Development of Intelligent Old-Age Medical and Health System Based on Data Fusion

Luo Guodong, He Jirong, Lin tianwen, and Yibai Wang*

Abstract—**Starting from the construction of an intelligent medical and health system for elderly care, it is proposed to use improved Particle Swarm Optimization Algorithm (PSOA) data fusion algorithm, network video surveillance technology, and hardware equipment such as Radio-Frequency Identification (RFID) smart bracelets and intelligent mobile robots to establish a distributed elderly care The intelligent service system collects vital signs, human movements, human posture characteristics, and position change information of the elderly, and uses improved PSOA data fusion algorithm, the data fusion processing of different types of human body information is completed, which not only greatly improves the utilization rate of medical resources for the elderly, but also ensures the data fusion accuracy of human health detection for the elderly. The improved PSOA neural network data fusion results can provide support for the intelligent care of the elderly care institutions.**

Index Terms—**Data fusion, smart pension, medical and health system, development**

I. Introduction

For the vital signs information, human body position and posture information of the elderly, data fusion technology and network video monitoring technology are introduced, combined with a variety of RFID smart bracelets and intelligent mobile robot hardware facilities to establish a smart elderly medical health system, Use the improved PSOA data fusion algorithm to perform fusion processing on the collected multiple elderly information, and output more accurate results of changes in vital signs or action attributes of the elderly, it can ensure the timeliness and perfect service of intelligent old-age care.

II. Key Technologies for the Construction of Smart Old-Age Medical and Health Systems

A. Intelligent Network Video Monitoring Technology

In the current urban intelligent old-age medical and health service system, the functional module for the collection of data and information of the old-age group is usually established by using camera monitoring module, network transmission protocol, back-end database and other components [1]. There are sensor devices such as network cameras and hard disk video recorders in the front end of video surveillance. The network transmission protocol ports include Transmission Control Protocol/Internet Protocol (TCP/IP) protocol, core switches, encoders and decoders, which can be used for external access authentication and data information transmission management control. The back-end data storage module, including the back-end server, database, memory and other devices, belongs to the network video monitoring information storage bottom layer, responsible for the elderly group data classification retrieval, resource storage, data service response and management.

In the face of the situation that the elderly may be unguarded in the elderly care institutions, a distributed network camera and a remote monitoring management platform are generally set up, and a plan of multiple cameras working at the same time and computer vision video automatic recognition is adopted to automatically find and lock the elderly The target of the population, according to the set improved PSOA data fusion algorithm, analyze and judge the abnormal condition of the target's action, and start the alarm in time once the abnormal condition is found, in order to facilitate the staff's video viewing and care for the elderly.

B. Intelligent Mobile Terminal Equipment Technology

Intelligent mobile terminal equipment for elderly care in elderly care institutions, including RFID smart bracelets (watches), smart mobile robots and other terminals, can be used for the collection of vital signs, human movements, human posture characteristics, and position change information of the elderly. First of all, the smart bracelet (watch) is beautiful in form, convenient and comfortable to carry, and has certain anti-fall and water resistance in the structural design [2]. RFID smart bracelet contains a variety of physiological sensors, such as human body sign sensor, General Packet Radio Service (GPRS) module/control module, Zigbee transmission module and other components. The sensor module can collect the body temperature, pulse wave, blood oxygen concentration and positioning information of the elderly population. The control module calculates the heart rate, blood pressure and other information of the elderly according to the measured pulse wave, and collects the vital signs of the above elderly population. The information is collected and transmitted to the background of the smart elderly medical and health system through the Zigbee module.

After that, the intelligent mobile robot is used as an auxiliary device for the elderly medical care. It is internally equipped with a software structure of a ZED binocular camera, a robot main body, a teaching programmer, and a data communication module. It is often connected with the smart bracelet and Android operating system through the communication mode of the smart gateway and Zigbee network communication protocol, which can realize cross-platform data resource sharing and transmission. After the robot is started, it can automatically locate the current

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position of the elderly care subject, and the robot itself has GPS positioning and automatic obstacle avoidance functions, which can avoid obstacles and move in the house space. If the elderly need help, they can choose to communicate with the elderly care service personnel online by pressing the SOS call button, and the call video image will be displayed on the screen installed by the robot. At the same time, the intelligent mobile robot can also automatically start the call button when the elderly population has an emergency, and the system platform will make a timely visit after receiving the SOS warning, so as to ensure the medical health and life safety of the elderly population to the greatest extent.

