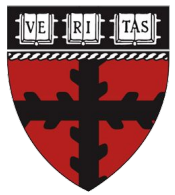
Lecture 1: Introduction

AC215

Pavlos Protopapas
SEAS/Harvard



Outline

1. Why should you take this class and why not?
2. Who are we?
3. Course structure and activities?
4. Class organization (Workload, Logistics, Grades).

Projects

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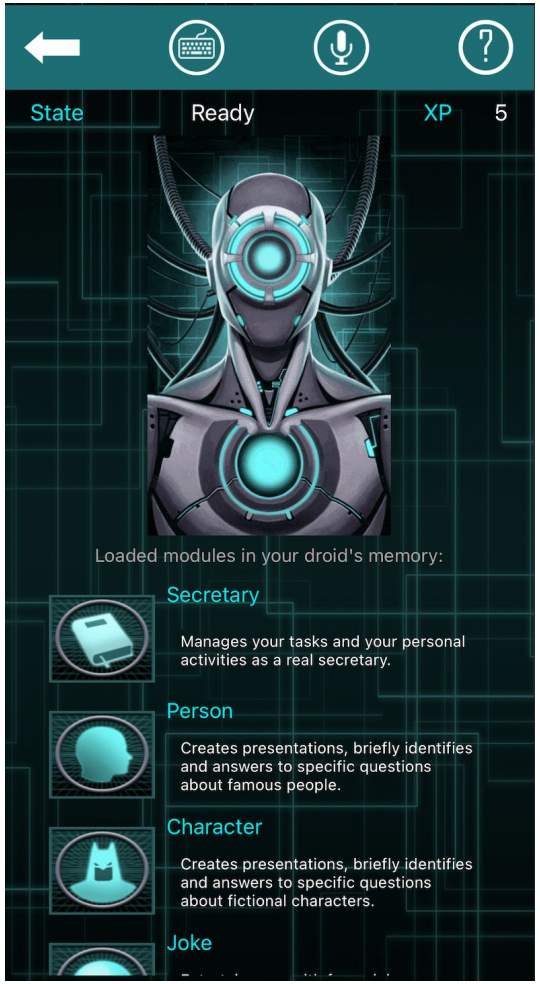
Projects

Why you should take this class

So you can build awesome apps like this:



- https://runwayml.com/
- https://www.databot-app.com/

Why you should take this class

Because you want to learn how to:

- Put your models in production
- Build an application using your models
- Take advantage of available models
- Integrate and orchestrate applications
- Deploy increasing amount of data

Reasons This Course May Not Be For You

1. Lack of Commitment: This course demands full engagement with materials and projects.

2. Expectation of a Traditional Lecture Format: This is a project-based course, with a focus on hands-on learning.

3. Limited Background in Prerequisites: If you are unfamiliar with key concepts from CS109A/B such as:
   - Basic Machine Learning
   - CNNs, RNNs, Autoencoders, GANs, etc.
   - Basic shell commands.

Why you shouldn’t take this class

4. Unwillingness to Receive and Apply Feedback: We provide detailed feedback on your projects, expecting you to implement changes in subsequent milestones.

5. Seeking a "Easy A": While project-based courses may seem easier, we hold rigorous evaluation standards.

Motivation

Mckinsey Global Survey findings on Adoption of AI shows nearly 25% year over year increase in the use of AI. 50% of companies spend between 8 and 90 days deploying a single AI model, with 18% taking longer than 90 days. A report by IDC that surveyed 2,473 organizations and their experience with ML found that a significant portion of **attempted deployments fail**, quoting **lack of expertise**, as one of the key factors.[1]

