13.11.25

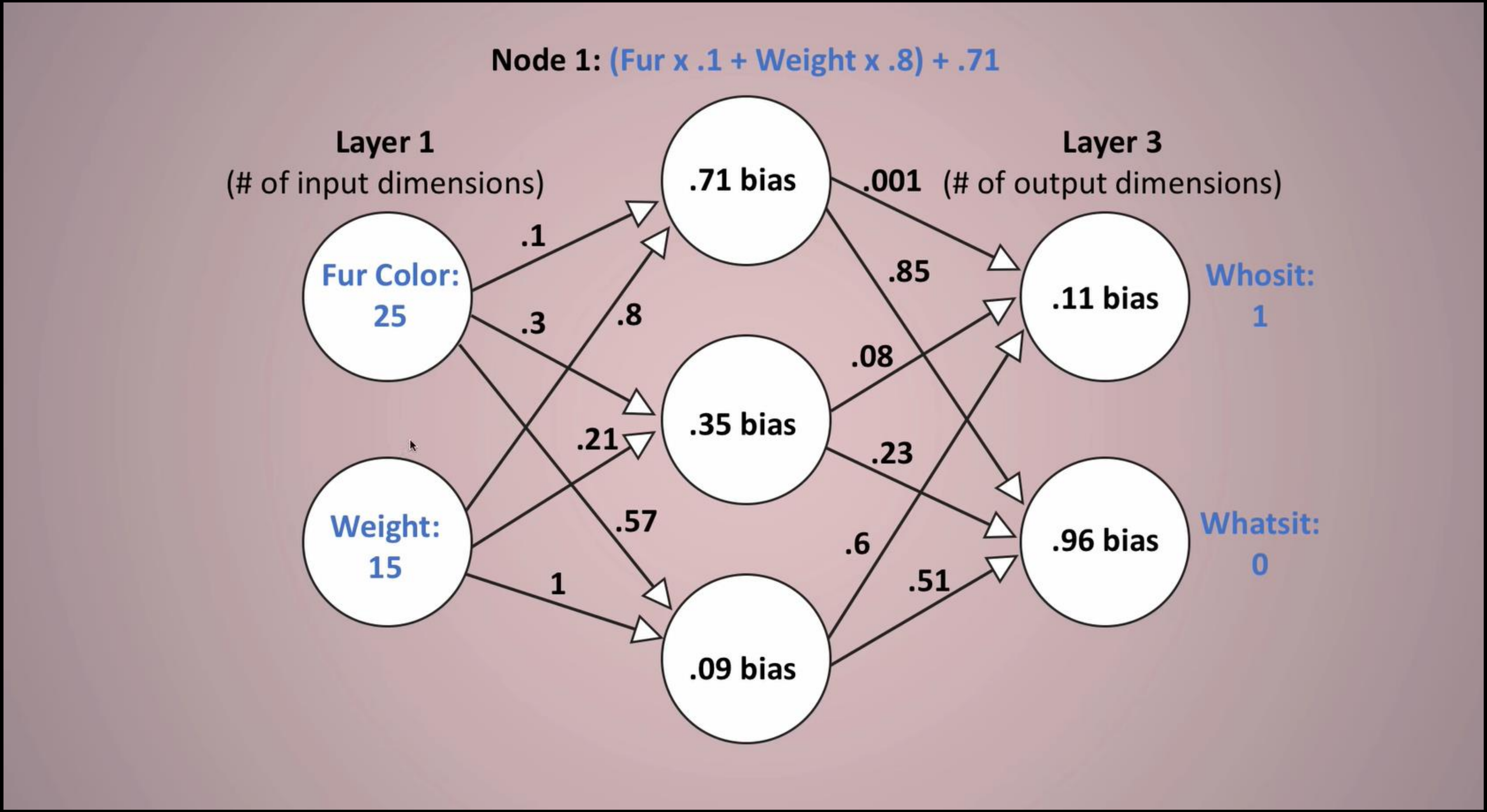
OPENCAMPUS.sh

Introduction to Data Science and Machine Learning

NEURAL NETS

- **Quiz**
- **Frameworks for Implementing Neural Networks (NN)**
- **Data Preparation and Implementation of a NN with TensorFlow**
- **Additional Layer Types for NNs**

