Law Enforcement Project

Final Project Report

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Partnered Company

Valor Vision (a subsidiary of Media Eagle LLC, also owned by John Lyden)

Abstract

Our mission was clear and urgent: to make police officers safer in tough and under-resourced work environments. We aimed to create a product that would boost the officers' well-being and also push the boundaries of technology. To do this, we teamed up with the ENGO Eyewear company and Valor Vision, and its CEO John Lyden, the trailblazer and visionary who came up with this idea.

This project aims to develop an iOS application for smart glasses that would provide real-time information and tools to aid police officers during investigations. The motivation for this project is to improve the efficiency and safety of police officers by enhancing their communication, coordination, and analysis capabilities. The goals of this project are to design and implement various features for the application, such as geofencing, breadcrumb tracking, points of interest, and police officer colleague location sharing. The project also involves testing and evaluating the application with a group of police officers and obtaining their feedback. This semester, the project achieved several milestones, such as selecting the appropriate tools and technologies for the development process, creating a UI mockup for the application, developing the features for the application, integrating the components of the application, and conducting tests and evaluations of the application. The methods used to make these achievements include Xcode, Swift, Bluetooth technology, ObjectBox database, SDK tool, and user testing. The results of this project demonstrate that smart glasses can be used as a platform for providing useful information and tools to police officers during investigations. The project also shows that the application is user-friendly and effective in aiding police officers during investigations. The completion of this endeavor has positive implications for both the field of smart glasses technology and the field of law enforcement. The project also has some limitations and recommendations for future work that are discussed in this report.

Acknowledgements

Our team, DP-11, would first of all like to acknowledge the help and advice provided to us by Prof. Zeljko Zilic of McGill. At important times, he gave us feedback on the product and the future steps that we need to take to make this project a success. We really appreciate you, Professor.

We would also like to thank John Lyden, the CEO of Valor Vision, for guiding us throughout the project and providing us with ideas of the features he would like to be included into the final and future versions of the app.

Additionally, we would like to thank Arnav Pawar, the software engineering intern at Valor Vision, who, in collaboration with the software engineers of our team, helped with developing the final app when some team members were absent or unavailable to work on the project during busy exam periods at the university.

Finally, we would like to express our gratitude to the design coordinators of the Capstone design project who made this amazing learning opportunity possible and who, throughout the duration of the project, have evaluated our progress reports, listened to us present our product, gave us useful feedback to continue toward the finish line, and who, in the end, organized an incredible event where we had the chance to showcase our final product.

Thank you to all.

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Objective and Motivation

Police officers often encounter dangerous situations in their daily work. For example, they may have to pursue suspects, enter crime scenes, or conduct raids. In these situations, visibility is crucial for their safety and efficiency. However, visibility can be limited by various factors, such as darkness, smoke, fog, or obstacles. Therefore, they need a device that can provide them with real-time information and tools to aid them during investigations.

Our work aims to develop such a device for police officers. We propose an iOS application for smart glasses that would display useful information and tools to the officers while they are performing their duties. Some of the features we developed for the application are geofencing, breadcrumb tracking, points of interest and police officer colleague location sharing. The application also enables the officers to interact with other officers nearby via calling or messaging. To achieve these features, we used various tools and technologies, such as Xcode, Swift, Bluetooth technology, ObjectBox database, and SDK tool. We also tested and evaluated our application with a group of police officers and obtained their feedback.

Our work is important for several reasons. First, it has the potential to improve the efficiency and safety of police officers by enhancing their communication, coordination, and analysis capabilities. Second, it has implications for both the field of smart glasses technology and the field of law enforcement. For the field of smart glasses technology, our work demonstrates that smart glasses can be used as a platform for developing applications that provide real-time information and tools for various purposes and contexts. It also shows that smart glasses can be integrated with other devices, such as iOS devices and Bluetooth connections, to enhance their functionality and performance. For the field of law enforcement, our work shows that smart glasses can be used as a tool for improving the efficiency and safety of police officers during investigations. It also shows that smart glasses can provide police officers with information and tools that are not available or accessible through other devices or methods.

