15-319 / 15-619 Cloud Computing

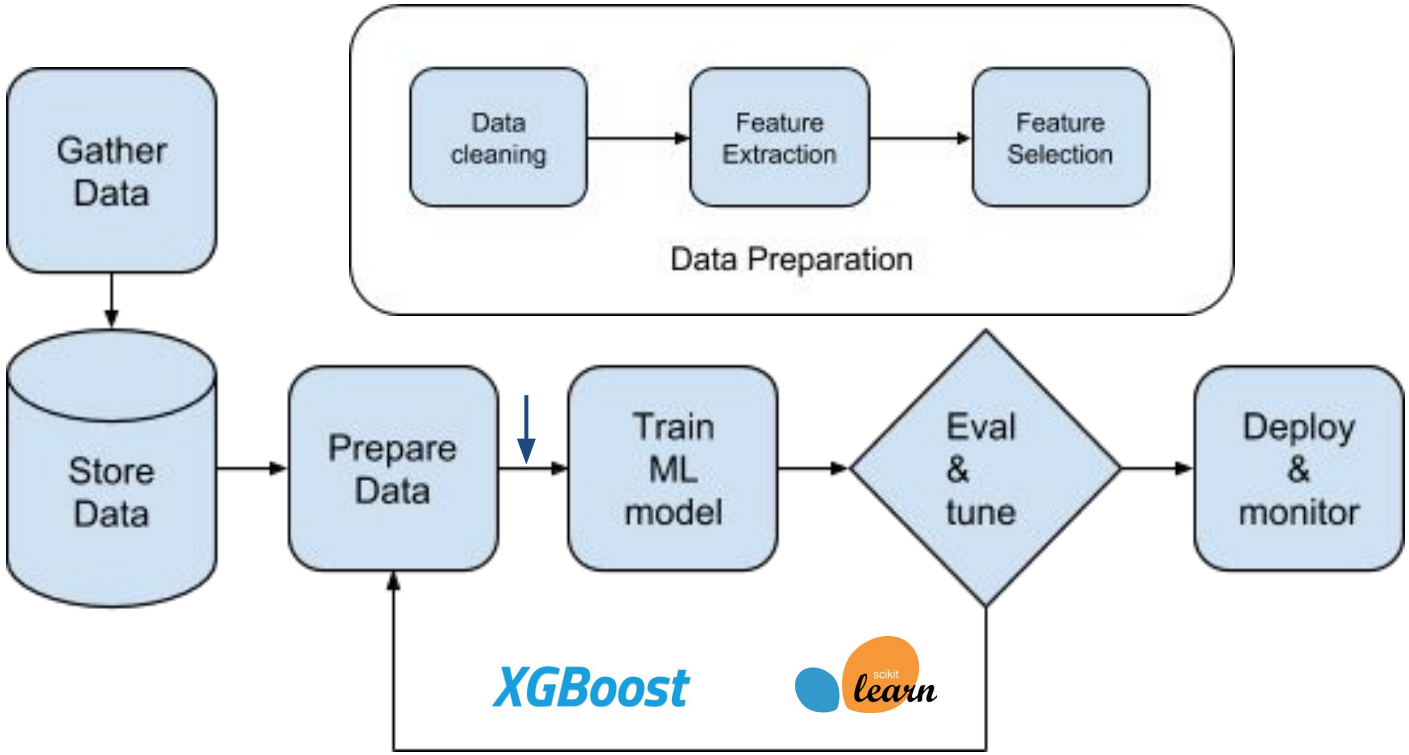
Overview 12

April 12th 2022

Overview

- **Last week's reflection**
  - Team Project Phase 2, Phase 3
  - Quiz 10
- **This week's schedule**
  - Unit 5 - Modules 21, 22
    - Quiz 11
  - Project 6
    - Machine Learning on the cloud
  - **Twitter Analytics: The Team Project**
    - Phase 3
      - Managed Web Service

