QMIND

Design Project Lookbook 2021-22

Innovation
Research
Disruptive Technology
Consulting

Welcome to QMIND's 2021 project lookbook. The work presented within this document is the collection of a year-long effort exerted by twenty-five design teams. This entails a series of projects spanning innovation, research, disruptive technologies, and client-facing deliverables. Each project is unique in scope and granted our members the creative freedom to imagine solutions to problems yet to exist. Our mission, to empower undergraduate students to unlock the full potential of AI, was delivered through hours of mentoring, problem solving, and fostering collaboration among the undergraduate student body.

Spending a second year filled with lockdowns, restrictions, and uncertainty was not enough to slow down the creative pursuit of each design team member. Every single person on QMIND took this as an opportunity to evolve and transcend the boundaries of the undergraduate level. Our clients witnessed this tenacity first-hand through the solutions our design teams posed to address their business needs. This excitement was expressed on multiple occasions throughout the year and is something we take pride in. QMIND is excited to show you what it means to lead real change.

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Hazelnut:
Understanding of New Environments without the Hustle of Maintenance

Dennis Huynh, Tristan Lawson, Braulio Autonio, Vanya Kootchin, Harsh Kaylani

Hazelnut attempts to create a navigation tool that helps with the understanding of new environments without the hustle of maintenance. It is designed to take all knowledge of an entity, and convert it into navigable visual content without the need for manual inputs and manual updates.

We use state-of-the-art Natural Language Processing models to extract relationships from text stored in docx, pdfs and even images in a given directory. It processes the text and converts it into vectors that we can visualize in a 2d graph.

Heart Monitoring:
Detect Early Warning Sign of Heart Conditions

Jingjing Mao, Kaleb Huneau, Aarti Singh, Graeden Lau, Bryson Ried

Our team's objective is to design a heart monitoring system that detects early warning signs of heart conditions. Analyzing biometrics, specifically electrocardiogram (EKG or ECG) data, we extract considered features such as the P wave, PR interval, T wave, heart beat rate, QT interval, and QRS wave complex.

These variables provide insight into to the electrical activity of a human heart in waveform. Therefore, we utilize this information as inputs to various machine learning models, such as multilayer perceptron neural network, decision tree, and label powerset to classify the heart conditions. We find the model achieving the highest accuracy by comparing the results of each model.

Overall, this reduces the time for applying a treatment and increases the accuracy of the correct treatment.

Legal Document Summarizer

Ori Gurevich, Matthew Stoltz, Brandon Cheng, Al-Barr Ajiboye, Freda Li

Our project aims to provide a means for people who do not undertsand typical legal-ese, do not have the time to read extensive legal documents, etc. that want to be able to remain up to date about the Canadian legal sphere. The project specifically focuses on the Canada Gazette, where many legal changes occuring in the nations capital are archived for everyday citizens to read. The project uses a BERT tokenizer to create and divide sentences, and then uses an extractive summarizer to create summaries based on the given entry.

LSTM Model:
Prediction of Electricity Demand

Tyler Cowie, Tibet Cem Gebes, Scott Justason, Joel Cross

The amount of energy drawn from the power grid can be unpredictable. Analogous to the stock market, Ontario's energy demand causes fluctuations in its cost throughout the day. To manage this demand, Ontario's grid operator has incentives in place for limiting power consumption during peak demand hours. Queen's University aims to meet these incentives by using their behind-the-meter generation while demand is high. By minimizing the power drawn from the grid at the right times, Queen's University can potentially save $1M annually. However, it is challenging to anticipate when peak demand hours might be. Electricity demand is influenced by a variety of factors, such as the season, temperature and day of the week.