C. Database Management Technology

Using the medical and health service system of the smart elderly care platform, after collecting and integrating the vital signs, human movements, human posture characteristics, and position change information of the elderly population, the database must be designed according to the logical structure of the data table to complete different types of elderly care. Data information storage and sharing management of subjects [3]. The logical model design of the data table structure for the elderly population of the specific smart pension platform is as follows:

(1) Equipment information table (tb device). The device information table is used to record the device information of different sensors, including the device ID, device type, binding gateway number, device activation time and other information. If the device ID name is set to deviceID, the data type is int, and the field description is “device d, main key, not allowed to be empty”; The device type name is set to deviceType, the data type is tinyint, and the field description is “device type includes all kinds of sensors and smart watch devices”; The binding gateway number is set to gatewayID, the data type is int, and the field description is “binding gateway number, tb_ gateway foreign key binding gateway”; The device activation time is set to useTime and the data type is timestamp.

(2) Smart Watch Collection Data Sheet (tb sensorData). This data table is mainly used to store a variety of data information collected and transmitted from physiological sensors. The specific contents are shown in Table I below:

TABLE I: SMART WATCH COLLECTION DATA SHEET

Smart watch data column name	Data type	Field description
gatewaylD	int	Device number, tb_gateway foreign key, not allowed to be empty
HR	tinyint	Heart rate
temperature	float	Body temperature, length represents a 2-digit integer, 1 is a decimal
oxygen	int	blood oxygen
lowPressure	tinying	diastolic blood pressure
highPressure	tinying	systolic blood pressure
pulse	tinying	Pulse frequency
action	tinying	Behavior, including walking, sitting, getting up, etc.
dateTimc	timestamp	Time

III. MODEL OF DATA FUSION ALGORITHM DEVELOPED BY SMART OLD-AGE MEDICAL SYSTEM

A. Attribute Reduction Algorithm Based on Multi-fork Tree

Assuming that the data set composed of multiple pension individual data is IS ={U, C, V, f}, where U and C respectively represent the set of data set information and the attributes of the data set, remember | C | = h, | U | = n, then the height of the bifurcation tree established by the data set is h +1, and there are differences in the ranking of corresponding attribute sets in different data sets, therefore, there are also differences in the arrangement of multi-tree data obtained [4]. is generally added from top to bottom according to the values of the attributes in the dataset. If you delete a dataset attribute, the number of nodes in the multiple tree level decreases, which indicates that the attribute in the dataset is critical. Otherwise, the attribute is redundant. If a dataset is represented as IS = {a, B, c}/IS = {B, a, c}, then using the multi-fork tree attribute reduction algorithm, the dataset model is established as shown in Table II and Fig. 1 below [5]:

TABLE II: MULTI-FORK TREE ATTRIBUTE DATASET

U	a	B	c	U	a	B	c
x1	1	0	0	X5	1	2	1
x2	1	1	2	X6	0	1	2
X3	2	1	2	X7	1	1	0
x4	0	0	1				

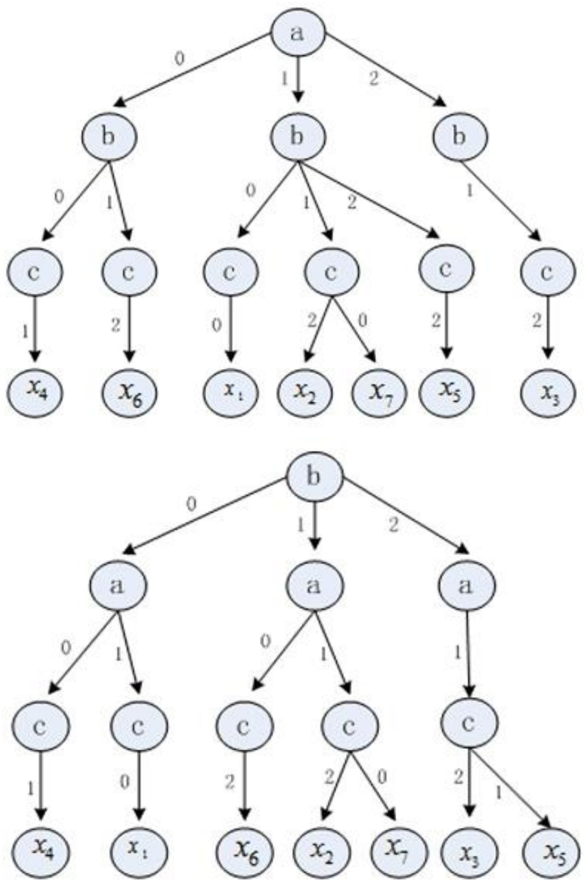

Fig. 1. Multi-fork tree attribute reduction algorithm model.