[1] https://arxiv.org/pdf/2011.09926.pdf

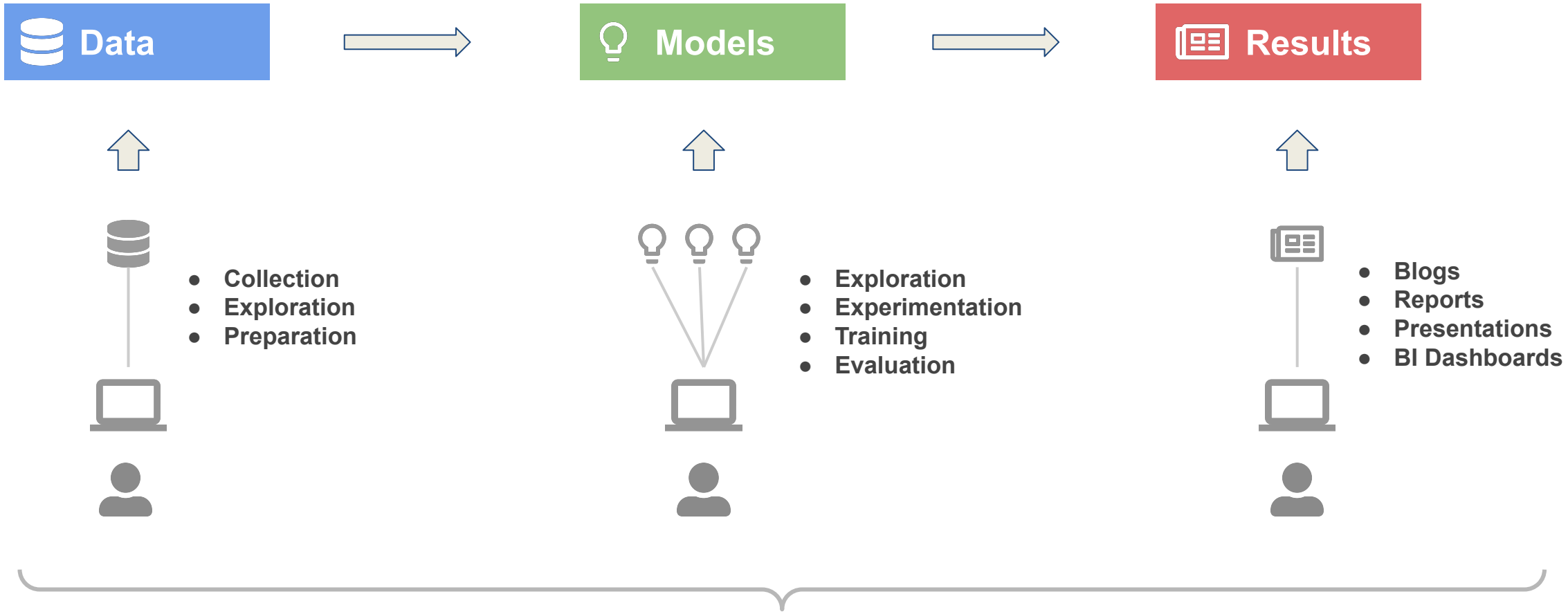
Motivation

A recent International Data Corporation (IDC) survey of global organizations that are already using artificial intelligence (AI) solutions found only 25% have developed an enterprise-wide AI strategy. At the same time, half the organizations surveyed see AI as a priority and two thirds are emphasizing an "AI First" culture.

IDC: https://www.idc.com/

Data Science Series to Real World

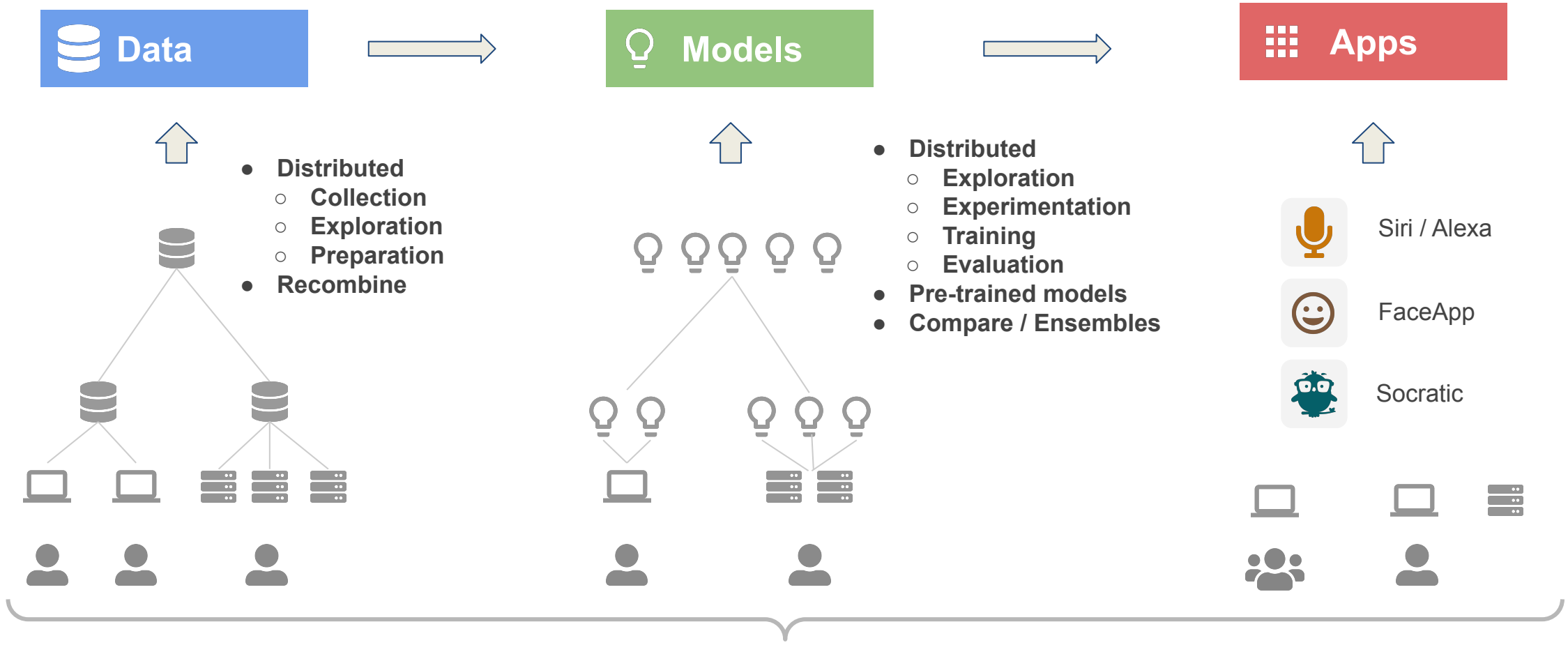
Data Science Series CS109 A/B



Single developer on one computer. Projects are individual to 2-3 member team.

Data Science Series to Real World

Real World



Team of developers on single/ multi node clusters on a Cloud Platform. Projects are 5+ member teams

Data Science Series to Real World (cont)

Challenges:

- Required Installations for Specific Operating Systems
- Guidelines for Code Collaboration
- Methods for Sharing Datasets and Models
- Requirements for Multi-GPU Usage or Extended Training Sessions
- Automation of Data Gathering and Model Training
- Onboarding Procedures for New Team Members
- Resolving "It Works on My Machine" Issues ¯_(ツ)_/¯

Ops for Machine / Deep Learning

Development Operations (DevOps):

Unifies software development (Dev) & operations (Ops) for efficiency.

