University of Nottingham
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COMP2043.GRP Individual Report: AI-Powered Digital Signage for Targeted and Personalized Advertisement

Team2024.06

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Other Group Members:

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Supervised by Kian Ming Lim

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School of Computer Science

University of Nottingham Ningbo China

Chapter 1

Individual Contribution Summary

1.1 Logistic Contribution

For any administrative and logistical tasks related to the project, I contributed the following:

- **Reviewing Course Requirements**
  I carefully reviewed course requirements and the marking rubric to ensure that our work met expectations. I ensured that each task was fully understood and that it followed the criteria outlined by the course.

- **Checking Task Specifications**
  I reviewed the specific requirements and evaluation criteria for each task, ensuring that all team members were clear about the expectations and standards for each deliverable.

- **Communicating with the Team**
  I made sure to accurately communicate the course requirements and task details to the team, ensuring that everyone understood what was expected.

- **Progress Monitoring**
  At key points during the project, I reminded the team members to accelerate their progress where necessary, to ensure that we stayed on track and met deadlines. I regularly checked that the tasks were progressing as planned.

- **Ensuring Timely Submissions**
  I played a key role in ensuring that all tasks were completed on time. I made sure

to remind the team to submit work before deadlines and coordinated to ensure that all deliverables were submitted on time.

1.2 Technical Contributions

For any design and implementation task for the project, I contributed the following:

1.2.1 Writing Bids

Before the project started, each group was required to submit three bids to compete for the project of our choice. I was responsible for writing one of the three bids that had to be submitted, making sure that it met the requirements and the goals of our group.

1.2.2 Ethics Forms

I completed the ethics forms required for the project. Before the initiation of the project, I thoroughly reviewed all relevant ethical considerations and familiarized myself with the UNNC policy, as outlined in the University Guidelines. I ensured the timely submission of the necessary ethics forms, as no work could proceed without their proper completion.

1.2.3 Group Project Website Content

I was responsible for filling in the text content of the website, ensuring that all necessary information was communicated and aligned with the objectives of the project.

1.2.4 UML Diagrams and UI Interfaces

I played a key role in creating all UML diagrams, developing a prototype. The following Figure 1.1, Figure 1.2 and Figure 1.3 will show the final image in the Final Report.

1.2.5 Research and Literature

I conducted research into relevant literature for the project, ensuring that we had a solid theoretical foundation for the work we were doing.

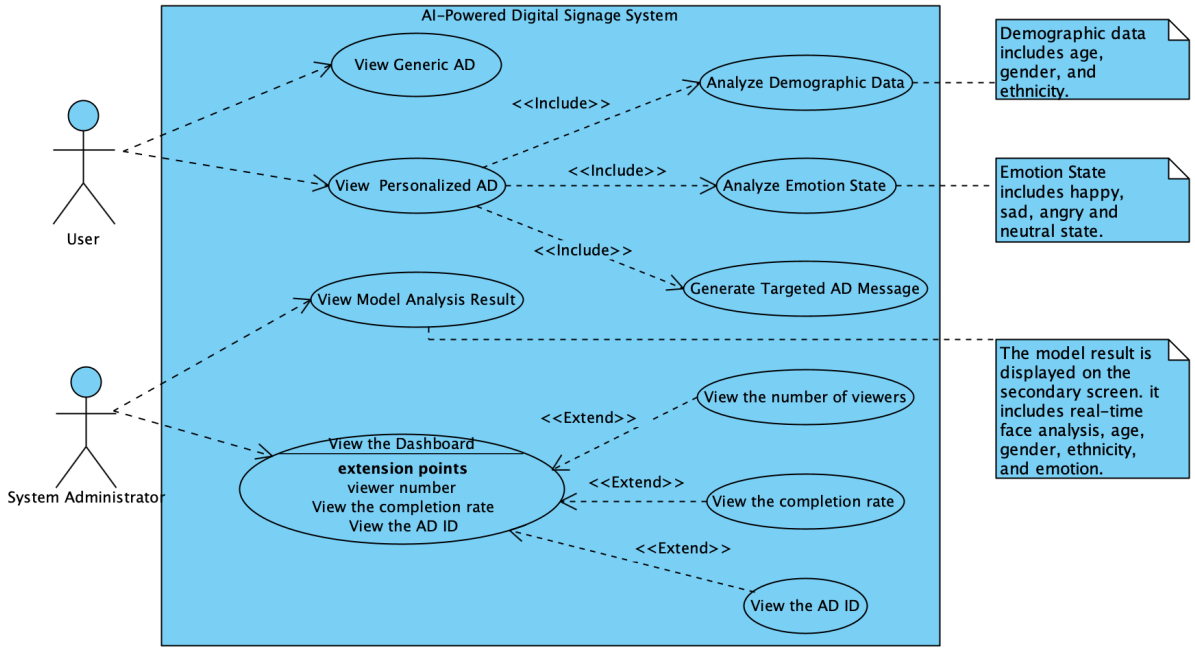
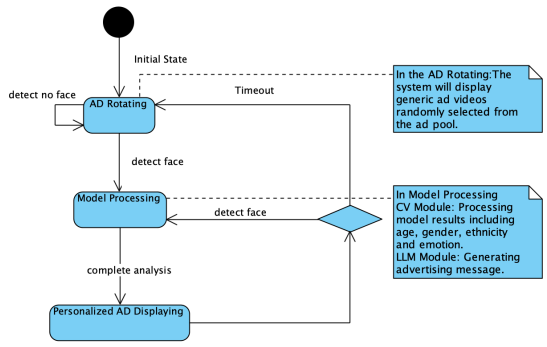
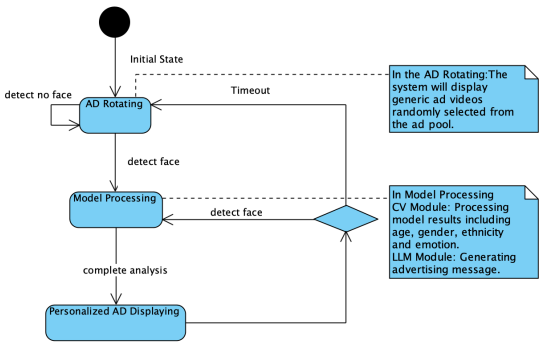


