Alpha Functionality and Milestone 2 Draft 2

Group 21 - Interactive Visualization for AI Education

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Abstract

Artificial intelligence and machine learning is becoming increasingly popular and present in tons of different industries and systems around the world. There currently lacks beginner friendly resources that both teach and tie multiple AI/ML concepts together. Through this project, we created a new web and notebook-based tool to provide users with both a high-level and optional in-depth (hands-on programming) experience of building three different machine learning models for varied use cases. The materials are organized by topic, introducing increasingly more complex concepts to users as they move through the site.

Table of Contents

1. Introduction

This paper will lay out an overview and progress update of the Interaction Visualization for AI Education project. Group 21 is the first team to work on a project of this nature allowing the team to build a new fun and educative tool from the ground up. The overall goal is to create an online learning tool that guides users from start to finish through creating a machine learning model to classify datasets and empower them to find their own datasets and build a subsequent classification model on their own.

2. Background

2.1 Project Introduction

This project aims to be an interactive visualization tool to teach beginners about artificial intelligence (AI) and machine learning (ML). This tool will allow users to interact and actively learn about complex computer science topics. Learning about artificial intelligence and machine learning can be difficult given that these topics are a complicated and niche sector of computer science. There lacks fun, interactive, informative education tools to teach beginners about AI and ML and so this interactive web application project aims to serve as an educational tool that will help novices become more acquainted with AI and ML. Users that will be included in testing this tool including students aspiring to learn about AI, students who have some background or experience with AI, and potentially faculty or industry professionals who are interested in AI visualization tools.

Oregon State University professor Dr. Minsuk Kahng had proposed this project to create a tool to help users learn about AI and how AI works. The current team members include: Junhyeok Jeong, Laura Jiang, Owen Markley, and Thuy-Vy Nguyen.

2.2 Problems

Machine learning and artificial intelligence can be difficult to pick up because of how overwhelming the field is. From understanding the terminology in artificial intelligence (AI) to the actual math underlying AI, this is a difficult topic to both attempt to learn on your own and to teach to other people. While there is currently a wealth of information on languages, frameworks, tools, and resources, it can feel overwhelming especially for beginners. What resource is best to start out with? How can a web application be useful to help both unfamiliar students and professionals?

2.3 Current Solutions

There are a few different methods that people currently use to help them learn about machine learning and artificial intelligence topics. Some of these websites include Coursera, EdX, and other universities which offer online courses on a variety of topics.

There are also a few sites out there whose goal is to abstract away programming and move towards visualizing machine learning to make the topic more accessible. Google in particular has a large collection of interactive tools and courses through their Google AI Education site. In particular, two of their popular tools include Teachable Machine and Facets. Facebook also has their own collection of tools, linked below.

Table 1. Collection of Existing Educational Tools for AI/ML

Source	**Value**
Google AI Education	Provides a mass collection of Google-backed resources, including visualizations, guides, and crash courses.
Teachable Machine	Also Google-backed. Easy method for on-the-fly creation of image classification to learn about epochs and learning rate.
Facets	A complex deep-dive into a particular dataset. One set is already provided on load, but the user can also choose to upload their own data.
Facebook AI	Provides a collection of resources related to implementation assets for programmers and hobbyists, such as languages, libraries, etc.

The distinguishing factor of the capstone project from these current solutions is that they do not give the user the full end-to-end experience of both learning and applying concepts at the same time. The Google AI and Facebook AI tools are both collections of resources but still lead to the issue of the user feeling overwhelmed and uncertain where to start. While Teachable Machine and Facets focus on visualization, they do not grant users any opportunity to learn what the programming aspect of machine learning looks like. The capstone project will remedy the issues from both groups by both providing an entry-level explanation for beginners and an opportunity to access and play around with code if desired.

2.4 Project History

This particular project does not have any prior history - this will be the first iteration of the project.

3. Vision

There are two main user segments that this capstone project is aimed at: students and professionals in the technology industry with an interest in learning about AI. The project will help solve two large pain points experienced by these two user groups.

The first pain point is an overwhelming amount of resources without a string between those resources, such as the resources provided by Google and Facebook AI mentioned above. By creating a website and a notebook application combination, the user is able to dictate their own learning experience and determine how much interaction and coding practice they require. This contributes to a very flexible and accommodating learning experience. Next, the second pain point is minimal instruction. Many existing interactive visualizations are complex and do not feel incredibly user friendly, such as Facets which is a deep-dive into a provided dataset.

