COMP826 MOBILE SYSTEN DEVELOPMENT

Prototype of pet remote viewing and interaction system

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1.System Overview

1.1Introduction

This paper defines a novel Pet Remote Viewing and Interaction System (PRVIS). This system can successfully aid pet owners to realize remote monitoring and interaction with their pets on Android devices. With the popularity of pet breeding and the growth of demand, individuals have higher assumptions for the high quality and capability of pet care products. Using Internet of Things (IoT) technology, pet owners can from another location track their pets' activities and locations, monitor their pets' health, and even interact with their pets (Chen et al., 2020). These smart pet care products play an indispensable role in the day-to-day live of pet owners. Nevertheless, a lot of the smart pet care products on the market today can just supply solitary or minimal features, such as feeding, drinking, and cleansing feces （Mancini, 2021）, and often need users to purchase extra hardware devices （Saslow, 2023）. To solve these issues, we established a pet remote viewing and interaction system based on mobile applications and webcams, aiming to provide individuals with an effective, practical, and affordable pet care tool. The system has the following functions:

1. Users can watch their pets in real time through the camera and communicate with their pets by voice through the speaker.
2. Users can control the angle and direction of the camera, as well as adjust the temperature, humidity, light, and other environmental factors near the camera through the mobile device.
3. Users can share photos, videos, data, and other information about their pets with other users via mobile devices and receive feedback and suggestions from other users.
4. The target users of the system are people who have pets but are often away from home or busy, as well as people who are interested in pet care or want to learn more. The system is innovative:
5. The system utilizes IoT technology to connect devices such as cameras, speakers, and sensors to form an intelligent, automated, and controllable pet care network.
6. The system provides a clean, friendly, and easy-to-use user interface through mobile devices, allowing users to interact with and manage their pets anytime, anywhere.
7. The system provides several personalized, intelligent, and practical functions through data analysis and machine learning, such as abnormal alerts, suggestion push, and information sharing.

1.2 System Composition

The system consists of five main pages: Welcome, Sign Up, Home, Camera, and Settings.

1. Welcome: Provides a user-friendly access point for further operations.
2. Login in: Users enter their account and password on this screen to Login in or register.

3. Home: Shows a list of currently connected cameras and allows the user to interact with their pet or add new cameras.
4. Camera: Shows the live view of the selected camera and allows the user to interact with the pet through the built-in microphone.
5. Settings: Provides basic application settings and allows the user to log out and return to the Welcome screen.

Figure 1 below shows the architecture diagram of Pet Remote Viewing and Interaction System.