Moreover, our work has the potential to have a positive impact on society and the environment. By improving the efficiency and safety of police officers, we can help to reduce the risk of operations gone wrong, creating a very positive impact on the quality of life in the police departments and the communities they serve. Additionally, the ENGO smart glasses are designed to be durable and easy to use, which could help to reduce the need for additional equipment, resources and replacement parts, leading to potential cost savings and environmental benefits in the long-term for both the law enforcement industry and our planet.

In conclusion, our work is of great importance and has the potential to make a significant impact on the visibility and safety of police officers in dangerous situations. We are confident that our product will be successful, and we look forward to seeing it being used in a real-world environment.

Background

The aim of this project is to create an app for police officers with navigation features that is also linked to a pair of smart glasses that the officer would wear. The app would primarily consist of a map that would be projected to the smart glasses, allowing the officer to save time and limit distractions during operations. The app would also have other features such as GPS tracking, compass, street names and intersections, points of interest, and geofencing capabilities.

To achieve this goal, we had to learn and use various technologies and tools, such as:

- ENGO smart glasses: These are lightweight and functional smart glasses that can display real-time data in the field of view of the wearer. They use ActiveLook microdisplay technology, which was recognized with an Innovation Award at the Consumer Electronics Show in 2021 [2]. They can connect to an iOS app via Bluetooth and display text, images, or videos sent from the app. However, they have some limitations, such as low frame rate (one or two frames per

second) and low battery life (two hours) [3].

Our research on the use of ENGO smart glasses by police officers was supported by a study conducted by the US Department of Justice [8]. The study found that the use of such technology could lead to an increase in efficiency, accuracy, and safety for law enforcement officers. Another study by the Police Executive Research Forum [7] found that wearable technology, such as smart glasses, can provide officers with increased situational awareness and access to critical information, leading to better decision-making and improved outcomes.

- Swift programming: This is a general-purpose programming language developed by Apple for iOS, macOS, watchOS, tvOS, and Linux. It is designed to be fast, expressive, and safe [1]. We used Swift to develop the iOS app that would communicate with the ENGO smart glasses and provide the navigation features for the police officers.

- ObjectBox database system: This is a software for implementing databases into Swift mobile applications. It is fast, easy to use, and scalable. It supports storing objects, queries, relations, transactions, and synchronization [4]. We used ObjectBox to store some of the information that the police officer makes use of inside the application, such as points of interest and settings.

We also had to research and understand some concepts and theories related to our project, such as:

- Navigation: This is the process of determining one's position and planning and following a route [5]. We had to learn how to use GPS data, maps, compasses, street names and intersections, and geofencing zones to provide accurate and useful navigation features for the police officers.

- Augmented reality: This is the technology that superimposes a computer-generated image on a user's view of the real world [6]. We had to learn how to use ENGO smart glasses to display the map and other information on the lens of the glasses, creating an augmented reality experience for the police officers.

- User interface design: This is the design of user interfaces for machines and software, such as computers, mobile devices, and other electronic devices [9]. We had to learn how to design a user-friendly and intuitive interface for both the iOS app and the smart glasses display.

By learning and applying these technologies, tools, concepts, and theories, we were able to create an app for police officers with navigation features that is also linked to a pair of smart glasses that the officer would wear.

A. ObjectBox for Database Management

ObjectBox is a database solution designed for embedded devices, mobile and IoT, which provides high performance, reliability and security. It is built for object storage and synchronization, and its APIs are designed to be simple and easy to learn. ObjectBox is mostly written in C/C++ for optimal performance and is loaded as a native library: a ".dll" on Windows, a ".so" on Linux, and a ".dylib" on macOS. The database file size only grows as required when data is added, and file areas are marked as unused when data is deleted, allowing ObjectBox to reuse existing file areas, which is more efficient than shrinking and growing the file [4]. ObjectBox has several features, such as transactions, database indexes, Kotlin support, and reactive extensions, among others. The ObjectBox Flutter database is ideal for cross-platform mobile and IoT apps that require minimal CPU, memory and battery usage. Additionally, ObjectBox provides out-of-the-box data sync for reliable data management on the edge. Finally, ObjectBox can be integrated into an app, used as a desktop or web app, and even stores all data in a single database file [4].