Comparative to other existing visualizations, this project is aimed to be beginner friendly and help develop skills for users new to machine learning. This tool will be beginner friendly in that it is an interactive and visual educational tool to teach users about introductory artificial intelligence concepts.

Since we decided to implement web-contents with Model/Data wise chapter plan, we will provide models from logistic regression, neural networks, image classification, to text classification. For example, in case of text classification with sentiment analysis, the multi-page web application that will guide users through creating a sentiment classification model from start to finish. Users will be introduced to concepts like how to train a model, what kind of data is suited for a classification model, loss functions, and building a classification model. Code for these elements can be optionally accessed by the users.

The team has decided to split the web application into two parts: a website and notebook based tool. The web application and the notebooks will have similar content and features, however, the web application is focused more on being user friendly and being for users who only want to read through content and code while the notebooks are for users who want to be able to change and run the code themselves and offers more complex and interactive visualizations.

3.1 Hypotheses

3.1.1 Growth hypothesis

Within the resource space for educational machine learning tools, the team anticipates that this product will see particular adoption because it stands apart from current solutions; users will naturally gravitate towards this product for its visual and hands-on learning experiences (visualization and programming access). Another hope for adoption is that this product will be directly helpful in a formalized education setting; educators can showcase and leverage this product as an instructive tool and students will be inclined to review and understand the concepts presented on the site.

3.1.2 Value hypothesis

It is hoped that customers will use this tool because they want an engaged and enriched learning experience. Customers who use this tool alongside other artificial intelligence or machine learning resources may have a deeper understanding of the content and be able to explain these concepts more easily due to the in-depth explanations that the site provides them. Compared to existing solutions, this product is designed to educate users from different levels of expertise and does not expect any pre-requisite knowledge. Additionally, this product will pair direct code snippets with educational text which is also a key distinguishing factor from the status quo.

3.2 Requirements

The larger goal is to build a web application paired with programming exercises that are able to both teach the user about machine learning concepts and grant them a platform where they can start playing around with a machine learning system.

Below is a more detailed description of the functional and non-functional requirements.

3.2.1 Functional requirements

- The system will contain a walkthrough of how to build a sentiment classification machine learning model.
- The system will include an interface that allows users to work through the website topics based on the user's learning interests.
- The system will provide visualizations and/or explanations of each step within the model based on the chosen dataset to educate the user about the ML model process.
- The system will feature code snippets that correspond to the topics being covered on that particular page.
- The system will walk users through the process for linear regression.
- The system should allow for user modification of that code and be able to run and display any changes through use of a notebook (Jupyter notebooks).
- The system will walk users through the process for classification with a neural network.
- **(STRETCH GOAL)** The system will walk users through the process for simple image classification.

3.2.2 Non-functional requirements

- The system will display changes made by the user within 10 seconds.
- The system should be able to load information on different pages or screens within 5 seconds.
- The system should be functional on different sizes of screens and browser windows.
- The system should be open source to encourage maintainability of the site and additional future updates.

4. Prioritized Project Constraints

4.1 Time

One obvious time constraint is that the Capstone timeline is to complete a project within the school year (9 months). By the end of fall term, the team hopes to complete the first prototype of a web application that can support some form of user interaction related to machine learning and demonstrate as a prototype for the design gallery. By the middle of winter term, the team would like a second or third prototype, iterating upon user research conducted in the first weeks of winter term.

At the end of fall term, the team was able to create a website to hold all of the interactive visualizations corresponding to the machine learning models, have easily copy-able code segments, and link to the jupyter notebooks. By the sixth week of Winter term the team was able to create multiple jupyter notebooks corresponding to machine learning classification models including: text classification with naive bayes, text classification using neural networks, and logistic regression.

For the winter term, we are working on creating visualization tools like an interactive confusion matrix and creating visualizations to visualize data points into vectors. Dr. Kahng, our project partner, has also updated his visions for the rest of the chapters. The team's will aim to improve the current chapters, add more visualizations, and add more chapters such as a dedicated chapter to neural networks and image classification.

Members of the team will allocate time for the Capstone project as appropriate. Each sprint will have features assigned to a particular team member. Although there is no particular time requirement, they will be expected to complement that task within the sprint. An estimate would be around 2 - 7 additional hours a week (not including the time required for team stand-ups or project partner meetings), depending on the task and the phase in the project.