Machine Learning in Production

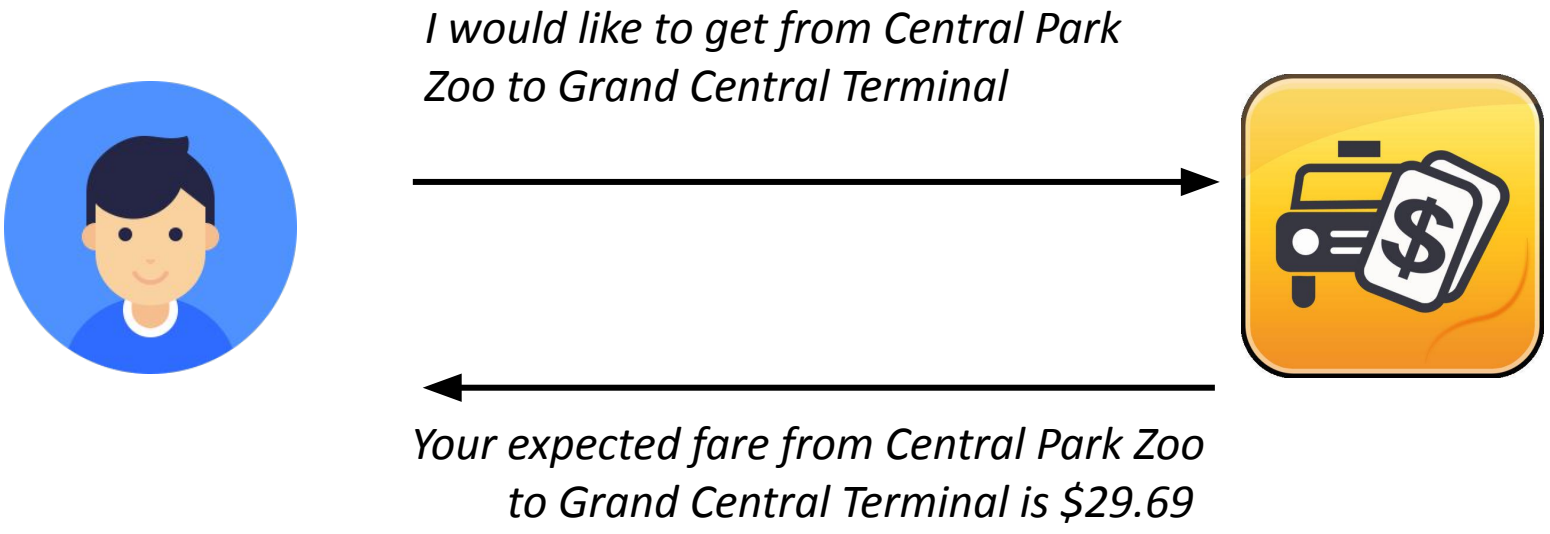


ML on Managed Services

- Model training on large datasets tends to be computationally intensive
- An increasingly affordable option for users without specialized IT infrastructure is to process ML workloads on the cloud with Managed Services like the Google AI Platform.
- Benefits:
  - No need to provision and configure virtual machines
  - Horizontal and vertical scaling is possible
  - No need to write custom logic to orchestrate multiple workers and achieve parallel training
  - Deploy your model to the cloud

P6 - Taxi Fare Prediction Application

- Accepts speech queries with origin and destination, returns fare estimate as speech