QUIZ



LearnCode.academy. (2018, June 11). *Neural Networks Explained—Machine Learning Tutorial for Beginners*. https://www.youtube.com/watch?v=GvQwE2OhL8I

Learning Rate:

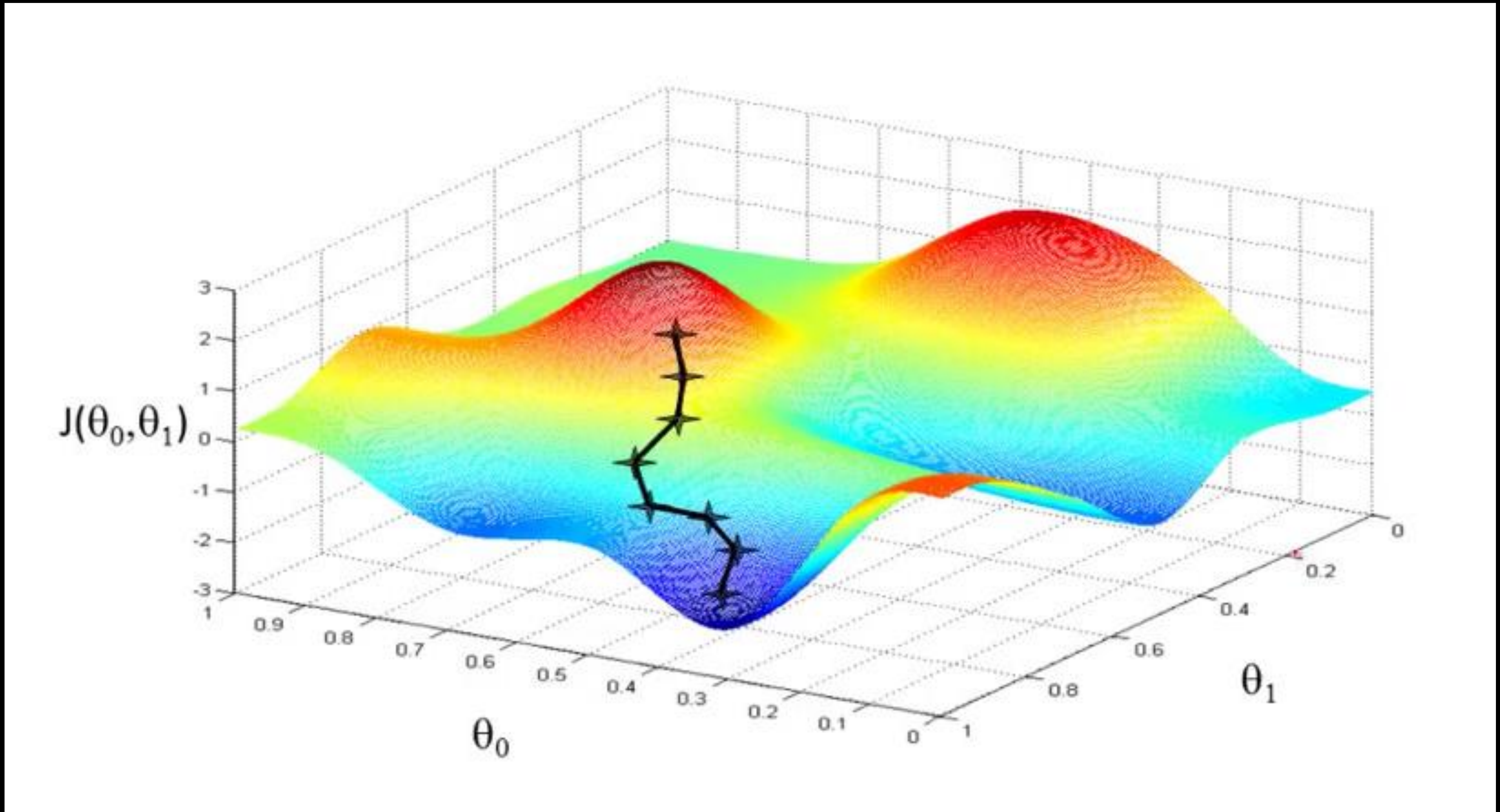
How much should this step outcome affect our weights and biases?

