EECE-4710 "IoT and TinyML"

Building Blocks of Deep Learning – Regression with (Dense) Neural Networks

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BE THE DIFFERENCE.

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Machine Learning: Models

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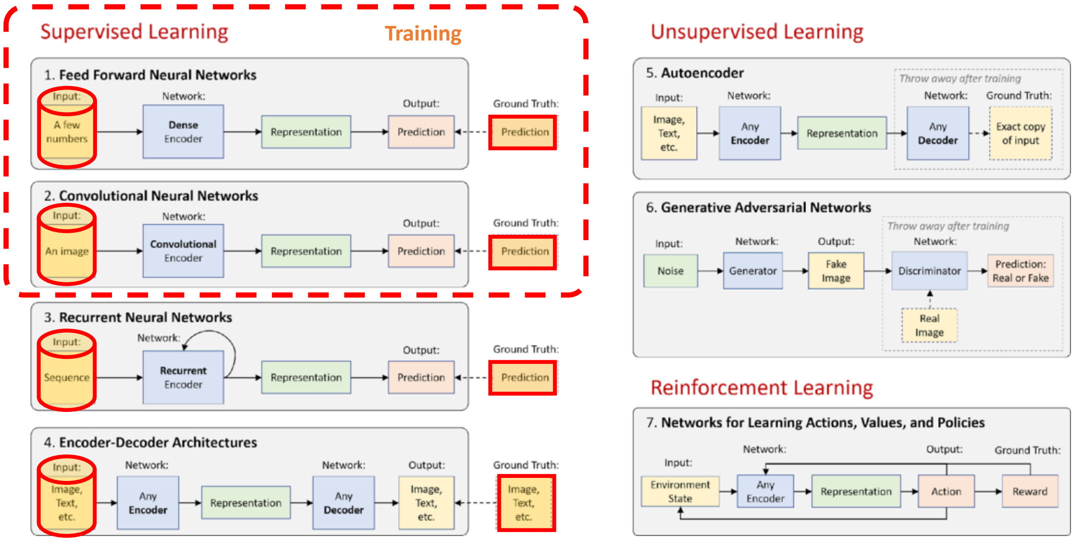
Machine Learning Types and Architectures



Source: Deep Learning Basics: An introductory lecture for MIT course 6.S094 by Prof. Lex Fridman

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Tiny Machine Learning

Supervised Learning

Regression

Classification

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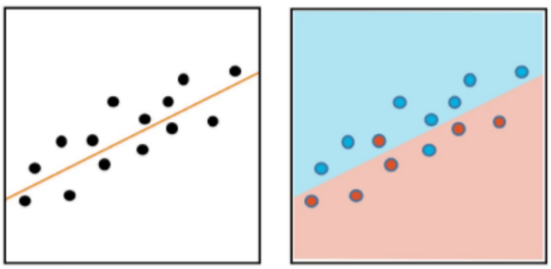
Tiny Machine Learning

Supervised Learning

Regression

Classification



a) Regression   b) Classification

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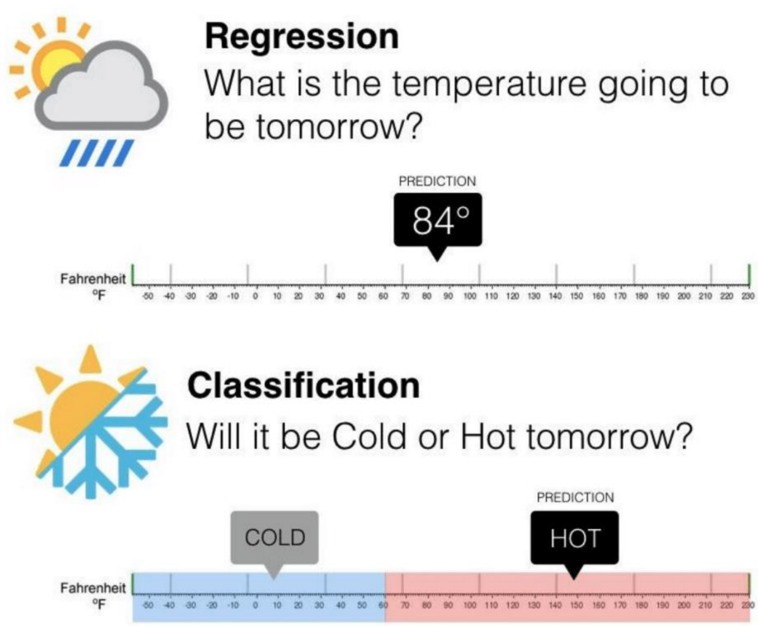
Regression

Classification



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Machine Learning:
Supervised Models - Regression