Problem and Requirements

The problem that we are addressing in this project is the lack of efficient and convenient navigation features for police officers during operations. Police officers often have to rely on their smartphones, radios, or dispatchers to get information about their location, route, or points of interest. This can be time-consuming, distracting, and unsafe, especially in high-risk situations.

The system that we are proposing to solve this problem is an app for police officers with navigation features that is also linked to a pair of smart glasses that the officer would wear. The app would provide the following features:

- Display a map that shows the current position of the officer and the direction they are heading.
- Display a compass that indicates the cardinal direction of the officer.
- Display street names and intersections as text, with the direction the officer is heading next to it.
- Allow the officer to set and view points of interest on the map, such as crime scenes, suspects, or backup units.
- Allow the officer to create and share geofencing zones on the map, which are areas that trigger an alert when entered or exited by the officer or other units.
- Allow the officer to see other police officers on the map during operations and access some information about them, such as their name, ID, and contact details.
- Allow the officer to enable breadcrumb tracking, which traces the steps taken by the officer on the map for post-operation analysis.

The app would communicate with a pair of smart glasses that the officer would wear, which would display the map and other information on the lens of the glasses. This would create an augmented reality experience for the officer, allowing them to see the navigation features without taking their eyes off the road or their surroundings.

The project requirements and constraints are as follows:

- The app must be developed using Swift programming language for iOS devices.
- The app must use ObjectBox database system to store some of the information that the officer makes use of inside the application.
- The app must connect to ENGO smart glasses via Bluetooth and send text, images, or videos to be displayed on the glasses.
- The app must use GPS data to provide accurate and reliable navigation features.
- The app must have a user-friendly and intuitive interface for both the iOS app and the smart glasses display.
- The smart glasses must be lightweight and comfortable to wear for long periods of time. Specifically, they must weigh less than 40g to not become too heavy and uncomfortable for the officer to wear for extended periods of time.
- The smart glasses must have a battery life of at least eight hours in order to be functional during almost a full officer workday.
- The smart glasses must have a frame rate of at least one or two frames per second.

Keeping these constraints and requirements in mind during the design process, we were developing an application that would respect the points mentioned above while also focusing on making the app easy to use and well-optimized for the officers to utilize on a daily basis.

Design and Results

A. Design Decisions and Process

As stated in the mid-project report, the project started off with the development of a chest-band device with sensors and lights to be attached to it as the initial product design idea. The design that we worked on can be seen on the left side of the Figure 1 below:

Figure 1: Initial design and concept of the chest band

The design process began by looking for the different sensors we could buy that would be able to be used by an iOS application. We also created a UI mockup to provide a visual representation of what the final product would look like. This mockup helped in obtaining an agreement between the development team and the company to ensure that everyone was on the same page. This can seen in the Figure 1 of the *Initial UI Mock-Ups for iOS App* annex in the *Appendices* section.

The mockup also helped provide more information to the developers about what was expected and instilled confidence in them during the development process. The client's satisfaction was also guaranteed as it ensured that the final product matched their expectations.

However, the company later decided to abandon the work on the iOS application as they deemed it too complex, and they requested that the team develop an iOS application for smart glasses. This was a significant design decision as it required the development team to pivot and shift their focus to a new platform. The team had to make several design decisions, such as selecting the appropriate tools and optimizing data transfer speed, to ensure that the smart glasses application could effectively replace the initial device.

To build the new application, the team had to send text and images to the smart glasses via Bluetooth, which is a slower connection compared to Wi-Fi and thus does not allow for the most optimal data transmission between the iOS device and the smart glasses. The team had to optimize the speed of data transfer despite the slow connection. We made this possible by implementing various techniques such as data compression, sending only the required data, and caching frequently accessed data.