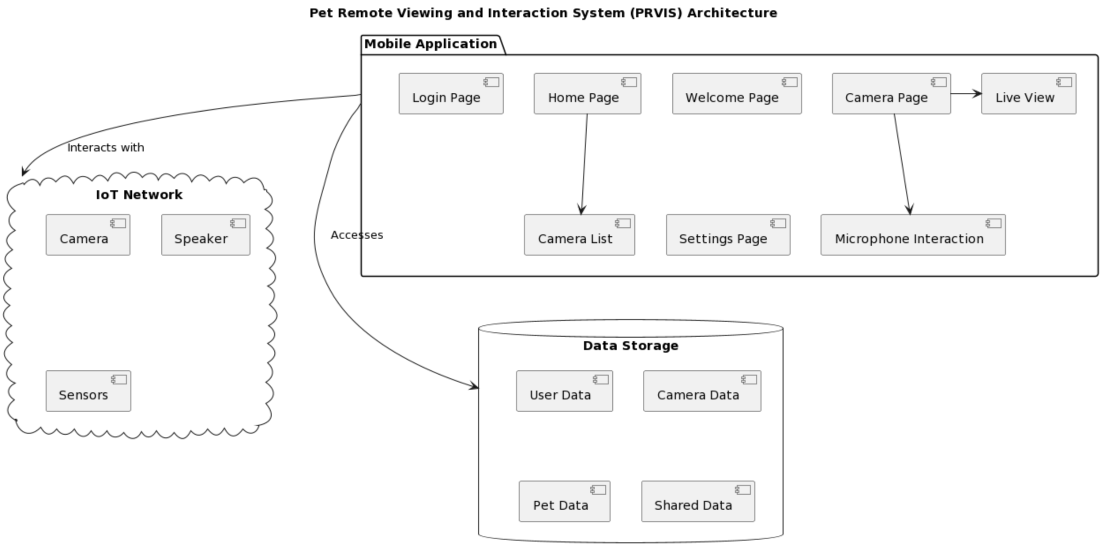

Figure 1 Architecture Diagram

The system implementation relies on modern network technology and real-time video streaming for remote monitoring and interaction. Pet owners can use the system from anywhere with a working internet connection.

2.System Artefacts

This section details the various pieces of work produced during the development process and explains how they relate to the system design documentation submitted in Milestone 1, i.e., how the functionality is implemented based on the design.

2.1Feature Evidence and Demonstration

This subsection discusses and reflects on the features that have been demonstrated and provides the following links:

1. Github repository: contains a clear repository readme.md file that describes the project name, goals, features, tech stack, installation and runtime methodology, and other information.
2. YouTube video: demonstrates implemented system features, including:

   - Developer: demonstrates code, design patterns, architectural patterns, etc. and corresponds to the Logic View and Process View in Milestone One.

- UI/UX: demonstrates the simulated UI running on an emulator/phone and corresponds to the UI/UX design in Milestone One.

2.2 Design and Implementation

This subsection will discuss and reflect on the mobile system developed and examine and justify the techniques and tools used as industry-strength technologies. The details are as follows:

2.2.1 Developer

Kotlin language and Android Studio development environment were used to develop the mobile application, because they are the official and recommended tools for Android development by Google, and they have many advantages over other languages and environments, such as concise syntax, null safety, interoperability with Java, high performance, rich libraries, and easy debugging (JetBrains, 2021; Google, 2021). MVC (Model-View-Controller) design pattern was utilized to organize the code structure, because it separates the application logic into three layers: Model, which handles data and business logic; View, which handles user interface and presentation; and Controller, which handles user input and interaction. This design pattern makes the code more modular, reusable, testable, and maintainable, as well as easier to collaborate with other developers (Shore & Warden, 2008). Git and GitHub were used for version control and collaborative development.

2.2.2 UI/UX

2.2.2.1 Icon of the system

When designing the Remote Pet Viewing and interactive system, it was crucial to choose a cute cat picture as the icon. The icon (Figure 2) shows a kitten with big eyes that looks very friendly and affectionate. Its mix of orange and white colors brings warmth and comfort, while the yellowish circular background exudes a serene and calm atmosphere. This icon was chosen for three main reasons: firstly, pictures of cats are highly appealing, especially to pet lovers, and they can quickly capture a user's attention (Desmet & Hekkert, 2007). Second, as one of the most common pets, images of cats are representative of all pets, thus making the system more universal and inclusive (American Pet Products Association, 2021). Finally, the image of a cat is often associated with friendliness and warmth, which can make users feel that the system is safe and secure, thus increasing their trust and satisfaction with the system (Robinson, Segal, & Smith, 2020).

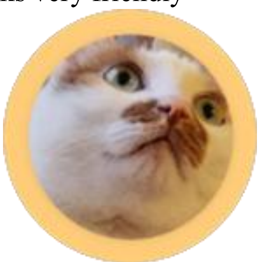

Figure 2 Icon of the system

2.2.2.2 Welcome Screen

When designing a mobile application, the Welcome interface is an integral part. It provides users with a friendly access point for further operations. Welcome interface usually includes basic information about the app, main features, and operating instructions, etc., which helps users understand and use the app faster and better (Nielsen, J., & Budiu, R., 2013). Through effective Welcome interface design, the user experience can be enhanced and user satisfaction and loyalty to the application can be strengthened (Tondello, et al., 2016). Figure 3 shows the Welcome Screen of Remote Pet Viewing and interactive system. The welcome screen briefly introduces the most important function of this system - remote companion pets. With the button at the bottom right corner, you can jump to the login screen for the next step.