Machine / Deep Learning Operations (MLOps):

Integrates ML/DL model development with app development & operations.

MLOps - Tasks

Machine / Deep Learning:

- Data collection & exploration
- Model exploration & selection
- Training & evaluation
- Distillation & compression

Application Development:

- APIs / Model serving
- ML integration
- Web & mobile apps
- Edge device apps
- Automation scripts

Operations:

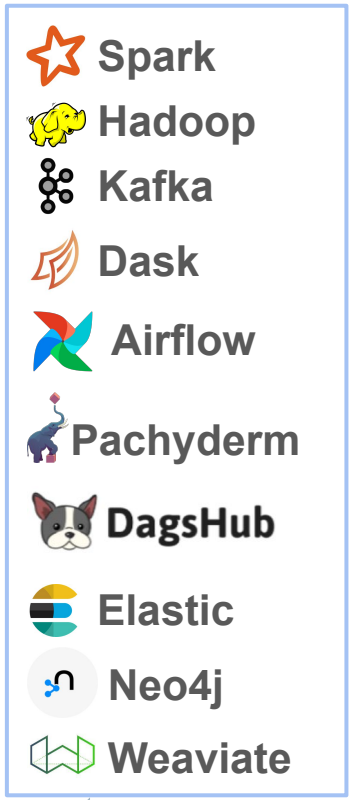
- Provisioning and managing deployment servers, on-demand GPU servers
- Maintain 100% uptime of app / apis
- CI/CD: Continuous Integration / Deployment
- Continuous Data Collection / Model Training
- Model/data monitoring
- Model/data versioning
- ML Workflow Management