Figure 1.1: *Use case Diagram*

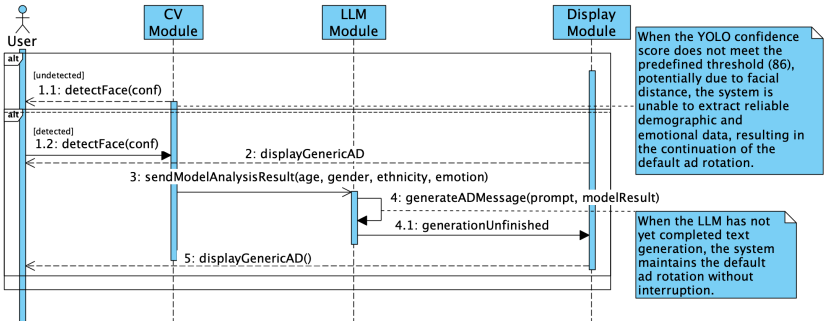


(a) *State Diagram: Ideal*

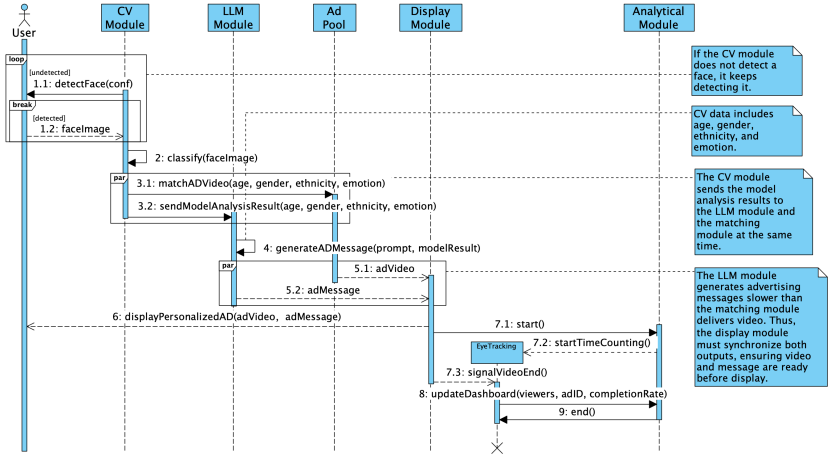


(b) *State Diagram: Realistic*

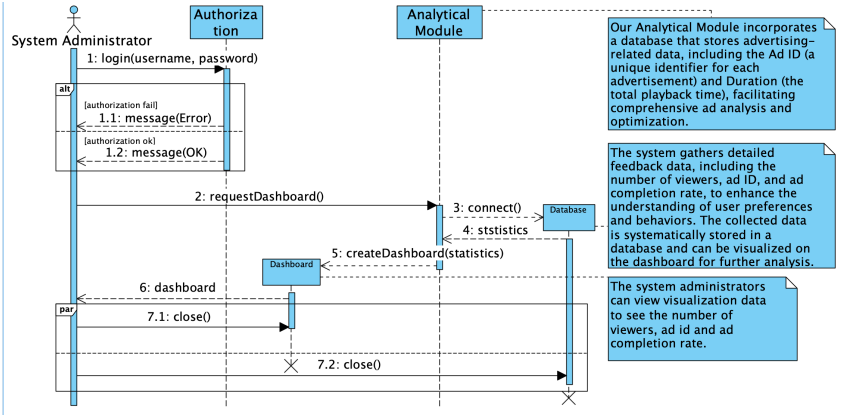
Figure 1.2: *State Diagram*



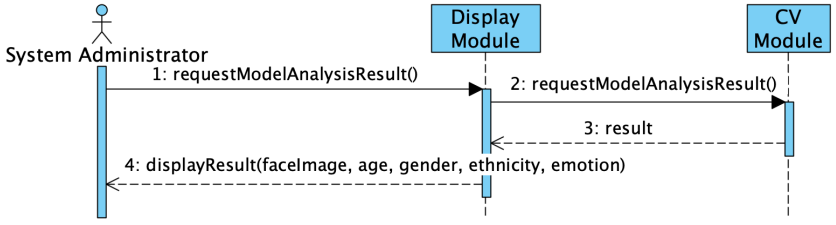
(a) *Sequence Diagram 1*



(b) *Sequence Diagram 2*



(c) *Sequence Diagram 3*



(d) *Sequence Diagram 4*

Figure 1.3: *Sequence Diagram*

1.2.6 HTML Development

I contributed to the development of the secondary screen HTML in Figure1.4, Figure1.5, Figure1.6, the ad carousel, and the QR code display. Although the decision was later made to exclude the QR code and rotation due to model generation capabilities, I created the HTML code and ensured it was ready for potential use.