From Fig. 1 above, it can be concluded that in the case of different attribute sorting in a data set, the corresponding multi-fork tree node sorting is also different. If the number of nodes in layer k and layer h +1 is the same in the multi-fork tree structure established according to the above data set, it indicates that the corresponding data set attribute between the two layers is redundant data, and the data set classification ability of the knowledge base is not affected after deletion. According to this law, the approximate simplicity of the attribute elements in the data set is completed, and the final data intensive simplification model is obtained, which can be used for the data processing of the PSOA data fusion algorithm and provide the effective attribute information of the relevant pension group.

B. Model to Improve PSOA Data Fusion Algorithm

PSOA data fusion algorithm is also called the adaptive classification algorithm of PSOA neural network, which is similar to the genetic algorithm of bird aggregation and foraging. In a simulated spatial model, the optimal solution is found through the iterative method of particle search. The particle is equivalent to the tracking and updating process of birds and particle search equivalent to “maximum value” and “minimum value”. [6] If the extreme value is the optimal solution that a particle can find, it is recorded as an individual extreme value, and if it is the optimal solution that can be found by the population, it is recorded as a global extreme value.

Assuming that a D-dimensional space contains m particles, the position of any particle can be recorded as $\vec{x}_i = (x_{i1}, x_{i2}, \dots, x_{id})^T$, I = 1, 2,..., m, d = 1, 2,..., D; The velocity of any particle can be recorded as $\vec{v}_i = (v_{i1}, v_{i2}, \dots, v_{id})^T$. The optimal solution experienced by the I-th particle in D-dimensional space can be recorded as the individual extreme value$i = (p_{i1}, p_{i2}, \dots, p_{id})^T$, the optimal solution of the particle position found in the whole population can be recorded as the global extreme value $\vec{p}_g = (p_{g1}, p_{g2}, \dots, p_{gd})^T$, and the global extreme value is used to represent the best position found so far for all particles in the population [7].

In d-dimensional space, m particles calculate the optimal value of particle position through iterative search. In this cognitive process, each particle will record its current velocity, position and other information, and collect the velocity and position information of neighboring particles. When it finds that the velocity and position information of neighboring particles are better, it will discard its existing attribute information and make adaptive adjustments to meet the iterative requirements of particle position in the environment. Specifically, the particle velocity and position calculation formula for the *t-th* iteration in the *d* (d = 1, 2,..., D) dimensional space are shown in the following Eqs. (1) and (2):

$$v_{id}^{t+1} = wv_{id}^{t} + c_1 r_1() * \left(p_{id}^{t+1} - x_{id}^{t}\right) + c_2 r_2() * \left(p_{id}^{t+1} - x_{id}^{t}\right) \quad (1)$$

$$x_{id}^{k+1} = x_{id}^{k} + \Delta t v_{id}^{k+1} \quad (2)$$

where v_{id}^t represents the speed of the t-th iteration of the *I-th* particle in the d-dimensional space, and x_{id}^k represents the position of the *t-th* iteration of the *I-th* particle in the d-dimensional space; c1 and c2 represent the acceleration constant (value 2),r1() and r2() represent the random change constant (value between [0,1]); wv_{id}^t indicates the previous velocity of the particle, w indicates the inertia weight, and △ *t* indicates the time it takes to iterate the particle.

However, due to the genetic iterative algorithm of PSOA data fusion, it is easy to fall into the local optimal in the process of finding the particle position. Therefore, it is necessary to introduce the maximum velocity v_d^{max} of the particle and adjust the inertia weight w to the speed of multiple iterations of the particle in the d-dimensional space. Make adjustments, use the iteration speed of the previous generation to affect the current velocity of the particle, and ensure that the particle can expand the search area and search ability in the d-dimensional space, realize the adjustment of the speed of particle motion, thereby preventing the particle from falling into local convergence and local optimal solution prematurely, and promoting the balance of the particle's local and global search capabilities, which can be described:

