Construction and application of intelligent mental health management system for prisoners

Zhifei Xu[1,a*], Jiagang Dong[2,b], Yichao Zhang[3,c]

[1]Zhejiang Police Vocational Academy, Hangzhou, China
[2]Zhejiang Yuying College of Vocational Technology, Hangzhou, China
[3]Hangzhou Yu'an Technology Co., Ltd, Hangzhou, China

e-mail:[a*]xuzhifei01@163.com,[b]giracle@yeah.net
[c]331657566@qq.com

Abstract. As a special group, prisoners' mental health problems endanger the safety of supervision and social security. The traditional psychological assessment scale for prisoners has a large number of topics and a complicated assessment process, which makes it difficult to quickly obtain and quantify psychological risks, and also lacks follow-up health promotion intervention. It is a practical and efficient method to carry out early risk assessment and early warning management on the psychological symptoms of prisoners by means of information technology. The intelligent health management system constructed in this study conforms to the development direction of intelligent medical treatment, and can make the mental health management of prisoners more objective, scientific and accurate. The system mainly uses the prediction model of integrated learning algorithm to evaluate the mental state of prisoners, and constructs a relevant knowledge base for personalized health management guidance. The system evaluation results show that the accuracy of the risk assessment model has reached 0.974, and the personalized health promotion function is also feasible. Therefore, the intelligent health management system can effectively assist the existing psychological assessment and correction work, find out the potential psychological abnormalities of criminals in time, intervene and correct in advance, so as to maintain the normal supervision and reform work, and ensure the safety of supervision and social stability.

Keywords: Prisoners; mental health; Health management; Risk assessment; Personalized health promotion.

1 Introduction

Prisoners, as a special group, bear huge psychological pressure and ideological burden, and will have psychological problems and psychological barriers such as tension, anxiety, fear, irritability, etc. Therefore, the possibility of prisoners suffering from various psychological diseases is far higher than that of normal people. A survey con-

K. M. Salleh et al. (eds.), *Proceedings of the 2023 International Conference on Applied Psychology and Modern Education (ICAPME 2023)*, Advances in Social Science, Education and Humanities Research 803,
https://doi.org/10.2991/978-2-38476-158-6_34

ducted by Guangdong Prison Administration Bureau shows that about 42% of prisoners have obvious mental health problems, among which 16.1% have serious mental problems, mental disorders and mental disorders or mental diseases.[1] If these psychological problems cannot be alleviated and corrected in a timely manner, they will not only be harmful to the education and reform of these prisoners, but also lead to radical ideas or behaviors, which will affect their future reintegration into society [2]. At the same time, bad psychological symptoms will also affect the mood and behavior of other prisoners in the same prison area, which increases the possibility of accidents endangering the safety of supervision and seriously interferes with the normal supervision and reform work. Even, a small number of prisoners turned their dissatisfaction with the criminal sentence and the reform of their sentences into an open act of frenzied revenge against the country and the people. The Ministry of Justice of the People's Republic of China has made statistics on relevant data. China's recidivism rate is at the middle level in the world, but in major criminal cases, 70% of the criminals are liberators after serving their sentences. To sum up, the mental health of prisoners is an important factor that affects the security of supervision and social security.

Although most of the prisons in China have been equipped with special psychological counseling rooms and counselors, it is difficult to implement effective psychological intervention in this traditional way of psychological counseling. The main reasons are as follows: The first reason is the particularity of the status of the prisoners. Their average cultural level is low, which makes it difficult to accurately understand the meaning of the scale problems, and they also lack the patience to complete many scale problems. Second, there are many prisoners in the charge of the correctional police, who are busy with their work, and may ignore their potential psychological distress and crisis events. Third, although each prison unit is equipped with rich educational reform and learning resources, the utilization rate of resources is limited, and there are many difficulties in providing mental health services for prisoners.

SCL-90 is a psychological test that is widely used in the field of psychological assessment and education and correction of prisoners [3]. However, the large number of questions in SCL-90 further brings difficulties to the management of mental health (Taking the SCL-90 Symptom Checklist as an example, 9 types of psychological measurement indicators, such as depression and anxiety, correspond to 9 subscales, with a total of 90 questions) [4][5].