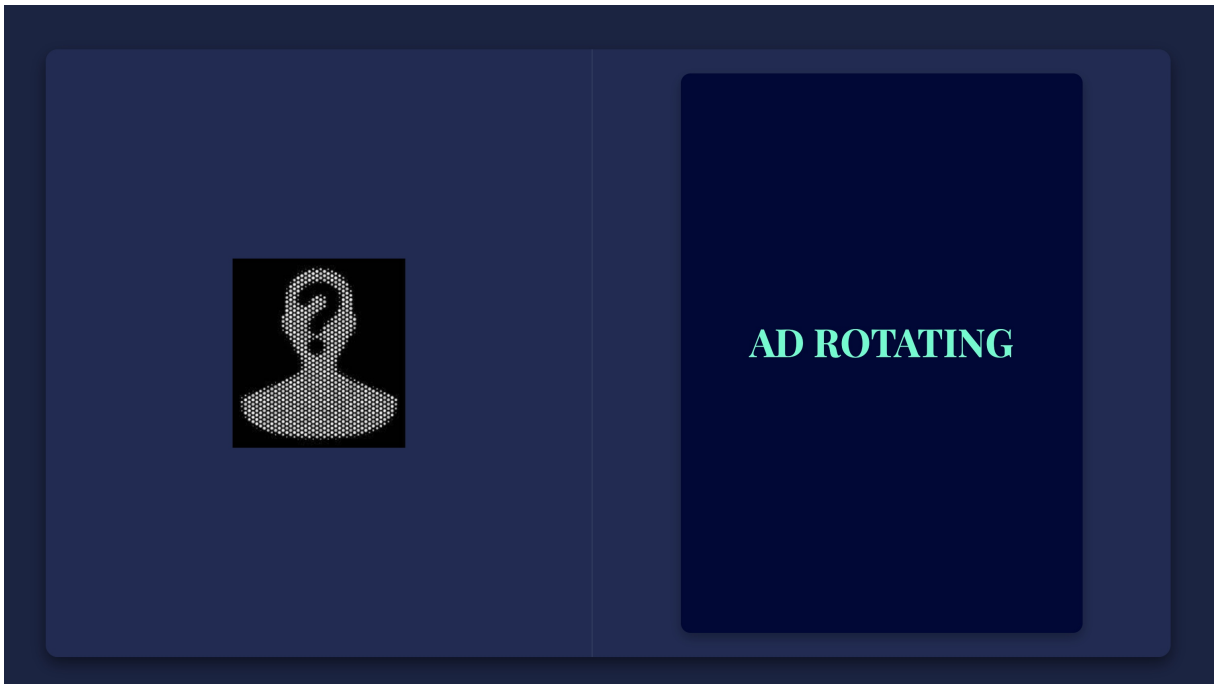


Figure 1.4: *Backend Screen-AD Rotating*

1.2.7 AD Pool and Database

In Figure 1.7, I played a key role in designing and developing the database to store videos, descriptions, contents, IDs and others. I also ensured that the database was integrated with the dashboard for easy access and data manipulation. Additionally, I researched and edited the advertisements required for our system, ensuring they were appropriately tailored for use.

1.2.8 Debugging CV Model and YOLOv8

I debugged the CV model and the YOLOv8 code, ensuring the output format was compatible and functional.

