4 cost function
- 5 avoid overfitting
- 6 variable learning rate η
- 7 epochs
- 8 regularization parameters, e.g., λ
- 9 mini-batch size
- 10 grid-search automation

Improving Model Performance

Introduction

Course
SurveyIntroductory
Intermediate
AdvancedTF
Playground

Hardware

Software

Shallow Net

- 1 Xavier Glorot initialization
- 2 problem simplification
- 3 layer architecture
- 4 cost function
- 5 avoid overfitting
- 6 variable learning rate η
- 7 epochs
- 8 regularization parameters, e.g., λ
- 9 mini-batch size
- 10 grid-search automation

Improving Model Performance

Introduction

Course
SurveyIntroductory
Intermediate
AdvancedTF
Playground

Hardware

Software

Shallow Net

- 1 Xavier Glorot initialization
- 2 problem simplification
- 3 layer architecture
- 4 cost function
- 5 avoid overfitting
- 6 variable learning rate η
- 7 epochs
- 8 regularization parameters, e.g., λ
- 9 mini-batch size
- 10 grid-search automation

Improving Model Performance

Introduction

Course
Survey

Introductory

Intermediate

Advanced

TF

Playground

Hardware

Software

Shallow Net

- 1 Xavier Glorot initialization
- 2 problem simplification
- 3 layer architecture
- 4 cost function
- 5 avoid overfitting
- 6 variable learning rate η
- 7 epochs
- 8 regularization parameters, e.g., λ
- 9 mini-batch size
- 10 grid-search automation

Improving Model Performance

Introduction

Course
SurveyIntroductory
Intermediate
AdvancedTF
Playground

Hardware

Software

Shallow Net

- 1 Xavier Glorot initialization
- 2 problem simplification
- 3 layer architecture
- 4 cost function
- 5 avoid overfitting
- 6 variable learning rate η
- 7 epochs
- 8 regularization parameters, e.g., λ
- 9 mini-batch size
- 10 grid-search automation

Improving Model Performance

Introduction

Course
SurveyIntroductory
Intermediate
AdvancedTF
Playground

Hardware

Software

Shallow Net

- 1 Xavier Glorot initialization
- 2 problem simplification
- 3 layer architecture
- 4 cost function
- 5 avoid overfitting
- 6 variable learning rate η
- 7 epochs
- 8 regularization parameters, e.g., λ
- 9 mini-batch size
- 10 grid-search automation

Tuning Hyperparameters

Introduction

Course
Survey

Introductory

Intermediate

Advanced

TF
Playground

Hardware

Software

Shallow Net

..in lenet_in_keras.ipynb:

```
model = Sequential()
model.add(Conv2D(32, kernel_size=(3, 3), activation='relu', input_shape=(28, 28, 1)))
model.add(Conv2D(64, kernel_size=(3, 3), activation='relu'))
model.add(MaxPooling2D(pool_size=(2, 2)))
model.add(Dropout(0.25))
model.add(Flatten())
model.add(Dense(128, activation='relu'))
model.add(Dropout(0.5))
model.add(Dense(n_classes, activation='softmax'))
```

..in lenet_in_tensorflow.ipynb:

```
# max pooling layer:
pool_size = 2
mp_layer_dropout = 0.25

# dense layer:
n_dense = 128
dense_layer_dropout = 0.5

# convolutional and max-pooling layers:
conv_1 = conv2d(square_x, weights['W_c1'], biases['b_c1'])
conv_2 = conv2d(conv_1, weights['W_c2'], biases['b_c2'])
pool_1 = maxpooling2d(conv_2, mp_size)
pool_1 = tf.nn.dropout(pool_1, 1-mp_dropout)

# dense layer:
flat = tf.reshape(pool_1, [-1, weights['W_d1'].get_shape().as_list()[0]])
dense_1 = dense(flat, weights['W_d1'], biases['b_d1'])
dense_1 = tf.nn.dropout(dense_1, 1-dense_dropout)
```

