UNIVERSITY OF WATERLOO

Engineering + CS Capstone Design Projects 2024

March 26, 2024

Teams

Projects

Audiogen: An Audiobook Generator with Dynamic Voices
Novel Illustrations
Invasive plant species detection with AI
Reverse-Engineering Synthesizer Values
PILAR: Productionizing Paramaterless Log Parsing
An Intelligent Code Review Tool
Mira Screenshare: High Performance Screensharing and Remote Collaboration
Multi-source information retrieval system and AI search bar
Wave: The ultimate WaterlooWorks companion app
SE 464 Revamp
UWTrade: A Student-to-Student Marketplace for University-Oriented Used Goods
Spacewalk: Adding a New Dimension to Presentations
XChange: Everything you need to plan your exchange term
S4DGE: Some 4 Dimensional Game Engine
Make reality your playground
A song-guessing game
Bet with your pride, not your wallet
Snowflake: censorship circumvention
Tether: An App to Bring Relationships Closer Together
Control theory in the GoLang Garbage Collector
Applying control theory for CS452 trains
Social Agents in a Dynamic Simulation
Muntalacier: An App for Face-based Fashion Recommendations

1 Audiogen: An Audiobook Generator with Dynamic Voices
Team Audiogen

Audiobooks are often preferred as a convenient alternative to books. They do not require listeners to provide their full attention; furthermore, audiobooks allow listeners to enjoy a novel completely hands-free.

However, with over 48.5 million books on Amazon [?] but only 200,000 audiobooks on Audible [?], less than 1% of books have an Audiobook format.

With the current market, listeners who would like an audiobook format of their favourite books can only wait for a publisher to create one.

Dylan Snelgrove, Russell Chan, Hannah Zhu, Kyle Anderson, Patrick Davies

[Program: SE; TA: Ahmed]

The objective of the Audiogen project is to bring books to life by synthesizing audio narration and dialogue in which each character has a unique voice.

The Audiogen system parses a textual book, assigns a unique voice to each character within based on learned or inputted attributes of the character (such as gender), and produces an audiobook where each character's pieces of dialogue are spoken in the voice assigned to that character.

In addition to who spoke each piece of dialogue, the system also identifies how they spoke it—the attributes of the dialogue—for example, emotion.

Accurate identification of characters and their attributes in the book is an important component of the system. Current state-of-the-art machine learning systems specializing in natural language processing, such as the CoreNLP library authored at Stanford University [?] and large language models like GPT-4, are well suited to the task, and can process a book in batches.

Another important component of this project is the task of generating natural-sounding audio narration and dialogue based on the information parsed from the book. Several text-to-speech services (such as Azure, AWS, IBM Cloud) exist and could be leveraged to partially solve this task.

While there are many text-to-speech, screen reader, and narrator products in existence, none bring books to life by synthesizing audio narration and dialogue in which each character has a unique voice. These alternatives do not speak dialogue is a voice matching the character speaking and do not adjust

the synthesized speech to dialogue attributes such as emotion. This project's scope is larger than simply converting text to natural speech, as alternatives do. It also focuses on identifying who speaks a piece of dialogue, and how the dialogue is spoken to generate a more natural-sounding audiobook.

There are other audiobook platforms such as Audible, but because our system generates audiobooks without the need for expensive human voice actors, the cost to make audiobooks is less. The cost savings is passed on to the listener, which means that listeners can access high quality audiobooks at a fraction of the cost.

As a measure of success, we will compute the accuracy of speaker identification against the quoteli3 dataset [?] which has quote attributions for each line of dialogue in Pride and Prejudice, Emma, and The Steppe. As for the audio portion, success can be measured qualitatively. We can conduct a survey that asks listeners for feedback on how "good" (smooth, accurate, engaging) the audiobooks are.

We will measure the success of the audiobook hosting and discovery platform by the number of users, the number of audiobooks downloaded, and the number of books uploaded.

2 Novel Illustrations
Team Pixel

Creating graphic novels has a huge barrier to entry. Finding an illustrator, designing the style, and creating the illustrations is a time-consuming and costly process that can result in a slow release or total abandonment of the project. This is highlighted by the difference in sales from printed novels compared to graphic novels; in 2021, nearly 810 million copies of print books were sold, whereas 95 million copies of comics and graphic novels were sold. However, since the pandemic, graphic novel sales have grown by 110
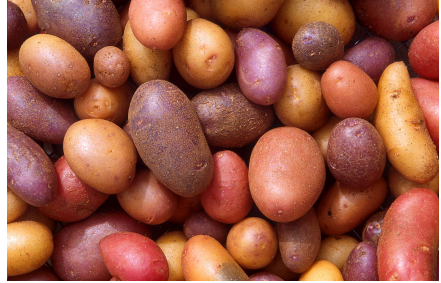
Alex Yee, Jack Douglas, Kevin Yang, Marco Liu, Yameen Abba
[Program: SE; TA: Ahmed]

The goal is to create a software system that can generate a graphic novel for any printed fiction. The advanced technology can be used by authors and/or readers. Users will upload a text file to the system. The system will allow users to customize the style and contents of the illustration with user-guided prompts. The system will enable the feasibility of creating graphic novels and accelerate the process for creating them. The output of the system is a PDF containing the graphic novel.

Our design approach is to first parse the story for the characters as well as divide the story into panel sized segments. Next, we will use pre-trained models such as Stable Diffusion to generate images based on story writing. To allow customizability, an interface will be provided for users to specify, if any, general story attributes to generate from, and to edit their generated character descriptions, and panel contents.

The main advantage of our design over major alternatives is the ability to generate images for pre-existing novels. Existing alternatives such as Comics Maker and Neural Canvas instead prompts the user to create a new story based on a set of parameters. In addition, their prompts are quite small in comparison to the length of the typical stories that our product would take in.

We expect our system to be able to take in text input, and output the corresponding graphical version. We expect the characters and other entities unique to the story to appear consistent throughout the graphic novel. We also expect our program to be efficient, and to be able to finish creating the graphic novel within a reasonable amount of time. For testing and benchmarking, we

will use "Tortoise and the Hair" for short stories, "Lamb to the Slaughter" for medium sized stories, and "The Great Gatsby" for longer novels.

www.pixelbeta.ml

3 Invasive plant species detection with AI Team ATARRA

Our project is an invasive plant species identifier which leverages AI to find probable areas of infestation from aerial satellite photos. In particular, we will begin by focusing on phragmites, a major invasive species in bogs and wetlands throughout Ontario. Invasive plants are a massive threat to biodiversity, and a very difficult problem for conservationists to solve. Phragmites, in particular, is Ontario's worst invasive species, and outcompete native wetlands plants, depriving frogs and turtles of their vital habitat [1]. Using technology to identify populations of phragmites will help conservationists save time and focus their efforts on high-priority areas.