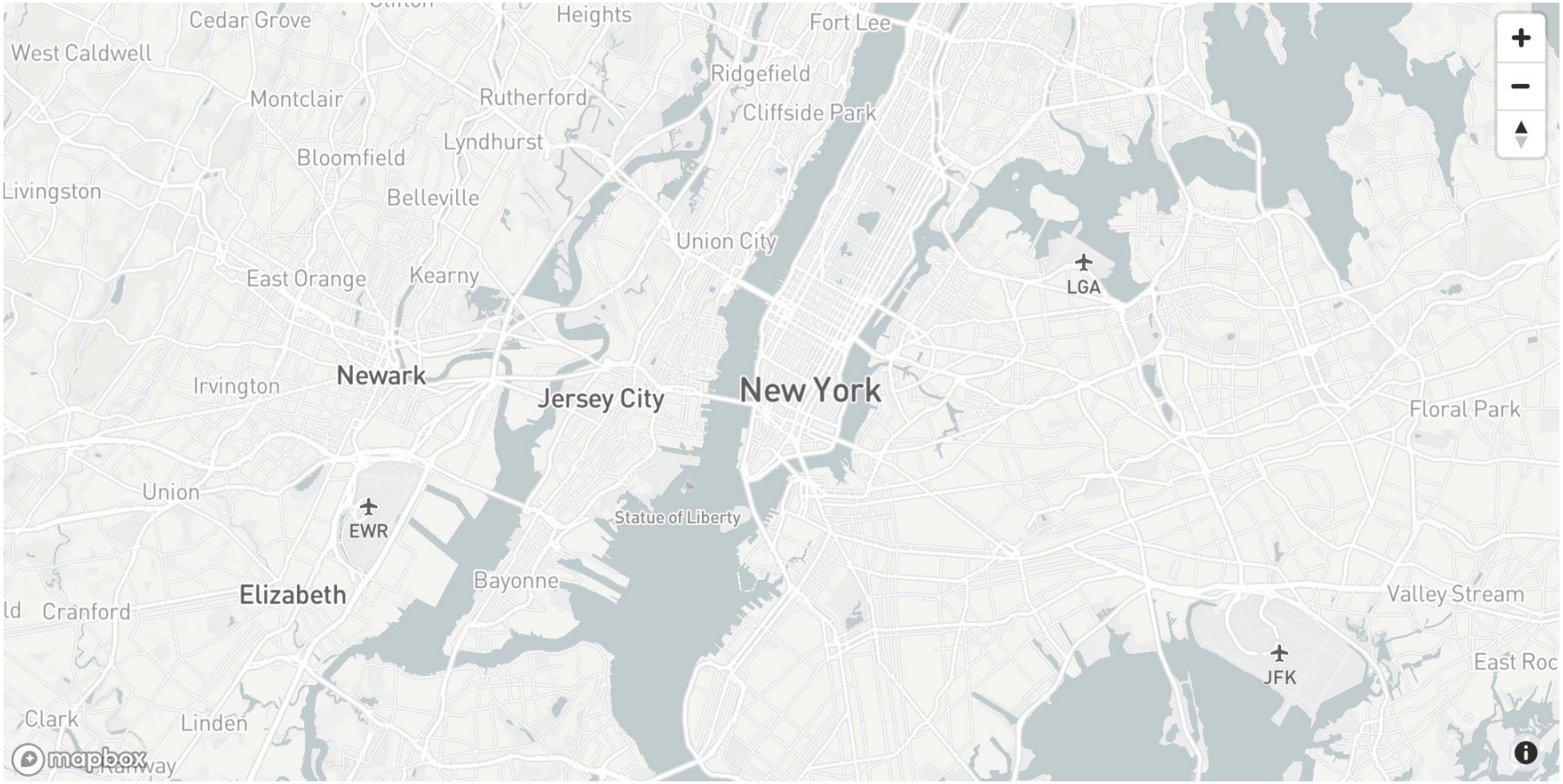
P6 - Overview of Tasks

- Task 1: Data Visualization and Feature Engineering
- Task 2: Training, hyperparam tuning, deploying your model using the Google AI Platform and serving queries.
- Task 3: Stitch together services into a pipeline to build a user-facing interface for fare predictions.
- Bonus:
  - Use Cloud Vision API to identify NYC landmarks
  - Use AutoML to train a custom model that accepts custom landmarks as input for prediction

Task 1: Feature Engineering - Data Visualization

- You are given a small training dataset containing historical data of fare prices in New York City.
- Steps to perform
  - Data exploration and visualization
  - Understand the data for Feature Engineering with regards to feature construction, data cleaning, etc.