MLOps - Tech Stack

Data Engineers | Data Scientists | Software Engineers | Systems Engineers

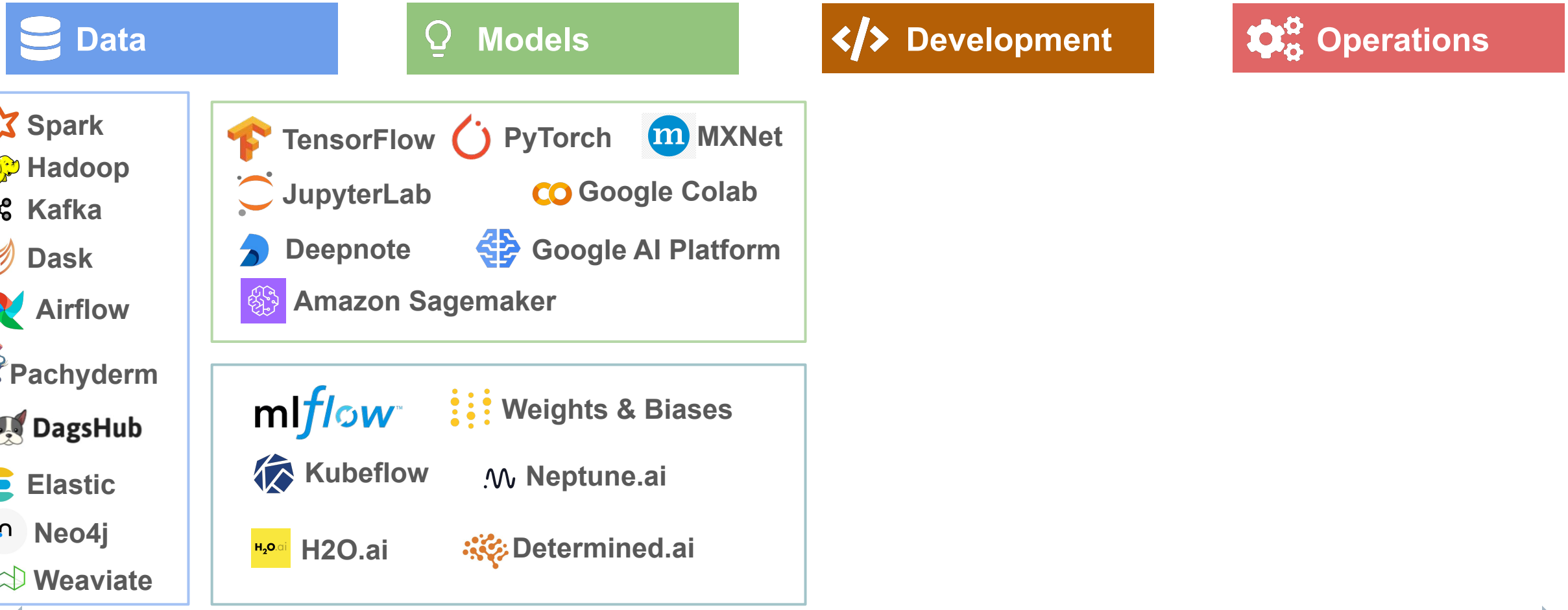
MLOps - Tech Stack

Data | Models | Development | Operations

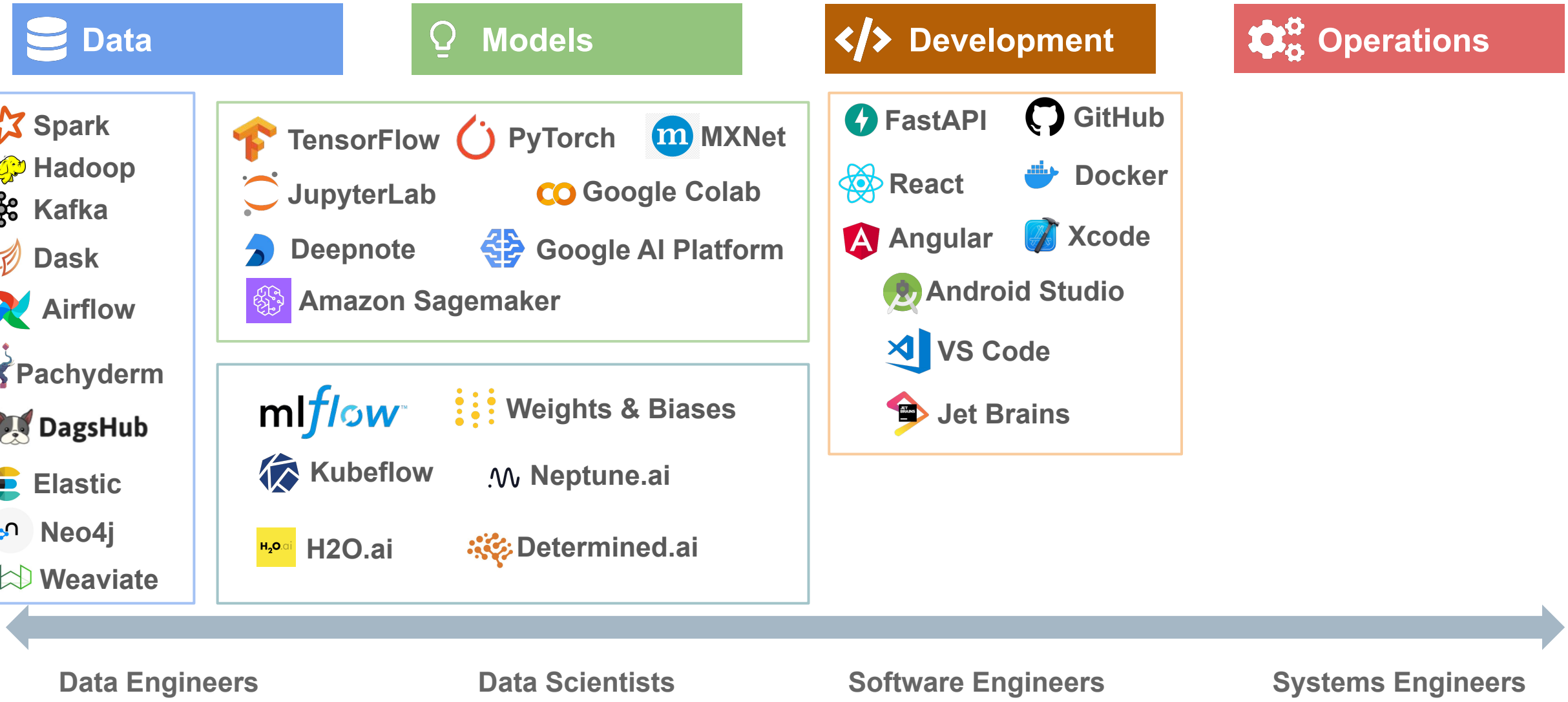


Data Engineers | Data Scientists | Software Engineers | Systems Engineers

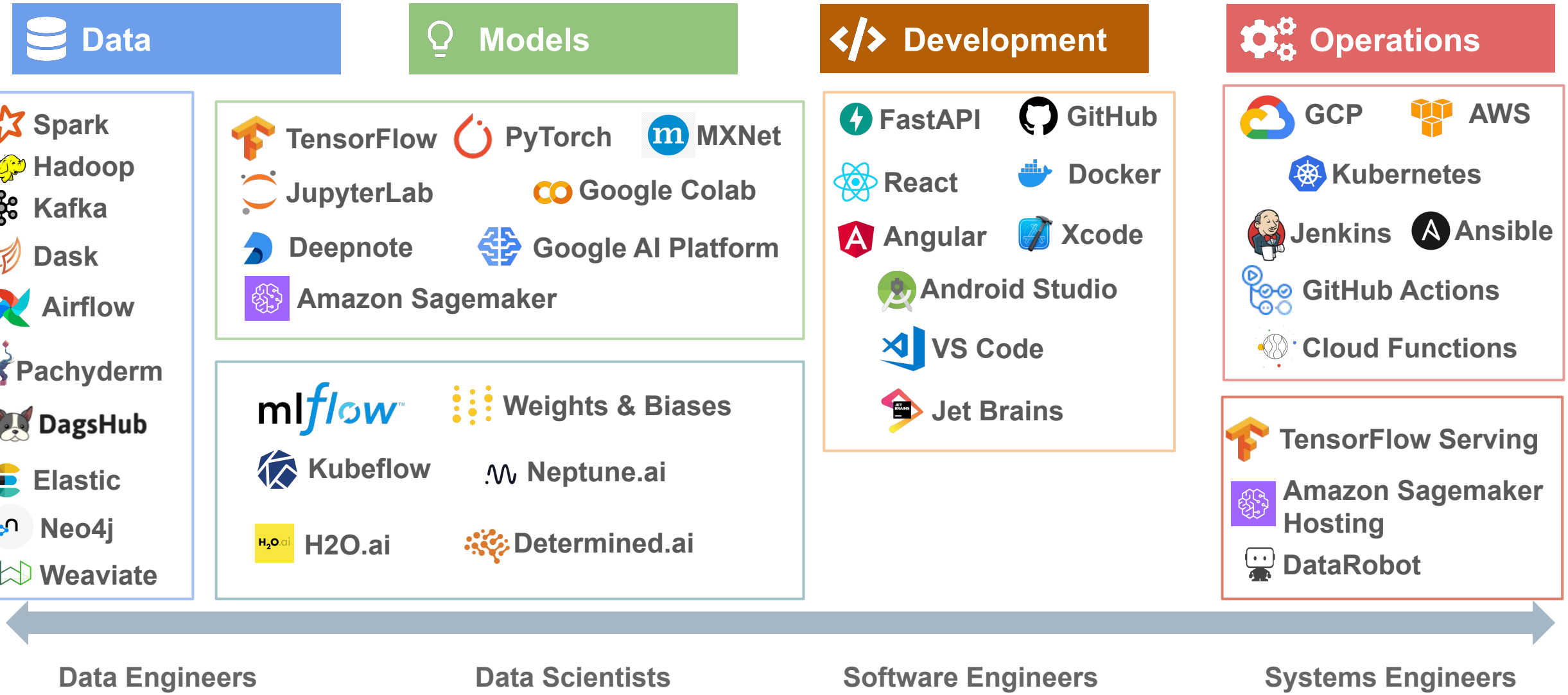
MLOps - Tech Stack



MLOps - Tech Stack



MLOps - Tech Stack



MLOps - Tech Stack

Deep Learning

Framework:
TensorFlow

Training:
Google Colab
Kubeflow

Tracking:
W&B
Custom

Development

APIs:
FastAPI
TF Model Serving

Frontend:
HTML
React

IDE:
VS Code
IDE of choice

Operations

Source Control:
GitHub

Containerization:
Docker

Cloud Provider:
Google Cloud Platform

Continuous Integration/ Deployment:
GitHub Actions, Ansible

Scaling:
Kubernetes

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Projects

Who? The Astro-AI-Statistician Who Rocks The Kitchen!

Roles:

- The Science Wizard: Scientific Director of IACS.
- Course Maestro: Instructs CS109a, CS109b, and AC215 like a boss.
- Astro-Guru: Stoked about the next-gen telescopes that are about to revolutionize our view of the universe!

Research Lab:

- StellarDNN Maverick: Tackles cosmic mysteries where astronomy, ML, and stats collide!
- His Interests? Cracking open differential equations with deep neural networks, being a detective in deep neural network inference, and teaching NLP techniques to chat with stars (well, in astronomical time series analysis, but let's keep it jazzy!).

Who? The Astro-Statistician Who Rocks The Kitchen!

Fun Facts:

- Musical Soul: Classical tunes and opera are his jam. The Boston Symphony Orchestra is his second home!
- Culinary Artist: Holds a cooking badge of honor from Le Cordon Bleu and enjoys both whipping up a storm and devouring the results.