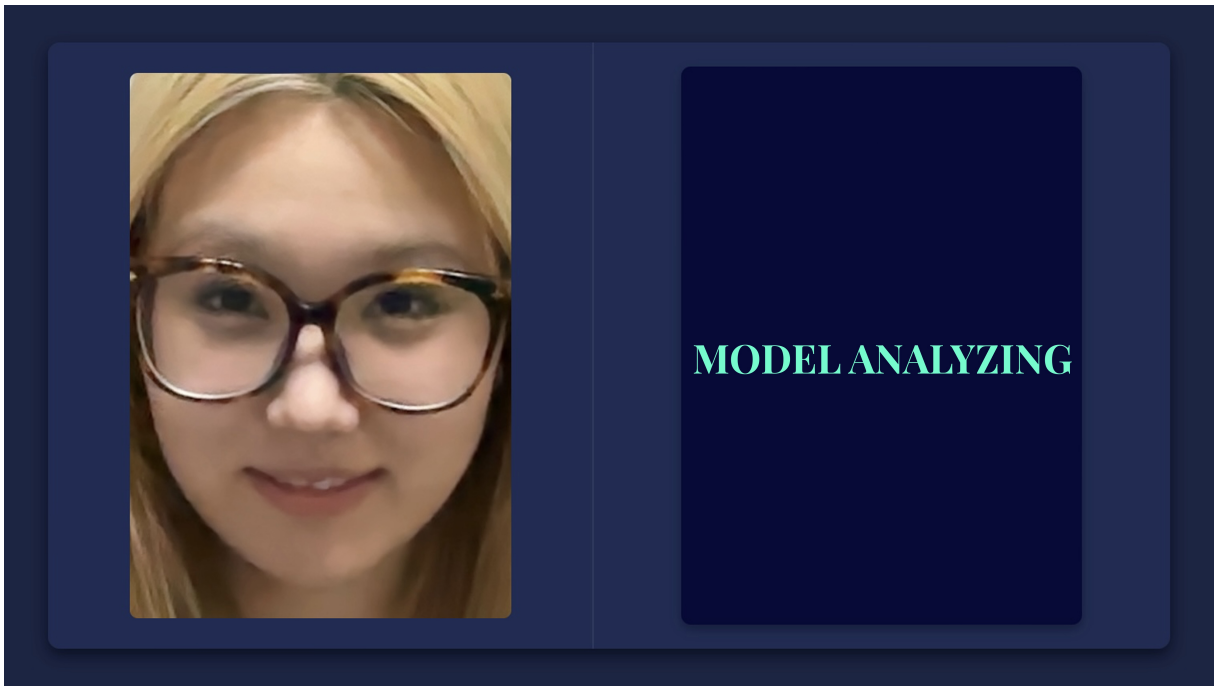


Figure 1.5: *Backend Screen-Model Analyzing*

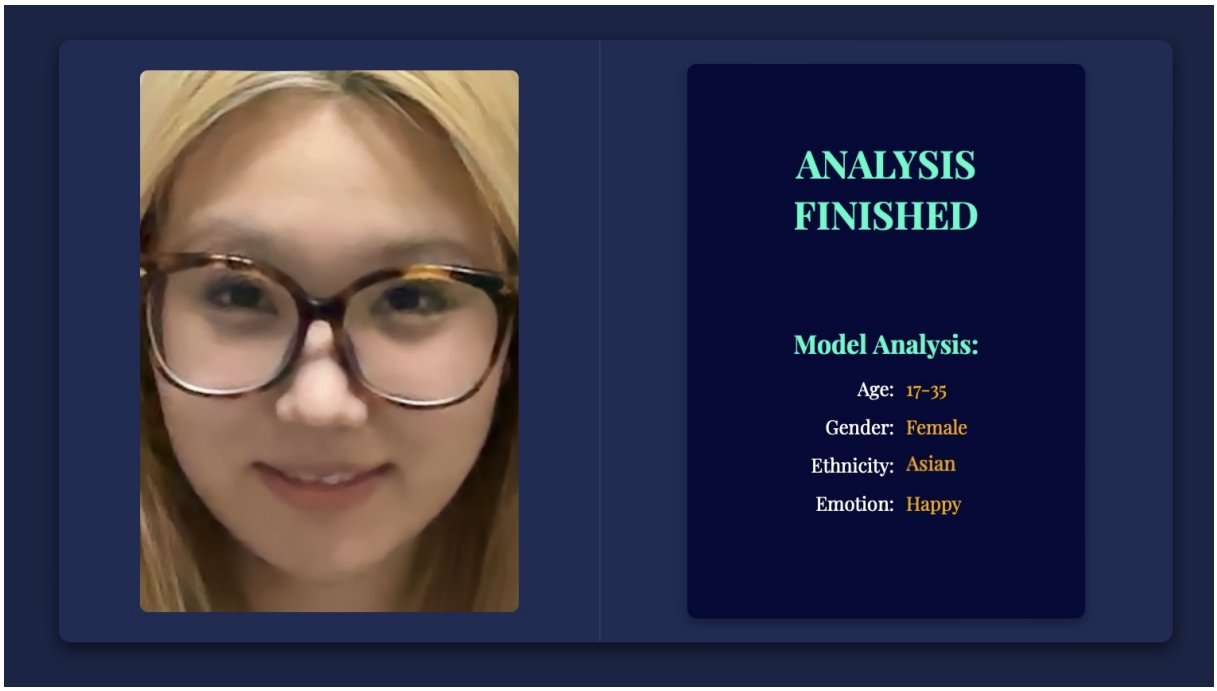


Figure 1.6: *Backend Screen-Model Analysis*

```
zoey@ZoeydeMacBook-Pro AD % sqlite3 advertisements.db
SQLite version 3.43.2 2023-10-10 13:08:14
Enter ".help" for usage hints.
sqlite> .headers on
sqlite> .table
ads           demographics  viewers
sqlite> SELECT * FROM viewers LIMIT 10;
viewer_id|demographics_id|ad_id|view_time|visit_date
1|20|14|4.35|2024-01-01
2|21|40|14.45|2024-01-01
3|10|6|1.52|2024-01-01
4|5|71|3.28|2024-01-01
5|5|39|11.68|2024-01-01
6|1|12|1.6|2024-01-01
7|11|71|13.58|2024-01-01
8|22|36|12.35|2024-01-01
9|21|77|0.86|2024-01-01
10|30|9|9.82|2024-01-01
sqlite> SELECT * FROM ads LIMIT 10;
ad_id|ad_content|ad_description|demographics_id|weight|product_name|duration
1|videos/0001.mp4|Ice cream is a beloved frozen dessert made from dairy or plant-based milks with added sweeteners and flavorings to give it a smooth, creamy, rich taste. It is a versatile treat that comes in diffe
rent flavors and can be enjoyed in cones, cups, or as part of creative desserts.|1|1.901|Ice Cream|26.63
2|videos/0002.mp4|KFC (Kentucky Fried Chicken) is a world-renowned fast food chain that serves a range of foods including hamburgers, French fries, and fried chicken.|1|1.791|KFC|14.77
3|videos/0003.mp4|Nike athletic shoes are renowned for their comfort, durability and iconic design, and whether it's running, basketball, training, or lifestyle wear, Nike's extensive range ensures there's a perfec
t fit for everyone looking for high-quality, stylish and functional footwear.|1|1.288|Nike Shoes|18.67
4|videos/0004.mp4|Pepsi is a globally recognized carbonated soft drink known for its bold, refreshing taste and the perfect combination of sweetness and fizz.|1|1.921|Pepsi|27.8
5|videos/0005.mp4|The mobile phone is an essential communication device that has evolved into a powerful tool integrating advanced functions such as calling, text messaging, Internet browsing, photography and mobil
e applications.|1|1.359|Phone|14.27
6|videos/0006.mp4|PUMA shoes are known for their blend of style, comfort and performance, making them a popular choice for athletes and casual wearers alike.|1|1.011|Puma Shoes|36.27
7|videos/0007.mp4|Soda is a popular carbonated beverage known for its refreshing, bubbly taste and a variety of flavors, from classic cola and lemon-lime to fruity and exotic drinks.|1|1.86|Soda|19.48
8|videos/0008.mp4|Sunglasses are a practical and fashionable accessory designed to protect the eyes from harmful UV rays, reduce glare and improve visual comfort and clarity in bright conditions.|1|1.782|Sunglasses
|22.0