Task 1: Feature Engineering - Data Visualization



Task 1: Feature Engineering

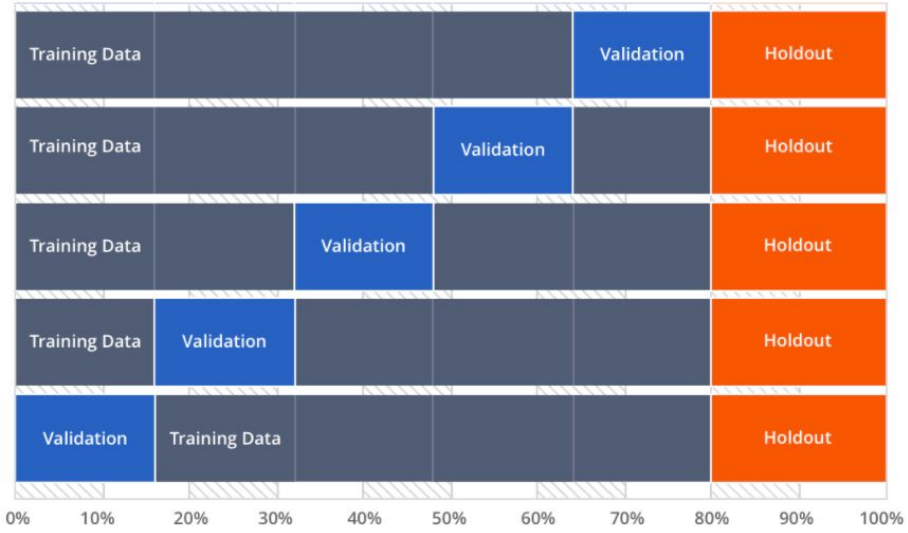
- You are given a small training dataset containing historical data of fare prices in New York City
- Steps to perform
  - Clean the data and remove outliers
    - Consider what you learned from the data visualization task
  - Extract or construct meaningful features that will improve performance over the baseline model (which uses raw features with no transformations)

Task 1: Feature Engineering

- Feature engineering = transforming domain knowledge into better features
- Some ideas for feature engineering
  - Calculate distance from the geo-coordinates
  - Calculate distance to landmarks
  - What are good proxies for traffic conditions?

Task 1: Feature Engineering

- Evaluating your model
  - Metric: Root Mean Squared Error (RMSE)
  - K-fold Cross-Validation
    - Used to assess the predictive performance of the model outside the training sample on unseen data



  - Plot feature importance

Task 2: Training, Tuning & Deploying

- Train and tune the model on complete dataset on Google AI Platform.
- Deploy the trained model to AI Platform.
- Develop a Flask application that accepts web requests and returns fare predictions.
  - Transform raw features from web requests using the feature engineering solution developed in Task 1.
  - Make API calls to the model hosted on AI Platform
  - Format and return a web response
- Deploy the Flask application on Google App Engine.

Task 2: Tuning with Google AI Platform

- **Hyperparameter Tuning**
- Parameters v/s. Hyperparameters
  - Parameters: internal, often not set by the practitioners
  - Hyperparameters: external, often set by the practitioners before training
    - Basically, configuration parameters that impact the training process
- Finding optimal hyperparameters with an exhaustive Grid Search is expensive