The goal of this work is to consider these factors in a recursive neural network to predict the times of peak electricity demand. The team will implement this model in a dashboard, allowing Queen's Energy Management to determine when peak demand is most likely each day. The dashboard will require no input from the user, as the model will be automatically retrained with new data using APIs. The team has made use of an LSTM model, a recursive neural network architecture typically used in time series forecasting applications. Currently, the model is performing with a root mean square error (RMSE) of 2.2 on the validation set, however further optimizations still need to be made. Ultimately, the team plans to add an ARIMA model as an input layer to the LSTM model to further increase the accuracy.

Scroll Screen With Human Eyes

Stefan Pitigoi, Daniel Martin, Tony Zheng, Ben Hui, Khoa Nguyen

In the current age where everyone is occupied with completing many daily tasks, having excess time is something that we all value greatly in our lives. With the digitalization of more and more information, the ability to effectively multitask while operating computers and mobile phones is an issue that always arises to help people save time and accomplish more. To help with this issue, this project was developed utilizing machine learning to allow a user to scroll a computer or phone screen with their eyes. The objective was to help users save time as they do not need their hands to scroll through a document or article on their electronic device.

The dataset was created by having the team take pictures of their face then having their eyes cropped out to feed into the model. The corresponding mouse vectors were also saved along with each of the cropped eye pictures. A custom convolutional neural network was developed and trained using the collected data. The accuracy of the product would be fully dependent on the quality of the collected data and the way data was collected. Testing is currently underway, with the goal being at least 75% accurate. Future work for this project would be to implement the model into an algorithm that would scroll a webpage based off of the model's predictions of a user's eye position. The project could be developed into a web extension that a user could turn on to scroll a webpage with their eyes.

Stock Market & Covid Cases: A Model to Improve Predicting the Stock Market

Ammar Lakdawala, Henry Wilson, Ciaran Byles-Ho, Adam Cormier, Hunter Hoogendijk

With significant research previously conducted into key factors affecting the stock market, the rise of COVID-19 and its correlation with the stock market opens an interesting research avenue for predicting stock market trends. As a result, our team has worked towards developing a model that leverages the COVID-19 case count, death count, and vaccination rate to improve previous attempts at predicting the stock market.

To achieve this, the team split the New York Stock Exchange and S&P 500 into various industries and analyzed COVID-19's impact on each sector individually. Due to the stock market's volatility, our project prioritizes predicting the direction of the stock market as opposed to a specific value. Various models have been tested on the resulting datasets including Support Vector Machines, Random Forests, K-Nearest Neighbors, and Multi-Layer Perceptron Neural Networks.

As a result, COVID-19 data has been shown to consistently improve baseline models which only use stock data statistics. Our team is working towards improving these accuracies and developing a system to use the model in real-time. Future work includes incorporating additional features such as key news headlines with Natural language processing models or social indicators.

Timeseries Forecasting Of Climate Data

Jacob O'Neil, Hilary Osler, Abdellah Ghassel, Nick Thorpe (not pictured)

Extreme weather events, rising global temperatures, melting arctic ice and rising sea levels have heightened awareness of climate change and its threat to humanity as we know it. It is expected that within the next eleven years, climate change and the damage it causes will become irreversible. However, given that changes in climate occur over long periods of time, it is challenging for individuals to understand the severity of the situation and that urgent action is needed by each of us to achieve the goal of reducing greenhouse gas emissions to net-zero by 2050 and preserve a livable climate.

The goal of this work is to educate individuals on the outcomes of climate change by developing an interactive tool that can be used to generate predictions for temperature and emissions values based on past data. Specifically, individuals who wish to learn more about climate change can select either a time period or a percent increase or decrease in emissions levels and observe a graph of the resulting future temperature and emissions trends. The team employed the vector autoregression statistical technique in a time series forecasting model. Global land temperature, water temperature, carbon emissions and atmospheric GHG levels are all input into the model. The result is a projection of future average temperatures and emissions levels, with educational pop-ups when certain threshold values are reached, such as when all polar ice caps have melted. Engaged and informed individuals are more motivated to make choices that are less harmful to the environment to help slow global warming.