- Adventure Junkie: From biking up mountains to skiing down them, from kayaking to hooking fish mid-air—this professor is always on the go!

Who ?

Rashmi Banthia

TF for many Data Science classes here at Harvard including CS109A/B.

Fun Fact: Enjoys kaggle competitions

Andrew Smith

Passionate about using machines to model and assist the human creative process

Fun Fact: Has produced concerts on five different continents

Connor Capitolo

Machine Learning Engineer

Graduated from Master's in DS program in May 2022

Fun Fact: Loves to go fly fishing

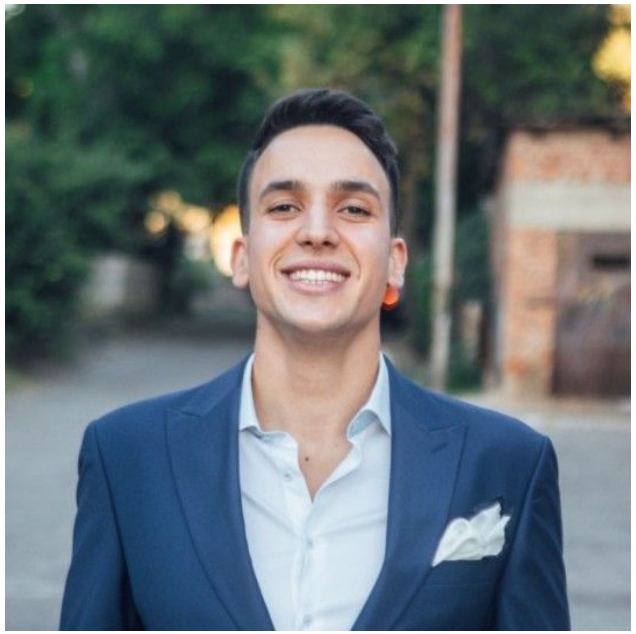
Who ?

Shivas Jayaram

Deep Learning Researcher, Educator and Practitioner

Currently working on a medical-pharma startup

Fun Fact: Just started a new hobby - Beekeeping



Tale Lokvenec

Tale is a Founding Machine Learning Engineer at Zenlytic, specializing in natural language processing (NLP) and ML system design.

Fun Fact: He is a super basketball player and until the age of 16 he was in the national team of Macedonia.

Matthew Nazari

Senior studying CS, NELC, Ling

Developing online language learning spaces for Northeastern Neo-Aramaic

Fun Fact: Once folded 130 Chipotle burritos in under an hour

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Course Structure and Activities

- Two lectures/tutorials per week.
- Projects

Two lectures per week - What to expect

There will be one reading suggestion per week

Topics

- Containers
- Data Pipelines, Dask & Cloud Storage
- Data Parallelization
- Data Versioning
- Advanced Training Workflows
- Advanced Inference Workflows
- Pipeline
- App Design, Setup, and Code
- APIs & Frontend
- Scaling (k8)

Team Projects: Crafting Your Own AI Solutions

Objective: Hands-on project development in AI & MLOps; transform your idea into a functional app.