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X ➡ -1, 0, 1, 2, 3, 4

Y ➡ -3, -1, 1, 3, 5, 7

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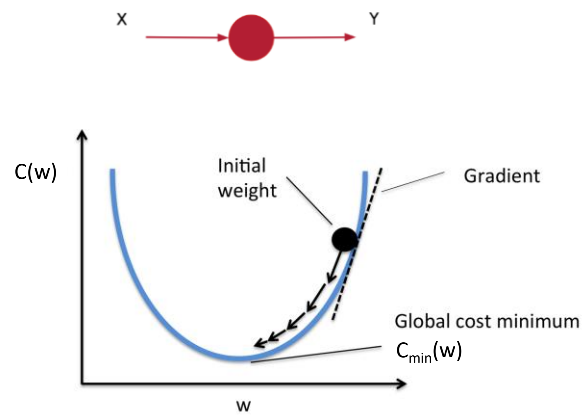
X	Y
-1	-3
0	-1
1	1
2	3
3	5
4	7



$Y = w*X + b$

Cost Function

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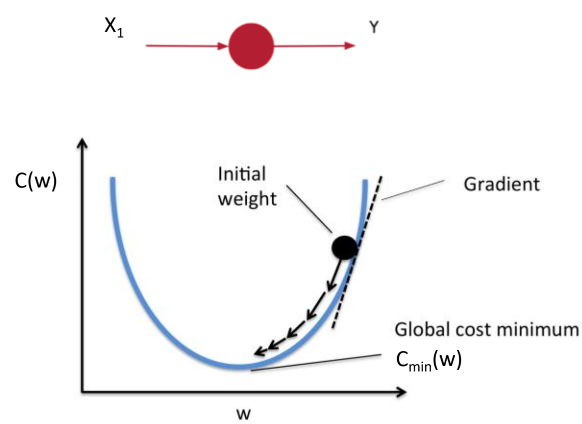
X_1	Y
-1	-3
0	-1
1	1
2	3
3	5
4	7



$Y = w_1 * X_1 + b_0$

Cost Function

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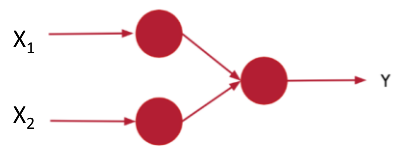
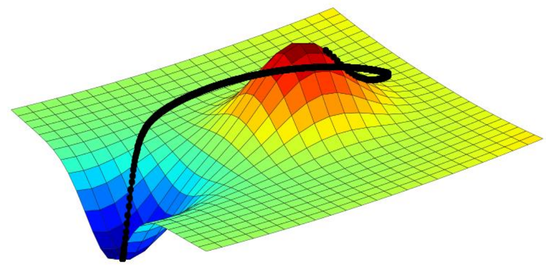
X_1	X_2	Y
-1	-8	-8
0	1	0
1	3	7
2	7	1
3	0	2
4	2	3

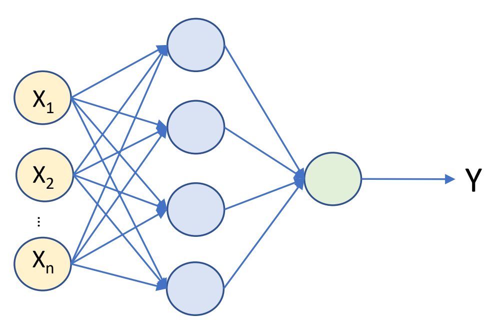




$$Y = w_1 * X_1 + w_2 * X_2 + b_0$$

Cost Function

X_1	X_2	…	X_n	Y
-1	-8		-81	-8
0	1		10	0
1	3		3	7
2	7		7	1
3	0		0	2
4	2		-7	3



$$Y = w_1 * X_1 + w_2 * X_2 + \ldots + w_n * X_n + b_0$$

Machine Learning: Workflow

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Machine Learning Workflow

Collect Data

```
data = tf.keras.datasets.boston_housing

(x_train, y_train), (x_test, y_test) = data.load_data()
```

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Machine Learning Workflow


```
from sklearn.preprocessing import StandardScaler
scaler = StandardScaler()
scaler.fit(x_train)

x_train_norm = scaler.transform(x_train)
x_test_norm = scaler.transform(x_test)
```

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Machine Learning Workflow


```
model = tf.keras.models.Sequential([
    tf.keras.layers.Dense(20,
                          activation='relu',
                          input_shape = [13]),
    tf.keras.layers.Dense(1)
    ])
```

```
model.compile(
    optimizer='adam',
    loss='mse',
    metrics=['mae']
    )
```

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Machine Learning Workflow


```
history = model.fit(
    x_train_norm,
    y_train,
    epochs=1000,
    verbose=0
    )
```

