UNIVERSITY OF
WATERLOO

Computer Science / Software Engineering Capstone Design Symposium
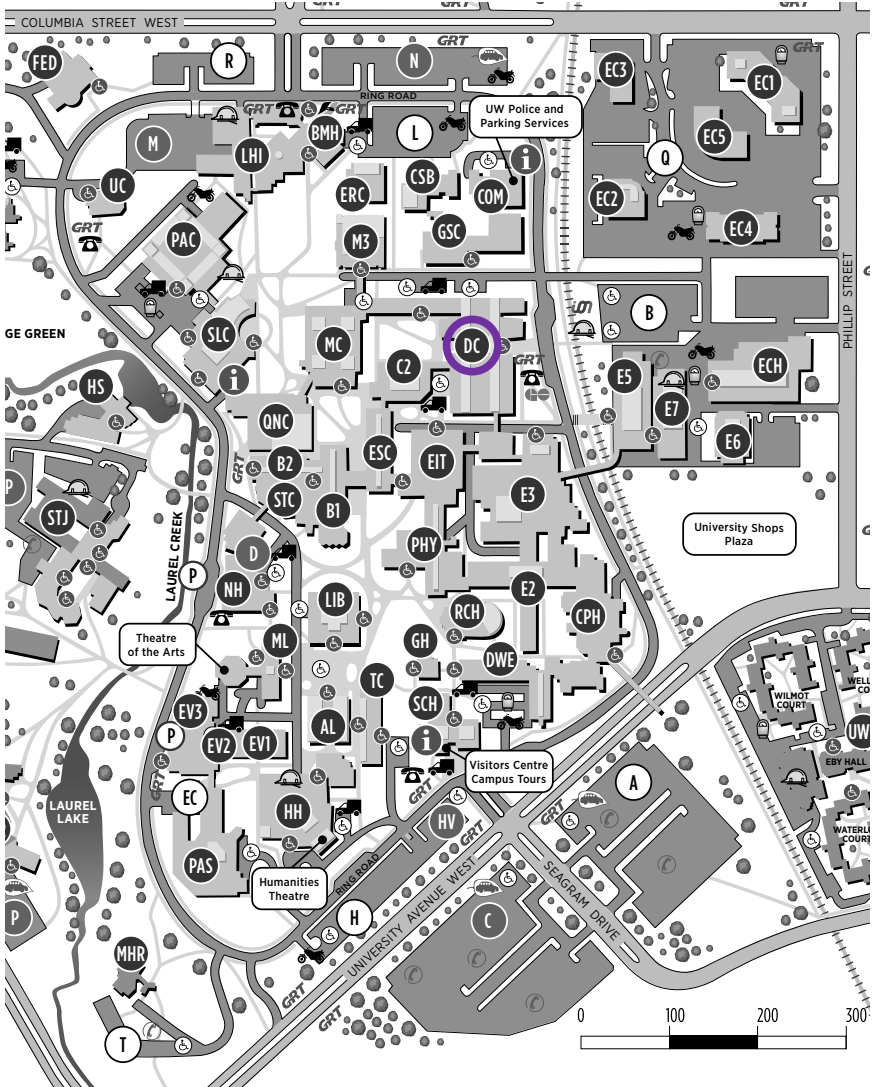
March 26, 2020
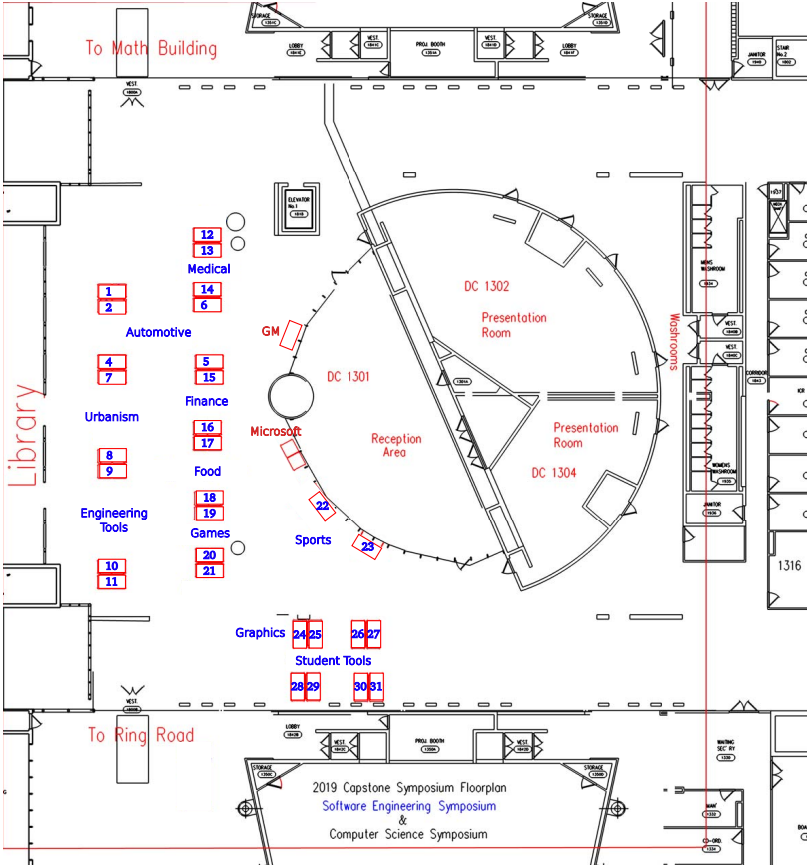*Talks:* 9AM–5PM
Awards: 6PM

UWaterloo Campus Map

COLUMBIA STREET WEST

RING ROAD

GE GREEN

LAUREL CREEK

LAUREL LAKE

PHILLIP STREET

UNIVERSITY AVENUE WEST

SEAGRAM DRIVE

RING ROAD

FED, R, N, EC3, EC1, M, LHI, BMH, L, EC5, Q, UC, PAC, ERC, CSB, COM, EC2, EC4, M3, GSC, SLC, MC, C2, DC, B, E5, ECH, HS, QNC, ESC, EIT, E7, E6, B2, STC, B1, E3, D, NH, PHY, E2, CPH, STJ, ML, LIB, RCH, GH, DWE, P, TC, SCH, EV3, AL, EV2, EV1, EC, HH, PAS, A, HV, C, MHR, H, T

UW Police and Parking Services

Theatre of the Arts

Humanities Theatre

Visitors Centre Campus Tours

University Shops Plaza

WILMOT COURT

EBY HALL

WATERLOO COURT

0   100   200   300

Davis Centre Floorplan

Presentations will be in DC 1302 and DC 1304.