B. Results Obtained

The development team was able to create an iOS application for the smart glasses with several features that help police officers have real-time information and tools to aid their investigations. The team developed features such as setting points of interest on the map (Figure 2), breadcrumb trailing (Figure 3), geofencing (Figure 4), and police officer colleagues location sharing (Figure 5). The Points of Interest feature allows to set points of interest on the map which would represent locations to investigate by the officer. Geofencing allows the police officer to set boundaries around specific areas of interest, and whenever they cross the boundary, an alert is triggered. Breadcrumb trailing enables the police officer to see the path they have covered, making it easier to retrace their steps during an investigation, as well as allows them to do post-duty analysis to improve efficiency of on-ground transportation for the next operations. Finally, the police officer colleague location sharing feature allows the officer to see the location of his colleagues right on the map and interact with them via calling or messaging.

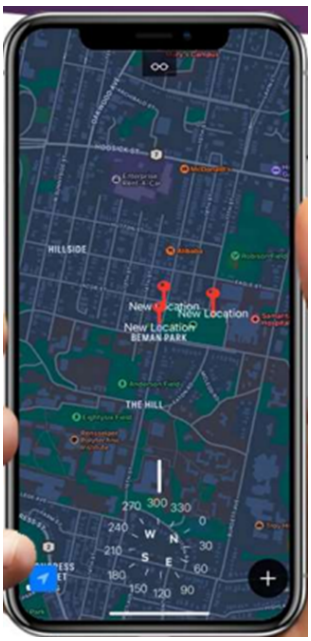

Figure 2: Screenshot of the Points of Interest feature of the mobile iOS application

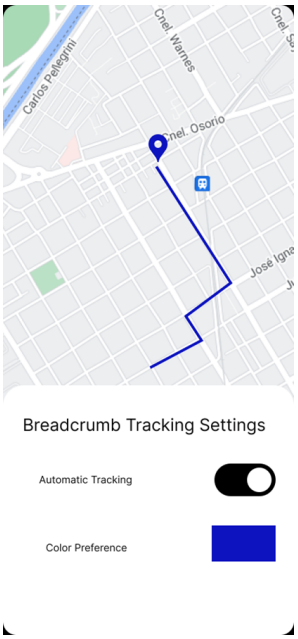

Figure 3: Screenshot of the Breadcrumb Tracking feature of the mobile iOS application

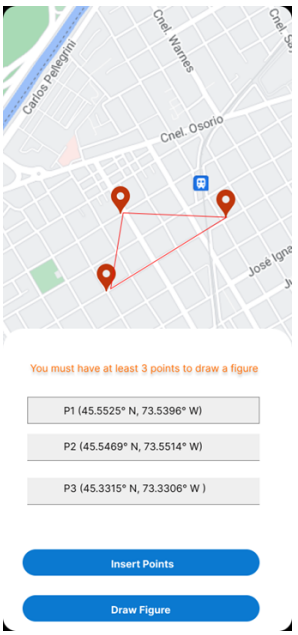

Figure 4: Screenshot of the Geofencing Delimitation feature of the mobile iOS application

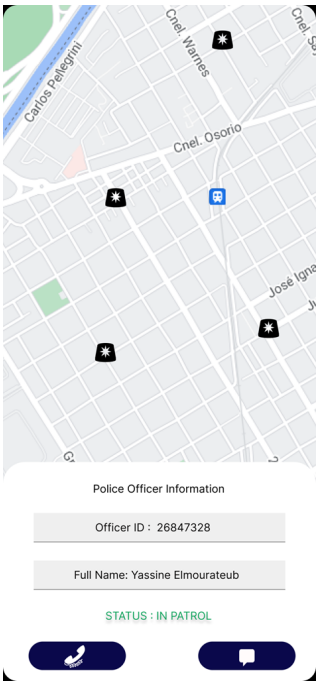

Figure 5: Screenshot of Police Officers Colleagues Location Sharing feature of the mobile iOS application

The team also conducted several tests to evaluate the effectiveness of the application. The tests were mostly functionality-related to see whether the feature that we worked on functions as expected on the iPhone's/iPad's in-app map and that the info is properly displayed in the smart glasses screen. The results showed that the application was reliable, accurate, and effective in aiding police officers during investigations. The feedback from the police officers who tested the application was positive, and they appreciated the ease with which they could access real-time information while performing their duties.