Ryan Dancy, Taya Davison, Amir Roshankar, Aariana Singh, Alex Van De Wiele, Raymond Zhou [SE]

[Program: SE; TA: Akin]

The project will use aerial images, specifically from satellites, to identify and map areas where phragmites is likely to be. In doing so, we hope to reduce the amount of time required by conservationists to physically map out potential areas of concern, which is a highly labour-intensive process. We will create an artificial intelligence tool to automatically identify regions of likely phragmites infestation, along with a web application for viewing the results and extracting insights. Users will be able to upload satellite images and shape files to our web application, and they will receive a heat map overlayed on the image showing the likelihood of phragmites.

At present, there are no commercially available software products focused on the detection of phragmites or of invasive species as a whole. There are several research groups with similar projects around other invasive species, and one project centred around the identification of phragmites using drones [2]. The most common solution for invasive species identification at present is "Ground Truthing", where landowners and park rangers trek over properties to check whether or not the invasive species is present. Our goal is to supply an easy to use, effective system for conservationists to find out where invasive species are likely to be in an easy and methodical way, so ground truthing can be more targeted and less frequent.

We will communicate directly with a small group of beta testers throughout the project lifecycle to determine the effectiveness and usefulness of the project.

We will divide our data into training and testing splits, allowing us to evaluate the accuracy of our AI model after training and before releasing it to the user. This will help us predict its performance on unseen data. To measure the accuracy of our machine learning model during development, we will use the intersection over union metric, which is commonly used in image segmentation problems like ours [3]. We will also gather statistics about the accuracy of the tool's prediction based on ground truth found by the users.

[1] https://www.natureconservancy.ca/en/where-we-work/ontario/our-work/stewar phragmites.html [2] https://cbc.ca/news/canada/montreal/drone-ai-invasive-species-iles-de-boucherville-1.6715500 [3] https://www.scitepress.org/Papers/2019/734

4 Reverse-Engineering Synthesizer Values
Team Micro Music

Reverse engineering sounds is a manual and tedious process for music enthusiasts. This involves guessing synthesizer parameters until it sounds similar to the target sound. However, developing this skill takes years of effort.

We're proposing a new product to help with sound design and music composition. The program will be used to generate synthesizer configuration files from existing audio snippets for reuse or modification.

Our solution will use a machine learning model to replicate the input

Timmy Thorpe, Eli Williams, Elliott Song, Peter Szczeszynski
[Program: SE; TA: Ahmed]

.wav file inside an existing software synthesizer (Vital). The output will be a synthesizer preset file, that when loaded into Vital will generate a similar sound to the input audio file. If successful, the preset will sound very similar to the supplied audio and can be used (or modified) in new songs by music producers.

The main technical challenge of our project is the development of this machine learning model. Furthermore, our model will require sufficient samples to train against along with some custom error 'function' to be able to determine the accuracy of its predictions.

There are few existing solutions for this, most relying on the user to choose the "type" of sound to create as opposed to providing a sample of the specific sound they want to create. In addition, our solution will generate large amounts of training data, allowing it to reconstruct more complex sounds than existing audio-based solutions. It will generate presets for an existing software synthesizer such as Vital (a free and widely used open source synthesizer) as opposed to generating sounds itself. This means that users can modify the generated preset later on to better suit their needs.

Our future project will be able to predict the synthesizer parameters used to generate a variety of different sounds. Our model will be able to predict the parameters used in a random sample of sounds with a loss percentage in training of 5% or less. This low training loss will build a generalized model that can be used to evaluate on unique and untrained sounds, which can be leveraged in a variety of applications.

5   PILAR: Productionizing Paramaterless Log Parsing
Team PILAR

Aaron Abraham, Yash Dani, Kevin Zhang [SE]

[Program: SE; TA: Akin]

Within the dynamic context of modern software systems, the task of transforming unstructured logs into structured templates is crucial for optimized monitoring, debugging, and analytical tasks. While there are various log parsers available, PILAR stands out due to its unique feature of eliminating user-defined parameters. This innovation streamlines the parsing process and makes it easier for engineers to deploy. However, there are still challenges that need to be addressed to make PILAR suitable for specialized engineering applications.

Our initiative focuses on extending PILAR's capabilities for effortless integration into advanced software engineering paradigms. The primary goal is to develop PILAR to meet the following challenges:

☐ Persistence: Utilize advanced database techniques to ensure that log data maintains its consistency, reliability, and accessibility, safeguarding against potential operational losses.

☐ Streaming: Implement real-time algorithms to enable on-the-fly parsing of logs, granting quick insights and response capabilities.

☐ Masking: Apply cryptographic methods to auto-redact confidential log details, balancing data integrity and security.

☐ Better Inference: Use machine learning techniques to enhance PILAR's ability to extract more precise and meaningful conclusions from the logs.

☐ Performance Enhancement: Optimize algorithms and techniques to handle expansive data sets more adeptly.

☐ Plugin Development for ELK: Develop plugins that allow seamless integration with the ELK stack (Elasticsearch, Logstash, Kibana), broadening its utility across various software environments.

☐ Can PILAR successfully integrate with the ELK stack after plugin development?

☐ Will the new features add value to PILAR in real-world software engineering applications?

With these advancements, our vision is to elevate PILAR to new heights of reliability, security, and efficiency, establishing it as an indispensable tool in the professional software engineering realm.

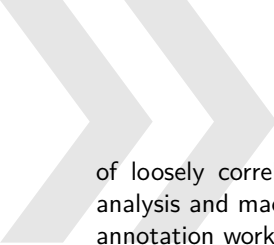# 6 An Intelligent Code Review Tool Team Narratives

Robert Craig, Ryan Ehrlich, Harris
Luo, Samuel Orend
[Program: SE; TA: Akin]

Code review is a critical step for catching bugs and maintaining code quality in most multi-person software projects. Before any code is added to or changed in a shared codebase, the proposed modification needs to be reviewed and approved by a developer who isn't the one who originally authored it. This process greatly reduces the probability of regressions making their way into the codebase, in addition to introducing a second opinion to help with optimizations and style issues that may have been missed by the original author.

Developers have access to a huge variety of powerful IDEs, extensions, and tooling that they can leverage in their workflows to help write good code quickly. For reviewing code, however, very few analogous tools exist. Current platforms for code review, such as the GitHub and GitLab web UIs, present reviewers with a single description blurb written by the original author, followed by before-and-after snippets for each file changed. These snippets are presented in an arbitrary, unintelligent order predetermined by the platform (e.g. alphabetical by file name). As a result, code review becomes a tedious and time-consuming process of scrolling back-and-forth between files as the reviewer tries to understand the complete consequences of a code change and how it affects the rest of the codebase. This gives way to a typical trend of developers being unmotivated to give deep and thorough reviews, hurting both productivity and code quality.