Your Deep Learning Project IV

Assessing

Introduction

Course
Survey

Introductory

Intermediate

Advanced

TF

Playground

Hardware

Software

Shallow Net



Generative Adversarial Networks

Unit 9: April 7th AM



Introduction

Course
Survey

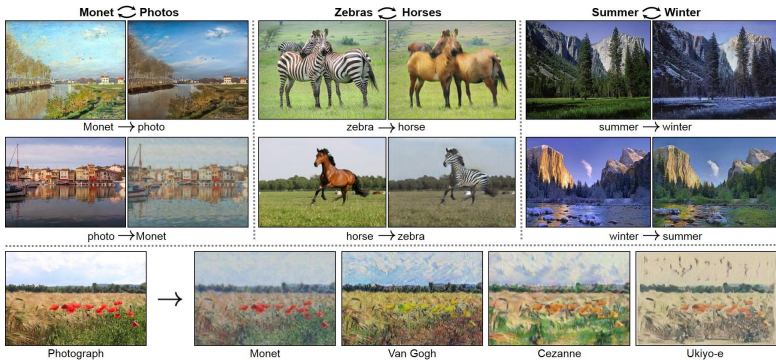
Introductory
Intermediate
Advanced

TF
Playground

Hardware

Software

Shallow Net



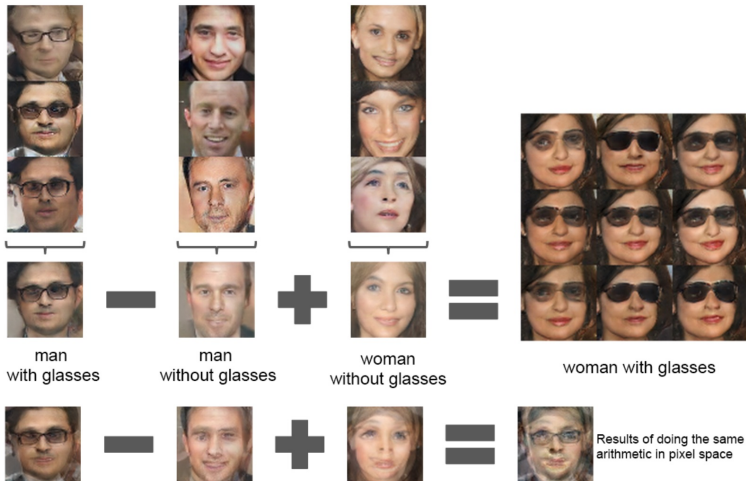
Introduction

Course
SurveyIntroductory
Intermediate
AdvancedTF
Playground

Hardware

Software

Shallow Net



Introduction

Course
Survey

Introductory

Intermediate

Advanced

TF
Playground

Hardware

Software

Shallow Net

[Quick, Draw!]

Unit 1

Introduction

Course
Survey

Introductory

Intermediate

Advanced

TF
Playground

Hardware

Software

Shallow Net

Introduction

Course
Survey

Introductory

Intermediate

Advanced

TF
Playground

Hardware

Software

Shallow Net

[GAN notebook]

Deep Reinforcement Learning

Unit 10: April 7th PM

Introduction

Course
Survey

Introductory

Intermediate

Advanced

TF
Playground

Hardware

Software

Shallow Net



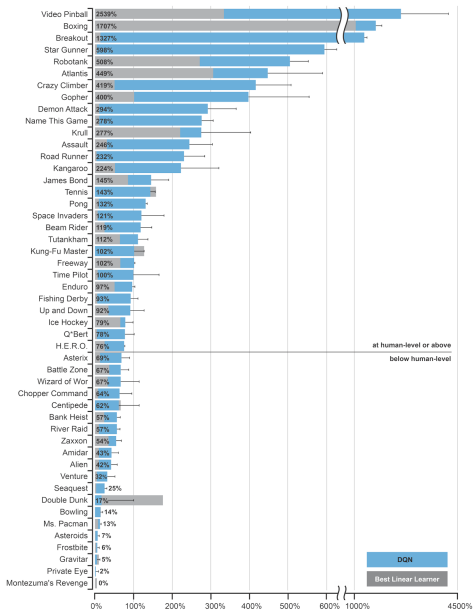
AlphaGO

Silver et al. (2016)



