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Intelligent Shelter System Designed to Prevent Crime and Recidivism among Rural Women

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Currently, most crime prevention efforts focus on social services, such as behaviour correction and resocialisation, with limited emphasis on the role of social support systems for rural women. Although the proportion of crimes committed by women is not significantly high, such crimes inflict deep harm on families and society. This paper aims to design and study an intelligent shelter system for rural women to address their support needs in the face of family and social problems and to indirectly prevent the occurrence of crime. Based on case studies of rural women offenders and an analysis of existing shelters, this research employs stakeholder mapping, user journey mapping and service blueprints to examine interaction dynamics. In addition, the addition of speech emotion recognition technology facilitates long-term support and crime prevention strategies. This approach enables the organic integration of resources and network connectivity for the prevention of crime by rural women and provides immediate guidance to them.

#rural women

#crime prevention

#social support

#speech emotion recognition

Introduction

With the rising level of criminal activity, crime has become one of the major problems in modern society (Pletikosa Cvijikj et al. 2015). Among all forms of crime, rural crime remains a key issue. As a large agricultural country, China is used in this article mainly as a case study. Although China's crime governance has been improving and stabilising in recent years, there are still limitations in the construction of crime prevention frameworks and social support systems in rural areas.

According to the seventh national census, China has a rural population that accounts for 36.11% of its overall population, with the scale of the floating population further expanding (Office of the Leading Group for the Seventh National Population Census of The State Council 2021). Empirical studies based on the Ministry of Public Security's annual criminal investigation statistics and village-level panel data indicate that since 2000, the crime rate in rural areas has shown an upward trend, and the outflow of labour has significantly increased both the victimization risks and the incidence of crime among the left-behind population (Zhang et al. 2018; Zhang and Kun 2016; Zhang et al. 2011). When confronted with discrimination and gender inequality, gender-related discourse is often minimised (Qin et al. 2024). For a long time, criminal research has often taken men as the default object, and the theoretical construction of and empirical research on crime in related disciplines have focused on male crime, with female crime entering people's fields of vision only incidentally and supplementally and not receiving as much attention as male crime (Coleman et al. 2017). Criminologists have also agreed that the probability of female crime is lower than that of male crime (Steffensmeier and Allan 1996). In fact, women who commit crimes – especially violent crimes – have different characteristics from men (Henderson Hurley 2019). This is because female crimes mostly occur between acquaintances and within intimate relationships, thereby undermining the harmony and social stability of the primary group. In addition, because women play a special role in social life, they will also directly affect the healthy growth of the next generation (Xiang 2019). In the case of rural areas, or taking into account the dimension of interpersonal ecology, although the number of female crimes is not significantly proportional to all crimes, female crimes are more harmful than those committed by men (Liu 2022). The post-incarceration experience is also influenced by gender and rural areas. Rural women face greater disparities in terms of mental distress, substance use and crime than rural men and urban dwellers. They have less formal education, have fewer employment options and are poorer (Callan and Dolan 2013; Coward et al. 2006; Hauenstein and Peddada 2007).

In surveys of rural women, it has been found that most of the participants face systemic daily challenges (Sultana et al. 2018). Factors such as traditional perceptions and social stigma have a direct or indirect impact on rural women's tendency to commit crimes (Steffensmeier et al. 1989). Of the many disputes in rural areas, it is these that affect rural women almost throughout their lives. The social mechanism of gender inequality in traditional societies makes rural women be regarded as those who are willing to make sacrifices for their livelihood, which solidifies and amplifies the anxieties and disputes that occur in life. Village committees tend to avoid families as private spheres, and the judiciary is more likely to prevaricate by saying that 'it is difficult for clean officials to decide family affairs' (Liu 2007; Liu 2022).

This study aims to address these gaps by examining the criminal process and social status of rural female offenders through interviews and by designing an intelligent system for rural women's crime prevention shelters. Using tools such as interest maps, user journey maps and service blueprints, we comprehensively analyse and optimise the design and operation of the system. Additionally, by integrating speech emotion recog-

nition technology, we aim to provide more accurate emotional support to help rural women better cope with and solve problems.