We aim to fill this gap in the software engineering workflow with our project, Narratives: an advanced technology that allows developers to tell a story about their code changes. Its main goal is to enable authors to convey the implications of their code changes in a way that is easier for reviewers to digest. Narratives will take the form of a graphical web app that layers on top of existing version control platforms. Authors will be able to customize the order in which code snippets are presented to the reviewer, or even separate unrelated snippets that happen to occur in the same file. They will also be able to annotate changes and organize them into logical sections so reviewers are presented with a clear, meaningful walkthrough of the code, as opposed to a sequence

of loosely correlated file diffs. Narratives will also leverage semantic code analysis and machine learning to automate some of the code organization and annotation work for the author.

At the end of the day, Narratives should help reviewers think critically about a code change to catch bugs and suggest improvements with little extra cost to the original author.

To assess the effectiveness of Narratives in solving the aforementioned problems with code review, we will perform studies with selected software engineering teams by integrating Narratives into their workflows. Candidate teams include other FYDP groups in SE 490 and related courses, as well as student design teams and student-run organizations such as UW Blueprint. To measure improvements in the code review process, we will conduct surveys in which testers can provide feedback on the user experience, on the time spent reviewing code with Narratives versus without, and on the correctness of committed code after being reviewed with the support of Narratives. These feedback cycles will be performed regularly to address developers' concerns in an iterative manner, with the aim of maximizing value-add and optimizing the user experience. We endeavour to develop Narratives into an advanced technology that industry professionals would be eager to integrate into their code review workflows.

7 Mira Screenshare: High Performance Screensharing and Remote Collaboration
Team Mira

Harry Yu, Mark Wang, Alison Zhang [SE]

[Program: SE; TA: Akin]

The pandemic has shifted a lot of workplaces and university labs to be remote. With remote jobs and studies, the problem arises that it is difficult for people to work efficiently with their teammates for collaborative work such as remote lab, pair programming and problem diagnosis. Our project is designed to make remote collaboration more efficient by allowing remote control during screen sharing in meetings. This mimics the situation in real life where programmers can ask their coworkers to come to their desks and do pair programming.

Our project is designed for those who wish to work on the same problem remotely. It would enable remote control during screen sharing and make the meetings more efficient and productive. The use cases include pair programming, gaming, and all other kinds of remote collaboration.

We envision the high level architecture of our tool, Mira, to consist of three parts, namely the sharer client, the viewer client, and the signalling server. The sharer client will be responsible for capturing and streaming the screen directly to the viewer through a P2P connection. Moreover, the viewer can dispatch input (e.g. keyboard, mouse events) to the sharer to achieve control of the sharer's operating system. The signalling server is reponsible for peer discovery and initial connection negotiations. In order to be competitive, the non-functional goals will ideally include achieving low latency (<140ms), high framerate (>60 frames per second) and high resolution (>=4K) for the screen sharing and control.

There are several competing products in this field so far. Tuple offers low-latency and high-resolution screen sharing and remote control. However, it is a pricey solution targeted for business users, and also supports only macOS. Zoom supports screen sharing and remote control but it has very high latency and the resolution is very limited. By contrast, our solution will be open-source, be low-latency and high-resolution, and will provide both a free self-hosted version for power users and managed options for inexperienced users.

The success of the project will be evaluated by its popularity, level of user engagement and satisfaction, which can be measured by the daily average number of users who start or join a session and the session durations, as well as the users' feedback, which can be recorded through an optional rating form prompted when the session ends.

https://mirashare.app

8 Multi-source information retrieval system and AI search bar
Team Elm Search

Ernst Mach, Peter Ke, Ray Yang, David Mehic, Yizhe Zhang
[Program: ECE + SE; TA: Anas]

In many companies, a lot of time and money is spent on building suboptimal internal tools from scratch. There is no standardization of how tools are built from company to company and most companies build their own tools or use a generic solution that is not taloried to their use case.

Elm Search formed from the this exact issue, during our co-op experiences we noticed that companies spent a lot of time and money on building suboptimal internal tools from scratch. We wanted to create a product that can easily be incorporated into any existing infrastructure, allowing companies to not have to make their own semi-optimal search bar and instead use an information retrieval system that is tailored to their needs. Our solution will work with both structured or unstructured data and can be connected to multiple different data sources at once. People who are looking to speed up the development of internal tools or are looking to centralize all sorts of different data source into a single search location will see great milage from our product.

A major issue with data storage and retrieval are cases where a company holds information in multiple different locations or there are multiple different data types for which data is stored. For example, companies may store important docs in files on some sort of cloud drive as well as have a wiki for information. We have had many cases during our co-op where we are unable to find critical information on the wiki because the information is in documents on some cloud drive. The wiki search engine does not connect to that cloud drive and as such we could not find those docs until we asked upper staff. Our product is a solution to this issue as we plan to have a information retrieval system that can connect to multiple different sources of data.

Initial deployment of Elm Search....

Metrics for evaluation:

1. Test cases on data flow of each unit

---

2. Measuring the ability of our search to find the relevant material in the index

3. Measuring the ability of our search to place relevant material high in the ranking

The datasets used to evaluate Elm search were the same datasets that were used to train these models here: https://www.sbert.net/docs/pretrained_ models.html

https://mirashare.app

9 Wave: The ultimate WaterlooWorks companion app
Team Wave
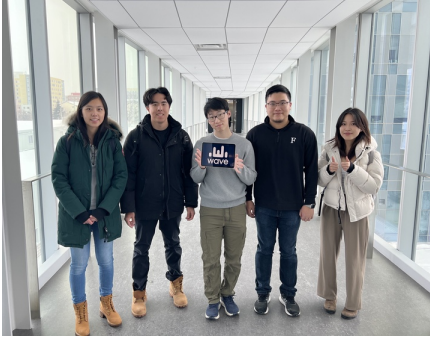
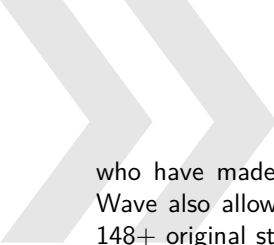Linda Jiang, Bryan Ling, Andrew Dong, William Qin, Michelle Wong

[Program: SE; TA: Ahmed]

Every four months, a new wave of over 9000 students at the University of Waterloo begin their search for co-op, dedicating time and effort to look for jobs despite having to handle their coursework. Unfortunately, the WaterlooWorks user experience is frustrating. The interface is unintuitive and unpredictable. For example, key search and filter options are hidden behind many layers of screens. Additionally, information about job postings, such as salary and reviews, is fragmented across various domains. Some students resort to creating their own spreadsheets to manage this information, and existing third party browser extensions like Azure offer limited functionality improvements beyond webpage styling. The existence of these difficulties are supported by a Fall 2022 survey, where 48% of all students wished they had more time to examine the available jobs and 55% of all students reported specific issues with WaterlooWorks. This presents a huge market opportunity for Wave to help students save time and land a better co-op job.