When the v_d^{max} value increases, the inertia weight W can be reduced to control the balance of particle global search ability. At the same time, when reducing the inertia weight w causes the number of iterations to decrease, it is necessary to control v_d^{max} the constant value first, and then appropriately increase the value of the inertia weight w, that is, increase the speed of particle search in the early stage, so that it can obtain higher exploration ability to find a more position, and accelerate the convergence speed in the later stage to ensure the accuracy of the convergence result. The linearization formula for the inertial weight w is shown in Eq. (3), and *G* represents the number of iterations:

$$w = w_{\max} - \frac{w_{\max} - w_{\min}}{G_{\max}} * G \quad (3)$$

IV. The Composition Framework Structure of the Smart Old-Age Medical System

The intelligent elderly health care system consists of a perception layer, a network transport layer, a middle layer, and a user layer. Different levels are responsible for physical sign perception, network data transmission, data preprocessing and integration, and service response and management of the elderly [8]. The specific framework is shown in Fig. 2 below.

A. Perception Layer

There are RFID tags, RFID readers, sensors, remote control cameras and other hardware facilities in the sensing layer. Physiological sensors, network cameras, and ZED binocular cameras can be used to read the blood pressure, blood oxygen, pulse, body temperature, and heart rate of the elderly., Respiratory frequency and other information.

B. Network Transport Layer

The network transport layer uses CC2530Zigbee chips and 5G network, WIFI and ZIGBEE network protocols to initialize the system clock, Random-Access Memory (RAM) and I/O interfaces. Then, according to the physical condition information of the elderly group collected by the sensing layer sensor, Operating System Abstraction Layer (OSAL) task polling is made, packaged as data packets, and sent to the next level via ZIGBEE module.

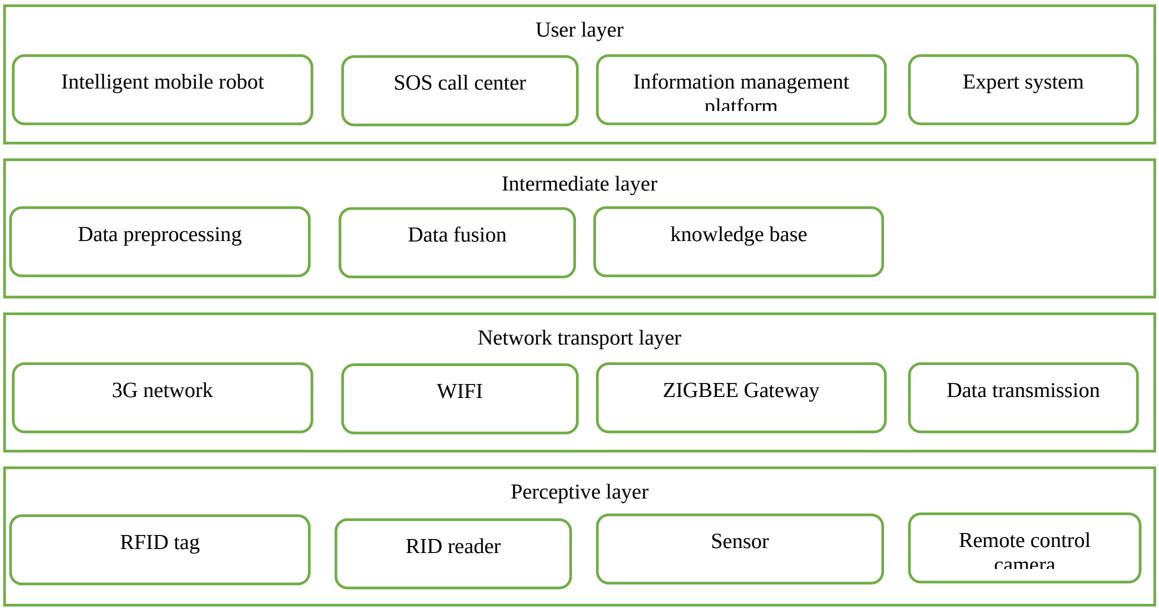

Fig. 2. The composition framework structure of the smart old-age medical system.

C. Middle Layer

The middle layer of intelligent elderly medical and health system covers the execution process of data preprocessing, data conversion, data fusion, extraction, etc. Among them, data preprocessing and conversion operations are a screening process with a clear purpose. After redundant denoising and missing preprocessing are carried out around the transmitted personal physical sign data of the elderly group, they are stored in the background knowledge base and database for use. Service response for intelligent old-age medical health.

D. User Layer

The user layer is the outermost layer used to respond to the needs of the elderly group, including intelligent mobile robots, SOS call centers, information management platforms, expert systems and other components. For RFID video linkage system, information management system and expert system developed, intelligent mobile robot, SOS call center, data fusion model and other functional service systems have been established to provide online video communication and SOS early warning response management services for the elderly in nursing homes.