9|videos/0009.mp4|The Trolley Case is an essential travel companion designed for convenience and practicality. With its sturdy wheels, retractable handle and spacious compartments, it provides easy maneuverability
and efficient packing for trips of any length.|1|1.635|Trolleycase|46.6
10|videos/0010.mp4|UNIQLO is a global apparel retailer offering a wide variety of apparel for men, women and children, including basics such as T-shirts, jeans and outerwear, as well as innovative products such as
warm HEATTECH and breathable AIRism.|1|1.18|Uniqlo|29.6
sqlite> SELECT * FROM demographics LIMIT 10;
demographics_id|age_group|gender|ethnicity
1|17-35|Male|Asian
2|17-35|Male|White
3|17-35|Male|Black
4|17-35|Male|Indian
5|17-35|Male|Other
6|35-50|Male|Asian
7|35-50|Male|White
8|35-50|Male|Black
9|35-50|Male|Indian
10|35-50|Male|Other
sqlite>
```

Figure 1.7: *Database*

1.2.9 Poster and PPT Creation

I created the project poster and developed the presentation slides for the pre-presentation, which helped communicate our project's progress effectively to the team.

1.2.10 LSEPI

Based on the preliminary ethics forms and the specific requirements outlined by LSEPI, I completed the final section of the LSEPI documentation. This section provides a more comprehensive description of our project's ethical considerations. It highlights the careful thought we gave to the ethical implications of our work, including Intellectual Property, Research Ethics, Data protection, Other Legislation and Broader Ethical and Social Considerations in our AI-powered digital signage system. We ensured that our project adhered to the ethical guidelines set forth, particularly focusing on the responsible use of data and the potential impact of personalized advertising.

1.2.11 Report

I was responsible for drafting several key sections of both the interim report and the final report, including the following:

- **Introduction**

  I outlined the project's background, objectives, and problem.

- **Design**

  I detailed the design process, including architectural choices and UML Diagram.

- **UI Interface**

  I described the user interface, focusing on usability and the design choices made to ensure an optimal user experience.

- **LSEPI**

  I discussed the ethical considerations specific to our project, in line with LSEPI guidelines, addressing privacy, fairness, and transparency in AI-powered digital signage.

- **Future Work**

  I proposed potential directions for future development and enhancements to the project, highlighting areas for improvement and expansion.

Chapter 2

Reflection

2.1 Project Achievement

The primary goal was to design and develop an AI-powered digital signage system that delivers targeted and personalized advertisements. The project involved multiple key modules and processes that work together to deliver personalized advertisements.