4.2 Resources

User studies will be conducted in order to most effectively design the product. The user studies will be conducted to understand motivations behind the project and how to design an intuitive website. The study process will be shortened to informal, short interviews or user walkthroughs to receive quick feedback.

Other resources include hosting the final polished project onto a website so that members outside of the team will be able to use it. The team has not decided where the site will be hosted but there is a high likelihood that the site will be hosted on a platform like AWS. The project partner will be available to host the site indefinitely as long as the project is seeing usage and occasional maintenance.

In addition, our project owner, Dr. Minsuk Kahng, can provide advice based on various data visualization and AI project experiences like ActiVis, GAN Lab, and ETable. These projects are related to this capstone project and will use similar tools for visualization.

4.3 Scope

The team has decided on a set of minimal features and functionality that should be completed by the end of the school year. This consists of the minimal interactions the user will need to have in order to effectively use this tool: providing training and test data for users, permitting users to modify certain parameters of the machine learning (ML) model, and an instructional guide to explain each step of the sentiment classification process to the users.

One important aspect of this capstone project is user studies and user research. The inclusion of user feedback may slow down parts of the project, limiting the scope of the project as well. There is no clear projection on what this will look like now.

Nevertheless, features may be altered or additional features may be added depending on time constraints, results of user studies, or discussion during team meetings.

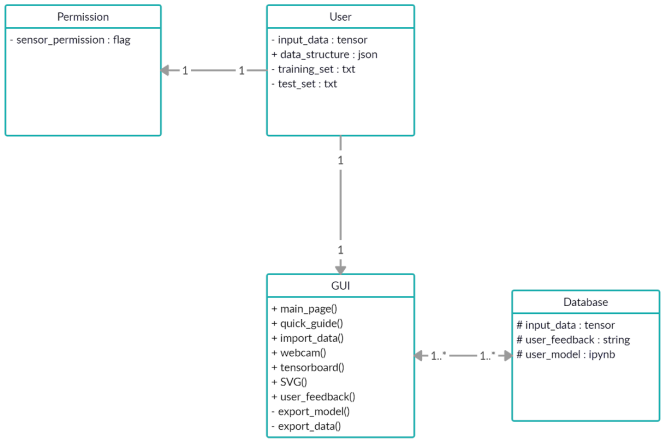
5. Scope

One central tenet of this project is designing for the user and understanding their needs. With a student or professional beginning to learn about machine learning, general concepts can take time to process and understand how to apply them. The web application should be easy to pick up and also take users through an engaging introduction of fundamental concepts in machine learning.

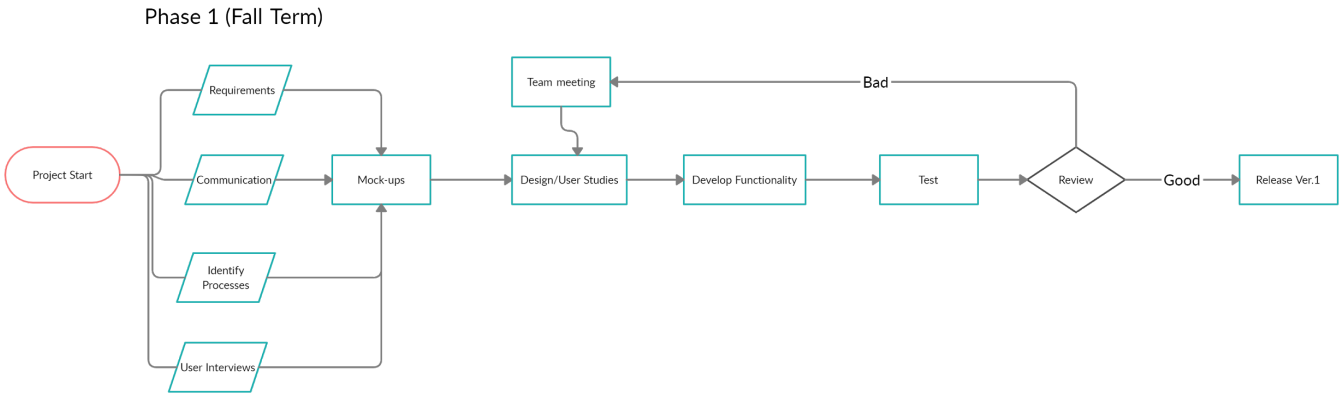
For the team's workflow, as mentioned, informal user testing will be central to improving the application. Accessibility and usability are the foundation of turning this into a highly successful project.