Teams

Coding Challenges	1	Swift
Digital Signage	2	Blimp
Retail	3	WeGo
Distributed Systems	4	Ctrl-C
	5	nfinite
SE Tools	6	ENVy
	7	Helix
Media	8	Jent
	9	Mocha
	10	Panic
Data Science	11	CRF
	12	Daudit
	13	TagBull
	14	Yummify
Formal Methods	15	Prop

Projects

Cipher Challenge: An SE candidate screening platform
Scinage: Digital signage made easy
CheckEx: Reimagining Retail Checkout
OpenAPI Standard for Kafka Cruise Control
nfinite.space: Distributed storage over unreliable nodes
The easy way to build development environments
Waterloo Oasis: Co-op Collaboration Platform
Jent.ly: Article Summary Chrome Extension
A Platform for Podcast Monetization
Mask: Toxic Comment Filter
A Novel Content Aware Citation Recommendation
Anomaly Detection For All
Crowdsourced labelling instead of ads
Finding recipes for your leftover ingredients
A simulator for Alloy transition systems

Teams

Projects

OCT-opus: Deep Learning to Enhance Retinal Images
TrakTab: The classic pillbox, reimagined.
Propagate
Feudal Fight
Life is Just Another Dungeon: A Dungeon Crawler
Minecraft Patchwork: A Peer to Peer Solution
A Message Board for Residences
Qurious: In-Class Q&A and Collaborative Notes
A Web App for Course Planning
Spritec: Spritesheets from 3D Models
Build better habits with science
Habitica: Implementing Offline for Mobile

1 Cipher Challenge: An SE candidate screening platform
Team Swift

Our customer, Correlation One, is a company that helps employers attract and evaluate top engineering and data science talent for hire. Although programmers are abundant, truly exceptional talent is hard to find and retain. Correlation One's products and services help employers find and evaluate this talent.
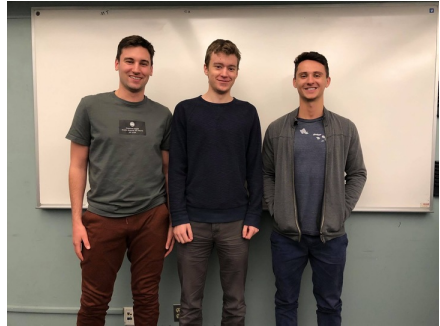
We've created a platform that allows employers to issue online challenges to job candidates as part of the pre-interview screening phase of recruitment. In addition to issuing

Matthew Murphy, Robert Sutherland, Dalton Sweeney

challenges, employers can use the platform to monitor candidate progress and analyze data on completion rates, attempt rates, and more.

The project objectives are to: a) speed up the recruitment process for both the employer and candidates; b) decrease the number of false positive candidates that make it through the screening phase; and c) attract a wider pool of applicants to a particular role at a company. Each challenge is meant to evaluate a skillset that is of interest to the employer and the role for which they are hiring. Thus, the nature and difficulty of the challenges can vary greatly.

Our platform allows for both crowdsourced and team built (Correlation-One and affiliates) challenges. Challenges can be built with any technologies but must adhere to a challenge guide and utilize a sanctioned API to maintain consistency. The API will expose utilities within a backend built by us, including endpoints for starting and progressing through challenges, as well as authentication. Design challenges chiefly include contriving sufficiently complex and interesting challenges, and deciding which tools are best for building these challenges, which are diverse and test a very broad spectrum of knowledge.

The main advantage of our platform over existing alternatives such as Hackerrank is that the challenges issued to candidates are not limited to algorithmic and competitive programming style problems. There is a large set of problems to choose from, testing skills and knowledge in various domains like cyber security, web developement, databases, and more.

2   Scinage: Digital signage made easy Team Blimp

Stanley Huang, Bhavika Sharma, John Huang, Holly Oegema, Samuel San, Riley Gowanlock

On large campuses like the University of Waterloo, there is a clear need to communicate announcements, events, wayfinding, and other important information. While the UW campus has rapidly increased in size and complexity, wayfinding and informational tools have not kept pace. The Campus Wayfinding Project is an initiative to modernize and centralize physical signage around campus. Digital signage on the other hand often uses bespoke software that is difficult to use, expensive, difficult to manage and hard to scale across large campuses. A small, limited-resource team out of Science Computing at the University of Waterloo has developed an open-source application called Scinage to address this. Scinage has quickly become the de-facto solution for centralized digital signage across all faculties on campus.

Our team has developed Scinage 3.0, and we've focused our work on shipping major features that enhanced our user's workflow, modernized the application, improved the reach outside of UW and fixed critical and major bugs to promote the upgrading of all digital screens on campus and to easily spread information to the public.

After sitting in on user training sessions and conducting interviews with current Scinage users, we cataloged main pain points with the application, along with the laundry list of requests from consultation with the original Scinage developers, we worked to make some key improvements to the Scinage application to improve ease-of-use, productivity, and maintainability.

We submitted 20+ patches which addressed 2 critical, 10 major and 16 minor features and bugs. Some of our major contributions include updating the codebase from Python 2 to Python 3, overhauling the Scinage UI completely with a new redesign, implementing improved workflow features such as PDF to slideshow generation, slide overlay, analytics dashboard for Scinage administrators, and improving the existing slide editor. Another part of our mission was to bring the magic of Scinage to other organizations, in order to achieve this we developed a custom authentication system, docker container and startup scripts to make contributions and use easier outside of Waterloo.

https://git.uwaterloo.ca/science-computing/Scinage

3 CheckEx: Reimagining Retail Checkout
Team WeGo

Long checkout queues are a common nuisance for retailers around the world. Retailers want to ensure customer satisfaction by increasing the throughput and reducing the latency of checkout queues. Stores have made multiple attempts to combat this issue, like implementing express checkout lines, self-checkout, and smartphone assisted checkout apps. There are many retailers that want
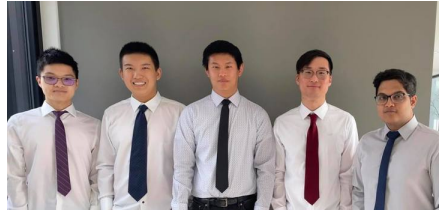
*Brian Ho, David Lu, Allen Huang, Hae Yoon Cha, Anmol Mago*

to improve the checkout experience, which creates a large market opportunity for CheckEx. Although many retailers seem to be trying to create an app to support online shopping.

Mobile assisted checkout has the potential to significantly speed up the checkout process. CheckEx provides shoppers with the ability to verify and scan purchases as they walk through the store, as opposed to scanning all their items at a traditional checkout station. CheckEx also provides shoppers with a new way to track their spending over time. This service will also be targeting difficulties in current inventory management and POS systems to make retailers' life easier as well.