Wave unifies new and existing information about each job into one powerful interface, built with modern web technologies and design standards. New information primarily consists of student community sourced information (e.g. r/uwaterloo salary spreadsheet and InternCompass reviews), AI generated keywords and job recommendations, and public information about the company, while existing information refers to the job posting and company ratings on WaterlooWorks. Wave also has information shared directly from students by allowing them to contribute reviews and ratings for jobs and interviews.

Wave was soft-launched in June 2023 and officially launched in September 2023, modernizing the old WaterlooWorks interface with a faster and more intuitive user experience. The unique software architecture of a web scraper integrated into a state-of-the-art full stack web application ensured compliance with WaterlooWorks copyright and brought major performance improvements to make Wave possible. As of January 2024, Wave has grown to 1140+ active users of the extension and jobs list interface (about 12% of the total market),

who have made over 24 000 search queries while organizing their shortlist. Wave also allows anyone to query public company information and read the 148+ original student reviews on companies. The Wave website has received a total of 4600 users and 75000 page views.

Moving forward, Wave will continue to collect user feedback and improve the core product. There are plans to open source the web scraper to ensure the longevity and sustainability of the project in bringing the best co-op search experience to University of Waterloo students.

https://uwwave.ca

10 SE 464 Revamp
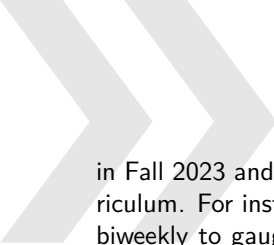## Team Based JAML

Jack Hu, Andrew Guo, Molly Yu, Laura Florea

[Program: SE; TA: Ahmed]

Software architecture is evolving at a rapid pace—from where we once had monolithic systems, we now have microservices, systems that need to integrate with machine learning models, and beyond. We believe that the design thinking needed for system architecture is what distinguishes SE and CS. SE 464 has a major part in being this distinguishing factor, but does not teach the modern high-performance design thinking that we believe is needed in an engineering course.

The objective of redesigning SE 464 is to develop a course that is centered around modern system design and software architecture. A re-imagined SE 464 would focus more on designing scalable, performant architectures that can handle petabytes of data or millions of users. As such, students will finish the course with essential industry-relevant knowledge on how to build robust, scalable systems that they can use in the rest of the SE program and beyond. In order to do so, lecture concepts will be supplemented with case studies. Course assessments will include an exam, labs, assignments, and quizzes. All of the course assessments will be specified in the course outline.

In the redesigned version of SE 464, there are two main components: the course material, and the labs. In terms of the course material, the large range of relevant topics and concepts make it difficult to fit a comprehensive curriculum into 11 weeks of lecture material. As such, the key challenge is designing the course material in such a way that the content is complete, digestible, and not too fast paced. Likewise, a second challenge is ensuring that the course material does not have $> 50\%$ overlap with other systems-related courses that are not antirequisites such as CS / ECE 454 and CS 451. As for the labs, the major challenge is designing labs that simultaneously allow students to put what they have learned into practice by building a system in which they think critically about the design while not introducing too much new coding work into 3B.

To demonstrate that the objectives of the course redesign have been accomplished, we plan to first have Prof. Derek Rayside teach the new curriculum

in Fall 2023 and then gather evidence to see how students respond to the curriculum. For instance, we can design quick surveys that students will be given biweekly to gauge student interest on the material and pacing. We can then iterate upon the course design for the Fall 2024 offering. This can similarly be done for the labs at the end of the course.

11 UWTrade: A Student-to-Student Marketplace for University-Oriented Used Goods
Team Zephatech

Hubert Zhu, Ryan Deng, Lizhuo You, Zuoqiu Liu [SE]
[Program: SE; TA: Akin]

According to the College Board, the average cost of textbooks and school supplies for college students in 2022-2023 was $1,240. This is a financial burden on students, especially for those from low-income families. Among these items, many are only used for a short period and are still in good condition to be reused by others.

To help students save money and reduce waste, we are creating UWTrade, a centralized, student-to-student platform for buying and selling university-oriented used goods.

The market opportunity for UWTrade is big, as there are around 40,000 students at the University of Waterloo. In addition, the come-and-go nature of students creates a constant demand and supply of used goods. For example, the unwanted used goods from students who are graduating/moving out are most likely needed by students who are studying/moving in. However, the current methods of trading these items have major pain points and can be solved by UWTrade.

UWTrade will emphasize the buying and selling of textbooks, as it is the most expensive and most relevant school supply. However, other university-oriented used goods such as furniture, kitchenware, and stationaries will also be allowed to be posted on the platform.

UWTrade brings three unique value propositions to the table: trust, convenience, and relevance.

Firstly, UWTrade establishes trust among users via the implicit trust of students, as all users will be verified by school email during sign-up. This trust will be further reinforced by our AI algorithms that detect and remove inappropriate postings, and our rating system. This sets us apart from other used goods marketplaces like Kijiji and eBay, where seller profiles are not guaranteed to be students, and trust between parties cannot be implicitly established.

Secondly, UWTrade streamlines the buying and selling process through its functionalities catering to every step involved in a successful trade, such as communication and meet-up arrangements. This minimizes the burden of execut-

ing a trade. This distinguishes us from existing university-focused marketplaces such as Facebook Marketplace and student forums, as they lack specialization in facilitating the end-to-end process of buying and selling used goods.

Lastly, UWTrade focuses specifically on trading university-oriented used goods. This narrowed scope ensures that the listed items are relevant for students. We will also utilize AI recommendation algorithms to suggest the most suitable items.

By combining trust, convenience, and relevance, our vision is to create a centralized platform that can cultivate a large user base and enable easy and seamless used goods trading. Both buyers and sellers will be incentivized to use UWTrade, as it offers sellers the opportunity to recoup money and allows buyers to save money in a way that is better than any existing platforms.

UWTrade addresses several pain points with current methods of trading used goods:

1. Illiquidity: Existing platforms lack a focused scope on university-oriented used goods, and this result in difficulties for buyers and sellers to find each other promptly, which leads to some buyers having to opt for buying new and paying a premium, and some sellers having to sell their items to middlemen for a lower recoup. UWTrade aims to become the preferred marketplace for students by providing a centralized platform specifically tailored to their needs, thereby increasing market liquidity.