Currently, most social support systems of justice for rural women are limited to services such as behaviour correction and resocialisation, with a limited emphasis on crime prevention. The existing shelter system, although helpful, has many shortcomings in terms of information transmission, practical assistance and emotional support. At the same time, female prisoners are more likely than male prisoners to experience physical and sexual abuse, severe mental illness, substance use problems and suicide (Willging et al. 2015) and to become the primary caregivers of children. However, the mental health and trauma currently faced by female prisoners in the prison system remains an unresolved issue (Chen 2024). Prevention of crime and recidivism requires adequate attention and support for female prisoners to ensure their smooth reintegration into society. In fact, existing systems can struggle to integrate various data sources, such as interviews, medical records and socioeconomic information, to provide comprehensive support plans for everyone. At the same time, the use of technologies such as speech emotion recognition and data collection raises serious privacy and security concerns. Protecting sensitive personal information is crucial, especially when dealing with vulnerable populations, and the lack of strong protocols to ensure user data protection can greatly hinder the development of shelter systems.

The most important innovation of this study is the establishment of a new model of shelter operation that coordinates and integrates the government, relevant units and non-governmental organisations to meet the needs of rural women in need of assistance, with the aim of preventing crime and recidivism. This study analyses the operation model of existing shelters rather than other prevention measures and innovatively integrates speech emotion recognition technology with machine learning to address the issue of follow-up support for rural women after they leave shelters. This study not only improves the efficiency and user experience of the shelter system but also offers new ideas and methods for enhancing the intelligence of social support systems. A comprehensive understanding of rural women's crime is essential to shaping effective strategies for rural revitalisation in China that have the potential to promote the process of poverty alleviation in relatively backward rural areas.

Related Work

Crime Prevention

There is a substantial amount of research aimed at designing systems for crime prediction from a user-centric perspective. CityWatch (Kadar and Pletikosa Cvijikj 2014) is a mobile application that supports crime prevention at the community level, helping users by analysing past events to learn common crime patterns and providing risk profiles and crime prevention tips. By focusing on the intent and motivation of content creation and consumption, Pletikosa Cvijikj et al. (2015) implemented a crime prevention mobile application that allows users to access and share crime-related information. Offering a general review of the existence of crime in today's society and its impact on citizens' daily lives, Pérez Vizcarra et al. (2019) proposed a mobile application based on social collaboration and cooperative learning that alerts users to their locations and surrounding risks. While these applications enhance user accessibility, they share common limitations in that they primarily provide regional crime prediction functions and lack practical crime prevention solutions.

Research on community crime prevention is also extensive. Bosse and Gerritsen (2010) used simulation technology to analyse the spatiotemporal dynamics of crime to predict and prevent crime.

Erete (2012) conducted online content analysis and field research on how low- and middle-socioeconomic communities use technology to solve crime problems and proposed the use of synergistic technology as a grassroots effort to reduce crime. Additionally, Erete et al. (2014) researched how communities in different situations can leverage information and communication technologies (ICTs) to assist grassroots communities in preventing crime. Using big data analysis, Li (2023) pre-processed text data and combined it with the Apriori algorithm to analyse the characteristics of cybercrime perpetrators and victims, further identifying key points for social security prevention and control and establishing a crime prevention mechanism. Geller et al. (2024) proposed the Crime Prevention and Response Program Evaluation System as a way to help cities make informed decisions on policy effectiveness and realignment for crime prevention and recovery. These efforts have provided many constructive suggestions for community crime prevention, and our project aims to further promote and implement these insights.

Intelligent System Designed for Women

Gender awareness remains a critical issue in today's society, and more intelligent systems designed specifically for women are needed to address core commitments, such as agency, fulfilment, identity, equality, empowerment and social justice (Bardzell 2010).

Bardzell (2010) integrated feminism more effectively into the study and practice of interaction design, exploring its productive role in related fields, such as industrial design, architecture and game design. GuardDV (Jordán Conde et al. 2008) is a system designed to address the safety of survivors of domestic violence who lack stable housing, thereby improving the quality of life for women experiencing homelessness. Abid et al. (2017) developed an interactive voice response application based on this system to provide the necessary information and advice to pregnant women in rural Pakistan. Parmar et al. (2009) presented a tangible user interface that successfully disseminates sensitive health information to rural women, granting them access to personal health information through ICT-based health systems. Shawket Rupok et al. (2018) established a model to assist various government organisations in helping unemployed rural women participate in fishing, enabling them to generate income from aquaculture.