In recent years, with the development of big data and artificial intelligence technology, the Ministry of Justice of China proposed the policy of comprehensively promoting the construction of "intelligent prisons" in 2019 [6]. The use of information technology to assist the management of prisoners has become one of the current research hotspots. This research intends to build an intelligent mental health management system for prisoners. Specifically, it analyzes the risk of mental health status of prisoners through integrated learning algorithms, builds a knowledge base using literature review and expert consultation, and builds a reasoning engine to provide personalized health promotion suggestions [7].

The innovations and main contributions of this paper mainly include: First, the machine learning-based intelligent risk assessment simplifies the process and improves the work efficiency on the premise of ensuring the effectiveness of computing. Sec-

ondly, the promotion and recommendation of personalized health management based on knowledge base can provide a basis for achieving accurate correction of prison inmates. The psychological evaluation and management of prison inmates is moving from experience to science, from extensive to accurate, and constantly improving objectivity, accuracy and real-time, which is an inevitable trend of the development of mental health management of prisoners in the big data era.

2 Methods

2.1 Overall system framework

The service architecture of this health management decision-making system includes four layers, namely, access layer, interface layer, service layer and storage layer from top to bottom. The specific system microservice architecture is shown in Figure 1. Based on the microservice architecture, each service function has the characteristics of low coupling, easy expansion, high cooperation, high cohesion, strong autonomy, etc. The overall system has a clear division of labor, and each service constitutes an overall mental health management system for prisoners. The details are as follows:

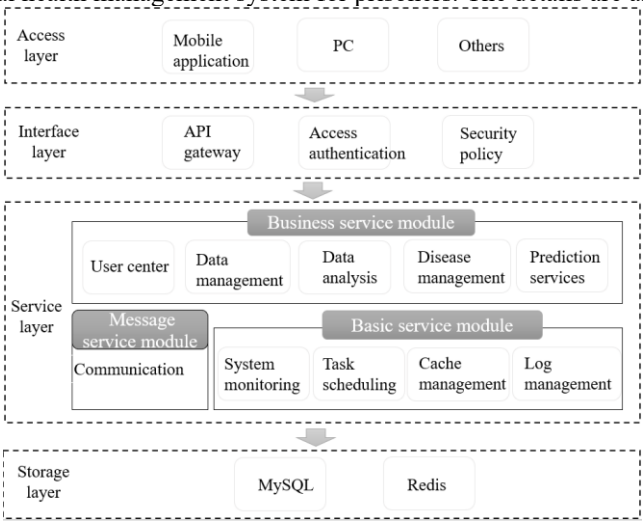

Fig. 1. System frame structure diagram

(1) The access layer includes mobile applications, PC terminals and other terminals.

(2) The interface layer is the bridge between the client and the microservice. It provides an API gateway to realize service discovery, registration, management, maintenance and load balancing. The implementation of access authentication and security policy is completed in the interface layer.

(3) The service layer includes the main service modules in the system, including business service module, message service module and basic service module. The mes-

sage queue implementation in the message service is applied to the communication between users. The basic service module includes system monitoring, task scheduling, cache management and log management modules. Business services include user center, data management, data analysis, disease management, prediction services and other modules.

(4) The storage layer uses MySQL database to store the data cluster in the system, and builds Redis cluster services to improve the query efficiency of pregnant women's prenatal examination information.

2.2 Key technology

2.2.1 Psychological Risk Assessment.

In order to avoid the error bias caused by a single model, this paper uses Voting decision level fusion algorithm and an integrated classifier based on voting idea to obtain the fusion results. Baseline classifiers for decision fusion include GBDT (Gradient Boosting Decision Tree) [8][9], RF (Random Forest Classifier) [10], and AdaBoost (AdaBoost Classifier), respectively [11-13].

GBDT is an integrated algorithm based on a decision tree, which works well in data analysis and prediction. The algorithm was proposed in 2001 as a Boosting algorithm with the CART (classification and regression tree) as the base learner. GBDT is characterized by high prediction accuracy, robustness, and flexibility. The core idea is to fit the residuals of the previous round of base learners by the negative gradient of the loss function and quantify the performance on the prediction classification problem.

The RF algorithm is an integrated algorithm based on decision trees and Bagging. The algorithm incorporates random attribute selection during each round of decision tree training. The RF algorithm is a commonly used predictive classification model because of its high accuracy, less susceptibility to overfitting, high noise immunity, and fast running speed.