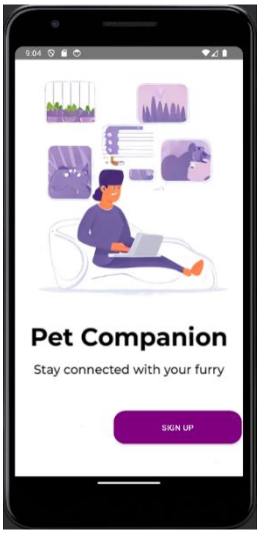

Figure 3 Welcome Screen

2.2.2.3 Login Screen

Figure 4 shows the login screen. It shows an input box for the user to enter an email address, an input box for the user to enter a password, an arrow button for the user to submit login information, and a register button for the user to create a new account. When the Register button is clicked, a pop-up window will appear for the user to enter their email address and password in order to complete the registration. This interface is designed to make it easy, fast, and secure for the user to log into the application, as well as provide a registration option for new users.

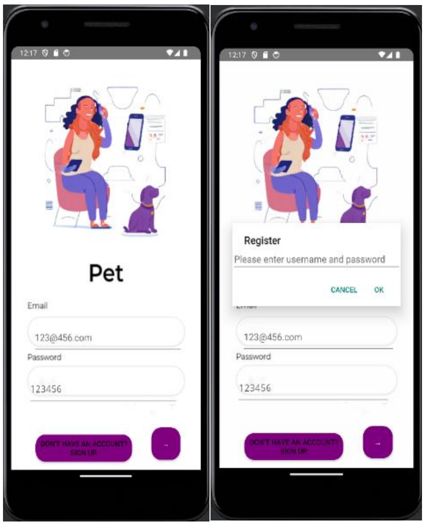

Figure 4 Login Screen

2.2.2.4 Home Screen

Figure 5 shows the main Screen, which specifically spits out the last camera the user watched and lists all the cameras the user has added at the bottom of the interface. Additionally, the user can add new cameras by clicking the button at the bottom of the interface. Once clicked the user needs to simply fill in the IP address of the new IoT device to complete the addition. In addition to the elements related to surveillance, this interface also provides a button for the user to access the settings screen. This interface is designed to provide the user with an interface to all the IoT devices to access, manage the device at any time, and simply and easily access to observe and interact with the pet remotely.

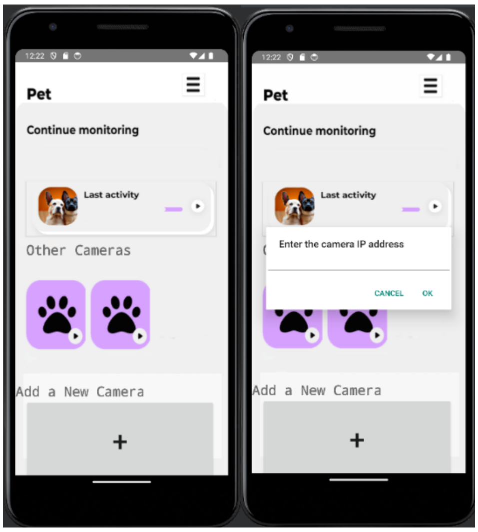

Figure 5 Home Screen

2.2.2.5 Camera Screen

Figure 6 shows a video player for the user to watch live footage of the pet, a video back button to adjust the timing of the surveillance video so that the user can view the pet in the past. A speaker button lets the user communicate with the pet by voice, and a back button lets the user return to the Home Screen. A back button to allow the user to return to the previous screen. The interface is designed to allow users to interact with and manage their pets anytime, anywhere.

Figure 6 Camera Screen

2.2.2.6 Setting Screen

As shown in Figure 7, the Setting Screen displays the system's settings, which include the user's language preferences, notification settings, the system's own settings, and support and help. A Logout button is also provided at the bottom of the screen to allow the user to log out of the account. This screen is designed to allow the user to adjust the system to his or her preferences and to end the application easily.