The user interaction with the AI-powered digital signage system is initiated when the user approaches the display, triggering the face detection feature. The computer vision (CV) module identifies the user's face and analyzes demographic attributes, such as age, gender, ethnicity, and emotional state. Upon detection and analysis of these parameters, the language generation module (LLM) utilizes the gathered data to select from a given pool of advertisements and generates personalized text for the ad. However, given the relatively slower text generation speed of the LLM, if the content is not yet ready, the system defaults to playing random ads from the pool, ensuring continuous screen activity. Personalized advertisements will only be displayed once both the LLM-generated content and the targeted advertising material are finalized.

In addition to personalized content generation, the system incorporates eye-tracking technology to monitor user engagement in real time. It records metrics such as viewing duration and viewer counts. These data are subsequently transmitted to the analytical module, allowing administrators to assess ad performance and implement optimization strategies. Collectively, the system integrates face recognition, personalized ad generation, and eye-tracking technology, offering a dynamic and tailored advertising experience.

In conclusion, the system integrates face detection, demographic data, emotion analysis, and AD real-time display, all of which contribute to delivering a seamless and personalized advertisement experience for the user. Additionally, the system incorporates eye-tracking for user engagement analysis and allows administrators to optimize performance based on key metrics.

2.2 Design and Technical Challenges

This section covers the major design and technical challenges encountered, our attempted solution, what was not achieved, and why.

2.2.1 Challenges For the Team

- **Eye-tracking Accuracy**

  Due to time constraints, our Eye-Tracking model cannot reset the view when a new viewer replaces the position of the previous viewer. This means that if one viewer leaves and another begins watching, the viewing duration continues to accumulate instead of being reset for the new viewer. We attempted to rectify this issue but did not yield any result.

- **Face Recognition Accuracy**

  The accuracy of face recognition is affected by external factors such as camera resolution, lighting conditions, and whether users are wearing masks or other facial coverings. We improved the recognition accuracy in terms of gender, ethnicity, and emotion. However, age recognition remained the greatest challenge that affects the effectiveness of personalized advertisements.

2.2.2 Challenges Specific to My Tasks

- **Eye-Tracking Model Training**

  Due to compatibility issues between the model and my laptop, as well as the difficulty in identifying a suitable model, I was unable to complete the training of the eye-tracking model. Ultimately, the team agreed that it was premature to proceed with the development of this feature, and the decision was made to postpone the

training. During the development of the eye-tracking model, I was also tasked with other responsibilities, so the completion of this task was eventually handed over to other team members.

- **Advertisement Personalization**

  I looked for open source ads to minimize licensing issues, but there was a lack of more refined and personalized ad display. While the ads met the basic requirements, this decision limited the potential of the ad system in providing highly personalized content.

- **QR Code Display Implementation**

  Although I initially implemented a QR code display feature, we decided not to use this feature due to concerns about user behavior (e.g. users might not be willing to scan a QR code to fill out a survey). In addition, I encountered technical limitations because standard surveys could not be integrated with the database I created. Given the time constraints and my own limitations, the team ultimately chose to use eye tracking to measure user engagement. This was achieved by tracking viewing time and ad completion rate, with longer viewing time indicating a higher preference for the recommended content.

2.3 Challenges on Running the Project

- **Project Planning and Time Management**

  The initial project schedule assigned tasks every week and reported progress on weekends, but as the project progressed, some tasks were postponed due to unforeseen challenges. Integration was particularly challenging due to the complexity of the code, and various problems occurred during the integration process, which further delayed the progress of the tasks. In addition, during the mid-term reporting stage, we failed to allocate time effectively, resulting in a hasty completion of the report. Therefore, I think in the time management and project planning process, the team needs to prioritize tasks, focus on core components, or divide different groups to complete the corresponding tasks to ensure the timely completion of the final deliverables.

- **Team Collaboration and Communication**

  Team collaboration was generally effective, but initially, the team held only one

in-person meeting per week, with individual tasks completed during the rest of the week. This approach led to occasional miscommunication during online interactions, resulting in slower progress. In the following term, we adapted by scheduling three in-person meetings per week. This helped us to hold each other accountable and raise questions immediately. However, the varying complexity and completion efficiency of different tasks meant that some in-person meetings were not as productive as anticipated. I believe a more efficient approach would be to allow team members to leave the meeting once their tasks are completed, or even to exempt those who have finished their work from attending group meetings. This would improve efficiency and provide individuals with more time to focus on other course-related tasks.

- **Technical Challenges and Solutions**

  Throughout the project, we encountered technical challenges and limitations with our personal devices, such as complex code integration and project model accuracy. For example, we trained multiple ML models for different tasks, and integrating all of them into one program required a lot of time to debug. On top of that, the accuracy of the ML models is limited by the external environment and the team's ability to train them. Finally, the model training process challenged our team members' technical capabilities as it was a complex task. When encountering unsolvable problems, we would start a group coding session to discuss and find a solution.

- **Project Flexibility and Adaptability**

  The project showed good flexibility in adapting to new insights and constraints. For example, our team initially focused on implementing QR code feedback mechanisms, but later decided to abandon these features after realizing that they did not align with user behavior. This shift allowed the team to focus more on refining core features, highlighting the importance of being more adaptable in the early stages of project development.