AdaBoost is a weighted boosting integrated learning algorithm proposed by Yoav Freund and Robert Schapire in 1995. The algorithm has a low generalization error rate and high accuracy and can be applied to most classifiers for dichotomous or multiclassification application scenarios.

2.2.2 Personalized health management promotion.

The knowledge base is the core of implementing personalized health management scheme recommendations, and the construction of the knowledge base can only be completed through the cooperation of medical experts and knowledge engineers. This study designed a set of clinical knowledge conversion methods, which can convert the textual standard of psychological intervention into the knowledge that the computer can perform reasoning. Specifically, based on a literature survey and expert consultation, a logical rule base is established by rule mapping, which are knowledge bases that can be used by computer inference engines.

Then, according to the risk assessment results of the prediction model in Section 2.2.1, including 9 types of psychological indicators (somatization, obsessive-compulsive symptoms, interpersonal sensitivity, depression, anxiety, hostility, terror, paranoia, and psychoticism), the above knowledge base is used to automatically give targeted guidance and suggestions, and ultimately achieve the goal of promoting their mental health.

In addition, this study also designed a Web service-based intervention scheme recommendation service to ensure the concurrency of system operation while maintaining low interaction coupling.

2.3 Main functions of the system

The main function of this system is to use the online psychological scale to assess the psychological status of prisoners, and provide personalized health management services in the follow-up. The purpose of this research and development system is to solve the shortcomings of traditional psychological correction work and resolve the hidden dangers and crises of regulatory safety. In addition, the system also includes basic functions such as user registration and service log.

2.3.1 Intelligent Risk Assessment.

After the login operation of the system, the prisoners answer the questions in the psychological assessment scale one by one, and submit this operation after completing all the questions. At the same time, managers can check the risk value of the prisoners in the 9 categories of psychological indicators in the background.

A total of 23 questions were used to assess the mental state of prisoners, each of which has five options, including "not at all", "a little bit", "moderately", "quite a bit" and "extremely". Prisoners should fill in each question item by item until all questions are completed. They can be allowed to skip some questions that cannot be answered temporarily, but they need to fill in these questions again after completing other questions. After checking all the contents filled in, the prisoners click the Submit button to submit the contents to the system, and the embedded risk assessment algorithm module calculates their psychological risk.

The risk assessment report interface displays the psychological risk assessment results of prisoners calculated by the model. It includes one overall prediction risk indicator and nine individual psychological risk indicators. The overall predicted risk expresses the comprehensive mental health status of the prisoners, and the single psychological risk indicator specifically shows the distribution of the prisoners' psychological risk in different psychological dimensions.

2.3.2 Suggestions on health management.

According to the results of intelligent risk assessment, combined with the establishment of a knowledge base, we will push targeted health management recommendations to prisoners.

The system will provide regular health education services for prisoners with normal overall predicted risk indicators, while for prisoners with abnormal risk indicators, the system will provide targeted health promotion suggestions based on specific risk factor distribution.

3 Evaluation

3.1 Evaluation of risk assessment model

In this study, the modeling parameters are determined by the Gridsearch method, and the optimal settings of some key parameters are shown in Table I. The voting method of Voting is "soft," i.e., the average probability that all the baseline model prediction samples are positive classes is used as the criterion, and the highest probability The corresponding type with the highest probability is the final prediction result.

The algorithm environment of the evaluation model is based on Windows 10 platform. The programming language is Python 3.7. The machine learning library is Scikit-learn, data analysis and processing with Pandas and Numpy. The hardware configuration CPU is Intel(R) Core (TM) i5-10210U CPU @ 1.60GHz 2.11 GHz, and RAM is 16.0GB.

To evaluate the performance of each classifier on the dataset, we use accuracy, precision, recall and F1 Core as evaluation indicators. The calculation method is shown in Formula (1) - Formula (4).

$$\text{Accuracy} = \frac{TP + TN}{TP + TN + FP + FN} \tag{1}$$

$$\text{Precision} = \frac{TP}{TP + FP} \tag{2}$$

$$\text{Re}call = \frac{TP}{TP + FN} \tag{3}$$

$$F1 - Score = \frac{2 * precision * recall}{precision + recall} \tag{4}$$

Table 1. PARAMETER DISTRIBUTION OF THE MODEL

Model	Parameter	Value
GBDT	loss function	deviance
	learning rate	0.10
	n_estimators	200
	min_samples_leaf	10
	min_samples_split	3
	max_depth	7
RF	n_estimators	200
	max_depth	7
	max_features	10
	min_samples_leaf	5
AdaBoost	max_depth	3
	min_samples_split	10
	n_estimators	200
	learning_rate	0.10