Deep Q-Learning

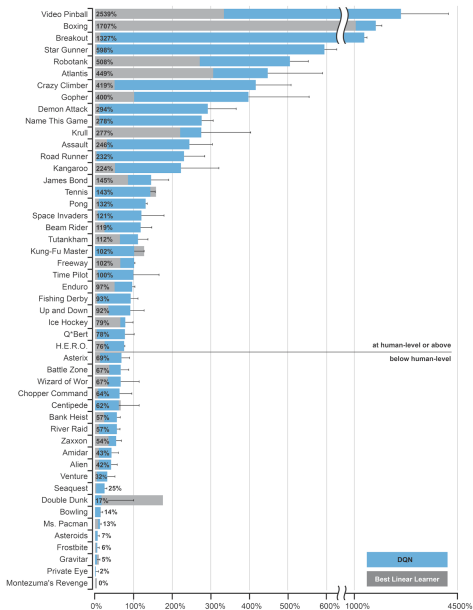
Mnih et al. (2015)



[Atari Games]

Deep Q-Learning

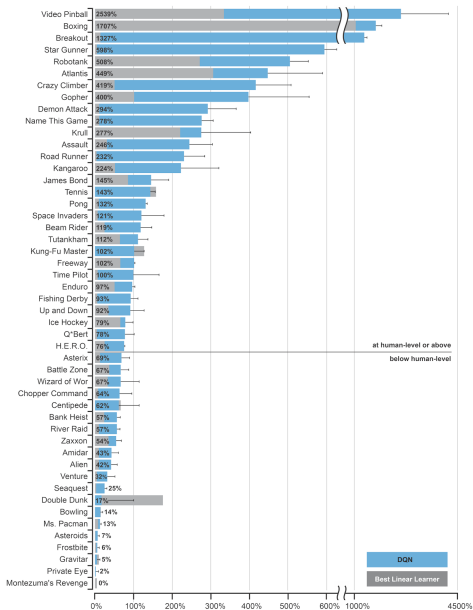
Mnih et al. (2015)



[Atari Games]

Deep Q-Learning

Mnih et al. (2015)



[Atari Games]

Introduction

Course
Survey

Introductory
Intermediate
Advanced

TF
Playground

Hardware

Software

Shallow Net

[*Deep Q-Learning Network* notebook]

[SLM-Lab]

Your Deep Learning Project V

Presentations

Introduction

Course
Survey

Introductory

Intermediate

Advanced

TF
Playground

Hardware

Software

Shallow Net



Demand for AI Talent

i.e., *Deep Learning* talent

“Of the ten most valuable quoted companies in the world, seven say they have plans to put deep-learning-based AI at the heart of their operations”

~ *The Economist* (Feb. 17th, 2018)

Demand for AI Talent

i.e., *Deep Learning* talent

Introduction

Course
Survey

Introductory
Intermediate
Advanced

TF
Playground

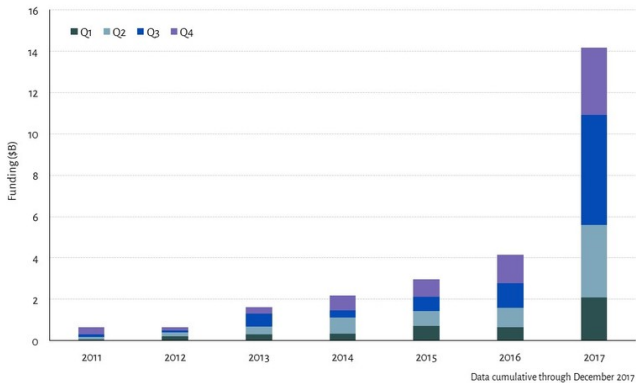
Hardware

Software

Shallow Net

 **ARTIFICIAL INTELLIGENCE**
Annual Funding Amount

VS/ VENTURE
SCANNER



Demand for AI Talent

i.e., *Deep Learning* talent

Introduction

Course

Survey

Introductory

Intermediate

Advanced

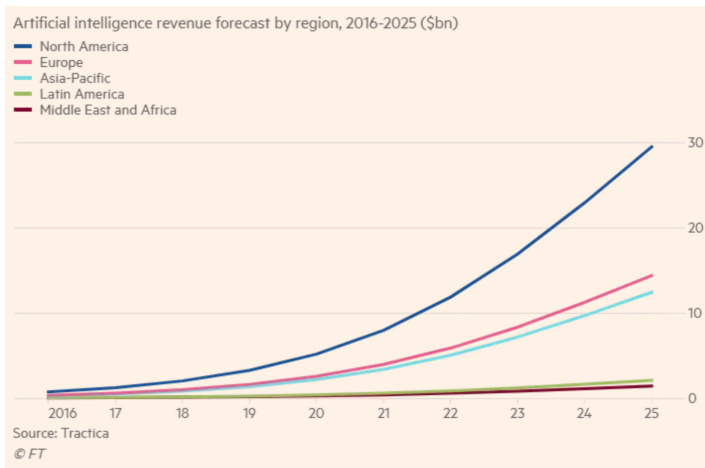
TF

Playground

Hardware

Software

Shallow Net



Demand for AI Talent

i.e., *Deep Learning* talent

According to JF Gagne's [Global AI Talent Report 2018]:

- 1 22k Ph.D.-educated researchers globally
- 2 3k of those currently looking
- 3 5k publishing / presenting at AI conferences

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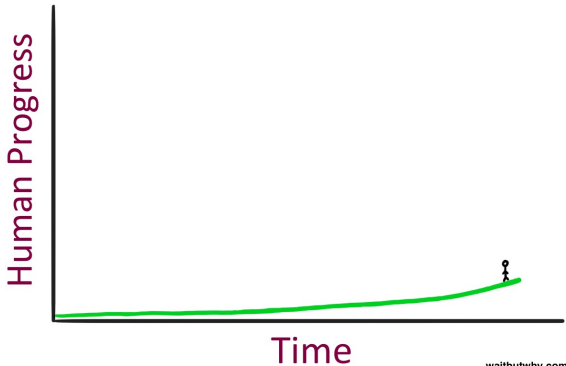
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The AI Revolution



The AI Revolution

Introduction

Course
Survey

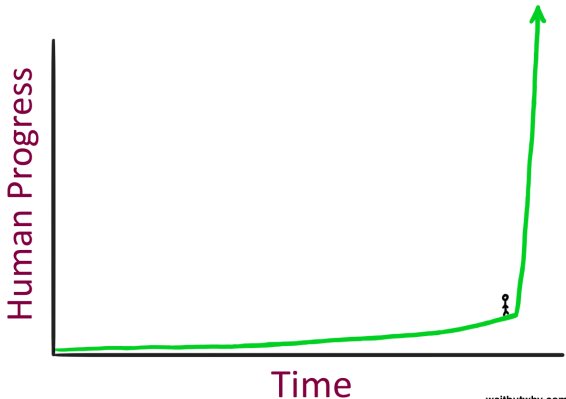
Introductory
Intermediate
Advanced

TF
Playground

Hardware

Software

Shallow Net



Outline

Introduction

Course
Survey

Introductory
Intermediate
Advanced

TF
Playground

Hardware

Software

Shallow Net

1 An Introduction to Neural Networks and Deep Learning

2 Course Survey

Introductory Units (1-3)

Intermediate Units (4-6)

Advanced Units (7-10)

3 Interactive Visualization of an Artificial Neural Network

4 Hardware Options for DL

5 TensorFlow Jupyter Notebooks within a Docker Container

6 A Shallow Artificial Neural Network

TensorFlow Playground

Interactive ANN Visualization

[TensorFlow Playground]

Outline

Introduction

Course
Survey

Introductory
Intermediate
Advanced

TF
Playground

Hardware

Software

Shallow Net

1 An Introduction to Neural Networks and Deep Learning

2 Course Survey

Introductory Units (1-3)

Intermediate Units (4-6)

Advanced Units (7-10)

3 Interactive Visualization of an Artificial Neural Network

4 Hardware Options for DL

5 TensorFlow Jupyter Notebooks within a Docker Container

6 A Shallow Artificial Neural Network

Hardware Options for DL

incl. how to build a DL server

- local machine
 - eGPU
 - (Tesla K80) cloud instance
 - (GTX 1080ti) monster box

Hardware Options for DL

incl. how to build a DL server

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incl. how to build a DL server

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Hardware Options for DL

incl. how to build a DL server

- local machine
- eGPU
- (Tesla K80) cloud instance
- (GTX 1080ti) monster box

Local Machine

Introduction

Course
Survey

Introductory
Intermediate
Advanced

TF
Playground

Hardware

Software

Shallow Net



Remote Cloud Instance

Introduction

Course
Survey

Introductory
Intermediate
Advanced

TF
Playground

Hardware

Software

Shallow Net

[GCP Ubuntu Instance]