We conducted user testing with a group of police officers, who provided valuable feedback on the application's usability and functionality. The feedback we received was used to refine and improve the application, and we were able to address any issues and concerns raised by the users.

Overall, we believe that our project was successful in meeting the requirements and needs of the client, and we were able to deliver a high-quality product that was well-received by the end users.

The final code can be found in the following Github repo:

https://github.com/VadimT7/Valor-Vision-SmartGlasses-App

C. Tool Suitability and Integration

The tools used in the development process were suitable for the task at hand. The team used various tools such as Xcode, Swift, and Bluetooth technology. The development team, although new to this technology, became well-versed in these tools as the project advanced and used them effectively to build the application. The team also had to integrate components, such as the Bluetooth connection into the iOS application that we built, to ensure that the application functioned correctly by establishing a firm Bluetooth connection with the ENGO smart glasses.. We used the ActiveLook SDK, created by ActiveLook, a parent company of ENGO Eyewear, to interact with the technology of the smart glasses.

After fishing the implementation, the team conducted several tests to evaluate the effectiveness of the integrated components, and the results showed that the components worked well together and the application behaved as expected.

The Figure 6 and 7 that follow showcase clear examples of displaying text and map containing information about the current location of the officer right to the ENGO smart-glasses:

Figure 6: Display of the street name and orientation of the user to the ENGO smart glasses

Figure 7: Display of the map of the user's current location to the ENGO smart glasses

D. Implications of results

The results of this project have implications for both the field of smart glasses technology and the field of law enforcement. For the field of smart glasses technology, this project shows that smart glasses can be used as a platform for developing applications that provide real-time information and tools for various purposes and contexts. This project also shows that smart glasses can be integrated with other devices, such as iOS devices and Bluetooth connections, to enhance their functionality and performance. For the field of law enforcement, this project shows that smart glasses can be used as a tool for improving the efficiency and safety of police officers during investigations. This project also shows that smart glasses can provide police officers with information and tools that are not available or accessible through other devices or methods.

E. Limitations of design project

Despite the success of this project, there were some limitations that affected the design process and the results. One of the main limitations was the slow data transfer speed between the iOS device and the smart glasses via Bluetooth connection. This limitation prevented the team from sending high-rate video data to the smart glasses display. The team had to optimize the data transfer speed by implementing various techniques such as data compression, sending only the required data, and caching frequently accessed data. However, these techniques may have compromised the quality or accuracy of some data or images.

Another limitation was the lack of testing with real police officers in real situations. The team only tested the application with a group of police officers in a controlled environment. This limitation may have affected the validity or generalizability of the results, as the application may perform differently in different situations or contexts.

A third limitation was the ethical issues of using smart glasses for law enforcement purposes. The use of smart glasses may raise some concerns about privacy, security, or accountability of both the police officers and the public, which may bring its own set of unpleasant consequences if the security and privacy parts of the app are not properly taken care of during the development process.

F. Recommendations for future work

Based on these limitations and results, there are some recommendations for future work that could improve or extend this design project. One recommendation is to improve the data transfer speed between the iOS device and the smart glasses by using a different technology or method, such as Wi-Fi connection or cloud computing. This could enable the team to send video data or large images to the smart glasses display without compromising their quality or accuracy.

Another recommendation is to test the application with real police officers in real situations or contexts, such as during an actual investigation or operation. This could provide more realistic and reliable feedback on the usability and functionality of the application, as well as its impact on the efficiency and safety of police officers during investigations.