Based on the rural situation in China, our intelligent system provides assistance to rural women who may be at risk of committing crimes. We collaborate with government and non-governmental organisations to help them solve problems and avoid criminal behaviour.

Speech Emotion Recognition

Speech emotion recognition enables intelligent and personalised human–computer interaction by analysing the emotional information in human speech. Methods for achieving emotional speech recognition include collecting voice data from real-world scenarios, evaluating and classifying emotions and using simulated scenes to induce corresponding emotions.

Considering the wide availability of unlabelled speech data, Deng et al. (2018) proposed a semi-supervised autoencoder to improve speech emotion recognition, which achieved high performance with a minimal amount of labelled data. Huang et al. (2014) employed a semi-convolutional neural network (CNN) to learn affective salient features for speech emotion recognition, which demonstrated stable and robust recognition performance in complex scenarios. To reduce the variability between the training and test conditions for

remote emotion recognition, Ahmed et al. (2017) used a novel combination of distorted feature elimination, classifier optimisation, several signal-cleaning techniques and trained classifiers with synthetic reverberation obtained from a room impulse response generator. This approach improved performance in various rooms with different source-to-microphone distances.

To better utilise speech emotion recognition, our system is set up for real-time, distant speech emotion recognition in indoor environments, allowing for more accurate detection of users' daily emotions.

Intelligent System Design for Shelters

Theoretical Foundations of Shelter Design

Based on Maslow's hierarchy of needs, the needs of rural women who require assistance can be summarised into three levels: practical needs, emotional needs and social communication needs. Therefore, ABC emotion theory, social support theory and empowerment theory were used to guide the design of the shelter functions.

According to ABC emotion theory, criminal behaviour is an irrational emotional reaction triggered by irrational beliefs. When rural women seek refuge in shelters, it is crucial to correct their irrational ideas promptly, implement targeted, reasonable corrections to their thinking and provide information to help them overcome their predicaments.

Shelters should actively seek assistance from the relatives and neighbours of rural women, build a comprehensive social network environment, integrate social resources and provide avenues for obtaining social support. This approach is based on the theory of social support.

Finally, a sense of empowerment should be incorporated into the shelter's work, enabling rural women to use the power of empowerment to resist external pressures and take control of their environments, building on this foundation to further their goals.

Stakeholder Map Analysis

Based on the interviews, we found that the current review process and cross-regional assistance of shelters are cumbersome and that it is difficult to achieve emergency avoidance for those seeking help. In addition, many shelters have low costs, single service functions and imperfect social linkages. In fact, help-seekers often have a variety of needs, but at present, a perfect linkage mechanism has not yet been formed, and public security, women's federations and the courts all deal with problems independently. Most shelters can only provide temporary accommodation and food security for applicants, and only a few shelters offer extended assistance services. As a result, we established a new model of shelter operation combining the government, NGOs and village councils to make the most of their respective strengths.

In Figure 1, a stakeholder map shows the relationships and interactions between various stakeholders in the system and provides basic data for system design by analysing the needs and resources provided by each stakeholder.

Rural women are the direct beneficiaries of the system. When they encounter problems, they can report the situation to a village council and obtain information about shelters to which they can go for help and support. Village councils act as a bridge between rural women and shelters, collecting and recording the needs and information of rural women and transmitting them to shelters. They also carry out publicity and popularisation work to help rural women understand and use shelters' resources. Shelters are at the heart of the system, receiving and integrating information

from all parties to help rural women solve their problems and recover their lives by providing practical assistance and emotional support. Governments and NGOs are responsible for the management and support of the system. The government provides shelters with hospitals, schools, supermarkets and other livelihood support facilities, as well as policy support, ensuring that the operation of shelters complies with relevant laws, regulations and policy requirements. NGOs assume responsibilities for shelters, providing professional staff and assistance while receiving reports from the shelters on case statuses and ensuring that the shelters can provide high-quality services and support as needed.

User Journey Map Analysis

Combined with the information in the stakeholder map, the user journey map (see Figure 2) shows the various stages that rural women go through in the process of seeking asylum and rehabilitating their lives. Each stage includes the rural women's behaviours, goals, touchpoints, ideas, emotions and pain points. Through this journey map, we can clearly see the journey of rural women as they seek help when facing family or social conflicts, as well as their emotional changes and pain points at various stages.