Build Your Own Monster Box

Introduction

Course
Survey

Introductory
Intermediate
Advanced

TF
Playground

Hardware

Software

Shallow Net



[PC Part Picker]
[Blog Post]

Unit 1

Introduction

Course
Survey

Introductory
Intermediate
Advanced

TF
Playground

Hardware

Software

Shallow Net



Unit 1

Introduction

Course
Survey

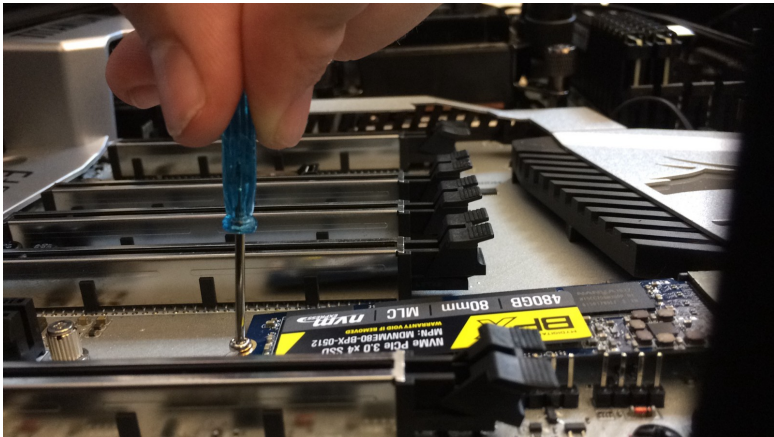
Introductory
Intermediate
Advanced

TF
Playground

Hardware

Software

Shallow Net



Unit 1

Introduction

Course
Survey

Introductory
Intermediate
Advanced

TF
Playground

Hardware

Software

Shallow Net



Unit 1

Introduction

Course
Survey

Introductory
Intermediate
Advanced

TF
Playground

Hardware

Software

Shallow Net



Unit 1

Introduction

Course
Survey

Introductory
Intermediate
Advanced

TF
Playground

Hardware

Software

Shallow Net



Unit 1

Introduction

Course
Survey

Introductory
Intermediate
Advanced

TF
Playground

Hardware

Software

Shallow Net



Outline

Introduction

Course
Survey

Introductory
Intermediate
Advanced

TF
Playground

Hardware

Software

Shallow Net

1 An Introduction to Neural Networks and Deep Learning

2 Course Survey

Introductory Units (1-3)

Intermediate Units (4-6)

Advanced Units (7-10)

3 Interactive Visualization of an Artificial Neural Network

4 Hardware Options for DL

5 TensorFlow Jupyter Notebooks within a Docker Container

6 A Shallow Artificial Neural Network

Software Installation

How did everyone get on?

[installation instructions]

Jupyter Notebooks

+ Docker + Nvidia GPU

[Dockerfile]

Jupyter Notebooks

+ Docker + Nvidia GPU + *TensorFlow*

[Dockerfile]

Introduction

Course
SurveyIntroductory
Intermediate
AdvancedTF
Playground

Hardware

Software

Shallow Net

- 1 An Introduction to Neural Networks and Deep Learning
- 2 Course Survey
 - Introductory Units (1-3)
 - Intermediate Units (4-6)
 - Advanced Units (7-10)
- 3 Interactive Visualization of an Artificial Neural Network
- 4 Hardware Options for DL
- 5 TensorFlow Jupyter Notebooks within a Docker Container
- 6 A Shallow Artificial Neural Network

A Shallow Neural Network

Introduction

Course
SurveyIntroductory
Intermediate
AdvancedTF
Playground

Hardware

Software

Shallow Net



A Shallow Neural Network

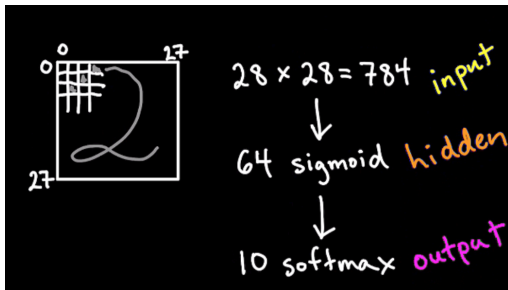
Introduction

Course
SurveyIntroductory
Intermediate
AdvancedTF
Playground

Hardware

Software

Shallow Net



[shallow notebook]