A third recommendation is to address the ethical issues of using smart glasses for law enforcement purposes by conducting a thorough ethical analysis or consultation with relevant stakeholders, such as police officers, public officials, or civil society groups. This could ensure that the application respects privacy, security, or accountability principles and standards, and does not violate any laws or regulations.

G. Conclusion

In conclusion, this section first started by mentioning the design of the chest band that we initially planned to build for police officers to wear, coupled with sensors (e.g., infrared) and LED lights to improve visibility at night.. The initial design idea was abandoned, and the development team had to pivot in the 2nd semester and create an iOS application for smart glasses with several features to aid police officers during investigations and on-duty operations. Despite the technical limitations such as the low rate of data transmission to the smart glasses, the team successfully integrated the utilized tools, tested them, and made the necessary modifications to ensure the smooth development process and a reliable final iOS

application for police officers to use. The team encountered several challenges during the integration process due to the slow data transfer speed in a Bluetooth environment, however, we still succeeded at displaying the map to the glasses and were the first team to do so in the world using the ActiveLook SDK.

Impact on Society and the Environment

Over the past several decades, policing agencies have implemented an array of technological advancements to improve operational efficiency and outcomes, especially in times of diminished resources and enhanced public attention on and scrutiny of law enforcement activity. However, much remains to be known about the prevalence and utility of technology among the nation's law enforcement agencies and the factors that influence its selection and implementation. Our product is designed to help improve policing and enhance the safety of police officers. Throughout the design and implementation of our product, we have analyzed its positive and negative impacts on society. Overall, the cost-benefit analysis points to its mass deployment.

One of the features of our product is crime mapping, which can map, analyze, and display quality of life complaints, crime patterns over space and time, and paths to crime showing distances between events within an incident. Using GIS, departments can identify clusters of crime incidents or types (i.e., hot spots and habitats), generate graphic displays of crime incidents for officers or the community, and identify other patterns of local crime activity that may ultimately help inform the allocation and deployment of officers into the field. This helps in efficient use of available policing resources and cost reduction.

Police officers with smart glasses will be able to access a graphical feature that enables 3D display. These 3D displays will provide a magnified view through small lenses, and when connected to their phones, will supply them with a wider view extending their perspective and thus giving them an advantage over the criminals while on duty. They will be able to see their phone apps and notifications and even use some apps from a binocular viewing angle. This feature can also be useful in the future for viewing movies in cinematic mode, 3D map view, navigation, and gaming. These smart glasses can be developed to support virtual reality-like gaming. Further development of these smart glasses and our app can help create recognition technology software that can identify several aspects of a person, including their face and voice. This will help in tracking criminals and discovering their location without being in sight.

Shot-locating sensors (a feature we are yet to implement) working within an area will help in detecting the sounds and alerting law enforcement when weapons are fired and what type of weapon is likely used. This will speed up the response time. However, we also recognize that this added technology may serve as a distraction to the members of law enforcement. As more advanced technology arrives and police officers use more of it daily, it can become distracting. For example, if a police officer has a variety of technological devices in the car while patrolling, they may pay more attention to them than to situations around them. They can avoid the potential distractions by learning to improve their focus and attention to detail while using technology.

Some people may view technologies like tracking systems and facial recognition as an intrusion on their privacy and autonomy. They may value their freedom to interact with others and conduct their daily activities without being monitored and recorded by cameras and tracking systems. These technologies can also cause disruptions in the lives of innocent people who may be falsely identified as suspects by the software, so it is crucial to verify the accuracy of the data in these cases. The implementation of these desired features can entail a high cost and require a significant investment in acquiring smart glasses and developing and maintaining the software. In consequence, this can pose a financial challenge but, despite the higher costs, the benefits of these technologies will significantly outweigh the costs in the long run.