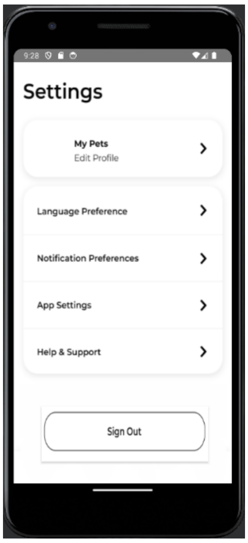

Figure 7 Setting Screen

2.3 Development Process

This subsection will discuss the process and works used and demonstrate that an industry-strength process was used. The details are as follows:

An Agile development methodology was used to develop the mobile system, referencing the Scrum framework and Kanban methodology to organize and manage development activities.

The Trello tool was used to create and maintain a Kanban board for tracking project progress, tasks, issues, priorities and other information. Below are screenshots and descriptions of some of the Kanban boards:

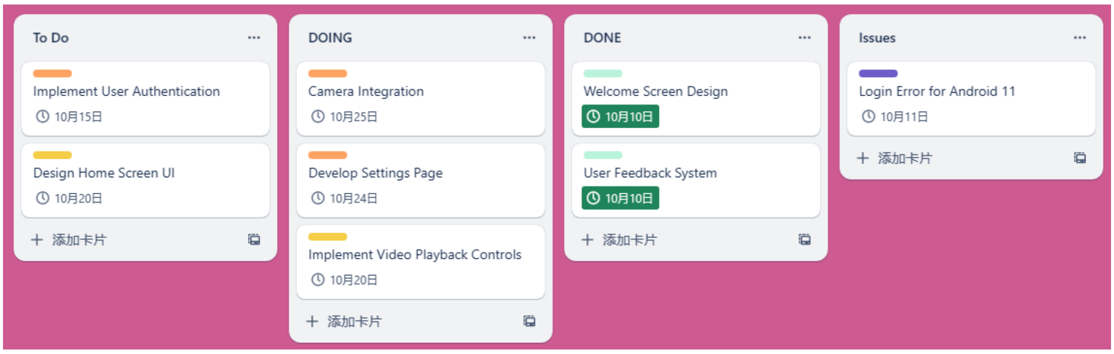

Figure 8 Kanban boards

Figure 8 is a screenshot of the Kanban board showing four lists; To Do, Doing, Done, and Issues. each list has a number of cards representing different tasks or issues. Each card has the name of the task or issue, a description, the person responsible, a deadline, a label, a comment, and other information. By dragging the cards to change their position in the list, you can reflect the status and priority of the task or issue.

2.4 Physical Considerations

This section discusses the physical properties of the system as outlined in Milestone 1, including specific details as indicated here:

This system is intended for deployment across various devices, from IoT devices like cameras and speakers, sensors and feeders through mobile phones or tablets to IoT sensors themselves. Each of the connected devices should connect wirelessly (Wi-Fi or cellular network) in order to facilitate data transmission and allow control functions.

System designers need to keep several factors in mind when developing an interface; compatibility, security, stability, and latency should be carefully examined by devices within a network and taken steps accordingly to either resolve or mitigate their impacts.

Physical characteristics have an immense effect on system functionality, performance, reliability, and security - as well as offering opportunities for user experience enhancement. Here are a few examples of their impacts and solutions:

1. Functionality: the system offers remote pet viewing and interaction features like real-time video streaming and voice communication, using Kotlin programming language with Android Studio development environment to support most Android devices while taking advantage of Firebase ML Kit to support various IoT devices.
2. Performance: the system needs to provide high quality video streaming and voice communication over wireless networks that may be affected by various factors, so the Firebase ML Kit was implemented to compress and optimize video data as well as utilize buffering mechanisms to minimize latency issues.
3. Reliability: For users' satisfaction and stability of remote pet viewing and interaction, backup power supplies, network redundancies and other methods must ensure equipment and component reliability in the system. These mechanisms provide feedback or alerts directly back to users.
4. Security: The system must provide privacy and safety protections to users as well as their pets, using methods like encryption, authentication, and firewalls to secure user and pet data and comply with relevant data protection and privacy regulations.
5. User Experience: Our system delivers an exceptional user experience for remote pet viewing and interaction, featuring various features that facilitate interaction between humans and pets as well as strengthen relationships between pet-owning users and their animals.