2. Inconvenience: Most existing platforms do not facilitate the end-to-end process of buying and selling used goods, so buyers and sellers usually have to use multiple platforms to complete a trade. This is time-consuming and inconvenient, and often leads to mishaps such as miscommunication and missed meet-ups. UWTrade streamlines the entire trade process, from surfacing relevant items to coordinating meet-ups, providing a seamless and convenient trading experience.

3. Lack of trust: Trust issues arise on other platforms due to the unverified student status of sellers which could result in potential scams. UWTrade addresses this concern by verifying users as students through school email verification and incorporating AI algorithms to mitigate fraudulent activities.

4. Middleman: To build on the first point, middlemen are often how sellers and buyers sell and buy used goods as it is very convenient, however, the added intermediary results in a loss of value for both parties. For example, school bookstores often buy used textbooks from students for a fraction of the original price (less than 50%) and resell them for about 80% of the original price. UWTrade eliminates such middlemen and allows buyers and sellers to trade directly with each other and ensuring all parties benefit from the trade.

Our goal is to develop and launch a web-based platform in 4A and collect user feedback to improve it in 4B. Additionally, we intend to develop a mobile app to offer users more options to access the platform, thus fostering growth

and better adoption of the app. The project's effectiveness and success will be determined by the number of user signups, the number of items posted, and the number of successful trades.

N/A

12 Spacewalk: Adding a New Dimension to Presentations
Team Spacewalk

While slideshow presentation software like PowerPoint are a powerful tool for realizing 2D visual effects, there is a gap between the output of such software and videos with 3D visual effects. A product that combines the visual impact and illustrative power of 3D VFX videos with the ease of use of presentation software (creation, editing) would bridge this gap.

There is also a gap between slideshow software and interactive 3D model viewers. The latter are useful for product demos or technical walkthroughs, but come with difficulties

Ibraheem Aboulnaga, Vaenthan Jeevarajah, Cole MacPhail, Olivia Misasi, Janakitti Ratana-Rueangsri, Anthony Wang
[Program: SE; TA: Ahmed]

in choreographing presentations, accommodating new or casual viewers, and sharing concrete outputs. This gap would be bridged by a product combining the benefits of interactive models with the repeatability, guided viewing, and common format of slideshow presentations.

We believe a single product addresses both of these spaces.

Our objective is to develop an intuitive web application to allow users to create presentations in 3D space with interpolated camera motion to provide an immersive experience to viewers. We hope to strike a balance between ease of use and an extensive feature set to give any user the ability to create these dynamic presentations. It will allow the user to customize the space and set keyframes for the camera position to define the camera path for each "slide" along with the ability to select different cubic-bezier curves for the camera velocity. We will also provide the option to share the presentation through various export options and shareable links.

It is challenging for everyday users to create artistic and professional-looking 3D presentations. While the technology exists to create 3D motion graphics that look like slideshows, they don't offer any guidance to help inexperienced users automatically polish their creations in a way that looks visually appealing. We want to make it possible for anyone to produce a "flythrough" of a 3D space that looks professional and cinematic, regardless of their experience in

art, design, or motion graphics - easy enough to use that even middle schoolers can produce good results.

To address the issue of a lack of polish in beginner presentations, our system renders user-created presentations in an opinionated way. This means an interface that skips many of the "fine-tuning" controls that may read as "clutter" to a more novice user, and instead incorporate design decisions into the product that help users produce cinematic presentations, without the need for an artistic background. Some examples include: automatically polishing lighting to make a scene look vibrant and clear; smoothing out transitions between camera angles and creating a cinematic feel; adding post-processing effects such as film grain or camera shake; and providing pre-built templates for 3D worlds, transition sequences, and effects.

To ease 2D presentation users in to our application and shallow out the learning curve, we start with a familiar presentation building interface, similar to Google Slides or PowerPoint. We then introduce them to the 3D functionality via tools and suggestions to automate or encourage typical 3D workflows; e.g. determining sensical anchor points on template objects and snapping other objects to them. We prefer layman's or artists terminology over technical terminology for menus, options, and tutorials. And we include flows that guide users towards choosing appealing combinations of visual effects for their presentation.

We are aiming for a closed alpha release in November 2023, which will offer all of the core features of the final product (presentation creation and sharing, object library, keyframes) with less polish. In this release, we will gather user stories from students in various faculties, and middle school educators and students if possible, focusing on the following questions: whether users find the tool easy to use (and what features help them feel this way), how often they see themselves using it (and for what use cases), and any features stand out as missing. After iterating on this feedback, we will aim for a public release in January, at which point we will begin marketing with a goal of 1000 user sessions total by March 2024.

13 XChange: Everything you need to plan your exchange term
Team Design Party

Going on exchange is a remarkable opportunity, one which a remarkable amount of students consider but do not pursue. The cost of exchange is high, and the academic logistics can be a nightmare. It is difficult for students to be well-informed about the living environment of potential schools, and it is challenging for students and advisors alike to identify foreign course sequences satisfying UW academic plans. XChange looks to ease these difficulties by providing a publically available web-service allowing users to query for schools and previously approved course equivalencies. As well, the website will allow students to discuss and post about their living experience on exchange, informing others about crucial topics related to safety, housing, finances, and the like.

Kevin Li, Aparajita Ghimire, Neha George, Zhengmao Ouyang, Andrea Anne Miranda [SE]

[Program: SE; TA: Akin]

At a high level, the user flow of XChange involves a landing page with an optional login and signup, which leads to a main query page for schools and courses. Here, students are able to search and filter for offered host universities as well as previously approved course equivalencies. For each host university, there will be a corresponding page containing reviews, tips, previous experiences, activities, and course information that can also be searched and filtered. Each host university page also provides information about previously approved equivalencies specific to that school.

XChange also allows for course queries in which a user may request all equivalencies approved at a particular foreign school as well as UW program. For example, a user may ask for all equivalencies that have been approved for SE students at the National University of Singapore (NUS). Moreover, the application will allow students to see entire past course sequences taken by a student at another school where applicable. XChange uses a relational database to scalably store information in various tables, such as users, host universities,

reviews, etc.

Currently, the UW exchange program is offered through the Student Success Office, which offers the Waterloo Passport web service. However, this service only provides relatively basic logistic and living information, leaving the majority of academic and experiential planning up to students and advisors - this is the gap XChange will fill. The intended impact of such a project is increased interest in exchange and an increased satisfaction with the application process.

The XChange team is currently working with the UW administration to consolidate past, current, and future exchange data in a reliable, consistent, and scalable manner, which is stored and maintained differently between faculties. In particular, we are liaising with Waterloo Passport and faculty exchange coordinators to discuss ideas and collect feedback. For now, we are manually collecting and scraping data off of Waterloo Passport and university exchange pages, but are working with university staff towards accessing, obtaining, and organizing official data. Ultimately, our aim for XChange is to create a community for past and current exchange students to share their experiences, and to provide for students in general a useful tool to plan academically for exchange.