V. Application of Data Fusion Algorithm in Smart Old-Age Medical System

A. Preprocessing of Vital Signs Information of Elderly Groups Based on Multi-fork Tree Algorithm

The information collection of the intelligent old-age medical and health system is usually performed by the physiological sensor of the RFID intelligent bracelet to collect the relevant vital signs of the elderly. According to the normal body temperature of the elderly body of 36.0–37.5 ℃, the normal heart rate of 60–80 beats/minute, the breathing rate of 16–20 beats/minute, the pulse frequency of 55–60 beats/minute, the pulse pressure difference is the absolute difference between systolic and diastolic blood pressure, ranging from 30–40mmHg, the vital signs information of the elderly body is preprocessed [9].

This paper selects human body temperature, heart rate, respiratory rate, pulse frequency and pulse pressure difference and other index information, assuming that in the system = {U, C, V, f}, set universe u = {x1, x2,..., x8}, C = {body temperature, respiratory rate, pulse frequency, heart rate and pulse pressure difference},| c | = h = 8, | n | = 5:

Assuming u = {body temperature, respiratory rate, pulse frequency, heart rate and pulse pressure difference} = {a, B, c, d, e}, the normal value range is $a \in$ (16~20), $b \in$ (55–60), $c \in$ (36.5–37.2), $d \in$ (60–80), $e \in$ (30–40), D = (good, general, danger) = (2, 1, 0). According to the sample data table given above, a multi-fork tree attribute reduction algorithm model is established, where the variable I = 1 and the attribute object j = 5. The number of nodes in the middle leaf sublayer of the multi-fork tree level is n = 8, and the fifth layer of the tree is also 8. Therefore, the redundant attribute E is deleted, including the column and layer corresponding to E in the information table[10], and {B, c, d} is the attribute reduction of the information system, that is, {pulse, body temperature, heart rate} is the attribute reduction of vital signs of the elderly human body.

B. Data Analysis of Elderly Groups Based on Improved PSOA Data Fusion Algorithm

In order to verify the effectiveness of the improved PSOA data fusion algorithm, 50 samples of the three attributes of the data set C = {pulse, body temperature, heart rate} are extracted respectively to form a training set with 150 data samples. In the learning process of the network, the actual output of the input network training sample is compared with the target output to determine whether the trained data set has achieved the desired accuracy. Using the improved PSOA data fusion algorithm, the sample training of the vital signs of the elderly population C = {pulse, body temperature, heart rate} in the intelligent old-age medical health system can be obtained, and the network training curve, network output and target value comparison results can be obtained. From the comparison results, it can be seen that in the initial stage, the adaptability of the network training samples is low, there is a large fluctuation, after 50 iterative training adjustments become stable, and 150 test samples after stable iterative training, there are only 5 to 10 classification errors, the classification error rate is 4%. In order to observe the convergence speed of the PSOA algorithm, this paper selects the first pulse sample as the observation target. It can be found that after the training of the PSOA data fusion algorithm, the dashed line of the network function represents the actual output value, the solid line represents the target value, and the error between the PSOA target value and the actual output value is controlled within an acceptable range, with only 0.2~0.4 error in vertical coordinates, meet the convergence speed requirements of intelligent old-age medical and health system.

V. CONCLUSION

With the rapid increase in the number of elderly people in my country in recent years, the issue of elderly care has become an important issue of concern to local governments and elderly care institutions. Under the development environment of the transition from family support to elderly care institutions, the medical care of elderly people of different ages For health care needs, a basic digital elderly care service system has been developed, using the data and information collected by sensors in the smart elderly care system, without any processing of the original elderly care group information, and directly into the old-age health care system integration treatment scheme. Then the PSOA data fusion algorithm and the multi-fork tree attribute is combined, the data fusion algorithm is used to deal with the classification of intelligent old-age data set, and the pixel-level data fusion and iterative processing are realized to provide intelligent and real-time old-age medical and health services for the vast number of elderly people.

CONFLICT OF INTEREST

"The authors declare no conflict of interest".

AUTHOR CONTRIBUTIONS

Luo Guodong and He Jirong organized the data and the prediction model. Lin Tianwen performed the statistical analysis. Luo Guodong, He Jirong, Lin Tianwen and Yibai Wang wrote the manuscript. All authors had approved the final version.

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