Wildlife Classification

Logan Hoogendijk, Dominic Thompson, Sarah Nassar, Ana Duvnjak, Alister Salmon

This project is meant to be a gentle introduction to machine learning where foundational skills are practiced to set the team members up for success in future Artificial Intelligence initiatives. The goal is to classify animal images while comparing image classification methods, models, and parameters. Basic convolutional neural networks (CNNs), published model architectures, transfer learning using pre-trained weights, and adjusting the learning rate are some of the things being explored. The CIFAR-10 dataset is being used for the supervised learning implementation. This dataset has 10 classes, six of which are animals, and 60,000 images in total. For each class, there are 5,000 images for training and 1,000 for testing, making the dataset balanced and having a train-test split of approximately 83/17. The images all have the same size of 32x32, are in colour, and are randomly ordered. VGG16 and Inceptionv3 are the main architectures being tested, with available pre-trained weights based on the ImageNet database, and the training is done using Google Colab's GPUs. With a current testing set accuracy of about 90 percent, the team is looking into the development of a web- or application-based user interface to facilitate the use of the model.

Deep Learning Network Through the Generation of LV Segmentations

Catherine Wu, Nicholas Falconi, Anirudh Tiku, Anshul Pattoo

Cardiovascular diseases (CVD) are the global leading cause of death, resulting in over 15 million fatalities each year. Despite varying symptoms and conditions, many CVDs are characterized by the shape and size of the heart's left ventricle (LV), the compartment from which blood flows into the aorta and through to the rest of the body. In medical interventions for CVDs, visualization of the LV allows for assessment of the ejection fraction metric – a measurement of the percentage of blood that leaves the heart in each contraction- informing physicians on both the current severity of the heart condition and the approach that should be taken towards a treatment plan. Unfortunately, human assessment of ejection fraction based on visualization of the LV is an arduous and laborious task for the clinician, and is subject to error and variance based on the both the clinician's experience and the patient's heart irregularity.

Our project focuses on the development of a deep learning network to automate this visualization process through the generation of LV segmentations on video ultrasound. We implement and train U-Net-based models on anonymized patient data, scoring each model's mean absolute error and root mean squared error based on expert-segmented ground truths. Ultimately, through our goal to generate anatomically accurate LV segmentations on cardiac ultrasound, we aim to improve both efficiency and precision of guidance during diagnosis and treatment for CVDs.

Generative Adversarial Networks

Etan Ossip, Stuart Fong, Awni Altabaa

Generative Adversarial Networks (GANs) are a class of machine learning algorithms which aim to learn to generate new data which mimics the distribution of the training data. This is done through simultaneously training two competing or “adversarial” networks in a zero-sum game: a discriminator and a generator. During the training process, both networks improve resulting in a generator which creates realistic new data.

In the 2021 paper “Rényi Generative Adversarial Networks” by Bhatia et al., a novel loss function based on the Rényi information measure was proposed which generalizes the standard crossentropy loss for GANs. This loss function preserves the equilibrium point guaranteed by the original GAN loss. Through an extra degree of freedom, the authors empirically show that the Rényi loss confers performance benefits in DCGAN and StyleGAN architectures. Specifically, training stability and generated image quality is improved.

In this research project, we evaluate this novel loss function on a different type of task and on more modern GAN architectures. In particular, we apply Rényi loss to multi-domain image-to-image translation using the StarGAN architecture initially proposed by Choi et al. in 2018, as well as Pix2Pix and CycleGAN. In doing so, we will build on the original paper by further validating the theoritical properties of this novel loss function and, in particular, examine its viability for image-to-image translation tasks.

Indoor Identify Objects in Small Area for Drone

Jonah Garmaise, Jordan Capello, Jagrit Rai, Matthew Li

AI piloted drones are becoming a highly coveted technology. AI powered drones are being used in a variety of different fields such as agriculture, energy production and defense.