14 S4DGE: Some 4 Dimensional Game Engine
Team Epsilon

Modeling and understanding higher spatial dimensions has captured mathematical interest and fascinated the imagination for almost 2 centuries. Something about the human brain's inability to conceptualize shapes and spaces in higher spatial dimensions makes the study of the shapes even more interesting. Capturing the fun of 4D in games has occasionally been performed, as in 4D chess, 4D toys, or 4D golf for example. There is incredible opportunity for gameplay which allows players to explore and use a 4th spatial dimension and potentially visualization opportunities for more scientific interests.

Luke Klassen, Royi Luo, Sunny Lan, Richard Sun, Boon Boonsiri
[Program: SE; TA: Ahmed]

At the core of our project, we believe there is fun and fascination to be found in playing in 4 dimensions. Team Epsilon's goal is to make a game in unity which uses and builds upon our 4D unity extension from SE390 in which interacting with a 4th spatial dimension is a core gameplay component. In part this will involve continuing development on the S4DGE (Some 4D Game Engine) in parallel to support the requirements of our game. Team Epsilon's goal is to make an open-source plugin for Unity which allows game developers to build games with a 4th spatial dimension as a core gameplay component. In this milestone, we will build a new, more powerful iteration of our previous Unity library produced in SE390, S4DGE, that will be able to render any 4D shape, rather than just 4D hyperprisms with limited rotation.

Ease of use for unity developers using S4DGE is especially difficult in this project. Our game plugin will have to cooperate with many of Unity's existing features, and provide developers with easy ways to test and create their 4D ideas. The plugin should allow any developer familiar with Unity to develop and experiment with games in 4D by placing our 4D renderer script on a camera, adding our 4D shapes or converting their own meshes into 4D, and positioning game objects with our 4D transforms.

For this we take 4D Toys as our competitor, for which a research paper was published in SIGGRAPH 2020 for their rigidbody physics system. As an advanced technology, S4DGE uses technically advanced processes to enable real

time rendering from 4 dimensions, and also fills a new niche, as no known open source 4D rendering is available for a game engine. Our project could implement these advanced ideas and make them accessible to all unity developers, and our success could also be measured in users on the unity extension page. To demonstrate the capabilities of the engine, a demo game could be developed and feedback from gameplay tests could be another measure of success.

15 Make reality your playground
Team Pursuit

Pursuit is a hide & seek mobile web application with geolocation to meet peers and get physically active in their surrounding environments. By leveraging location tracking technology, Pursuit allows users to create or join game sessions based on their current location. Participants can set the boundaries of the playing area, defining the area where the game will take place. This feature enables individuals to connect with like-minded peers nearby, fostering social interaction and the formation of new friendships.
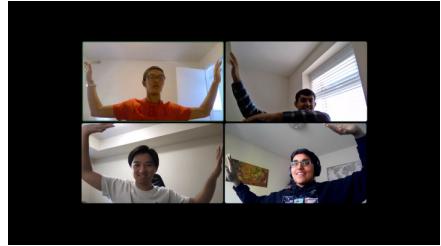
Het Shah, Maahir Gupta, Josh Cheng, Danny Wu
[Program: SE; TA: Ahmed]

Geolocation can be used for players to find hiding players in real time, where hiding players will occasionally release a ping that places a marker on a map to denote where the player is hiding. This adds an additional layer of excitement and challenge to the traditional game and streamlines the seeking process for faster games.

Taking advantage of the widespread use of geolocation technology and smartphones, Pursuit taps into the innate human desire for play, exploration, and social connection, by revitalising the traditional game of hide and seek for the digital age. It offers a unique market opportunity by merging virtual experiences with real-world interactions, catering to a broad demographic range and aligning with the growing interest in physical activity and immersive gameplay experiences.

Users are drawn to Pursuit to have fun with their friends by playing in person games from their childhood. Pursuit enables these games to be played at a larger scale and makes them more competitive, which makes these games attractive to all age groups and not just children. Users may also be drawn to Pursuit to engage in physical activity in a fun way and engage in social activities.

By leveraging geolocation technology, the Pursuit mobile web application solves pain points regarding lack of social interaction and physical activity for adults. The traditional game of hide and seek can become monotonous and is probably something an adult wouldn't think about, but Pursuit revitalises the traditional game by adding excitement and challenge through real-time geolocation.

Adding geo-location technology renders the game much more competitive, and the technical nature of this application means that new game modes and configurations can always be released, to keep the experience fresh. This promotes an easy and attainable way for adults to get outside and play a childhood classic while solving their issues of exercise and social isolation. Pursuit will create an engaging and healthier experience through a revamped and digitised childhood classic.

The initial release of the game will be in August 2023, where we intend to support multiple lobbies (private and public) with a basic hide and seek game mode. Our goal is to acquire at least 50 active weekly users that play at least 1 game per week. We hope that a user base of this size can provide us with adequate feedback to help us prioritise further game refinements and extensions. Possible extensions include hybrid and novel game modes, tournaments and leaderboards, and more.

16 A song-guessing game
Team forgs

. . . a song-guessing game that is not like Wordle and is not real-time . . .

Broccoli is a popular and nutritious vegetable that has been cultivated for over 2500 years. While broccoli originated in what is now Italy, it is eaten around the world, with 73% of the modern crop grown in India and China. There are billions of people around the world who enjoy broccoli on a regular basis, creating a huge market opportunity for our BB app.

Ryan Hoffman, Iniyan Chelladurai, Ahsan Nadeem
[Program: ECE; TA: Ahmed]

Blanching is a fast, healthy, and delicious way to cook broccoli, either for immediate eating or as a preparatory step for freezing or sauteing. Broccoli that has been blanched before freezing retains up to 1300% more vitamin C than broccoli that is frozen directly. There are two distinct blanching techniques in common use, and both are supported by BB: boiling and steaming.

A major challenge in blanching is knowing how long to apply the heat. BB uses a feedback control system based on two forms of advanced image processing to ensure perfectly blanched broccoli every time. First, the initial time target is set by measuring the average floret size on the cutting board. Second, during the blanching process, the time target is continuously optimized based on the colour transformation of the vegetable in the pot.

Initial deployment of BB to the public was done during the fall harvest season, in collaboration with the Student Success Office and the St Jacob's Farmer's Market. Farmers reported that broccoli sales to younger adults increased by 57%. Interestingly, the app also drove broccoli sales to newly retired older people, a significant subset of whom are looking for new projects to engage with. App usage was not significant amongst adults of working age. The Student Success Office reported overall improved physical and mental health amongst students who improved their diet by using the BB app.