The primary challenge of checkout systems is latency. Customers do not like waiting in lines to check out. Even current self-checkout systems still have queues to use the self-checkout machines. As most customers already possess a mobile device, leveraging it for checkout will greatly reduce the time that customers stand in line. This pain point is also felt by merchants, as customers who have waited too long will leave the store before purchasing items.

We have a backend, frontend web app and android app built out with a handful of core features. This includes user hierarchies, OAuth, transaction level reporting, purchasing, tax calculation and Square as a POS system. In addition, we have performed user studies to validate the usefulness and usability of the CheckEx app.

4 OpenAPI Standard for Kafka Cruise Control Team Ctrl-C
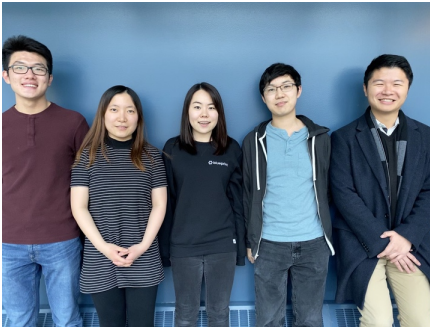
William Lo, Jing Li, Jeffrey Fei, Ian Hu, Emily Ki

For massive Kafka clusters, issues such as broker deaths and workload balancing amongst different brokers must be resolved on a daily basis. Cruise Control is an open-source project developed by LinkedIn that automates load balancing and self healing of Kafka clusters. Cruise Control's code base is rising in popularity due to the widespread use of Kafka, but it is lacking in usability due to its poor API documentation.

Originally, there is no single source of truth for Cruise Control's API endpoints. Users need to dig through the API documentation on the Github Wiki, which is typically not kept up to date due to the low number of maintainers, then cross-reference it with the source code to understand the purpose and functionalities of each endpoint. After integrating with OpenAPI, users can easily generate language-agnostic clients that interact with the API and clearly view all respective API schemas.

There were two common issues brought up consistently with Cruise Control's code base. Firstly, there were multiple Github issues raised about the lack of updated API documentation. This made it very hard for new users to understand the system and its capabilities. The second issue is that with every change to Cruise Control's API interface, surrounding tools (i.e. the officially supported CLI tool) that depend on the interface definition would become out of date. This makes maintenance difficult for developers.

Our solution of enforcing an OpenAPI standard allows users to easily view all API documentation and generate clients to create tools that can fully interact with the newest version of Cruise Control.

We have worked with the Cruise Control maintainers to design and implement the OpenAPI yamls with surrounding integration tests for Cruise Control in its release version 2.0.83. As a result, users can now easily interact with the API by generating clients in any programming language. Currently, the code we have merged is actively being used by the community as the source of truth for API endpoints documentation. We have also contributed features and bug fixes that improve the usability of API endpoints.

https://github.com/linkedin/cruise-control

5 nfinite.space: Distributed storage over unreliable nodes
Team nfinite

At the moment, there exist countless internet-connected hard drives which have unused storage space. `nfinite.space` is a cloud storage network capable of utilizing these unused drives as storage for its network, addressing issues of security, reliability, and availability that come with untrusted peers. This allows `nfinite.space` greater utilization of existing resources and offers the potential to provide the same service as a traditional cloud storage provider at a lower cost.

To overcome the difficulties of building a reliable system over an unreliable set of nodes, we've built a central monitoring service, which coordinates the actions of each node and validates the correctness of its behaviour, along with a simulation tool that provides insight into the dependability of the whole network based on the dependability of the peers.

Stephen Melinyshyn, Daniel Prilik, James Hageman, Ethan Hardy

6   The easy way to build development environments
Team ENVy
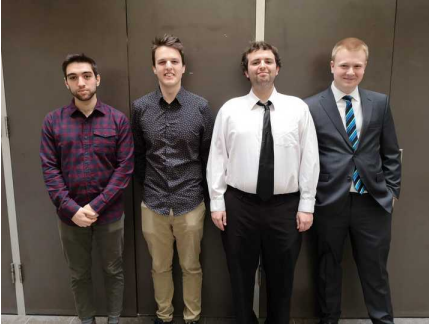
Omer Strumpf, Greg Bateman, Timothy Willard, Alex Roth

One of the more annoying parts of starting development work on an existing software project is getting your development environment set up. For many projects, the setup guide (if it exists!) is pages long. Even in the corporate development world, some projects can take days of developer productivity to get set up on. If developers didn't need to think about setup time before working on an open-source project, we believe that contribution rates would increase significantly. This could be a huge boon to open-source maintainers.

Developers who are interested in contributing to open source (from a small bugfix to a larger feature) are often held up by setup guides - why spend four hours setting up to spend 5 minutes fixing a bug? This can also make it difficult for open-source maintainers to find contributors. By using ENVy, a simple envy up command performs all of the required setup. Once done, envy nuke will destroy the development environment.

Docker is a common way of providing a ready-to-go development environment, but is often difficult to set up correctly - and every project needs to implement the same boiler plate to allow working comfortably within the environment. ENVy solves these problems - we offer an easy way to build custom Docker environments, and take care of the boilerplate around running scripts or using a shell within the environment.

Initial deployment of ENVy to the public has been slow so far. We were able to roll it out for personal projects, as well as projects at one of our employers. We've opened a number of pull requests, and are awaiting feedback from maintainers.

envy-project.github.io

7 Waterloo Oasis: Co-op Collaboration Platform Team Helix

Every school term, thousands of Waterloo students apply to jobs for their upcoming coop term on Waterloo works. Yet, with all their experiences, Waterloo coop students still don't have all the information they need to make the best decision for their careers and personal goals.
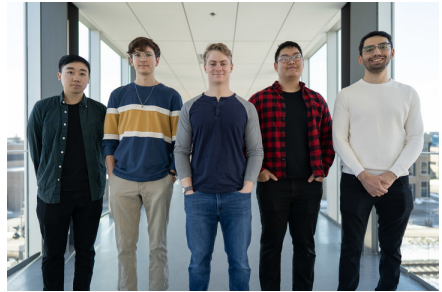
Currently, students will head to the University of Waterloo subreddit (/r/uwaterloo) to obtain co-op related information in a megathread. However, the mega thread is disor-

Raymond Lam, Russell Clarey, Dane Nespoli, Jack Chen, Tariq Aziz

ganized and hard to index as students ask their questions in the same thread. This makes it difficult to filter for information based on company or job listing. Additionally, these mega threads are replaced with new ones every term, resulting in a loss of relevant information from term to term.

However, with Waterloo Oasis, Waterloo students can anonymously share information about any aspect of a coop job, including details about the recruiting process, compensation, and overall job reviews. The data for each job will be maintained across coop terms, which allows students to continue to find value out of older reviews. The platform will restrict posting to Waterloo students, but will allow viewing for the public. Having a Waterloo-centric platform improves the quality of data that will be provided to our users, as information such as coop terms, academic programs, and other Waterloo-specific data will be enabled.