Drone technology is extremely useful for generating maps of unexplored environments as drones are able to traverse large distances and are highly maneuverable.
For this project specifically, we are using a drone to fly around an indoor environment and identify objects of interest in a small area. Once all the objects are identified, a map of the environment with the locations of the identified objects will be generated. The drone will then fly out again and perform a task such as drop a projectile on each object of interest identified.

Track the 3D Shape & Pose of Two-Hands

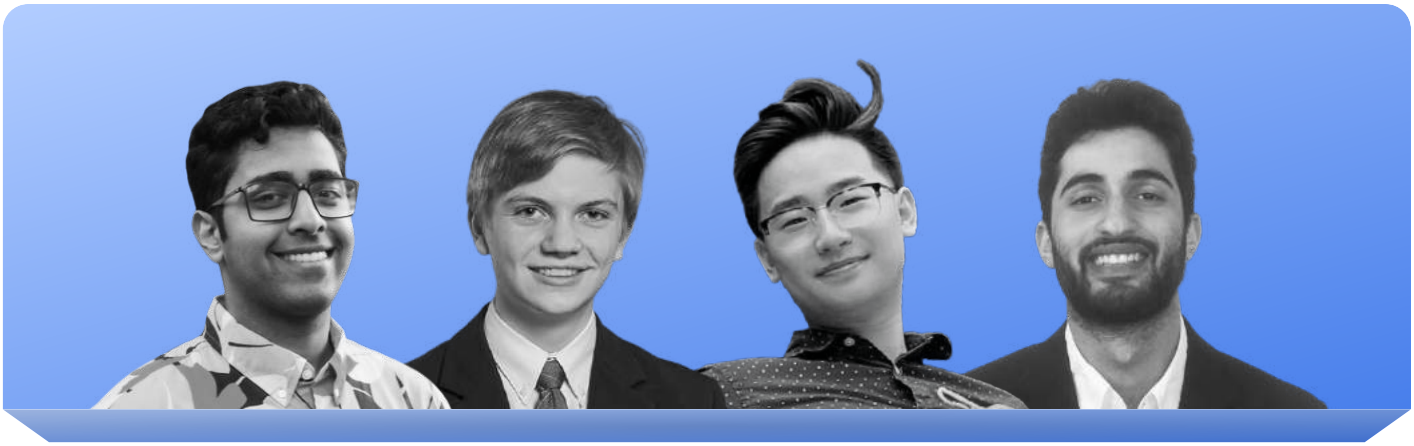
Lucas Coster, Maxime Vincent, Noah Cabral, Madeline Mackie, Oscar Lu

Our team has chosen to tackle the following problem - to track the 3D shape and pose of two-hands through high hand-to-hand and hand-to-object contact, using just a monocular RGB input. Many of the actions that we take with our hands involve occlusion: we might interlace our hands while thinking, we might pick up an object, or we might wash our hands, to name a few. It is natural for hands to be in consistent contact and occlusion. As such, it remains an essential problem, if not the problem in hand tracking research.

Effectively addressing this problem will enable new modes of experience for users of mixed reality applications, but maybe most importantly, a proper solution should enable seamless and expressive communication through sign-language. This research also has great potential to improve medical and military training simulations, improve complex two-hand gesture tracking for general computer vision tasks, and improve the field of motion capture for digital media.

To be precise, the motivation of this research is primarily an engineering one, where the goal is to develop an intelligent system that solves a real problem better than all alternative approaches. In doing so, our plan is to first implement state-of-the-art approaches, then ideate and implement novel architectures from there. Our current model is based on MobileNet, where the input images are fed through an encoder to generate general image features, then through a CNN to estimate pose and shape parameters. Finally, the shape and pose parameters are fed through the popular differentiable hand model, MANO, for generating the full 3D mesh of the hand.