17   Bet with your pride, not your wallet
Team Go Time

Braydn Moore, Jacob Meleka,
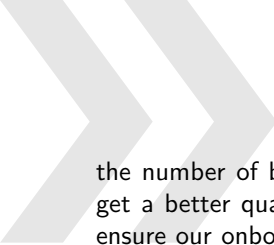Nicholas Makharinets
[Program: SE; TA: Ahmed]

Online sports betting is a rapidly growing market expected to grow from 36 billion in 2022 to 116 billion by 2032 with the central contributor to this growth being legalization across jurisdictions. For instance, California, Texas, and Florida (the three most populous US States) have not yet legalized online sports betting but are expected to over the next 5 years. Even without widespread legalization across the U.S., 1 in 5 Americans reported they have bet money on sports in the last year, with nearly 80% doing so in private betting pools with friends and family. Despite its popularity, gambling literacy is still relatively low, with the National Council on Problem Gambling reporting that 75% of young male respondents viewed sports betting as either a great way to make money or were unsure. This is contrary to reality, in which a sports bettor is expected to lose 3-10% on every dollar wagered due to hidden sportsbook fees.

Bet Together offers a service to fill the same niche as sports gambling without the financial risks associated. It does this by introducing "tokens", in-game currency with no connection to real-world currency. These tokens can only be acquired via winning bets, daily check-ins or by doing well in leagues/competitions. Additionally, Bet Together will allow players to create configurable leagues to play with friends or other bettors around the world.

As previously stated, the average bettor is expected to lose 3-10% on every dollar wagered. For regular bettors, this can amount to thousands of dollars a year in losses. Bet Together's "tokens" would alleviate any financial risk to the user, allowing them to bet with their friends completely free. Additionally, the 80% sports bettors who do so in private betting pools with friends and family have been limited in their ability to play with friends on the existing sportsbooks. Bet Together's league system would unlock this possibility.

When evaluating the performance of Bet Together, a few measurements can be used to get a complete picture. Account creations give a great general sense of site health, however users creating accounts isn't a direct proxy for user interaction. To get a estimate for interaction, Bet Together will track

the number of bets placed as well as the number of tokens bet per user, to get a better quantitative understanding of user interactions. Additionally, to ensure our onboarding experience is as frictionless as possible, we will consistently measure and reduce the "Time to First Bet". Another metric which will be measured is user sentiment, which will be measured quantitatively via the number of user referrals, and qualitatively by polling early adopters of the site.

18 Snowflake: censorship circumvention Team Gols

Andrew Wang, Anthony Chang, Kieran Quan, Michael Pu, Yi Wei Zhou

[Program: SE; TA: Ahmed]

Snowflake is a WebRTC Pluggable Transport circumvention system that allows users to access the free and open internet through a censorship circumvention system such as Tor. Pluggable Transports are tools that transform network traffic between a client and the bridge to bypass censorship. Tor is an open-sourced software that allows users to anonymously browse the internet. (https://gitlab.torproject.org/tpo/anti-censorship/pluggable-transports/snowflake/-/wikis/home).

One of the biggest challenges with circumventing censorship is the process of connecting clients with proxies. In Snowflake, this is known as the rendezvous stage. This process is managed by a Broker, which is a third party service that is responsible for securely matching Snowflake clients with Snowflake proxies using SDP. Domain Fronting is used during the rendezvous process to allow clients in filtered regions to connect to Brokers by taking advantage of HTTPS and the CDNs of large third-party internet companies such as Google, Amazon, and Microsoft.

One key area of improvement for Snowflake is to add support for new rendezvous methods. Some particular methods of interest that we are looking into are rendezvous using Amazon Simple Queue Service (SQS) and using DNS over HTTPS. In addition, we are hoping to explore and prototype other third party services that could be good candidates as Brokers.

☐ Were we able to create a new rendezvous method?

☐ Can we access the Tor network over this new rendezvous method?

☐ Do we see any improvement using our new method vs. existing methods?

☐ Were we able to merge our new method into the Snowflake codebase?

☐ Is this new rendezvous method being actively used?

19 Tether: An App to Bring Relationships Closer Together
Team Sasquatch

As students who are always moving around from city to city, many members in Team Sasquatch have had to navigate their interpersonal relationships from a distance. While the internet age has introduced some digital aids to facilitate communication, maintaining a connection with a significant other still remains a challenge. Realizing this to be a shared experience, Team Sasquatch wanted to build a tool specialized for couples that would close the emotional distance often felt due to a lack of shared experiences and communication when couples are apart.
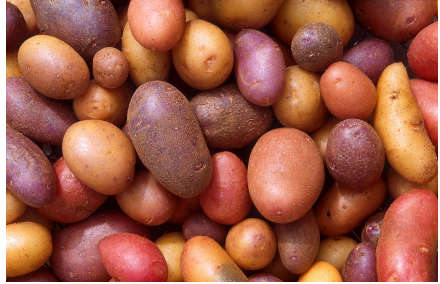
Jessica Lui, Yash Arora, Oustan Ding, Matthew Geng, Armanya Dalmia, Tony Zhao

[Program: SE; TA: Ahmed]

Couples in long-distance relationships often rely on digital means of communication to sustain their relationship. However, merely texting, calling, or video chatting sometimes isn't enough, as synchronous experiences aren't always possible. Asynchronous experiences such as shared digital art, music, generative AI can help bridge the gap between long-distance experiences and rich in-person ones.

One of the pain points of long-distance relationships is the lack of close interactions. This makes it difficult to get to know one another, share common interests, and develop the relationship in general. We will resolve this pain point using a combination of personalized features and application of artificial intelligence. For instance, for newer relationships, asking questions allows people to know each other better - AI could be leveraged to generate meaningful questions and follow-ups to accomplish this. When combining personalized features such as Spotify integration, photo memories compilation and virtual pets, couples can still build an organic relationship despite being physically distant.

Tether's results will primarily be gauged by our user count and comprehensive user studies. We'll also benchmark our achievements by contrasting them with key competitors. Emphasis will be placed on tracking the growth and retention rates of our user base. To assess our application's quality, we will facilitate in-person user interviews and solicit feedback through online sur-

veys. These user interviews will focus on what features users respond positively to and what needs aren't being met. For a holistic perspective, we'll evaluate our product both qualitatively and quantitatively against competitors, with SumOne and Locket Widget being notable examples.

20 Control theory in the GoLang Garbage Collector Team Collector Control

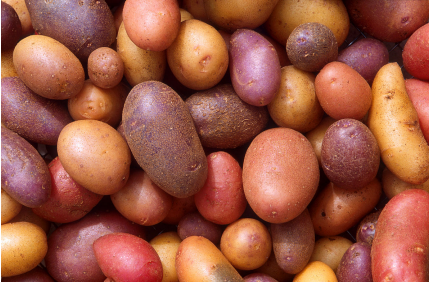The GoLang Pacer concurrent garbage collector has been experimenting with applying control theory. There appears to be room for improvement.