These features promote a collaborative culture and provides a centralized platform to students to discuss WaterlooWorks. We currently have some users that have posted useful information about their co-op experiences. In particular, several upper-year students have added reviews for multiple internships, which allows other users to track their coop progression, which is a key feature that we are proud to provide.

8 Jent.ly: Article Summary Chrome Extension Team Jent

Jerry Liu, Essa Saeed, Nicholas Huang, Tony Liang

Internet web pages can be long and descriptive with lots of irrelevant information. With the internet becoming more accessible across the planet the number of online article readers keeps increasing, as does the number of articles. Instead of reading every word of an article, a person can use a summarizer to provide a quick abstract and highlight the key points, saving their time and attention. Our impact is significant, a few minutes a day adds up quickly in today's society of convenience.

We've created a Chrome extension that summarizes the key points of an online through an easy-to-use user interface. Our summarization backend uses a combination of semantic and syntactic analyses on the article's text to determine which sentences are most important. We decided to focus on Chrome because it's the most popular browser.

There are some existing summarization solutions, for example TextSummary (a Chrome extension which requires the user to first select the text to summarize) and SMMRY (a website that requires the user to copy and paste the text to summarize). The main advantage of our solution is that it requires minimal user intervention. We automatically summarize text and present the summary in-line, which also makes it easy to read around the highlighted parts if more context is needed. Our extension is published on the Google Chrome Web Store and we're actively developing a user base. We are always thinking about ways to improve our extension and listening to feedback from our users. We have an official website for Jent.ly at jent.ly, a terms of service page and we've set up marketing channels for user outreach, like support@jent.ly, our Facebook page, and an ad campaign on Facebook.

For us, success is when we have over 100 daily active users, a Chrome extension rating of more than 4 stars from at least 20 reviews, rich community interaction through social media and high feedback scores for our summarization quality. We're currently sitting at around 45 users, of which around 15 are daily users, and a 5 star rating from 11 reviews on the Chrome Web Store.

jent.ly

9 A Platform for Podcast Monetization Team Mocha

Over the last ten years, podcasts have grown significantly from a niche community of audio-bloggers to one-third of Americans listening every month. Despite the growth in listenership, monetization has lagged compared to other forms of digital media. In general, digital media has been moving away from purely advertising-based monetization models. Companies that have shown success with alternative models include Netflix, Spotify, and The New York Times who earn a majority of their revenue from subscriptions.

Liam Coleman-Aulenbach, Muhammad Rehman, Vlad Cojanu, Tianyu Guo

The Chinese on-demand audio market is valued at $7B, most of which is monetized directly from listeners. Meanwhile, the North American market is valued at $300M and primarily driven by ads. We believe this disparity means there is an opportunity to enable podcasters to capture more of the value they create through direct monetization instruments.

Currently, podcasters rely on negotiating individual deals with advertisers to monetize. Some use Patreon or Paypal to collect payments and manually send subscribers a link to a private RSS feed. Larger podcasters such as Sam Harris and Dan Carlin have contracted developers to build custom websites or apps for them to sell subscriptions or individual episodes.

Focusing on selling ads every month is time-consuming and an unstable source of income. Providing private content through Patreon or Paypal entails importing private RSS feeds, which is a poor listener experience and prone to piracy. Finally, the custom solutions used by large podcasters don't scale to small and medium podcasts. Mocha solves all the previous problems by providing a platform for podcasters to sell their content and engage with their audience. We deliver the private podcast feed through a custom landing page where podcasters can sell premium content directly to their listeners using subscriptions and one-time purchases.

We've built an MVP that two podcasters are actively using. The team has reached out to over one hundred podcasters, and five of them intend to join the platform.

mocha.fm

10 Mask: Toxic Comment Filter
Team Panic

Kitty Cao, Veronica Huang, Georgia Hong, Jeff Seto, Henry Quan

87% of today's youth have witnessed cyberbullying.[1] As the online community grows, it becomes more challenging to provide a safe environment on social forums.

The user bases we wish to target are those who want to enforce censorship for a clean workplace online environment and those who want to filter out unproductive toxic social discussions. Our targeted users include people who want to be in a space that promotes healthy discussions.

Filtering out toxic comments is still a manual process in many places, including the Engineering Society at the university. By using machine learning, the model figures out a pattern for toxicity from the data to automate on behalf of human moderators. Our current scope is to target Reddit subreddits since accounts are semi-anonymous, resulting in many toxic comments. We cache the most popular threads to minimize latency.

Our competitor, Tune, has not kept up with changes in major social media platforms that it promised to support whereas we are more likely to do so because of our smaller scope. Tune also has latency issues that are unaddressed by its developers. Moreover, Tune still allows users to see the filtered out comment if they are curious, which is a bad design choice since it entices people to open it.

For the symposium day, we have deployed our app to the Chrome Extension Store and have received many positive feedback. Our machine learning algorithm has 91 for sklearn and 99 for tensorflow roc auc scores.
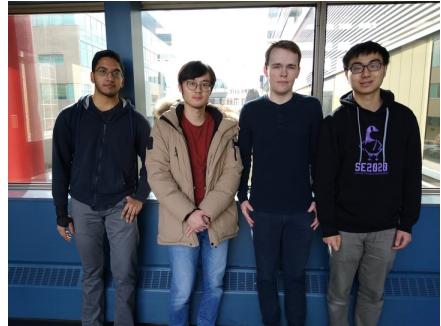
References

[1] McAfee, 2014. Teens and the Screen study: Exploring Online Privacy, Social Networking and Cyberbullying.

https://bit.ly/mask_filter

11   A Novel Content Aware Citation Recommendation
Team CRF

In recent years, there has been a considerable amount of effort invested towards building a citation recommendation tool for research articles. A study counted over 200 papers on citation recommender systems between 2000 and 2015.[1] Despite this being the case, citation recommendation systems are not widely used. As pointed out by Beel et al., one of the main reasons for this is that reproducibility is often ignored in many of the papers. Minor variations in dataset, algorithms and user

Spandan Garg, Andy Lee, Carson Craig, William Zou

populations lead to major differences in accuracy of prediction results, and the specifics of these variations are often not reported. We build a replicable and scalable content-based system that recommend citations for an academic paper draft. We rank the papers using co-authorship distance and syntactic similarity using keywords extracted with tf-idf, then rerank the model using embeddings that capture semantic meaning.

References

[1] J. Beel, B. Gipp, S. Langer, and C. Breitinger, "Research-paper recommender systems: a literature survey," International Journal on Digital Libraries, vol. 17, no. 4, pp.305–338, July 2015.