Report on Teamwork

One of the main objectives of this project was to develop students' ability to collaborate effectively in challenging tasks in a team setting with serious responsibilities. The process of teamwork we have mastered started with clear goal setting and objectives, then building trust among the members and finally following the Gantt chart. However, any team can face issues and ours was no exception. Our team began smoothly but, due to pressure, some members could not function properly. Therefore, after the first few meetings our team decided to choose Vadim as our project manager who ensured we met the deadlines and attended the meetings. As a team we managed to complete the project and meet all the expectations and requirements from Valor Vision and our mentor, Zeljko Zilic. By the end of the project, we reached a consensus on team expectations, the importance of team communication and leadership.

As a team we learned that effective communication is essential for success and we continued to improve our efforts by checking in more frequently and being aware of the due dates, as well as informing others if any problems occurred.

Our team had a responsibility to keep individual commitments to the deadlines to allow more time for compilation, edits, and peer reviews but we could not achieve this as some members did not take the deadlines seriously. We also realized that it is necessary for all team members to give their final feedback on the assignments before the leader submits them to the assignment folder to ensure a unanimous team approval. At first, there were doubts that the team members would work well together so it was necessary to maintain a positive attitude for the group. And at last, our expectations about the group were met; they were even exceeded, and we completed the report and work on the app successfully, just as we envisioned from the start of the project.

In conclusion teamwork is a necessity in every modern workplace and starts with individual efforts of each member. An effective communication, openness, trusting each other to do their part are keys for success in a team project. Our experience has taught us that team effectiveness relies heavily on balance between clearly established goals and clear communication with a project/team leader leading by example.

The *Table I* from the "Table of team members responsibilities" annex in the *Appendices* section shows a summary of the responsibilities taken on by each individual member of the team during the first and second semesters of the design project.

Conclusion

In this semester, we have accomplished the goal of creating an app for police officers with navigation features that is also linked to a pair of smart glasses that the officer would wear. In order to achieve this goal, we have learned and used various technologies and tools, such as ENGO smart glasses, Swift programming, ObjectBox database system, and user interface design. We have also researched and understood some concepts and theories related to our project, such as navigation, augmented reality, and geofencing. The team has developed, tested, and evaluated the app and the smart glasses for functionality, usability, and performance.

The next steps for our project are to improve the design and interface of our app and smart glasses based on the feedback from the users and instructors, to implement more features for our app and smart glasses, such as infrared sensor, video transmission, and Wi-Fi connectivity, and to conduct more tests and experiments with our app and smart glasses in different scenarios and environments that the police officers would find themselves in.

Through this project, we have learned how to apply our knowledge and skills in a real-world problem that has social and ethical implications. We have learned how to work as a team and collaborate with different stakeholders, including with Valor Vision and ENGO Eyewear team, the police department, and the instructors, and have learned how to overcome challenges and limitations of the technologies and tools that we used, such as the low frame rate and battery life of the smart glasses.

We are thrilled to share the amazing progress we have made this semester on our project, despite some bumps on the road. We started by developing an iOS app that enabled police officers to control LED lights and access video from the IR sensor and HD camera in our innovative product. But then we got some feedback from Valor Vision and its visionary CEO John Lyden, and we realized we had to switch gears and concentrate only on the iOS app design for the final product.

This was a tough challenge, but it also gave us a great opportunity to learn how to be adaptable and responsive to our clients' needs. We worked hard to create a new app that integrates with smart glasses as Valor Vision requested. We are confident that our product will be a game-changer for law enforcement (particularly for officers on duty) and will enhance their navigation capabilities while on active duty.

We can't wait to see how Valor Vision will implement our app and what positive impact it will have on our future customers and society at large.