Kieran Quan [SE]
[Program: SE; TA: Akin]

21   Applying control theory for CS452 trains
Team Train Control

Connor Byers
[Program: SE; TA: Sagar]
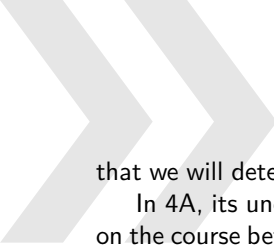
For CS452 Trains, we want to look into applications of Kalman Filters and control theory in the course to improve the accuracy of estimations (mainly kinematics when tracking train velocity and position) while simulatenously reducing the use of time intenstive trial and error methods. This work can help propose the addition of Kalman filters and other applications of control theory that could be taught in SE380 to make the course more relevant to Software Engineering students and for other majors that want to take CS 452 in 4th year.

In CS 452, students face the problem of tracking the current location and velocity of the train on the track in order to decide whether to increase speed, come to a stop to avoid a collision, etc. Students can get an estimated average velocity by finding the difference in time between 2 sensors were hit and using it in the usual delta d / delta t formula where delta d is the physical distance between both sensors. They do that by running multiple experiments and doing calculations based on the data points they receive. There are some more methods that have been used by students in the past like doing something like a binary sort algorithm to nail down velocity, acceleration, etc. They are all incredibly time consuming and is error prone. There is some randomness involved as there is latency between the user's kernel to making the request to the train for sensor information and when it comes back. There is further complications as there are multiple speed levels the train can be running at 0-14 and the acceleration needs be considered in order to be accurate. Any errors here can lead to the user's code assuming the train is at one position and velocity and make decisions based on that, but in reality, it could be far off, causing collisions and undesired behaviour.

Applying Kalman filters and control theory to be able to track the train's position, velocity, stopping distance would be 1. More accurate 2. Less trial and error (time consuming) 3. Fun application of control theory that SE students could use

There could be other applicatons of control theory outside of kinematics

that we will determine as we discuss with the professor and investigate further.

In 4A, its unclear at the time of writing if I will be allowed to start working on the course before my 4B term while I take CS 452. But we will definetely aim to have at least some MATLAB code or simulations that would demonstrate our work's validity.

But at symposium, I would have completed CS 452 with the applicaton of kalman filters and control theory we will develop this term.

To measure results, we could - Track how accurate our train's position and velocity modelling is by comparing what our code thinks with the train's actual position on the track. We could compare with others students or ask the professor if he sees any improvement compared to previous CS 452 students' models. - Track how long it takes to code the control theory and use it to determine position, velocity and compare with other/previous students. - Ideally, if Kalman filters and other applications from this project get applied to SE 380's curriculum, we could see if future students find this information useful and use it.

22 Social Agents in a Dynamic Simulation
Team Goose
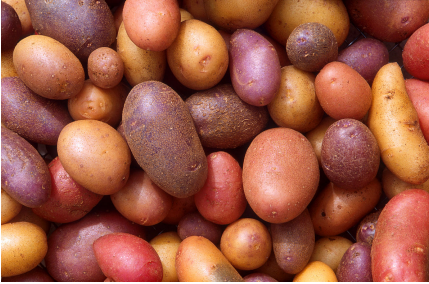
Jerry Qu, Will Harris [SE]
[Program: SE; TA: Akin]

Recent innovations in large language models (LLM) have paved the way for exciting new products and technological applications. One interesting application of LLMs is to model human-like social autonomous agents within a virtual environment, such as in the paper "Generative Agents: Interactive Simulacra of Human Behavior" by Park et al.

Team Goose is working on a project that places social agents within a dynamic virtual environment that can be mutated by its inhabitants. We aim to discover the interesting ways in which social agents choose to change their environment as well as the challenges involved in producing interesting emergent behavior.

23 Muntalacier: An App for Face-based Fashion Recommendations
Team Muntalacier

Each and every day, technology is improving the way we educate one another. Learning platforms are an excellent example of this. Platforms tailored to their users are prevalent in the space. Whether that be to teach coding to high school students, or allow professionals to gain certifications in their field of choice, learning platforms offer a wide range of uses. A subset of learners for whom this is most beneficial are university students. These students spend all of their time learning, and these tools are especially useful for streamlining this process.

Aly Muhammad Mithani, Muntaqim Rahman, Md. Abdul Chowdhury, Asim Bhatia, Faiz Momin, Aryan Patel
[Program: SE; TA: Ahmed]

University students want to learn. They are enrolled in full-time or part-time studies with the intention of gaining more knowledge in their field of study and earning some sort of certification of their accomplishment in the process. Learning platforms have already found ways to improve this process and allow students to learn in more streamlined ways than ever before. As such, students are constantly on the lookout for new tools which will help them with this endeavor and make their lives easier in the process.

Finding learning platforms online for undergraduate students that are tailored specifically to their coursework is difficult. Oftentime, students want to try tackling questions that are similar to those they may expect to see in their final exams, but are unable to find them. Such students must then rely on questions from the limited practice problem sets they receive from their instructor, often without input from other students on how to begin tackling them. Students also want to find ways to work together with students in their courses on answering such questions and practicing for their evaluations. They also seek to utilize technology which would make their time studying as efficient as possible.

Chasm is a learning platform designed to assist students gain a deeper understanding of course materials for better academic results. The software provides users with a space to access questions for their specific courses orga-

nized by topic, and tackle those questions head on. Once attempted, students can then get access to a forum-like environment discussing the question, complete with other students' thoughts, attempts and opinions specific to that question. This will allow students to better engage with the material and help prepare for evaluations. In addition, students will be recommended questions in a sequence to ensure their time spent studying is efficient and effective for their goals, whatever they may be. Future features of the software includes an AI model that automatically trains on data from previous posts (of questions) and answers in discussion boards to curate a list of new questions for users to get practice.

Initial deployment of our app will take place during the start of the year in February, strategically placed before midterms. Marketing will be done beforehand to garner hype and traction surrounding our app. Throughout the release points of our application, we will spectate the user download metrics, as well as monitoring consistent usage. These metrics will also transfer into reviews for our application once published, which is a great tool to receive feedback.

Student Index

In memory of Grace Chi Hung Leung 1932–2020

UNIVERSITY OF
WATERLOO

FACULTY OF MATHEMATICS
**DAVID R. CHERITON SCHOOL
OF COMPUTER SCIENCE**

FACULTY OF ENGINEERING
**DEPARTMENT OF ELECTRICAL
AND COMPUTER ENGINEERING**