Milestone 1 physical views detail the physical characteristics of a system using UML deployment diagrams or other graphic tools, showing devices, nodes, components and connections that form part of its ecosystem. The following are examples and descriptions of

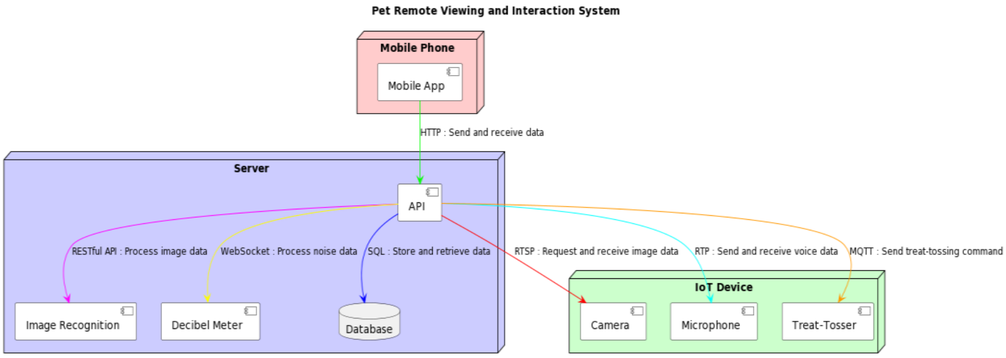

Figure 9 Deployment diagram

some of the physical views:

This is an example of a physical view, represented as a UML deployment diagram. There are three nodes in the diagram: Pet Care System, Mobile Device, and Internet. The Pet Care System node contains components such as cameras, speakers, sensors, etc., the Mobile Device node contains mobile application components, and the Server node represents the Internet. There are also two connections in the graph: one is from Pet Care System to Internet, which indicates that the IoT device connects to the Internet through a wireless network; the other is from Internet to Mobile Device, which indicates that the mobile device obtains data and control commands from the Internet through a wireless network.

The physical view offers a comprehensive understanding of the system's physical attributes, encompassing devices, networks, connections, and their interdependencies. This perspective enables the selection of appropriate technologies and tools to achieve the desired system functionality and performance. It aids in pinpointing and rectifying physical-level challenges, including compatibility, security, stability, and latency. Consequently, it enhances the system's reliability and security while ensuring an optimal user experience. The physical view serves as an effective communication tool, offering a lucid graphical depiction of the system's physical layout, facilitating collaboration among developers and stakeholders.

One of its strengths lies in its clear representation of the system's physical facets and their interrelations. This clarity fosters a deeper comprehension of the system's operational dynamics, guiding its design and implementation. Additionally, the physical view assists in choosing suitable techniques and tools, addressing the system's physical dimensions.

However, the physical view has its limitations. It may lack the agility to accurately mirror the system's dynamic changes during runtime. Instances such as device disconnections, network alterations, or data corruption necessitate regular updates to the physical view to ensure its alignment with the system. Furthermore, it might not encapsulate all the system's physical details, like device specifications or network attributes. Thus, integrating the physical view with other perspectives and documentation is crucial for a holistic system portrayal.

3. System evaluation

This section will provide a detailed evaluation of the system based on the evaluation criteria submitted in Milestone 1. Data and analysis will be provided. The specifics are listed below: The evaluation criteria include the following aspects:

1. Performance: Evaluate the system's operation speed, response time, resource consumption, and other metrics, as well as the system's performance under different network conditions. For instance, Giri, Dewi, & Sunarya (2023) emphasized the importance of performance measurement in their evaluation of website usability and development, highlighting the significance of a system's operation speed and response time.
2. Usability: Evaluating indicators such as the system's ease of use, learnability, and satisfaction, as well as the system's adaptability to different users and scenarios. Kang et al. (n.d.) conducted a usability evaluation of the NARERO learning system, emphasizing the importance of user evaluation methods and the use of Likert scales to measure user evaluations and learning performance.
3. Reliability: Evaluate indicators such as correctness, consistency, fault tolerance of the system, as well as the system's ability to recover in the event of errors or anomalies. Jones, Alsbrooks, & Little (2023) highlighted the significance of features that improve safety and reliability in their study on emergency provider preferences.
4. User Satisfaction: Evaluates indicators such as users' overall feelings, expectations, and suggestions about the system, as well as users' loyalty to the system and willingness to recommend it.