By analysing the needs and pain points of rural women, the design and implementation of the system are optimised, thereby providing a user perspective for the design of a service blueprint and ensuring that the system design can meet the actual needs of rural women.

Service Blueprint Design

Figure 3 depicts the service blueprint of the intelligent system, illustrating the entire service process for rural women within the shelter system. Integrating stakeholders from the stakeholder map and user behaviours from the user journey map, the blueprint is divided into three parts: frontstage, backstage and support process. The service blueprint shows the entire process, from rural women experiencing problems to returning to normal life, as well as the processes at each stage of the shelter's intelligent system and the specific operations and interactions of relevant departments and organisations.

System Function Modules

The intelligent shelter system consists of three functional modules: information registration and evaluation, service scheduling and support and sentiment monitoring and data management. Shelters, village councils, governments and NGOs can access the corresponding portals on the system's web pages (Figure 4) and provide comprehensive support to rural women to help them solve practical problems and emotional distress.

Information registration is the first step in the system. When rural women encounter problems, they report to a village committee, which registers their basic information and issues into the system (Figure 4a). The recorded information is then transmitted to a shelter, which performs an initial assessment and prepares for the rural woman's admission. This functional module ensures that rural women's problems are documented and addressed in a timely manner.

Based on the results of the situation assessment of the registration information, the shelter provides living facilities, emotional support and other necessary assistance and dispatches and arranges personnel in the system (Figure 4b). All registered information is kept in the system, and the daily situations of rural women in the shelter are also recorded (Figure 4c). After rural women leave the shelter, their emotional state will be monitored in real time through speech emotion recognition technology and updated in the database.

Application of Speech Emotion Recognition Technology

To better follow up on the situations of rural women after returning to their villages, the shelter's intelligent system introduces speech emotion recognition technology, which can monitor the mood changes of the recipients in real time by analysing their voice signals.

Principles of Speech Emotion Recognition

Datasets. We made use of two different datasets. The first, RAVDESS, includes approximately 1500 audio files from 24 actors, of whom 12 are male and 12 are female. These actors recorded short audio clips according to eight different emotions: neutral, calm, happy, sad, angry, fearful, disgust and surprised. The other dataset was CASIA's voice-emotion database. The CASIA Chinese emotion corpus includes recordings from four professional speakers exhibiting six emotions – angry, happy, fearful, sad, surprised and neutral – with a total of 9600 different utterances. Among these, 300 sentences are from the same text but read with different emotions, allowing for the comparison and analysis of acoustic and prosodic performances in different emotional states. The other 100 sentences are different texts designed to match their emotional attribution, enabling the recorder to express emotions more accurately.

Feature Extraction. The next step involved extracting features from the audio files to help the model learn from these files. For feature extraction, we used the LibROSA library in Python, which is widely used for audio analysis.

Model Testing. We evaluated the predictive evaluation of the trained model, obtaining a model accuracy of 0.704, and visualised the results to show the number of predictions for each emotion, reflecting the recognition effect of the model on various emotions. We also conducted a real-time speech test, with the emotion recognition results of the speech content displayed after each user entered their speech.

Wearable Device. To improve the usability and coverage of the system, we designed a wearable device that comprehensively monitors rural women's mood and health status by combining speech emotion recognition and physiological data monitoring with the data recorded in the system database.

System Optimisation and Future Prospects

In the future, we will continue to improve the intelligent shelter system to ensure its stability and effectiveness.

Speech Emotion Recognition Technology Optimisation

Since the technology involves a classification problem, a CNN seems the obvious choice. We also built multilayer perceptrons and long short-term memory models, but they underperformed, yielding very low accuracies that could not pass the test for predicting the correct emotions.

Building and tuning a model is a very time-consuming process. The idea is to start small without adding too many layers just for the sake of complexity. In the future, we will continue to adjust the optimisation model and experiment with different layer configurations to improve training and validation accuracy, ensuring the system's stability.

Evaluation of System Effectiveness

Users can also evaluate the emotion recognition function, assessing whether it accurately identifies and responds to emotional changes. Additionally,

they can evaluate wearable devices for comfort and effectiveness in monitoring health data. The system's effectiveness can be optimised by collecting feedback from rural women and relevant managers and by conducting both quantitative and qualitative analysis methods.