12 Anomaly Detection For All
Team Daudit

Vinit Shah, Arash Rai, Sam Haves, Zain Zulfiqar

In the modern technical world, data drives business decisions and crucial analytical models. In an effort to streamline this process, companies have created pipelines to relay production data to train their models. Issues arise when there is corruption of data along these pipelines that is hard to detect and may take days to propagate into the models. Daudit aims to provide early detection of these anomalies in order to prevent corruption of these data models and increase user confidence in the correctness of their data.

Data integrity issues can be very costly. IBM estimates the yearly cost of poor data, in the US alone in 2016, was over three trillion dollars.[1] Daudit aims to provide a first line of defence against data anomalies for minimal effort and zero cost. Technical requirements are minimal and the onboarding process is extremely easy. User data never leaves their database nor is it ever stored on any external third party servers in order to maintain security. In fact, Daudit itself is installed and run directly on servers owned by the users. The fluid Slack functionality of the tool makes it easy to update anomaly thresholds to combat false positives.

A major challenge with complex data pipelines feeding data into machine learning models is detecting corrupted data quickly and efficiently. Training models can take several days to complete and therefore it can take even longer to determine if data was corrupted. Daudit reduces this turnaround time significantly through periodic audits of data and anomaly detection.

13   Crowdsourced labelling instead of ads Team TagBull

Increasingly, many engineers are turning to artificial intelligence (AI) systems to tackle difficult problems. One drawback of AI systems is that they require large amounts of labelled training data; these labels often must be generated by humans (and tend to be expensive).

In a different field, mobile game developers are faced with the issue of making money. Without many other options, game developers often opt for intrusive, unpleasant mobile ads to monetize their games.

TagBull is a framework for image

David Mediati, Matt D'Souza, Kevin Peng, George Utsin

labelling that allows mobile game developers to replace advertisements with labelling activities. Rather than viewing mobile ads, players are presented with an interface to help annotate some aspect of an image (e.g. to draw a bounding box around pedestrians on a roadway). The benefit here is twofold: TagBull serves as a platform to label large datasets, and as a monetization strategy which turns players' time into something valuable. The typical price points for labelled data and mobile ads make TagBull a cost-effective choice for both dataset labelling and game monetization.

Our project seeks to compete on quality with existing human-in-the-loop annotation systems. Since our annotations come from mobile game players instead of trained contractors, the accuracy of any particular label can be unreliable. To ensure our labels are accurate, we implement a variant of Find-Fix-Verify, a crowdsourcing algorithm developed at MIT, which relies on player consensus across multiple samples.

We have already run a few user studies for adding bounding box labels to images using Mechanical Turk; we found positive results in the quality of the bounding boxes and received praise from Turkers about the effectiveness of the interface. To validate the project on a larger scale, we intend to label a subset of Google's Open Images Dataset and compare our results with the existing crowdsourced labels.

https://tagbull.com/

14 Finding recipes for your leftover ingredients Team Yummify

Ryan Wong, Johnson Chen, Yifan Ma, Sheldon Ni

Cooking at home is an activity which many adults find enjoyable and financially feasible. Research from the NPD Group shows that approximately 82% of meals in America are prepared at home. However, after preparing several home-cooked meals, it is difficult to properly use the leftover ingredients for the next meal. This is especially difficult for adults who only cook for themselves. This often leads to the ingredients spoiling or having to be thrown out. According to the Food and Agriculture Organization of the United Nations, approximately one third (1.3 billion tonnes) of food produced for human consumption is wasted. From financial, social, and environmental standpoints, food waste is a pressing issue which many of today's adults struggle with.

Yummify's objective is to offer delicious recipes that best leverage all of the ingredients the user has on hand. Yummify is designed to be an Android and iOS app built using Flutter, a cross-platform mobile framework. Users start by entering their ingredients into Yummify. Yummify will support entering ingredients through taking a picture and recognizing the ingredients in the picture. Yummify will then perform a sophisticated search for recipes that best match the user's search and that allow the user to effectively use their leftover ingredients.

Our two main differentiators over other "find a recipe" tools are: 1. Competitors' primary recipe search is category-based (eg cake recipes). Our primary recipe search is ingredient-based. Our algorithm uses advanced techniques, such as ingredient substitutions, ingredient omissions, and staple ingredients, to intelligently find the best recipes for the given ingredients. 2. We use advanced computer vision technology to greatly improve the convenience of entering ingredients.

The key metrics that are used to determine the project's success are weekly active users, number of app downloads, overall app rating, and number of recipe impressions. The Yummify app is deployed to Android and iOS.

https://yummify.herokuapp.com/

15 A simulator for Alloy transition systems Team Prop

Formal methods are mathematical techniques used in software engineering to specify and verify the behaviour of complex systems. Modelling is one method used to express and validate software systems.

The Alloy modelling language allows users to verify the correctness of a specified system. Alloy's tool, the Alloy Analyzer, produces satisfying instances of a specification, and exposes invariant violations by generating counterexamples. Our work focuses on transition systems: mod-

Aman Dureja, Paul Zhang,
Aditya Keerthi, Andrew Liang

els that define a set of states and transitions between them. Real world systems, such as traffic lights and elevators, can be modelled in this fashion.

Currently, designing and debugging transition systems in Alloy is difficult and time-consuming. Users are forced to return to an initial state when exploring alternate execution paths, which inhibits incremental exploration. Furthermore, viewing a generated counterexample can result in unwieldy output, obfuscating the root causes of flaws.

Our team has built a command-line simulator for Alloy transition systems, with the aim of reducing iteration time for model development by simplifying defect discovery. It provides the ability to sequentially step through a transition system, including stepping forward, backward, and exploring alternate or constrained execution paths. Additionally, users can step through counterexamples to pinpoint the source of their issue.

16 OCT-opus: Deep Learning to Enhance Retinal Images
Team OCT-opus

Samin Saberi, Kathleen Wang, Pei Lin Li, Kenneth Sinder, Céline O'Neil

Team OCT-opus is engaged in optics research with Prof. Dida Bizheva from Physics. We created an image processing pipeline using the pix2pix conditional generative adversarial network (cGAN) deep learning approach to enhance visibility of retinal capillaries in cross-sections of rat and human retinas captured non-invasively. The resulting sequence of images can be used to create a 3D vascular map without requiring expensive hardware or software to capture multiple acquisitions of each spot, useful in diagnosis and monitoring of illnesses affecting the eye.