5.1 Process Flows

UML Class Diagram



UML Activity Diagram



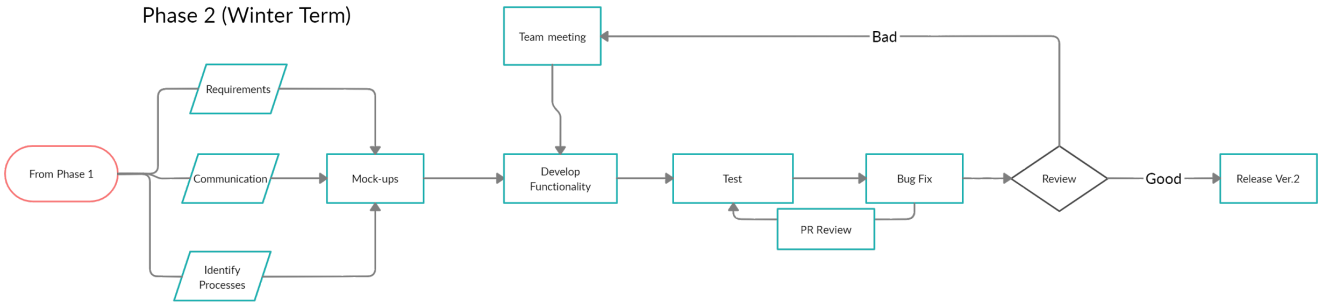


Fig 1. UML Class Diagram

Fig 2. UML Diagram for User Flow

5.2 User Stories

1. As a college student trying to learn about how to build my first classification model I need an inclusive step-by-step tutorial so that I do not need to jump between different resources to learn any prerequisite concepts.
2. As a hobbyist programmer I need to understand how changing the learning rate affects the accuracy of my classification model so that I can learn what learning rates are more effective when building my own models.
3. As a user I need to understand what a training set and learning set is so that I know what a classification model's prediction accuracy is founded upon and how I can improve the model's accuracy.
4. As a high school student interested in AI, I need a singular tool for learning AI so that I am not overwhelmed with information or background knowledge that I am expected to know and I can move at my own pace.
5. As a technical product manager, I need to understand the technical underpinnings of what a classification model is and precisely how it can classify an incoming message so that I can communicate between the engineers and our customers to explain how my company's spam filter works.
6. As a college student working with machine learning models for the first time I need a way to build upon my knowledge of machine learning so that I can build confidence and comfort in this subject.
7. As a technical product manager I need to understand different basic machine learning concepts so that I can better communicate with my engineering team and better understand the products that my company is building.
8. As a software engineer, I need to spin up an accessible demonstration of a machine learning model for non-technical people so that I can demonstrate machine learning to other teams.
9. As a college student, I need a step-by-step guide on what an interactive visualization does so that I can effectively use that tool to supplement my learning.

6. Alpha Functionality

6.1 Junhyeok Jeong

Junhyeok Jeong is a senior with a computer science major at Oregon State University. He focuses on Artificial intelligence and Computer Vision as his CS applied plan. Since he has taken CS331: Introduction to Artificial Intelligence, CS434: Machine Learning & Data Mining, and CS499: Deep Learning, he will contribute to the implementation of AI concepts and various models based on topics.

Junhyeok has created the AI models with Jupyter notebooks. The topic of the first model is text classification for sentiment analysis. He has made three different models for text classification. The models are naive bayes, simple neural networks, and pretrained models with Google Hub because the project team plans to provide various models on each chapter. As the next model, he recently worked on logistic regression with Tensorflow-Keras and manual model.

6.2 Laura Jiang

Laura is a senior at Oregon State University following a custom CS applied plan. She is most knowledgeable about building out web applications and is in charge of design and development of the web-based application in the capstone project.

Laura has built out the entirety of the site, which she has built out using React/JavaScript, and is in charge of converting the complex topics conveyed in the notebooks into a digestible format for users who may not be able to or do not want to dive into the notebooks. She is also working to add the different visualizations created by Thuy-Vy onto the site, integrating educational content with code snippets and interactive components. In regards to the notebooks, Laura will also be adding additional commentary and explanations for navigating through the notebooks.