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Appendices

1. Initial UI Mock-Ups for iOS App

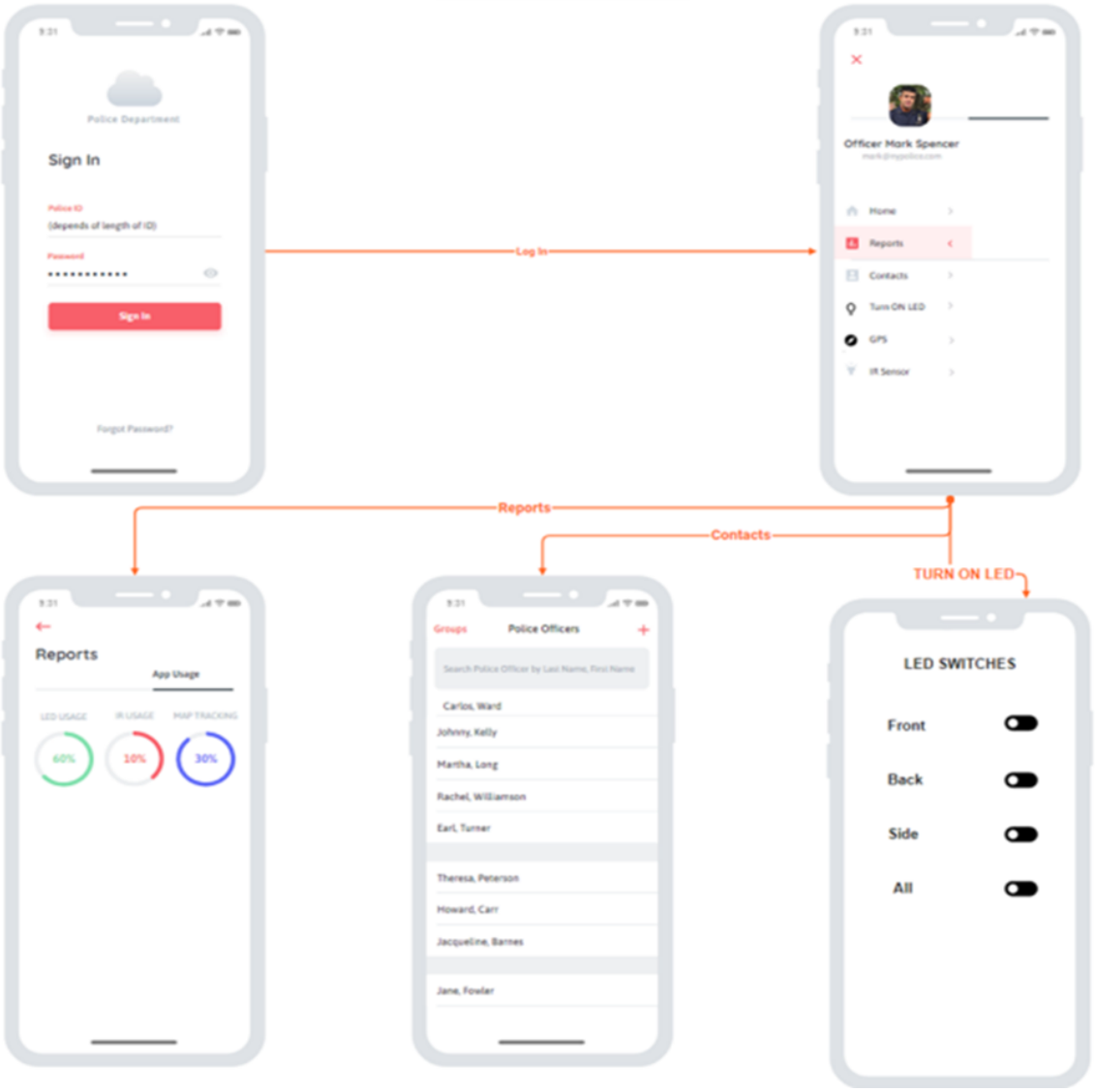

Figure 1: Initial version of the UI mock-ups of the iOS application for law enforcement officers

2. Table of team members responsibilities

Team Member	Roles and Responsibilities
Vadim	Team coordinator and leader Communication with Valor Vision Presentations communicator iOS app development with Swift Coordination of work with ENGO smart-glasses support team and Valor Vision intern Arnav
Yacine	iOS app development using Swift; UI design creation
Irene	No participation
Lawi	Hardware design and testing; Impact of Technology Reflection and Reporting

Table I: Distribution of work and the responsibilities of every team member during the entirety of the project (2022-2023)