Our software system, powered by TensorFlow, will contribute to Prof. Bizheva's broader research and our paper also demonstrates how our deep learning algorithm improves on the state-of-the-art. Our inferred blood flow maps are of comparable quality to those generated from multiple-acquisition imaging as evaluated visually and using the structural similarity (SSIM) index for cross-sections captured from sedated rats. We have submitted an abstract to the SPIE Optics + Photonics meeting taking place in August 2020 with a paper submission deadline of July 29, and hope to publicly release our code for feedback and peer review later in 2020 as well.

Challenges for our team have included working in a new field of study having varying levels of past experience with machine learning as well as learning how the research world works.

17   TrakTab: The classic pillbox, reimagined. Team TrakTab

Medication adherence is a growing issue for seniors, with 81% of adults 65 and older taking prescription drugs on a daily basis; 66% are taking 5+ medications each day. But of all pill users, only half of them say they're taking them properly. Further, prescription non-compliance causes 25 percent of hospitalizations and 23 percent of nursing home admissions in Canada. While in the United States this has created a tremendous problem resulting in the loss of up to $289 Billion and over 125,000 lives annually according to the New York Times.

*Spencer Dobrik, Ryan Wang,
Aaron Cotter, David Tsenter*

Traktab closes the loop on medication adherence by creating an incredibly familiar interface that adds reliable, low-cost monitoring for families but sacrifices none of the physical ease-of-use for elderly patients. After a simple initial setup with no manual input, the user will be able to keep family and healthcare staff informed on their adherence rates while receiving audible, visual, and even phone-based alerts if the user has an iPhone. This information is securely sent to our backend service through the new cellular standard for low-bandwidth devices, LTE-M, thus requiring no WiFi connection. In addition, Traktab is designed to require minimal maintenance and can even be passively charged through solar. Caregivers and loved ones are able to view adherence information from easy to understand graphs built to give peace of mind in a quick glance.

TrakTab will be competing with the current connected medical adherence devices which cost upwards of $30month and often require technicians to install them. TrakTab also has the capability to be used in a Monitor-Only mode which removes all reminders and instead is used purely to track medical adherence without intervention. The Monitor-Only mode is very useful for clinical trials, currently participants keep written logs of when they took their pills in conjunction with a Medication Event Monitoring System (MEMS) which replaces the lid of the pill bottle and counts each time it is opened, but requires a wired connection to transmit the data.

traktab.com

Medical   Computer Science / Software Engineering

18 Propagate
Team Ampharos

Isabelle Sauvé, Jasper Chapman-Black, Sean Purcell, Zhenyu Yang

VR is gaming's next frontier. Recently, large players like Valve, Facebook (Oculus), Google, and Nintendo have begun investing in VR, highlighting the companies' confidence in VR. In fact, the market size for VR gaming was 4.15 billion USD in 2018, and this is projected to reach over 70 billion USD by 2026. Due to its novelty, VR gaming has yet to be saturated by developers. Our game, *Propagate*, aims to fill the niche of VR puzzlers, while remaining cheap and accessible to potential users who are new to VR.

We've designed puzzles that play around with light, primarily in the form of lasers. We wanted to attract players by creating interesting puzzles with an intuitive user interface. As opposed to traditional platforms like current generation consoles or PC, we took advantage of the VR space to fully immerse players in the puzzles we design. Additionally, we've built our game for the Google Cardboard, which is a much cheaper alternative to VR devices such as the Oculus. Thus, *Propagate* has a much lower barrier to entry than other popular alternatives.

Dedicated commercial VR headsets range from $500-$1300 CAD and usually require a high-powered PC to drive them. While these devices offer high quality experiences, they aren't accessible to new users who may be interested in casual VR games. In comparison, our game only requires players to own the Google Cardboard, the current cheapest option in the space, and is designed to not require additional peripherals such as a separate controller.

The game has been available for private testing with no wide public release yet. We have a lot of cool ideas and some fine-tuning remaining before we can confidently release *Propagate* to a wider audience. The private response from our friends has been positive and has also shown some necessary remaining steps. After some final touches on the game from the private feedback we've been given, we plan on releasing the game to the Google Play Store.

19 Feudal Fight
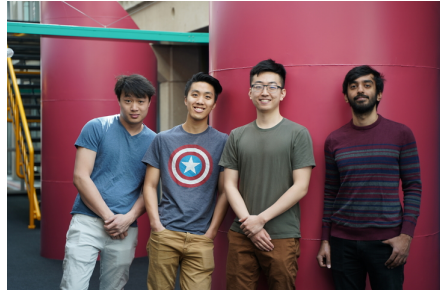## Team Glorious Goose Games

Millions of gamers love playing arena fighting games like Super Smash Bros, Towerfall, and Nidhogg. Super Smash Bros Ultimate has sold 15.72 million copies, Street Fighter 2 has sold 15.5 million copies, and even an indie title like Towerfall garnered over $500,000 in revenue.

Some casual games are easily approachable and great for having fun with friends. However, these games tend to lack replayability due to their simple mechanics. Other games have more complex mechanics and com-

Alston Lin, Dominic Fung, Charlie Zhang, Danyal Raza

petitive scenes, but can be challenging to start playing. Some games that were in between didn't have the fast-paced gameplay we were looking for. We wanted a game to bridge this divide.

Our team created Feudal Fight, a 2D platforming arena fighting game for PC designed to be approachable, yet replayable. The game features users playing characters that move around an arena with the aim of defeating other players. Players can move around using grappling hooks and jumping, while attacking with arrows and melee attacks. The game is approachable with intuitive controls and clear visuals. Our fast movement, quick attacks, and one-hit KOs lead to the fast-paced gameplay we sought out.

When it comes to PC fighting games, casual games tend to be simple, but quickly feel boring due to a lack of strategy. Our game bridges the gap between approachable and complex by using the rock-paper-scissors triangle system. The idea is that each available option (eg rock) beats the next option (eg scissors) in a cycle. This technique adds a layer of complexity for gamers who want to push further without complicating the core mechanics. The game appeals to both casual and more experienced gamers through fast-paced gameplay with mechanics that are easy to learn, but hard to master.

We released a beta version in early March and have 50+ downloads with positive feedback.

20 Life is Just Another Dungeon: A Dungeon Crawler
Team Shiba
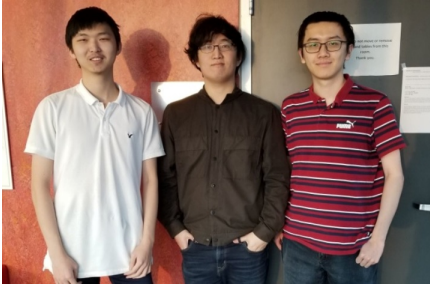
John Zhou, David Lee, Yang Lu

We believe that throughout life, we face various dilemmas that impact our lives and sometimes we make life choices that doesn't end well for us. Although we now know that we adapt and learn from the mistakes and move on as we grow up, but younger generations that are not experienced may feel stressed out as they may feel that they are getting behind. We were hoping that this game would remind the people that there is more than one path in their life and look back at their life decisions. We believe that making the game in rogue like would make the game feel random, just like our real life. Also, we want the players to play our game multiple times to explore various paths that they may not have visited, and ultimately show them that there is more than one path in their life.