Blockchain Medical Record Management

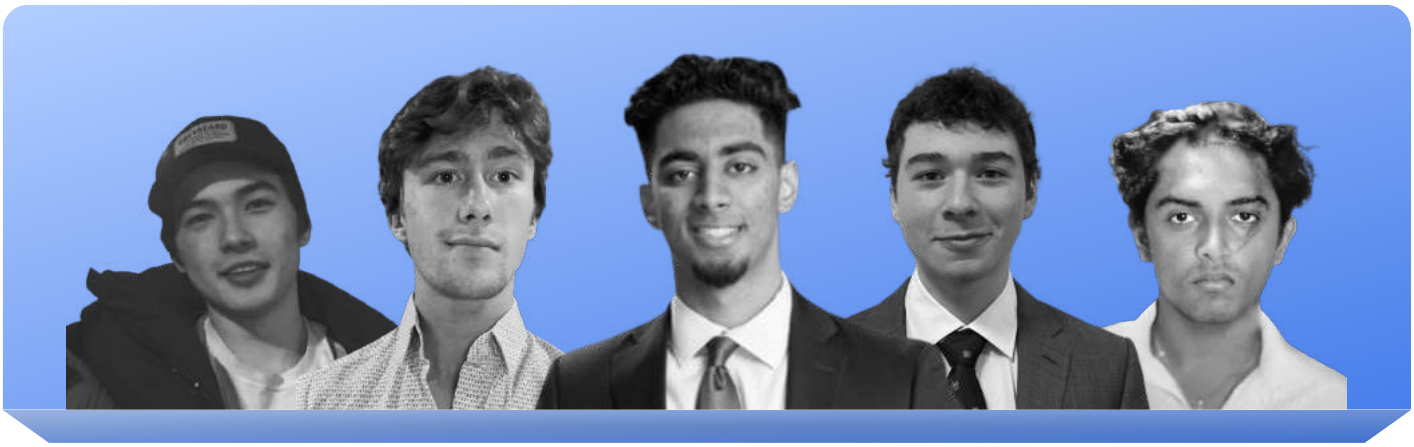


Mustafa Tariq, Jax Hodgkinson, David Courtis, Khalil Jouaneh

Currently digital medical records are an absolute mess. Split between different maintainers and hard to keep track of. Doctors sometimes have to wait days or even weeks for access to patient medical data in order to ensure security. In medicine, days or weeks mean death.
A blockchain is a decentralized continuously growing online ledger or records validated by members of the network. Traditionally it is used for cryptocurrencies however this application can extend towards creating a blockchain based electronic medical record system.

Smart contracts act as an intelligent representation that links patients and providers to the addresses of existing medical records. The blockchain medical record does not store the record directly; rather encodes metadata that allows records to be accessed securely by patients, unifying access to data across disparate providers. The metadata contains information about ownership, permission and the integrity of the data being requested. Additionally, in a decentralized secure system secure and anonymous analysis can take place to help doctors administer better treatment and help give more accurate diagnoses.

Decentralized Supply Chain Network: Ethereum based Smart Contracts



Max Kang, Andrew Sutcliffe, Bhavan Suthakaran, Mitchell Sabbadini, Mit Patel

Traditional supply chains present several challenges due the lack of transparency, inefficient decision making, unexpected delays as well as rising execution errors. Given the increasing popularity in blockchain technology and smart contract-based solutions, our team explored the possibility of building a decentralized application on the Ethereum blockchain. The project particularly focuses on a proof-of-concept supply chain system for a hypothetical automotive industry and takes into consideration major stakeholders involved in the making of an automobile. Smart contract capabilities helped us in digitizing contractual obligations and allowed for processing of data based on predefined conditional statements.

The contract successfully allows for self-enforced processing of transactions, automates relationship management and governance, while reducing the need for management oversight from a centralized body. Once a contract has been instantiated, stakeholders can register their credentials along with their responsibilities within the network using their Ethereum addresses. Once approved, the smart contract would then assign roles to each stakeholder and grants appropriate permissions to authorize and process transactions. All interactions are mutually verified and published on the blockchain, making way for increased traceability and trust amongst the parties involved. Future enhancements to this project can include, implementing a reputation-based system that flags bad actors within the network and expands the functionality to account for varying demands of a real supply chain.