- **Ethical and Privacy Issues**

  Privacy was a key aspect of the project, especially when it comes to handling facial data. The team's decision not to store facial images after detection reflects the team's commitment to user privacy. However, this decision led to backend screen refresh issues as the system would lose facial images when refreshing. While

it was essential to prioritize privacy, this trade-off impacted both user experience and system functionality. Going forward, balancing privacy concerns and system performance will be an area for further improvement.

To summarize, while the project was successfully delivered, some features, such as ad refinement and personalization, eye tracking accuracy, face recognition accuracy, and backend screen refresh, remain unfinished. These tasks were delayed due to time constraints and technical limitations. The unfinished parts of the project highlight areas for future development.

2.4 Personal Insights and Growth

- **Learning and Application of New Technologies**

  Through this project, I gained significant technical skills, particularly in database design and development, as well as in the design, debugging, and optimization of the backend screen. I also gained a deep understanding of CV models and YOLO v8, learning how to process image data and improve the output format for accurate analysis. Additionally, I explored the workings of LLMs (Large Language Models), and how they can be integrated with the project for personalized advertisement generation. Furthermore, I developed the skill of writing bids, which helped me learn how to articulate project ideas and proposals clearly and persuasively.

- **Team Collaboration and Communication**

  This project provided early exposure to collaborative software development and the importance of clear communication within a team. I learned how to manage task distribution effectively, track progress, and ensure that each team member remained on track. Additionally, I gained experience in conveying complex technical information in a simplified manner to ensure everyone understood the requirements. I also learned how to tactfully remind team members about pending tasks and subtly encourage the timely submission of work, ensuring accountability within the team. Moreover, I gained experience in supervising and checking the completion of tasks within the group.

- **Project and Time Management**

1. **Task Prioritization and Time Management**

   Throughout the project, I learned how to prioritize tasks effectively based on their importance and deadlines. This included adjusting the project plan when urgent tasks emerged. Reflecting on the project's timeline, I realized that better time allocation and advanced planning would have led to more efficient task execution.

2. **Flexibility and Adaptability**

   I also developed a stronger ability to remain flexible when unexpected challenges occurred. I learned to re-evaluate task priorities, dynamically adjust the plan, and respond quickly to changing requirements. This adaptability proved crucial, especially when technical issues delayed certain tasks and new solutions were needed.

- **Ethical and Privacy Considerations**

  One of the most important aspects of the project was learning to handle sensitive user data, particularly facial images and personal demographic information. I gained a deeper understanding of the ethical issues surrounding privacy and how to balance the technical functionality of the system with strict privacy standards.

- **Reflection and Improvement**

  The project provided numerous opportunities to learn from both successes and mistakes. For example, the challenges of the eye tracking model taught me the importance of choosing compatible technologies and understanding their limitations early in the process. Furthermore, the lack of fine-tuned advertisement personalization highlighted the need for more detailed planning in system design. I also observed how the team workflow could be improved, particularly in areas such as task delegation and communication. These reflections will help me identify and address potential issues more effectively in future projects.

2.5 What I Would Do Differently

If I had the opportunity to restart the project, I would focus on the following areas to improve both my contribution and the overall outcome:

- **Completing the Eye-Tracking Model and Integration**

  I would continue to work to complete the training of the eye tracking model and integrate it with the relevant code. The eye-tracking functionality was one of the key features we could not fully implement, and I believe that improving it would enhance user engagement measurement.

- **Learning How to Implement the Questionnaire with Code**

  I would take the time to learn how to create and integrate the questionnaire functionality with the database. This would involve understanding how to dynamically generate questionnaires based on user responses and store the results efficiently in the database.

- **Training the CV and LLM Models**

  I would actively participate in training both the CV model and the LLM model. Gaining hands-on experience with machine learning models is essential for improving system accuracy and ensuring that the models are fine-tuned to deliver better results in real-world applications.

- **Experimenting with the Dashboard Implementation**

  I would attempt to implement the dashboard features earlier in the project to gain a deeper understanding of how data visualization can be used to track key metrics, such as user engagement and ad performance. This would improve my understanding of how backend data can be used to inform system optimization.

In summary, while my current technical abilities are limited, I hope to learn more by focusing on coding-related tasks and expanding my knowledge in future projects. By taking a more active role in these technical aspects, I would be able to contribute more significantly to the overall success of the project while gaining valuable experience.

Chapter 3

Peer Assessment

The following Figure 3.1, Figure 3.2, Figure 3.3 and Figure 3.4 present my peer assessment ratings for each group member based on their performance and contributions throughout the project.

COMP2043.GRP Peer Assessment Form

Complete one copy of this form for each member of your GRP group except yourself. Enclose all completed form as an appendix with your Individual Report. Rate the group member in question by ticking or marking with an "x" *exactly one* box for each evaluation aspect in the table below. Give a brief written justification for each assigned rating in the space provided below the table. For further information, see the Peer Assessment section of the GRP Student Handbook.