Guidance: Weekly demonstrations from Pavlos' project provide practical insights and a reference point.

Milestones: Assess project evolution and grasp of MLOps concepts; crucial for grading.

Creativity: Open platform for start-up ideas, research, or personal hobbies.

Assessment: Milestones are key to **grades** and holistic development.

Group Formation: Starts today, aiming for teams of 3-5.

Projects Milestones

Milestone	Description	Due Date	Points
MS1	Project Proposals & Team Formation	09/14	5
MS2	MLOps & Advanced Training	09/26	10
MS3	Scalable Computing	10/05	15
MS4	Midterm Presentation	10/24	25
MS5	Full-Stack Development	11/14	10
MS6	Final Presentation and Deliverables	12/12	35

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Projects

Workload

- 1 hour *Reading*
- 2.5 hours *Lectures*
- 1 hour *Office Hour/meet with your TF*
- 7.5 hours *Project Milestones*
- ~ 12 hours/ week

Expectations: Attendance

Attendance in class is not merely a requirement; it is a criterion I heavily weigh when considering academic and professional endorsements. Please understand that consistent presence and engagement in the classroom are highly valued in this course.

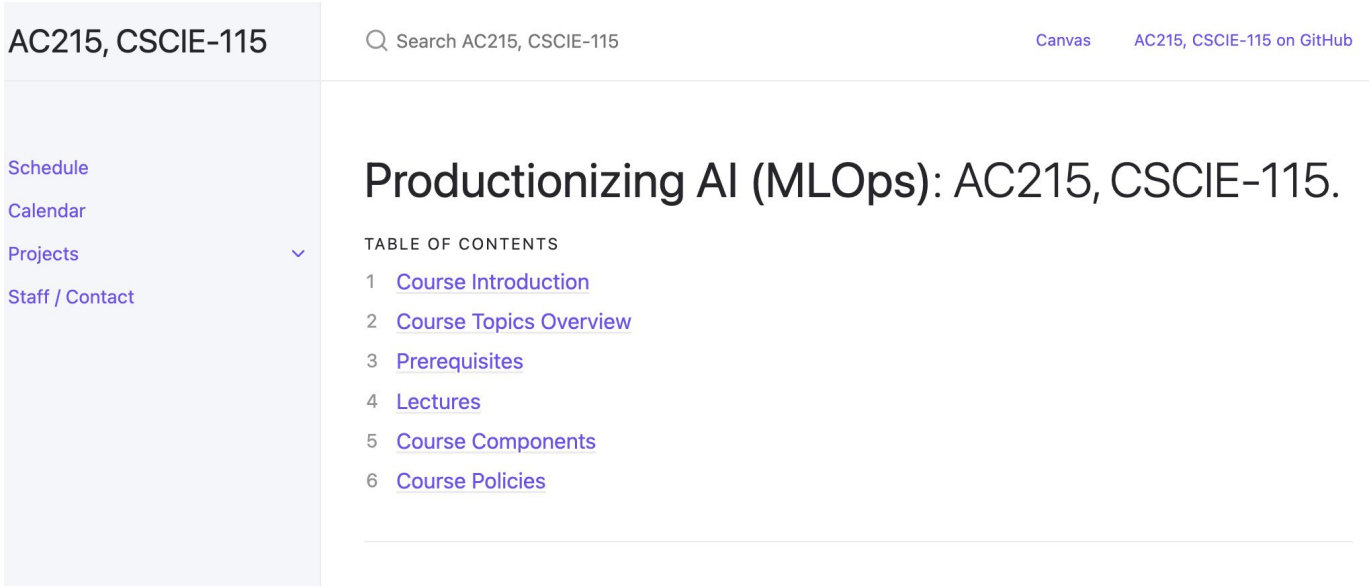
Expectations: Projects

This course is project-based, and your entire grade will depend on the quality of your project. We will place significant emphasis on both the effort you put into the project and the quality of your completion of its milestones.

While project-based courses generally make it easier to achieve a high grade, we will thoroughly assess each component and provide comprehensive feedback. We expect you to incorporate this feedback into your work for subsequent milestones.