Task 2: Tuning with GCP HyperTune

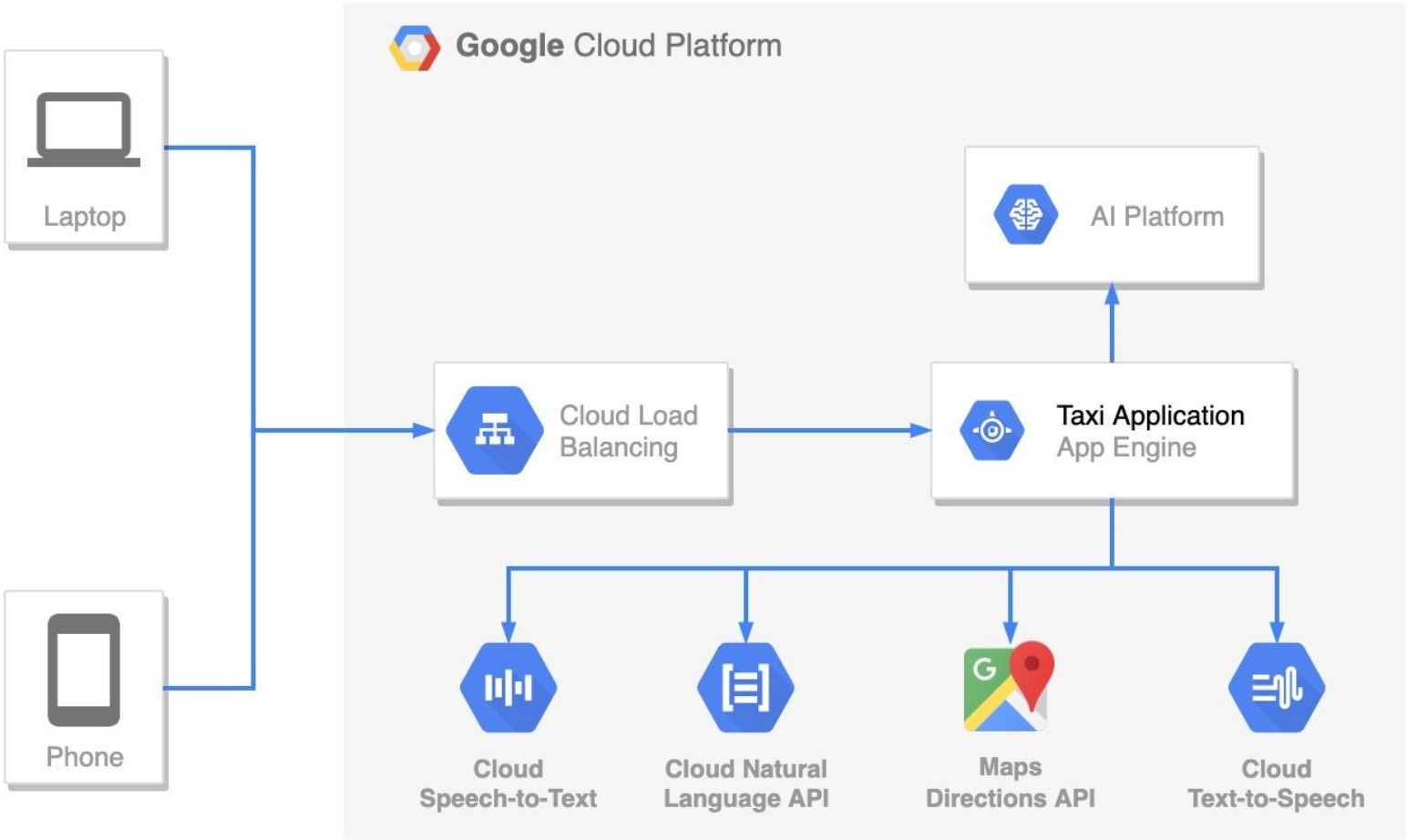
- Black box optimization service (does not need access to the underlying model)
- Need to specify a config yaml file that describes which hyperparameters to tune
- Uses a method called Bayesian Optimization to efficiently search through different combinations of hyperparameters

Task 2: Deploying Model to AI Platform

- **To get a full score in this task, you need to:**
  - Enable HyperTune, add at least 3 additional parameters to tune, run the hypertuning job and create a model on Google AI Platform.
  - Deploy the fare prediction application to GAE that uses the model you created and serves web requests correctly.
  - The predictions should achieve a target accuracy, measured by RMSE.