Our objectives are to create a game that is i) fun, ii) replayable, and iii) meaningful. Firstly, the game has to be fun in order for people to want to play it. Secondly, since the length of a playthrough of the game is relatively short, we want for it to have replayability. The game should also feel meaningful so that players are motivated to repeatedly play it.

We feel that users generally dislike repetitive playstyle that is caused by templated map and predefined paths. This method allows the game developers to have extremely polished user experiences, yet we believe that this does not fully reflect our intention to the younger generation that there is more than one path to their life. We are using procedural map generation to increase replayability. In addition, by creating a dungeon crawler with a variety of player stats, enemies, and choices, we hope to prod the player into considering which choices lead to the result that they would like to achieve.

We displayed an MVP for our project at the end of 4A. We are still working towards an initial public release of the project. The metrics we will be looking at are playtime distribution, ratings, and feedback.

21 Minecraft Patchwork: A Peer to Peer Solution
Team Patchwork

Minecraft is a 3D Sandbox Adventure Game released by the Mojang Corporation on November 18th 2011. By late 2019, it had sold over 180 million copies, making it the best selling video game of all time. The game offers a multiplayer mode which allows players to play together on centralized server, but we wanted to take it in another direction and allow for a peer-to-peer solution.
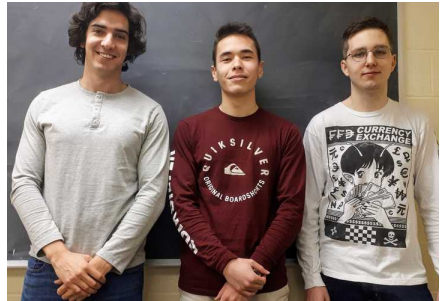
Mark Joaquim, Thomas Nguyen, Duncan Uszkay, Anass Lahnin

Users have two options when going the traditional client-server route: they either host the server themselves, or pay for server hosting. Both these approaches have downsides. When the users host the server themselves, they are burdened with the network traffic and resource usage of the entire server. And if they cannot always stay online, then nobody using that server can play until the server comes back online. The downside of paying for server hosting is two-fold: you lose ultimate control over your server, and of course you have to pay.

Enter Minecraft Patchwork: a custom written Minecraft server which allows you to take control of bounded areas we call 'maps' and combine them with other player's 'maps' into something we call a 'Patchwork'. Players host their own instance of Minecraft Patchwork and connect with other players who are also using Minecraft Patchwork, and stitch their maps together (hence the name 'Patchwork'). There's no special client needed- just the Minecraft client that comes with a purchase of the PC game. Once the player logs into the local instance of Patchwork, they're free to walk between their map and the maps of those they connect to, and their traffic moves with them. When standing on a peer's server, it's exactly as though you logged onto their server directly.

For this Symposium we've constructed a playable demo of the Patchwork software that will allow players to break and place blocks, as well as take full advantage of the peer-to-peer solution to interact with others on separate servers.

https://github.com/DuncanUszkay1/Patchwork

22   A Message Board for Residences
Team Skybunk
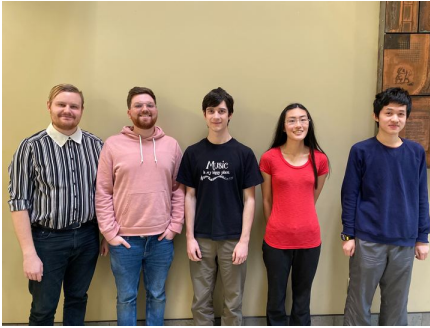
*Erik Mohr, Ryan Martin,
Matthew Pollex, Miranda Zhou,
Jiayin Huang*

Skybunk is a virtual bulletin board that enables students and residence staff to communicate effectively within their residence. Many University and College residences have struggled to facilitate community and coordination amongst their students. They typically use email blasts or Facebook groups in an attempt to do so, but engagement tends to be low. For example, Conrad Grebel University College found that many students ended up muting their Facebook group because of a spam of notifications that were not relevant to the student. Additionally, fewer and fewer incoming students had Facebook, and were reluctant to get it for a variety of reasons.

Skybunk is a better fit for residence communications. It offers tailored notifications which allow students to subscribe to only the topics they are interested in, and residence-specific features such as don schedules, caf menus, and event signups. Slack and Discord were considered as alternatives, but they are not a good fit for this use case because they have a steeper learning curve and serve more as a messaging platform rather than a "bulletin board", where users make posts which can be individually followed and commented on.

Skybunk was initially developed for use in Conrad Grebel by an external team which includes two members of our capstone team. Before taking it on as an FYDP project, Skybunk offered limited functionality and it was not possible to scale it into other residences. Our team focused on allowing Skybunk to be introduced into more residences. This included enabling multiple separate instances and developing new features such as polls and a complete admin dashboard with detailed analytics. We also ensured maintainability and stability by rearchitecting overly complex areas of the platform, implementing a complete CI pipeline with isolated development environments, enabling and writing unit and integration tests, and documenting the codebase. We were able to successfully launch Skybunk into St. Paul's residence alongside Conrad Grebel, and increase Skybunk's userbase from ~200 users to over 550.

https://skybunk.xyz

23   Qurious: In-Class Q&A and Collaborative Notes
Team Smurf

Students often find it intimidating to ask questions in class. Moreover, in lectures with hundreds of students, raising one's hand to ask a question may simply be infeasible. As a result, instructors don't always get the feedback they need, and students often leave class with a lot of their questions unanswered. When class discussion does take place, the valuable lessons and ideas generated are not always recorded and are lost after the lecture. While a good number of students use some facility for taking their own notes, there is no one platform to conveniently create and share notes with classmates.

Wentao Chen,
Mohammed Khairul Islam,
Karan Garg, Kaan Ozkan,
Renato Zveibil

Students currently need to navigate between multiple platforms to access all the tools and material they need in class: Learn, or the class-specific website to get lecture slides; an app such as OneNote for note-taking; Piazza for asking questions. Furthermore, none of these platforms focus on live in-class interaction. Professors need their own arsenal of tools: whether it is to gauge student understanding, receive feedback, increase class engagement or enforce attendance. They rely on solutions such as iClickers, quizzes on Kahoot, surveys via Learn or mid-term course evaluations.

Qurious aims to provide a single platform for all in-class interaction. It facilitates cross-communication among students and between the students and the professor. Qurious turns the notoriously monotonous, one-way powerpoint presentation into a bustling, multi-way intersection of thoughts and ideas.