Conclusion

Rural women are an important and significant group in crime prevention and recidivism. The challenges and dilemmas they face are largely influenced by gender factors, making it necessary to adopt targeted prevention methods that address their unique needs. This study proposed a smart shelter system that combines intelligent technologies, such as speech emotion recognition and wearable devices, to provide women facing various social and family difficulties with necessary facilities for daily life; integrate medical, psychological and legal services; expand the service functions of shelters; improve social support networks; help rural women return to society smoothly after getting out of difficulties and avoid the problem of having to commit crimes or reoffend due to their inability to obtain various types of help; and promote the realisation of international crime prevention goals. However, current models still have limitations in accurately interpreting emotional situations. They may fail to understand the subtleties of rural women's expressions, especially when there are cultural differences in the way emotions are expressed or perceived. This study also needs to be more universal, so it should be compared in other cultural contexts. In the future, we plan to improve the system's stability and effectiveness and successfully implement it to assist more rural women in need.

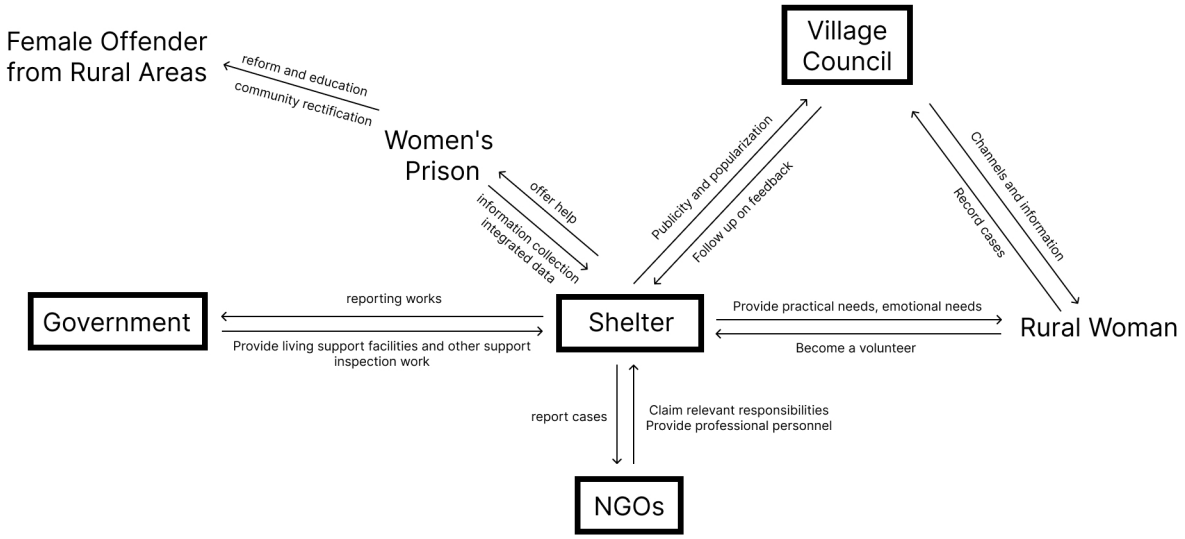
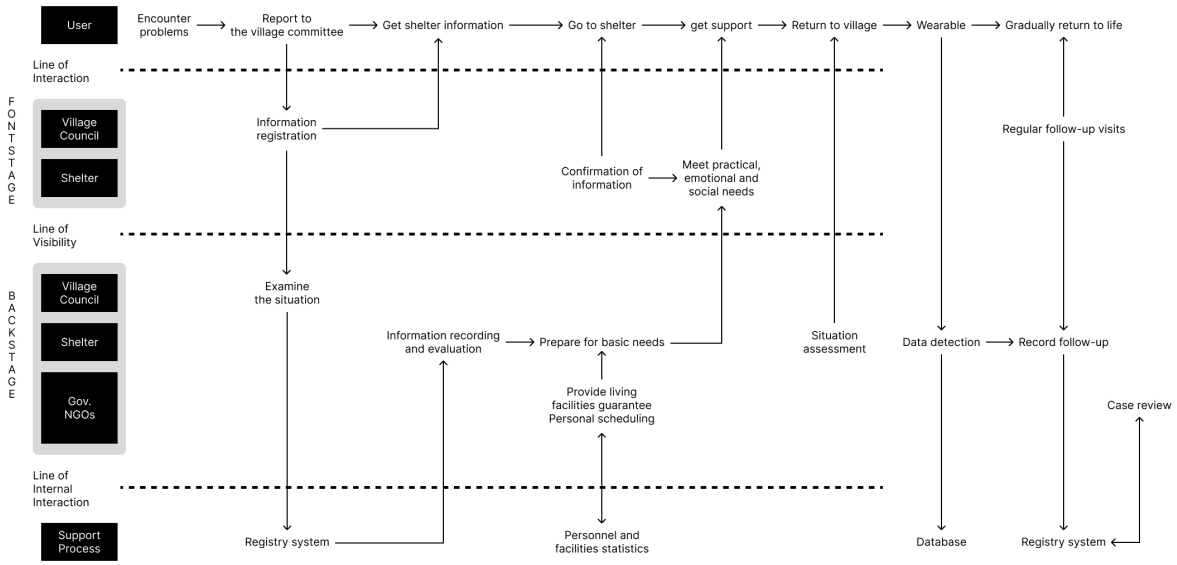
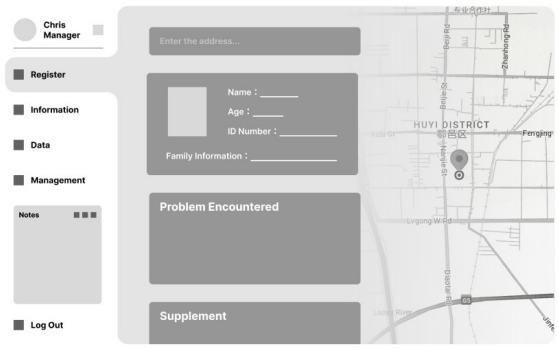