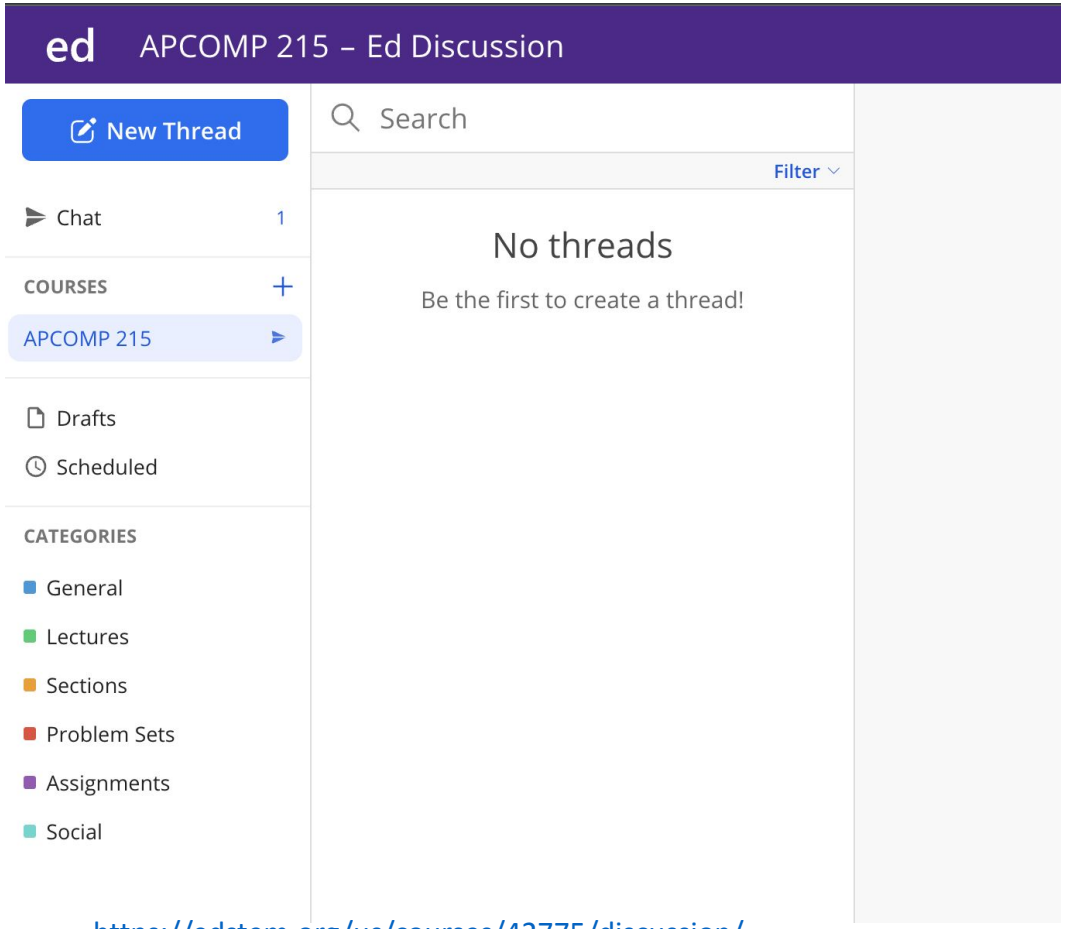
Course Components

Course web page



https://harvard-iacs.github.io/2023-AC215/

ED Stem



https://edstem.org/us/courses/42775/discussion/

Grades

Assignment	Final Grade Weight
Milestone 1	5%
Milestone 2	10%
Milestone 3	15%
Milestone 4	25%
Milestone 5	10%
Milestone 6	35%
Total	**100%**

Final Details

- We will be using ED for discussions, announcements and surveys
- Canvas for some of the submissions and group formations

Submissions for project milestones and projects will be using GitHub – details will follow soon

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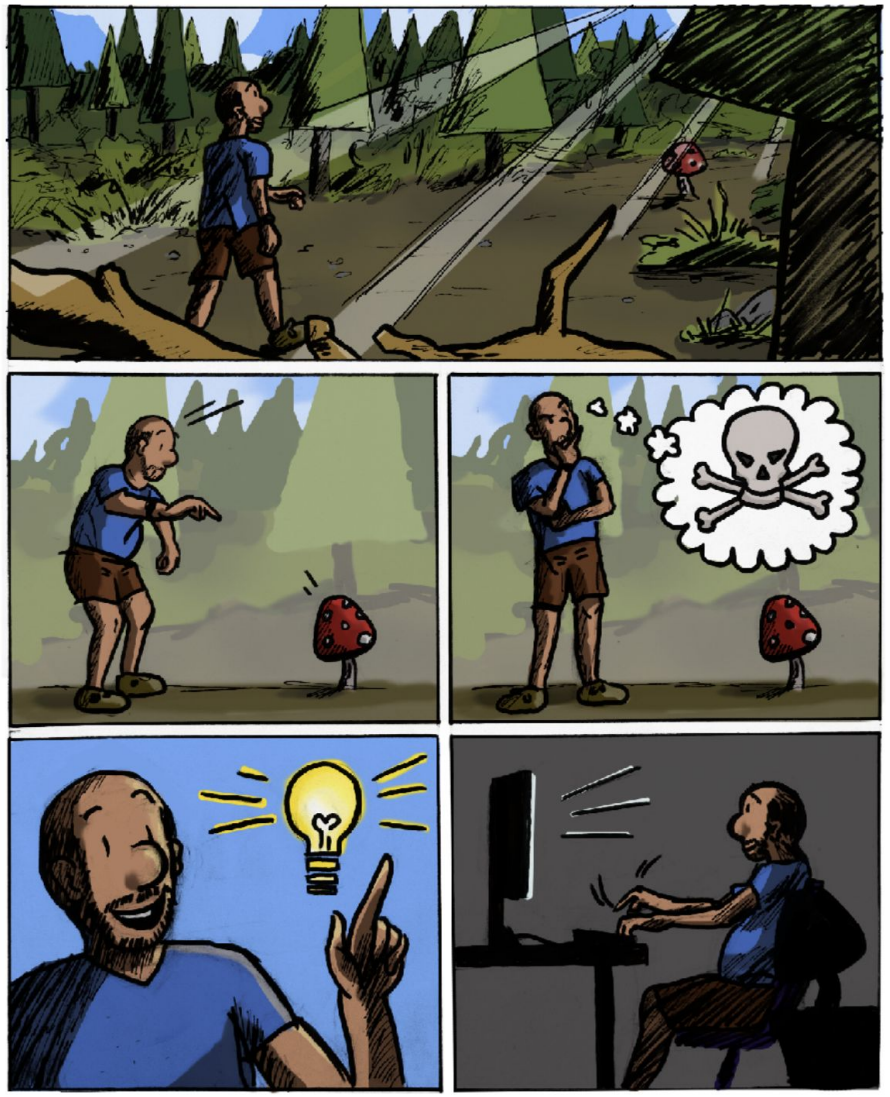
Projects