Although Laura does not have any background in AI or ML concepts, she is also currently working on a notebook written in Python to introduce the concept of neural networks.

6.3 Owen Markley

Owen is a senior at Oregon State University currently pursuing a computer systems degree. His background in artificial intelligence and machine learning comes primarily from the course CS 434: Machine Learning and Data Mining, offered at Oregon State University. He also possesses introductory knowledge of JavaScript and popular JavaScript libraries for web development.

Owen has taken JavaScript visualizations developed by the team, and integrated them into the AI models presented in the project's Jupyter notebooks. He has also made visualizations more universal and applicable to different chapters of the project, as well as creating a Python library to make visualizations easier to add to additional notebooks. He has also developed additional functionality to extract data from AI models along intermediate points during the fitting process of models.

6.4 Thuy-Vy Nguyen

Thuy-Vy is a fourth year Computer Science student at Oregon State University with a Human Computer Interaction focus. As she has taken CS458: Introduction to Information Visualization and CS 331: Introduction to Artificial Intelligence and is currently in Dr. Kahng's XAI Lab at Oregon State, she will be working primarily on the visualization aspect of the project and helping with the machine learning topics with creating notebooks, code reviews, and writing the educational content to explain the machine learning algorithms.

Thuy-Vy has taken lead with the interactive visualizations on the project. She created the initial interactive confusion matrices that allow for users to explore the data points and their categorization and enabled filtering to see how this impacts

model accuracy. She also created the vector visualizations that convert a data point's features into vectors that have visualizations based on the content of the features.

Thuy-Vy also created the introduction notebook that introduces artificial intelligence and machine learning, explains the main categories in these fields, and defines beginner and common terms in artificial intelligence. Thuy-Vy created the first classification notebook, "Text Classification using Naive Bayes" which explains how to accomplish sentiment classification of restaurant reviews using naive bayes algorithms. Thuy-Vy created all of the runnable code associated with the algorithm as well as wrote all of the educational content .

7. Iteration Plan and Estimate

7.1 Fall Term

The current expectation is that two sprints be completed by the end of the fall term. The team's sprints are broken up into 2 week periods. The first of these sprints will focus primarily on gaining a deeper understanding of the needs of the different users that are expected to be using this tool, as well as developing a basic prototype that will represent the user experience. Information from interviews and user research will be incorporated into this first iteration. Subsequent interviews and interactions with users, as well as feedback from Dr. Kahng will determine the form of the functional and nonfunctional requirements initially provided by Dr. Kanhg.

While working on this first sprint, the users' needs will always be in focus. In depth diagrams and supplementary material will also be updated as the prototype progresses. Supplementary material should map directly to the users' needs. During this phase it will also be determined as to which frameworks, databases, libraries will be used. By the end of this first sprint, there should be some form of deliverable to show our progress, and more importantly, a clearer vision for a development.

The second sprint is dedicated to further developing the first iteration of the user interface, and having a fully functional backend built for at least one type of model. Ideally, this iteration would be able to work with sample data sets to build out the sentiment classification model. Once a basic backend and user interface has been created and is usable, the team may then seek another round of user feedback. At this point time and resources can be allocated towards either tracking and adjusting existing functionality to better suit the needs of the user or working to create a rough prototype of what the incorporation of code would look like on the user interface side.

Lastly, any remaining time is dedicated to ensuring that there are no bugs or issues with the functional prototype that would render it unusable. It should be ensured that every single one of the predetermined goals for the term is met, and that functional requirements are being implemented. This portion may also be partially dedicated towards the testing of a working prototype. Once the final sprint is completed, a plan for the subsequent Winter 2020 term may be created by the team.

7.2 Winter Term

The team has moved to weekly sprints where Dr. Kahng guides the team by evaluating the progress reached over the previous week and assessing needs for the projects for the following week.

For the previous weeks (1-5), the team has worked on refactoring the code and finalizing the plan for our project, establishing a productive workflow between all the different parts of the project including the jupyter notebooks, the website, and the visualizations associated with machine learning models, and finalizing the Text Classification chapter of our project. We have formally established the goals we have for the remainder of Winter Term; this includes creating new chapters including: Logistic Regression and Image Classification, and creating new visualizations associated with these models and the ones completed already.

We hope to have all of these chapters working and running smoothly by the end of Winter Term so that Spring Term will be focused on improving the educational content on the chapters and the development and hosting of the website.