Momentum:

How much should past outcomes affect our weights and biases?

change = (learningRate * delta * value) + (momentum * pastChange)

OPTIMIZER PARAMETERS



Quelle: https://www.coursera.org/learn/machine-learning

- **Step size for approaching the cost minimum ("Learning Rate")**
- **Resistance to direction changes ("Momentum")**

PARAMETERS OF THE "ADAM" OPTIMIZER

- **Learning parameter for optimization:**
  alpha (learning rate)

- **Proportion of current gradient in calculating the next optimization step:**
  - **beta1 (decay rate for the direction) and**
  - **beta2 (decay rate for the magnitude of gradients)**

(UN-) IMPORATANT HYPERPARAMATERS IN NEURAL NETS

- Architecture Definition:
  - Number of hidden layers in the network
  - Types of hidden layers
  - Number of neurons per hidden layer
  - Selection of activation function

- Selection of the optimizer

- Setting of the learning rate for the optimizer

LIBRARIES FOR NEURAL NETS

Keras

TensorFlow

scikit learn

PYTORCH

Transformers

- **TensorFlow 0.1 (Nov 2015):** Released as open source software by Google; developed by the Google Brain Team for internal research and production)
- **TensorFlow 1.4 (Nov 2017):** Development of the Keras API as a high-level API for TensorFlow and other ML libraries, to increase user-friendliness for commonly used models.
- **TensorFlow 2.0 (Sep 2019):** Keras is integrated as a high-level API into TensorFlow.
- **TensorFlow 2.3 (October 2020):** Significant performance improvements, distributed training, quantized training, and improved mobile deployments.
- **Keras 3.0 (Dec 2023):** Major release that extends support for multiple backends, including TensorFlow, JAX, and PyTorch, making Keras a versatile framework for various deep learning needs.

🤗 Transformers

- **Transformers 0.1 (November 2018):** Initial open-source release providing an implementation of BERT in Pytorch.
- **Transformers 1.0 (July 2019):** Inclusion of other models beyond BERT
- **Transformers 2.0 (July 2019):** Inclusion of the TensorFlow framework
- **Transformers 3.0 (June 2020):** New Tokenizer API, enhanced documentation & tutorials
- **Transformers 4.0 (November 2020):** Fast tokenizers and file re-organization
- **Transformers 4.x Series (2020-Present):**
  - 56 minor release until today
  - supporting state-of-the-art architectures: LLaMA, Mistral, Gemma, Qwen, Phi, and many others
  - advanced multimodal capabilities (vision-language, audio-text, video understanding)

DATA PREPARATION

For every modeling, the data must have the following properties:

1. There must be no missing values.
2. All values must be numbers.
3. Categorical variables are one-hot encoded.

EXAMPLE DATA PREPARATION FOR THE TRAINING OF A NEURAL NET

Import Libraries and Data

```python
# Import necessary libraries
import pandas as pd
import numpy as np
import os

# Import Data
data = pd.read_csv("https://raw.githubusercontent.com/opencampus-sh/einfuehrung-in-data-science-und-ml/main/house_pricing_data/house_pricing_train.csv")
data.head()  # Print first few rows to verify
```