Students can view all their lecture slides, conveniently synchronized with the professor's live presentation. They can annotate slides to take notes and share them publicly with the class or in private groups. They can ask questions and upvote/downvote them to bring them to the attention of the instructor. Instructors, on their end, can create quizzes/polls for students and easily embed them within the presentation.

Qurious was launched in beta in February. Qurious is being used in multiple classes at Waterloo by professors and students.

www.getqurious.net

24 A Web App for Course Planning
Team WatCourse

Alexandra Jaszkul, Utkarsh Lamba, Siddharth Vaknalli, Varun Gupta, Bhavya Shah

It is difficult for students to choose courses and manually verify that they meet all the prerequisite requirements for a course. In addition, they must also keep in mind course availabilities and their program calendar requirements. University of Waterloo students find it very tedious to select their courses manually while ensuring they are on the way to meeting their program requirements. This creates a huge market opportunity for our WatCourse web application.

Currently, most students use an Excel file or pen and paper for course planning. The process includes finding out whether the courses that they want are available that term, whether they meet the prerequisites for it, and finally, whether it will fulfill one of their program requirements. This leads to having several tabs open and ends up consuming lots of hours. With WatCourse, all of this functionality is in one place and users can create their plan and it automatically checks if prerequisites are met, whether the course is offered that term and etc. Furthermore, users can decide to change their plan at any time and no manual work would need to be done.

WatCourse allows users to drag and drop the courses they wish to take and provide immediate feedback on things like whether prerequisites are satisfied and whether the course is offered that term, making it much easier to plan courses for future terms. Additionally, we integrate with DegreeCompass to help users keep track of whether they are meeting their degree requirements and to make the course planning process as painless as possible.

We performed the initial deployment at the end of January 2020, which was before the course selection period for the next term. We will be gaining a lot of feedback on how students interact with the app, which features they think the app is lacking and how has the app made course planning easier.

https://watcourse.com/

25 Spritec: Spritesheets from 3D Models
Team ProtoArt

Indie games are dominating the gaming market with more than $1 billion in sales every year on just Steam alone. These include giants like *Stardew Valley* which has sold over 3.5 million copies since January 2018. Stardrew valley is a "pixel art" game which means that its art style involves drawing lower resolution images known as "sprites". At low resolutions, every pixel is important.

Mara Gagiu, James Shi, Bill Chen, Sunjay Varma

Creating art as an indie game developer can be extremely difficult. Existing tools like aseprite require artists to create sprites one frame at a time. Characters have to be drawn at every pose, camera angle, resolution, and lighting condition. Some games end up with hundreds of sprites. For an indie game developer with limited time and resources, this can make it almost impossible to iterate due to the amount of time it would take to redraw everything. Not everyone can afford an artist to work on their game, and creating good art is a difficult skill that takes years to master. Online game assets exist, but it's hard to find assets that fit the particular theme and style of the game a developer is creating.

There is a large market of indie game developers who work in 3D tools like Unity and Blender. Spritec is a standalone program that acts as a post-processing step in their 3D workflow. Developers import a 3D model into spritec and specify the animations, camera angles, resolutions, and lighting it should apply to create the final spritesheet. Spritec features a grid layout engine for customizing the spritesheet layout and is capable of processing a glTF file's geometry, texture, camera, light, animation, and rigging/skinning information. With spritec, iteration is no longer impossible. Game developers can edit just a single 3D model without the fear of having to redraw every sprite by hand.

https://github.com/ProtoArt/spritec

26   Build better habits with science
Team Cued

Justin Pezzack, Nikola Vasiljevic, Tyler Zhang, Katherine Lu

Habits have always been a powerful way for people to improve their lifestyle, build up important skills, learn new things, and so on. In fact, over 60% of human behavior is driven by habits. However, it is no easy task to create a new habit or change an existing bad habit. Many existing apps attempt to solve this problem, but users often find themselves failing to find success with these apps. Recently, research has emerged in popular books such as The Power of Habit that detail a habit-building process called the Cue-Routine-Reward system, in which an individual perceives some type of audio/visual/mental/physical cue (e.g. feeling hungry, getting home, going to the washroom), which triggers their brain to perform a specific routine (e.g. doing a quick exercise, drinking water, going for a run), after which they feel some kind of reward (mental, physical, emotional) that compels them to want to repeat this cycle. So there is clearly a proven system that exists, yet there are no habit-loop-based habit apps that make use of this system to help users develop lasting new habits or change existing habits.

Our habit application focuses on teaching users about the Cue-Routine-Reward system for developing habits, and demonstrating to them how to create their own habits using this system. We walk the user through each step so they can see how the Cue-Routine-Reward system works first, and once they gain a strong understanding of it, we provide them with an interface with which they can create and track their own custom habits.

Too many existing habit apps end up turning into generic reminder/calendar apps, pestering the user with notifications and reminders without actually teaching them the basics of how to create an effective routine. Hence, the user is not motivated to actually perform any of the habits and build up a routine. Our app focuses on teaching the user from the ground up how to make use of the Cue-Routine-Reward system to select effective cues to trigger routines to build effective habits, or how to use the system to change existing bad habits.

27   Habitica: Implementing Offline for Mobile Team Raven Lich

"Habitica is a video game to help you improve real life habits. It 'gamifies' your life by turning all your tasks (habits, dailies, and to-dos) into little monsters you have to conquer. The better you are at this, the more you progress in the game. If you slip up in life, your character starts backsliding in the game."

Habitica is available for free at Habitica.com with a large active userbase growing continuously. Development is aided by the generousity of open source contibutors for art, programming, and testing.

Tyler Nychka, Leanora McVittie

Users of the Habitica app define a set of habits or tasks that they want to take on. The app then rewards the user for marking their habits or tasks as complete with gold, coins, or other rewards like character skins or accessories. This 'gamification' of real-world goals can give users the feeling of having earned a reward when they mark a habit as successfully done, and leads to them continuing to complete the habit.

The Habitica platform is available for both Web and Mobile, however the Mobile applications can only exectute functionality when the app can communicate with Habitica's servers. The server computes information about the rewards that the user receives as a result of completing an action, and updates their model in the database. This is a problem for users becuase there are many times when data and wifi may not be accessible, such as on the subway, yet they still want to check off the completion of a habit. This lack of offline functionality severly limits users' ability to integrate Habitica's task management software into real life.

The first step in the process was to create a shared multiplatform codebase for both platforms to use. This architectural improvement should also facilitate other future enhancements of Habitica. The offline data synchronization functionality was then built on top of this re-architected multiplatform codebase. A pull request of this new functionality has been created.

Habitica.com

Student Index