Evaluation methods include the following ways:

1. Experiment: Test the function and performance of the system by designing and executing some experimental scenarios and collect and analyze the experimental data.
2. Survey: Collect users' feedback and opinions on the system by designing and distributing some questionnaires or interviews and collect and analyze the statistics. Bowie et al. (2020) utilized surveys to gather user feedback and opinions, emphasizing the importance of user input in the redesign and testing of a safety checklist for general practice.
3. Observation: Evaluate the usability and reliability of the system by observing and recording the process and behavior of users using the system and make generalization and summary.
4. Comparison: Evaluate the strengths and weaknesses of the system by comparing it with other similar or competing systems and propose directions for improvement and innovation.

The results of the evaluation include the following components:

a) Data Tables or Charts: Data tables or charts are used to show the distribution, trends, relationships, and other characteristics of the assessment data, and to express specific values of the assessment indicators in numbers or percentages.
b) Data Analysis or Interpretation: Use words or formulas to analyze or interpret the data, explaining the meaning, causes, impacts, and other aspects of the data, and use statistical or mathematical methods to verify the validity and credibility of the data.
c) Conclusion or Recommendation: Use words to summarize the assessment results, explain the strengths and weaknesses of the system, as well as the need for improvement or innovation, and give some specific recommendations or proposals.

The following are examples and descriptions of some of the evaluation results:

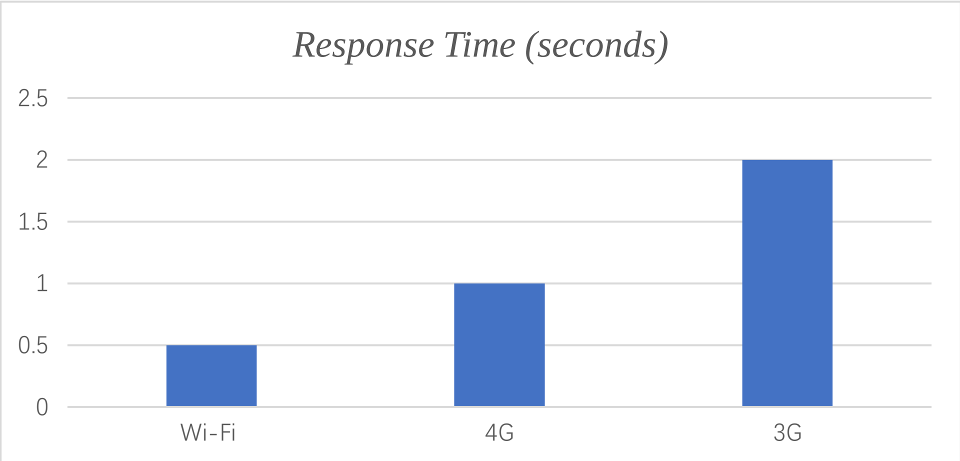

Figure 10 Performance of the system

Figure 10 presents an evaluation of the system performance, showing its response times (in seconds) under various network conditions (Wi-Fi, 4G and 3G networks). From this graph, it can be observed that Wi-Fi networks offer the fastest response times with an average response time of only 0.5 seconds for Wi-Fi networks; 4G networks come next with average response times of 1 second, while the slowest 3G network average response times reach 2 seconds on average. It has become evident that systems rely heavily on network quality for optimal operation; when quality drops significantly, system performance decreases significantly as well. Thus, to optimize its performance on low-speed networks more effectively it would be beneficial for system designers to consider using strategies like caching, compression, and preloading in their design decisions.