[1] ✓ 5.5s Python

	id	date	bedrooms	bathrooms	sqft_living	sqft_lot	floors	waterfront	view	condition	...	sqft_above	sqft_basement	yr_built	yr_renovated	zipcode	lat	long	sqft_livi
0	6840701095	20150403T000000	3	1.00	1740	4400	1.5	0	0	3	...	1740	0	1924	0	98122	47.6059	-122.300	
1	1025049114	20140717T000000	3	2.25	1270	1566	2.0	0	0	3	...	1060	210	2014	0	98105	47.6647	-122.284	
2	4025300360	20150326T000000	3	2.00	1130	16875	1.0	0	0	4	...	1130	0	1947	0	98155	47.7489	-122.300	
3	5536500200	20140918T000000	5	3.50	3760	4857	2.0	0	3	3	...	2820	940	2004	0	98072	47.7398	-122.167	
4	1245003660	20150321T000000	3	2.00	1470	6000	1.0	0	0	3	...	1090	380	1950	1996	98033	47.6829	-122.202	

5 rows × 21 columns

Data Preparation

```python
# Define categorical features
categorical_features = ['bathrooms', 'zipcode', 'condition']

# Inspect data types and unique values for categorical columns
print(data[categorical_features].dtypes)
print("Unique Values:\n",data[categorical_features].apply(lambda x: x.unique()))
```

EXAMPLE DEFINITION AND OPTIMIZATION OF A NEURAL NET

Importing the Data

We will start by importing the data and taking a look at the first few rows.

```python
# Import the necessary libraries
import pandas as pd

# Define the file paths
subdirectory = "pickle_data"
training_features_path = f"{subdirectory}/training_features.pkl"
validation_features_path = f"{subdirectory}/validation_features.pkl"
test_features_path = f"{subdirectory}/test_features.pkl"
training_labels_path = f"{subdirectory}/training_labels.pkl"
validation_labels_path = f"{subdirectory}/validation_labels.pkl"
test_labels_path = f"{subdirectory}/test_labels.pkl"

# Read the pickle files
training_features = pd.read_pickle(training_features_path)
validation_features = pd.read_pickle(validation_features_path)
test_features = pd.read_pickle(test_features_path)
training_labels = pd.read_pickle(training_labels_path)
validation_labels = pd.read_pickle(validation_labels_path)
test_labels = pd.read_pickle(test_labels_path)

# Verify the loaded data by printing their shapes and a few rows
print("Loaded Training features dimensions:", training_features.shape)
print("Loaded Validation features dimensions:", validation_features.shape)
print("Loaded Test features dimensions:", test_features.shape)
print()
print("Loaded Training labels dimensions:", training_labels.shape)
print("Loaded Validation labels dimensions:", validation_labels.shape)
print("Loaded Test labels dimensions:", test_labels.shape)
print()
```

BREAKOUT

- Load the example notebooks from below into your Codespace and run them once unchanged.

- Supplement your data preparation with the steps performed in this example notebook:
  1) One-hot encoding of categorical variables
  2) Removing cases with missing values
  3) Export of training and validation data as pickle files

- Estimate a first neural network based on this example notebook.

BATCHES, STEPS AND EPOCHS

Batch

- **The entire set of training data is divided into separate subgroups of equal size.**
- **The standard batch size in TensorFlow is 32.**

Step

- **A single iteration of gradient descent performed on one batch of data, during which all model weights are updated once.**

Epoch

- **Optimization of the model using the complete training data:**
  Number of Steps × Batch Size = Training Sample Size
- **Depending on the model, very few epochs may suffice, or several hundred or thousand may be needed for optimization.**

NORMALIZATION

Definition:

- **Subtracting the mean and dividing by the standard deviation.**

Ensures all input features are on similar scales, which stabilizes training and speeds up convergence.

BATCH NORMALIZATION

- Performing normalization at the batch level

Additional optimization parameters:

- Exactly identical means and standard deviations are not necessarily optimal for modeling purposes

→ Normalization parameters are incorporated as trainable parameters

LEARNING RESSOURCES

- Watch this video (7 minutes) to better understand the properties of dropout layers.
- Watch this video (5 minutes) to better understand the benefits of normalization.
- Complete the first chapter of this course on DataCamp to learn about identifying missing values.

TASKS

- Examine all your model variables for the existence of missing and implausible values.
- Prepare your dataset by correctly encoding all categorical features and removing all rows with missing values.
- Train a first neural network for your dataset.
(Delete all rows with missing values.)