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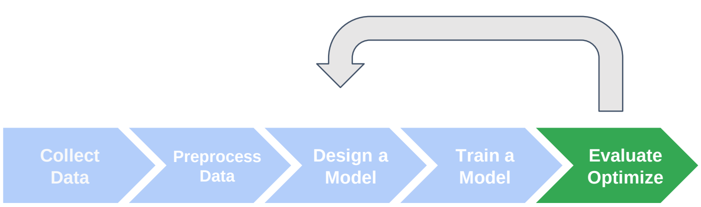
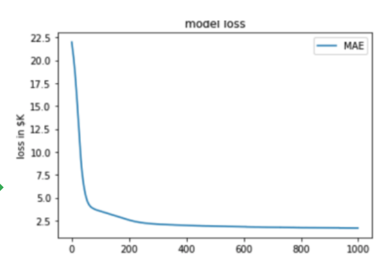
Machine Learning Workflow






```
train_eval = model.evaluate(x_train_norm, y_train)
print ("Training data MSE: {:.2}".format(train_eval[1]))
```

```
tuner.search(
    x_train_norm, y_train,
    epochs=500,
    validation_data=(x_test_norm, y_test))
```

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Machine Learning Workflow


```
xt = np.array([1.1, 0., 9., 0., 0.6, 7., 92., 3.8 , 4., 300., 21., 200, 19.5])
xt = np.reshape(xt, (1, 13))
xt_norm = scaler.transform(xt)
yt = model.predict(xt_norm)
```

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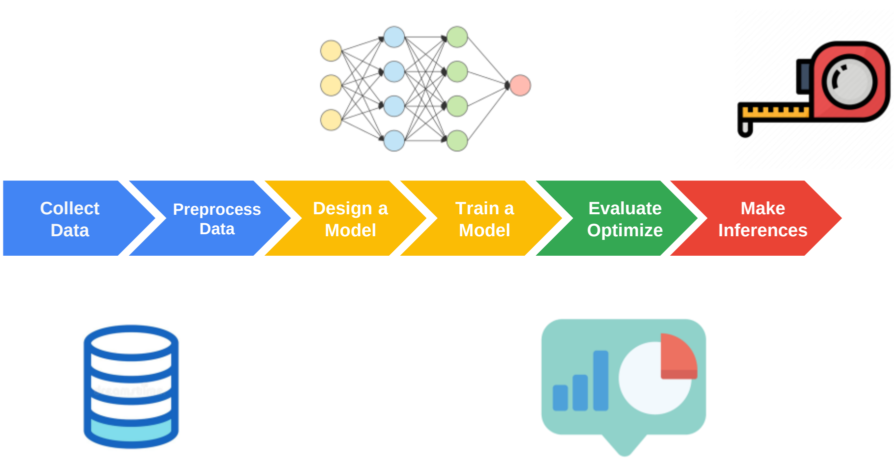
Machine Learning Workflow



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Regression using Dense NN with TF2

Code Time!

TF_Boston_Housing_Regression.ipynb

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Credits

- A previous edition of this course was developed in collaboration with Dr. Susan C. Schneider of Marquette University.
- We are very grateful and thank all the following professors, researchers, and practitioners for jump-starting courses on TinyML and for sharing their teaching materials:
- Prof. Marcelo Rovai - TinyML - Machine Learning for Embedding Devices, UNIFEI
  - https://github.com/Mjrovai/UNIFEI-IESTI01-TinyML-2022.1
- Prof. Vijay Janapa Reddi - CS249r: Tiny Machine Learning, Applied Machine Learning on Embedded IoT Devices, Harvard
  - https://sites.google.com/g.harvard.edu/tinyml/home
- Prof. Rahul Mangharam – ESE3600: Tiny Machine Learning, Univ. of Pennsylvania
  - https://tinyml.seas.upenn.edu/#
- Prof. Brian Plancher - Harvard CS249r: Tiny Machine Learning (TinyML), Barnard College, Columbia University
  - https://a2r-lab.org/courses/cs249r_tinyml/

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References

- Additional references from where information and other teaching materials were gathered include:

- Applications & Deploy textbook: “TinyML” by Pete Warden, Daniel Situnayake
    - https://www.oreilly.com/library/view/tinyml/9781492052036/
- Deploy textbook “TinyML Cookbook” by Gian Marco Iodice
    - https://github.com/PacktPublishing/TinyML-Cookbook
- Jason Brownlee
    - https://machinelearningmastery.com/
- TinyMLedu
    - https://tinyml.seas.harvard.edu/
- Professional Certificate in Tiny Machine Learning (TinyML) – edX/Harvard
    - https://www.edx.org/professional-certificate/harvardx-tiny-machine-learning
- Introduction to Embedded Machine Learning - Coursera/Edge Impulse
    - https://www.coursera.org/learn/introduction-to-embedded-machine-learning
- Computer Vision with Embedded Machine Learning - Coursera/Edge Impulse
    - https://www.coursera.org/learn/computer-vision-with-embedded-machine-learning

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