An independent verification set of 5816 prisoners is used to evaluate the performance of the risk assessment model. The classification performance of Voting decision level voting fusion algorithm and three types of baseline models is shown in Table II. The accuracy of Voting decision level algorithm is 0.974 compared with other models. In addition, recall and F1 score are also the highest, reaching 0.90 and 0.92 respectively. In conclusion, the Voting method used in this paper has a relatively stable performance on this dataset.

Table 2. The Classification Performance Of The Voting Algorithm With The Three Types Of Baseline Models

Model	Acc	Precision	Recall	F1-score
GBDT	0.971	0.92	0.90	0.91
RF	0.971	0.95	0.87	0.90
AdaBoost	0.973	0.94	0.89	0.91
Voting	0.974	0.94	0.90	0.92

3.2 Evaluation of risk assessment model

In this study, a questionnaire was used to evaluate the functions of the health management recommendation scheme constructed in this paper. A total of 6 psychological experts participated in this work, including two from universities, two from relevant units of the public security, procuratorial and judicial organs, and two from medical institutions. The six experts were assessed by anonymous questionnaire, and the experts filled in the assessment form according to their subjective experience.

The evaluation dimensions include effectiveness, safety, economy and social adaptability. The score of each question in the evaluation table is divided into six options: 0 means "no comment", 1 means "very unimportant", 2 means "not very important", 3 means "generally important", 4 means "important" and 5 means "very important". Table III lists the evaluation results of experts on the system functions.

Table 3. HEALTH TECHNOLOGY ASSESSMENT OF THE SYSTEM

Evaluating Indicator	Avg	Std
effectiveness	4.17	0.69
safety	4.50	0.50
economy	4.17	0.69
social adaptability	4.67	0.47

We can see from Table III that the experts have a good overall evaluation of this function, and the system can, to a certain extent, achieve the prediction, early warning and prevention of the psychological abnormalities of prisoners.

4 Discussion

At present, most of the prisons in China have been equipped with special psychological counseling rooms and counselors. However, due to the large number of prisoners

in a prison and their special identity, it is difficult to implement effective psychological intervention through traditional psychological counseling. Therefore, the mental symptom health management system for prisoners based on artificial intelligence technology is in line with the development direction of psychological correction work and can make the psychological evaluation results of prisoners more objective, scientific and accurate.

This research is based on the idea of "preventing disease from changing" of the concept of "treating disease before disease", with the aid of intelligent tools to assist the existing psychological assessment and correction work, and develops a mental health risk assessment and early warning management system for prisoners based on big data and artificial intelligence technology. The system can quickly realize the psychological evaluation of prisoners and identify the types and severity of different psychological abnormalities. The system can then perform classified summary, scoring sorting and intelligent alert on the evaluation results. Our main purpose is to timely find out the psychological abnormalities of criminals and signs of violations of rules and regulations, provide basis for early intervention and correction, and finally achieve the effect of "solving problems in the bud".

In addition, this study has some limitations. First, the risk assessment model is carried out on the traditional scale data set, without using the fusion of voice, expression and other data information based on multiple sensors, and without considering the time series information. More importantly, the real effect of the model still needs large-scale, multi center verification. Second, the logical rule base for health promotion suggestions is still based on manual construction, so the reasoning process cannot meet the requirements of complex use scenarios.

Therefore, the later work mainly focuses on the following two aspects. First, collect more multi-dimensional feature information of individuals including voice, expression, physiology, etc., comprehensively analyze the psychological symptoms of individual prisoners from various aspects, and design more appropriate in-depth learning network model to improve the performance of risk assessment model; The second is to use natural language processing technology to construct the mental symptom health management knowledge map of prisoners and explore more appropriate health promotion programs.

5 Conclusion

The health management system studied in this paper realizes the early prevention, control and scientific management of the mental health of prisoners, guarantees the safety of supervision and social stability, and protects the safety of people's lives and property.

Acknowledgment

This article is the research result of the 2019 General scientific research projects of Zhejiang Provincial Department of Education(Y201941100) and Basic Public Welfare Research Program (LGF21G010006).

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