Quantum Generative Adversarial Networks

Jacob Ewaniuk, Adam Grace, Spencer Hill, Joshua Otten, Cameron Estabrooks

Generative Adversarial Networks (GANs) have recently gained enormous popularity in the machine learning community. Although conceptually simple, they have demonstrated cutting-edge results in generation tasks and the ability to learn underlying probability distributions. However, GANs have large computational costs and training issues such as modal collapse. Quantum Machine Learning offers a potential solution to these problems.

Our team has created a Quantum GAN (QGAN) that combines quantum neural networks with classical optimization heuristics. Parametrized rotational ansatzs have been implemented for the generator and discriminator models that are trained using quantum gradients. Our trained model is capable of generating hand-written images by using dimensionality reduction and qubitization to encode the data on quantum circuits. We trained our QGAN on the MNIST dataset, achieving a 94.98% reduction in trainable parameters against state-of-the-art classical models while maintaining similar qualitative performance. We also integrated a variational autoencoder model for data dimensionality reduction, which expands upon the body of work in this field and achieves superior qualitative results when compared to other QGAN models.

Variational Quantum Image Classifier

Tristan Austin, Julia Everitt, Matt Wright, Robbie Huang, Conner Chappell

Quantum computing presents an entirely new paradigm of computation with a new set of algorithms that offer massive increases in efficiency. Underpinning these algorithms are the quantum phenomenon of superposition and entanglement. However, with the noisy intermediate-scale devices available today, many of these quantum algorithms cannot meet the required demand to be practical in real-world applications. This, along with the developments in classical machine learning, has spurred recent research into hybrid quantum-classical algorithms that use parameterized quantum circuits which are trained using classical optimization techniques. This led to the field of quantum machine learning.

This project has two goals: to learn and explore the field of quantum machine learning and apply these techniques to the specific problem of image classification. With the high-dimensionality of quantum spaces, quantum computing offers various efficient image encoding schemes. We are developing a quantum algorithm inspired by the convolutional neural network. This algorithm was applied to the MNIST dataset as a proof of concept.

KFL&A Public Health: Emergency Department Wait Time Prediction

Zachary Stenstrom, Jesse Pound, Ben Graham, Charlotte Lombard

The goal of this project is to create an efficient model to estimate the current wait time for emergency departments in Ontario. Using training data from six emergency departments, we are developing an approach to predict the current wait time, given only basic admission data. This approach is valuable as many emergency departments do not record wait time data independently.

Marine Object Detection for ADGA Group

Camila Izquierdo, Alexander Nechyporenko, Sijia Huang, Tung Pham

Our team was tasked by cybersecurity and space intelligence consulting firm, The ADGA Group, to perform an analysis between diverse object detection algorithms. Recently, ADGA has developed a machine learning platform called Amari to detect characteristics near land and at sea, all from earth observation datasets. This platform can be leveraged to detect marine objects, oil spills or icebergs, aid in analyzing current port capacity status, and classify agriculture.

Object detection can be a tedious task in which it is necessary to find the correct algorithm to assess, train, and test datasets with. There are simple object detection algorithms such as YOLO (You Only Look Once) which lack detail but act quickly, and then there are more complex algorithms such as Faster RCNN's (a deep convolutional neural network). For this reason, ADGA consulted QMIND to compare against various algorithms to observe the difference and advantages to certain frameworks.

For our research, the team focused on detecting marine objects near ports and at sea. Using the TensorFlow Object Detection API, we created an object detector that can be easily fitted multiple algorithms to output a trained model. Upon completion of training and testing, the models created by the detector were comparatively assessed by the team and a recommendation was provided to the client.