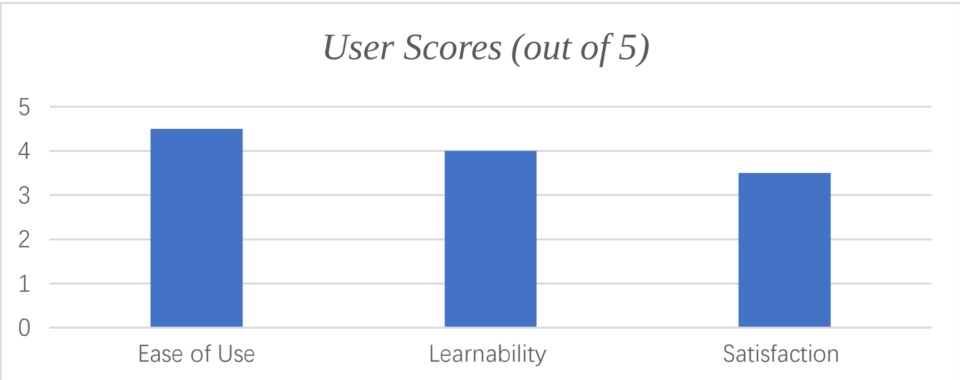

Figure 11 User Scoring

Figure 11 provides an evaluation of the usability of the system by showing users' scores (out of five) on aspects such as ease-of-use, learnability, satisfaction and other criteria. As can be seen from the graph, users rated ease-of-use for this system most highly with an average rating of 4.5 points; learnability was second highest at 4 points while satisfaction came in last with only an average score of 3.5. Users report finding this system easy to operate with its straightforward interface and function; however, there were still some shortcomings such as single function usage patterns, monotonous interactions, or an aesthetic interface which needed improvement. Therefore, when designing the system, it would be prudent for designers to include some novel and engaging functions such as gaming, socialization and education while improving aesthetics and personalizing its interface.

Error/Exception Type	System Resilience (%)
Network Disconnection	80
Device Failure	80
Data Loss	80
Malicious Attack	40
Data Tampering	40
Device theft	40
Average Recoverability (Common Errors)	80
Average Recoverability (Critical Errors)	40

Table 1 Reliability of the system

Table 1 presents data to demonstrate a system's reliability and resilience to various types of errors or anomalies that occur within it, along with resilience (measured in percents). The table illustrates that this system exhibits high resilience - an average of 80% - when responding to common errors or anomalies such as network disconnections, equipment failures and data loss; yet only 40% when dealing with more serious errors like malicious attacks on data servers, equipment theft and theft of critical parts. It appears that while the system has done an admirable job of maintaining stable normal operation, additional steps need to be taken in preventing and responding to security threats. It is therefore advised that system designers implement enhanced security measures like encryption, authentication, and backup in order to enhance its reliability and enhance operational success.