Figure 1 (top). Stakeholder map of the intelligent shelter system. *Source: Author.*

	Contradiction Appears		Go into Hiding		Turn Back
STAGE	Emerging questions	Accumulation of contradictions	Escape the place of residence	Find a place to live	Return to residence
BEHAVIOUR	Endure and move on	Get outside help	Go to shelter	Shelter	Leave the shelter
GOAL	Immediate emotional counseling	Offer practical help Solve the problem	Get shelter information Let the rescuers arrive safely	Meet practical and emotional needs	Let the rescuer start a new life Follow up the follow-up
TOUCH POINT	Family, relatives and villagers	Village committee and related departments personnel	Family, village council and shelter staff	Family members, shelter personnel and other shelter helpers	Family and villagers
IDEA	Things will get better, won't they? I have to put up with it.	What can I do? Do something about it?	Give up all, what will happen next?	It's a temporary reprieve. But if you go back, won't it be the same?	Going back to my old life. When does life take a turn?
EMOTIONS	Endure	Pain and helplessness	Confused	Loneliness and anxiety	Without prospect
PAINPOINT	Emotions can't be channeled Lack of financial resources Rural public opinion pressure	The avoidance of relevant departments	Shelter awareness is low Cumbersome check-in procedures	Lack of professional services such as psychological counseling and rights protection for rescuers and their families Inadequate facilities Professional shortage	No way to know what happened to the rescuer

Figure 2 (bottom). User journey map of the intelligent shelter system. *Source: Author.*





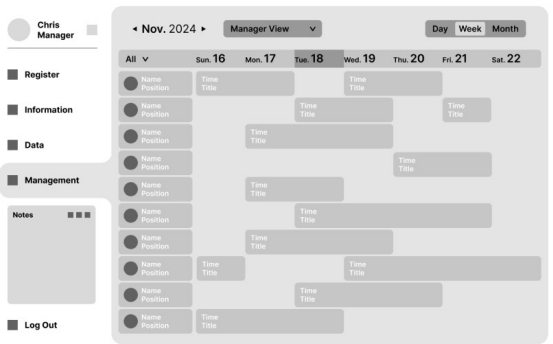


Figure 3 (top). Service blueprint of the intelligent shelter system. *Source: Author.*

Figure 4 (bottom). Part of the web operation interface of the intelligent shelter system. (a) Registration screen of the system. (b) Personnel management interface of the system. (c) The user's personal information interface. *Source: Author.*

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Bio

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