Name of assessed group member: Yiwei LI

	None	Lacking	Adequate	Good	Excellent
Research & information gathering			√		
Creative input			√		
Co-operation within group			√		
Communication within group				√	
Concrete contribution[1]				√	
Attendance at meetings					√

Justification of assigned marks:

The member showed a reasonable understanding of the project and participated in information gathering when needed. However, he did not take a leading role in research.

This member often contributes ideas to group discussions. He also proposed some ideas about the UI layout; however, at times, the suggestions were too detailed and difficult to implement.

This member followed the team plan and completed assigned tasks on time last semester. However, this semester, he has completed very few tasks, with most of the tasks being carried out by other team members.

He is responsive in group chats and meetings, sharing his thoughts when necessary and giving constructive feedback.

This member actively participates in the project implementation, including writing parts of the report, assisting with coding, and helping with presentation production, among other tasks.

The member demonstrates high motivation, attends every meeting, is punctual, and actively participates in discussions.

Figure 3.1: *Peer Assessment-Yiwei LI*

COMP2043.GRP Peer Assessment Form

Complete one copy of this form for each member of your GRP group except yourself. Enclose all completed form as an appendix with your Individual Report. Rate the group member in question by ticking or marking with an "x" *exactly one* box for each evaluation aspect in the table below. Give a brief written justification for each assigned rating in the space provided below the table. For further information, see the Peer Assessment section of the GRP Student Handbook.

Name of assessed group member: Ang LI

	None	Lacking	Adequate	Good	Excellent
Research & information gathering			√		
Creative input				√	
Co-operation within group				√	
Communication within group					√
Concrete contribution[1]				√	
Attendance at meetings					√

Justification of assigned marks:

The member showed a reasonable understanding of the project and participated in information gathering when needed. However, he did not take a leading role in research.

This member often contributes ideas to group discussions. He also proposed some ideas about UI layout.

This member follows the team plan, completes assigned tasks on time, and communicates with other team members.

He is responsive in group chats and meetings, sharing his thoughts when necessary and giving constructive feedback.

This member actively participates in the project implementation, including writing parts of the report, assisting with coding, and helping with presentation production, among other tasks.

The member demonstrates high motivation, attends every meeting, is punctual, and actively participates in discussions.

Figure 3.2: *Peer Assessment-Ang LI*

COMP2043.GRP Peer Assessment Form

Complete one copy of this form for each member of your GRP group except yourself. Enclose all completed form as an appendix with your Individual Report. Rate the group member in question by ticking or marking with an "x" *exactly one* box for each evaluation aspect in the table below. Give a brief written justification for each assigned rating in the space provided below the table. For further information, see the Peer Assessment section of the GRP Student Handbook.

Name of assessed group member: Xinna SU

	None	Lacking	Adequate	Good	Excellent
Research & information gathering					√
Creative input				√	
Co-operation within group				√	
Communication within group					√
Concrete contribution[1]				√	
Attendance at meetings					√

Justification of assigned marks:

This member demonstrated exceptional initiative in research tasks. They consistently found useful resources, shared them with the team, and helped us build a strong foundation of understanding for the project.

This member often contributes ideas to group discussions. She also proposed some ideas about UI layout, poster, PPT and videos.

This member follows the team plan, completes assigned tasks on time, and communicates with other team members.

She is responsive in group chats and meetings, sharing his thoughts when necessary and giving constructive feedback.

This member actively participates in the project implementation, including writing parts of the report, assisting with some coding, and helping with presentation production, among other tasks.

The member demonstrates high motivation, attends every meeting, is punctual, and actively participates in discussions.

Figure 3.3: *Peer Assessment-Xinna SU*

COMP2043.GRP Peer Assessment Form

Complete one copy of this form for each member of your GRP group except yourself. Enclose all completed form as an appendix with your Individual Report. Rate the group member in question by ticking or marking with an "x" *exactly one* box for each evaluation aspect in the table below. Give a brief written justification for each assigned rating in the space provided below the table. For further information, see the Peer Assessment section of the GRP Student Handbook.

Name of assessed group member: Zelin XIA

	None	Lacking	Adequate	Good	Excellent
Research & information gathering				√	
Creative input			√		
Co-operation within group				√	
Communication within group					√
Concrete contribution[1]				√	
Attendance at meetings					√

Justification of assigned marks:

The member showed a reasonable understanding of the project and participated in information gathering when needed. For example, the research about the LLM Module and the license of the LLM module.

This member often contributes ideas to group discussions. He also proposed some ideas about UI layout and design of PPT. However, he did not propose any meaningful revisions because he himself said he had no aesthetic sense.

This member follows the team plan, completes assigned tasks on time, and communicates with other team members.

He is responsive in group chats and meetings, sharing his thoughts when necessary and giving constructive feedback.

This member actively participates in the project implementation, including writing parts of the report, assisting with coding, and helping with presentation production, among other tasks.

The member demonstrates high motivation, attends every meeting, is punctual, and actively participates in discussions.

Figure 3.4: *Peer Assessment-Zelin XIA*