In Class Demo Mushroom Identification App

Project Idea

- Pavlos likes to go the forest for mushroom picking
- Some mushrooms can be poisonous
- Help build an app to identify mushroom type and if poisonous or not
- Project Summary



Credit: Nikolas Protopapas

Problem Definition

Pavlos enjoys visiting the woods to collect mushrooms, finding the endeavor both enjoyable and beneficial since some mushrooms can be eaten. However, the forest where he gathers mushrooms is also home to numerous toxic varieties. While some are easy to identify, there are others for which he needs assistance in recognizing.

Proposed Solution

When Pavlos is in the forest, he always has his phone on hand. Imagine if he could simply snap a photo of the mushrooms, and an app could identify the species and indicate whether they are poisonous or safe to eat.

Project Execution Steps

- Project Ideation / Requirements
- Data Exploration
- Model Exploration
- Prototyping
- Model Serving
- Product Development
- ML Integration
- Deployment

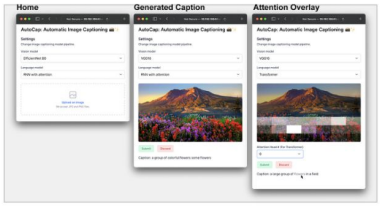
Previous Year's Projects

https://medium.com/institute-for-applied-computational-science/ac215-fall2021-projects/home

Improved StyleCLIP for Text-Based Image Editing

This article was produced as part of the final project for Harvard's AC215 Fall 2021 course.

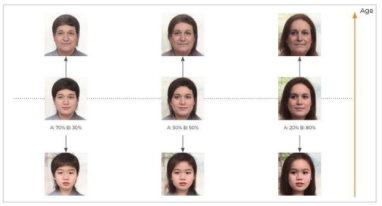
Michael Fein
Dec 13, 2021 · 7 min read



AutoCap—Image Captioning

This article was produced as part of the final project for Harvard's AC215 Fall 2021 course.

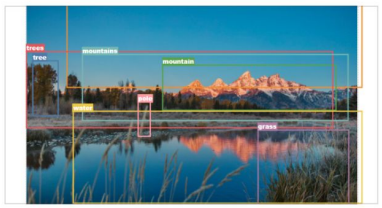
James Parker
Dec 30, 2021 · 11 min read



Multifaceted face generator

Harvard AC215: Advanced Practical Data Science Author: Dongyun Kim, Vasco Meerman

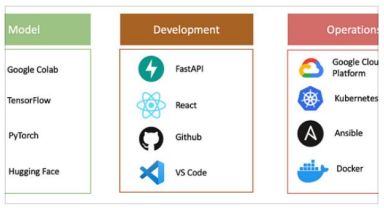
Dongyun Kim
Dec 14, 2021 · 8 min read



ExBERT Image Captioning

Authors: Yuanbiao Wang, Shuyi Chen, Chunyi Li and Xinyi Li

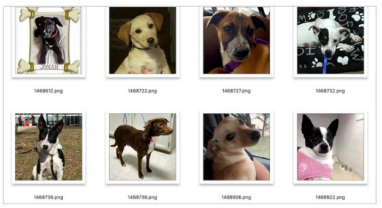
Xinyi Li
Dec 30, 2021 · 6 min read



Project Garble: Long Audio to Short Text Summarizer

We're going to build an app that takes a long audio file and generates a paragraph long summary—with all the main ideas included!

Joseph Kim
Dec 14, 2021 · 9 min read



An End-to-End Approach Leveraging Computer Vision, NLP to Enable Better Pet...

This article was produced as part of the final project for Harvard's AC215 Fall 2021.

Guanhua Shu
Aug 29 · 7 min read

How to Scope your Project

Proof Of Concept (POC)

- Experiment potential ideas
- Check feasibility of the idea
- Use a subset of data to make experiments simpler to run
- E.g.: Verify if our language task can be performed by transfer learning using a transformer model
- **Users:** Internal team
- **Duration:** Days to few weeks

Prototype

- A mockup or functional product that can showcase your ideas
- E.g.: A mockup web app to show user experience and flow
- **Users:** Internal team
- **Duration:** Weeks

Pilot

- A usable and functional product of your solution
- Used to test out the product with real users and performing real use cases
- E.g,: An api endpoint of a model for prediction, a simple one page app to showcase a model's prediction capability
- **Users:** Internal / External
- **Duration:** Weeks

Minimum Viable Product (MVP)

- Expanding on the Pilot to build something that real users can use
- E.g.: Production deployed app that can predict if a mushroom is poisonous or not
- **Users:** External
- **Duration:** Months

Project Scope (Mushroom App)

Proof Of Concept (POC)

- Scrap mushroom data
- Verify images
- Experiment on some baseline models
- Verify new unseen mushrooms are predicted by the model(s)
- Visualize model activations to analyze what the model is seeing

Prototype

- Create a mockup of screens to see how the app could look like
- Deploy one model to Fast API to service model predictions as an API

Minimum Viable Product (MVP)

- Create App to identify Mushrooms
- API Server for uploading images and predicting using best model

Logistics

- Survey
- Make project groups
- Setup & Installations

THANK YOU