Visualization of Patients' Usage Data for WaiveTheWait

Jake Zeldin, Emma Oland, Jordan Siwak, Amaar Jivanji

We partnered with WaiveTheWait to develop a data pipeline that reads CSVs and automatically creates PowerPoint presentations displaying visualizations and statistical summaries of patient's usage data for clinics. This resulted in a substantial time save and easier access to reports for both the client and medical clinics.

The team also developed a machine learning model to predict how long a patient will need to wait for an appointment at a given medical clinic. This information is being used by clinics to increase efficiency and reduce wait times.

NDA Project for TD

Ryan Turnbull, Muhammad Ahmed, Fabian Sosa, Zack Katsiroubas, Thomas Tesselaar

Unfortunately, specifics of the project cannot be shared due to a client requested NDA. However, the team performed well and were able to deliver their project to the client at the end of the school year.

NDA Project for TD

Brian Arthur, Liam Salass, JP Leblanc, Isaac Noori

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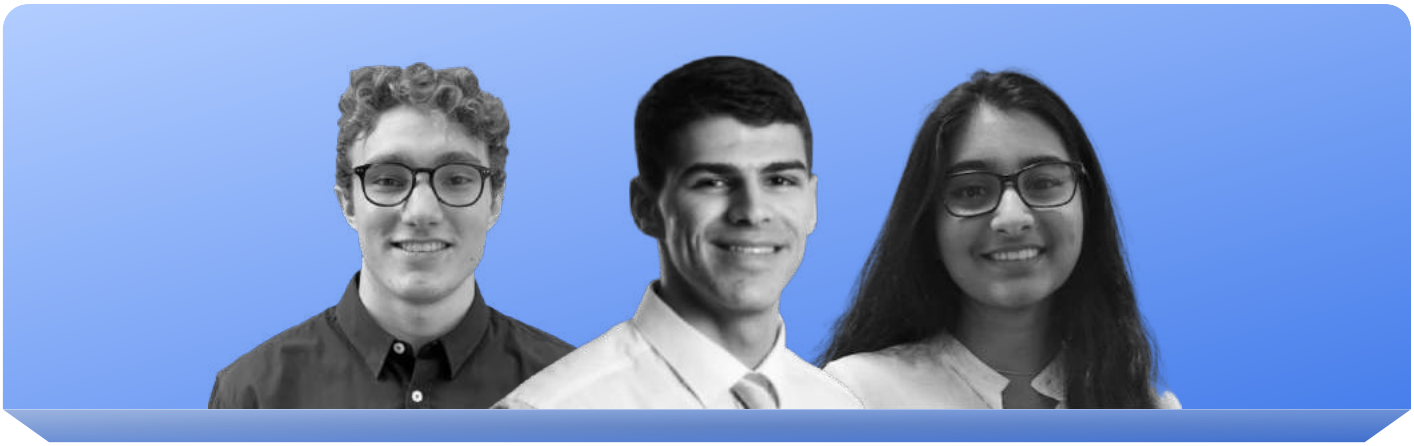
NDA Project for Loblaws Digital



Michael Treagus, Hani Khatib, Sanindie Silva

Unfortunately, specifics of the project cannot be shared due to a client requested NDA. However, the team performed well and were able to deliver their project to the client at the end of the school year.

NDA Project for Cleanlist

Harley Latsky, Marcus Warren, Dennis Huynh, Ryan Saweczko

Unfortunately, specifics of the project cannot be shared due to a client requested NDA. However, the team performed well and were able to deliver their project to the client at the end of the school year.

NDA project for Validere

Rabab Azeem, Michael Assheton-Smith, Ayaz Vural, Victor Tarnovski

Unfortunately, specifics of the project cannot be shared due to a client requested NDA. However, the team performed well and were able to deliver their project to the client at the end of the school year.

NDA project for Ninepoint Partners

Cameron Overvelde, Sebastian Wakefield, Luca Trombetta, Elijah James

Unfortunately, specifics of the project cannot be shared due to a client requested NDA. However, the team performed well and were able to deliver their project to the client at the end of the school year.