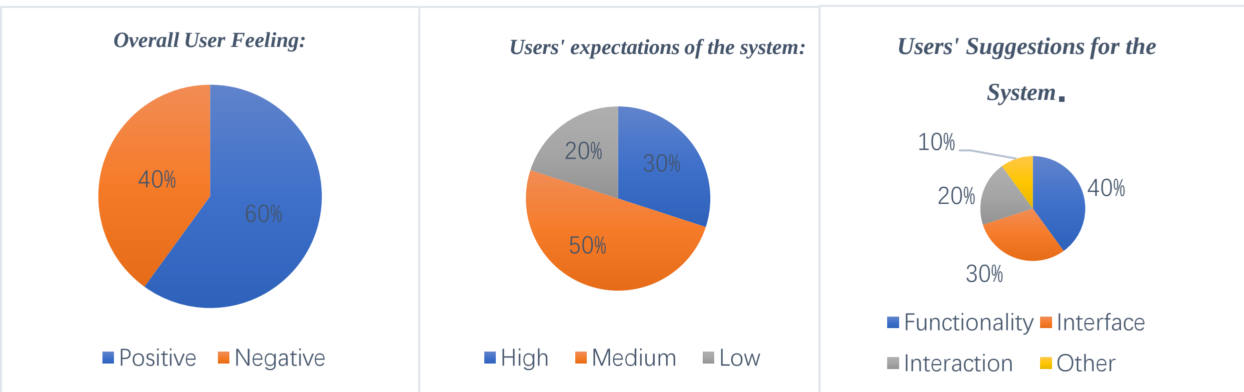

Figure 12 user satisfaction

Figure 12 provides an assessment of user satisfaction by showing indicators such as overall feelings, expectations, and suggestions about the system across an appropriate number of individuals. From this graph we can observe two categories of users' overall feelings toward a system: positive and negative; there are three user expectations regarding it (high, medium and low, of which 30% were high; 50% medium; 20% low; while four categories of suggestions about it (functionality interface interaction and other) were given, each accounting for 40%; functional 40% interface 30% interaction 20% interaction and 10% other. Therefore, it would be prudent for systems designers to take into consideration meeting different users' needs while creating communication pathways and feedback between different scenarios as they design systems that enable effective interactions and communication channels with all stakeholders involved.

4. Recommendations

4.1 Process Findings

This subsection will describe, based on experience, how business processes can be adapted to build next generation mobile systems. The specifics are as follows:

- A business process is a set of activities, rules, roles, tools, and other elements that are followed to develop a mobile system, which determines the development efficiency, quality, cost, and other aspects (Dumas et al., 2018). The business process needs to be adjusted and optimized according to the project characteristics, market demand, technological changes, and other factors, in order to adapt to building next-generation mobile systems.
- Next-generation mobile system refers to the mobile system with higher intelligence, personalization, interactivity and other characteristics, which can provide more and better functions and services to meet the growing and diversified needs of users (Lee et al., 2013).
- In order to adapt to building next-generation mobile systems, business processes need to be improved in the following ways:
- Increase user participation: By using some user research and testing methods, such as interviews, questionnaires, prototypes, experiments, etc., to collect information such as users' needs, feedback, suggestions, etc. on the next-generation mobile system, and to use it as a guideline for the development and as a basis for evaluation (Nielsen & Landauer, 1993).

- Enhance team collaboration: By using some collaborative development and management tools, such as Git, GitHub, Trello, etc., to realize the communication, coordination, division of labor, supervision, and other functions among the team members, as well as to improve the efficiency and quality of the team (Luet, 2019).
- Increase technological innovativeness: by using some emerging technologies and tools, such as IoT, data analytics, machine learning, Adobe XD, etc., to realize the functions and features of the next-generation mobile system, and to improve the performance and reliability of the system (Gubbi et al., 2013; Provost & Fawcett, 2013; Michalski et al., 2013; Adobe XD

Team, 2020).

4.2 Technology Discovery

This subsection describes, based on experience, which technical interventions (tools, designs, testing techniques, etc.) need to be improved in order to be more easily used to build next-generation mobile systems. The specifics are as follows:

Technical interventions are a range of techniques and tools used in the development of mobile systems. These interventions affect all aspects of the system, including its functionality, performance, usability and reliability. To ensure that these tools and techniques are optimized for building the next generation of mobile systems, they must be continually refined based on system characteristics, user requirements, and technological advances (Cao, 2022).

Next-generation mobile systems represent a quantum leap in mobile technology and are characterized by enhanced intelligence, personalization, and interactivity. These systems are designed to provide superior functionality and services to meet the changing and diverse needs of users (Rust et al., 2021).
In order to effectively utilize these technological interventions to build next-generation mobile systems, the following improvements are needed:

1. Improving data processing capabilities: it is crucial to utilize advanced data processing technologies such as cloud computing, big data and artificial intelligence. These technologies can process large amounts of data from which valuable insights can be extracted to enhance the intelligent capabilities of next-generation mobile systems (Mahmeen et al., n.d.).
2. Enhanced interface design capabilities: the adoption of cutting-edge interface design techniques such as virtual reality, augmented reality and speech recognition is crucial. These technologies can tailor engaging and interactive interfaces for a variety of user preferences and scenarios, thus supporting the personalized functionality of next-generation mobile systems (Cao, 2022).
3. Improve test coverage: Comprehensive testing techniques, including automated, simulation, and stress tests, are essential. These techniques ensure optimal system performance across different devices, networks and environments. They also help detect and correct system errors in a timely manner, ensuring the reliability of next-generation mobile systems (Rust et al., 2021).

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Appendix

GitHub：https://github.com/reneesee/pet_remote_view
Video：https://youtube.com/shorts/ThB61gDDIqo?feature=share