Task 3: ML Application Pipeline

- Build an end-to-end application pipeline to predict car fare requests using the following architecture.



Task 3: ML Application Pipeline

- Your application will include multiple APIs
  - Functional APIs to be implemented
    - **/predict -** Generate fare predictions for a JSON array of inputs
    - **/speechToText -** Convert WAV audio to text string
    - **/textToSpeech -** Convert text string to WAV audio
    - **/namedEntities -** Identify landmarks in a given sentence
    - **/directions -** For two given NYC landmarks, determine the latitude / longitude for each pickup and drop off pair

Task 3: ML Application Pipeline

Putting it together:

- **/farePrediction** - Given a WAV audio ride request, determine the predicted fare
  - **Response**
    - { "**predicted_fare**": "23.78",
      "**entities**": ["Charging Bull", "Carnegie Hall"],
      "**text**": "Your expected fare from Charging Bull to Carnegie Hall is $23.78",
      "**speech**": <BASE64 ENCODED AUDIO> }

- General solution flow
  - Speech to text ride request (/speechToText)
  - Extract entities from text ride request (/namedEntities)
  - Get the coordinates of the pickup and drop off locations (/directions)
  - Query the AI Platform model to get the predicted fare (/predict)
  - Convert the text response to speech (/textToSpeech)

Bonus: Landmark Recognition

- (5 points) Use Cloud Vision to identify NYC landmarks
- (5 points) Add unique destinations using AutoML

- **/farePredictionVision**
  - Unlike **/farePrediction**, the ride request will not be sent as WAV audio
  - The API will accept the source and destination as images of NYC landmarks
  - Must query the Cloud Vision API and custom AutoML model to determine the landmark names
  - Continue with the same request as **/farePrediction**

Bonus: Landmark Recognition

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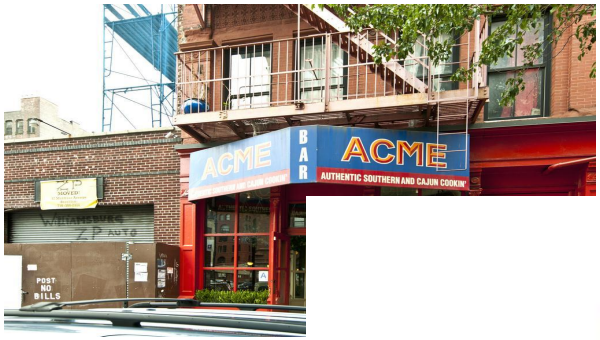
Bonus: Landmark Recognition



Cloud AutoML Vision

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Hints

- Task 1: Feature transformation
  - The exact same feature transformations must be applied to the training and the test set
  - Don’t use stateful functions, for example:
    - get_dummies()
    - df.qcut()
  - Store state like bin ranges and categorical values to apply the transformation consistently
  - Jupyter: command not found (use virtualenv)

Hints

- Task 2: HyperTune
  - Read the XGBoost hyperparameter doc to understand which hyperparameters can help most.
  - You can change the number of workers for the AI Platform training job to parallelize the training process.
  - Learn to make good estimates for the cost for each run
    - Cost = Consumed ML Units * $0.49

Issues to Consider

- Overfitting
  - RMSE on training data is much lower than test data
  - You should not filter outliers just because it makes your cross validation scores look better, since some of these records may be representative of the patterns in the real world.
    - Students who do this may pass Task 1, but will fail Task 2.
    - You should make sure you have good features first, before trying to play around with filtering outliers.

Upcoming Deadlines

- Project 6: Machine Learning on the Cloud
  - Due Tuesday, April 26, 2022, 11:59 PM ET
- Team Project: Phase 3
  - Live-test:
    - Sunday, April 17, 2022 3:00 PM ET
  - Code and report due:
    - Tuesday, April 19, 2022 11:59 PM ET