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Research on the Application of AI Intelligent Machines to Enhance the Quality of Life and Happiness of the Elderly in the Context of Great Health

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ABSTRACT

With the arrival of the aging society and the continuous improvement of human civilization, people pay more and more attention to the quality of existence, quality of life and happiness index, and the elderly service is becoming a hot issue of social concern. The article proposes a set of intelligent monitoring system for the elderly based on ROS service robot in the context of big health. The system is based on the machine vision following module to design the neural network-based fall detection module and the monitoring module of power consumption abnormality to realize the remote contact method between the elderly and the guardian. The article measures the quality of life and happiness index of 600 elderly people in old age through questionnaires, and systematically understands and comprehensively grasps the influence and effect of the monitoring system proposed in this paper on the quality of life and happiness index of the elderly from seven target levels and several index levels, including the quality of healthy life, economic quality of life, family quality of life, social quality of life, cultural quality of life, personal value realization and sense of identity and belongingness , with more than 97% of the elderly believing that the quality of cultural life has been improved by utilizing this AI intelligent machine.

Keywords: visual following, fall monitoring, neural network, electricity anomaly monitoring, ROS service robot

1. Introduction

With the continuous development of society and the gradual aggravation of the phenomenon of population aging, the quality of life and happiness of the elderly has become a topic of great concern. As an important member of society, the quality of life and happiness of the elderly are directly related to the stability and harmony of the whole society [1-4]. Therefore, improving the quality of life and

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happiness of the elderly has become an urgent and important task, and AI intelligence and its ability to play an important role in this process [5-6].

In today's era of rapid technological development, Artificial Intelligence (AI) has been gradually integrated into all aspects of our lives, from smart home to healthcare, from transportation to education, its impact is everywhere. Artificial intelligence is no longer a far-fetched science fiction concept, but a powerful tool for us to improve the quality of life and increase the sense of happiness [7-10]. Artificial intelligence has a wide range of applications in improving the quality of human life and happiness. It can improve the healthcare system, enhance the convenience and safety of transportation, realize the comfort and intelligence of smart homes, and provide personalized recommendation services [11-14]. However, we also need to realize that the development of AI technology needs to be combined with ethics and privacy protection to ensure its benign and sustainable development, so that AI technology can truly become a great tool to enhance the happiness of human life [15-17].

Literature [18] integrates perspectives from multiple disciplines and provides a broad and multidisciplinary study from the roots of human behavior to the impact of digital technology on daily life, which is an important reference to delve into the significance of AI for human beings. Literature [19] overviews the framework of PT, including computer vision and machine learning, aiming to promote physical, emotional, and social well-being in older adults. The gap between theoretical needs and technical system availability is emphasized and future research directions are indicated. Literature [20] aims to discuss the impact that smart homes have on the quality of life of older adults and categorizes them into five application areas that can serve older adults based on the literature review, and the results point out that older adults have positive attitudes towards smart homes, especially in the areas of health and lifestyle services, but are concerned about issues such as privacy and security and overreliance. Literature [21] discusses the RobWell system that focuses on the field of AI in order to predict the moods of home-bound seniors and provide guidance. The system consists of actuators, robotic platforms, and other components. Integration and testing of the actuator and robotic platform etc. were carried out by building a test smart home system. The results specified that the robot has sufficient autonomy. Literature [22] designed a system to monitor the emotions, mental health and services of the elderly based on their personal profiles, physiological indicators and other information, and applied OpenCV to realize video monitoring. The results of the study show that AI-based emotion detection scenarios are superior to manual intervention, which is conducive to promoting the application of AI technology in elderly organizations and improving the emotional experience of the elderly. Literature [23] aims to develop a multifunctional elderly emotional experience product to make it practical, entertaining, and easy to use in order to alleviate the loneliness of the elderly, and discusses its application, impact, and development prospects. Literature [24] narrates chatbots talking to older people with age-related issues. By describing the use of chatbots in the lives of older people, it emphasizes its important role in the mental health of older people and outlines the personality of the bot's and its acceptance by older people. Literature [25] examined the feasibility of a GBM-powered medical robot to provide personalization and support to older adults. It learns and improves through its interactions to better meet the needs of older adults. The results of the study reveal that the system effectively improves the quality of support for older adults and facilitates the construction of patient-centered healthcare strategies.

The article provides an overall design of a monitoring system based on ROS service robots. Specifically, the depth camera vision following algorithm is first studied. Then it proposes a fall detection neural network construction method under hardware and software constraints, using a network structure search method to construct a maximum search space that meets the constraints, and iteratively searching each possible network structure using a simulated annealing algorithm. Then a performance evaluation strategy based on network confrontation is proposed so that the distribution of different scene data extracted by the feature extractor is confusing enough to learn scene-independent intrinsic features of the fall action and improve the robustness of each network structure. Then a hybrid multi-timescale neural network based abnormal power usage detection model is proposed to relay the real-time situation to the guardian. Finally the article analyzes the performance experimental comparison of the system proposed in this paper as well as the effectiveness of the system in practical use.

2. Method

2.1. Design of monitoring system based on ROS service robots

2.1.1. ROS service robots. This system optimizes and innovates the current algorithms and develops new algorithms to make them integrated into an intelligent elderly guardianship system to reduce the burden of the elderly in China. The hardware architecture of the ROS service robot is shown in Fig. 1. This system provides a hardware facility collocation based on ROS service robot, including ROS service robot industrial controller, power supply, STM32 motion chassis, LED screen, 2D radar, Kinect depth binocular camera, and audio device [26]. The said power supply is used to provide energy support for the ROS service robot to ensure that the intelligent system can operate normally, the LED screen is used to provide operation support for the user, the Kinect depth binocular camera is used to collect the current data and transmit the RGB image and the current real-time screen to the intelligent system, and the industrial control machine is used to carry the intelligent system of the present invention and centrally process the data transmitted from the radar and Kinect depth binocular camera and make further tracking decisions. The industrial computer is used to carry the intelligent system of the present invention and centrally process the data transmitted from the radar, Kinect depth binocular camera and make a decision to continue tracking or dialing audio and video calls, the STM32 motion chassis is used for controlling the ROS service robot to move, the 2D radar is used for detecting the distance between the ROS service robot and the guardian and obstacle avoidance, and the audio device is used for audio relay between the guardian and the elderly.

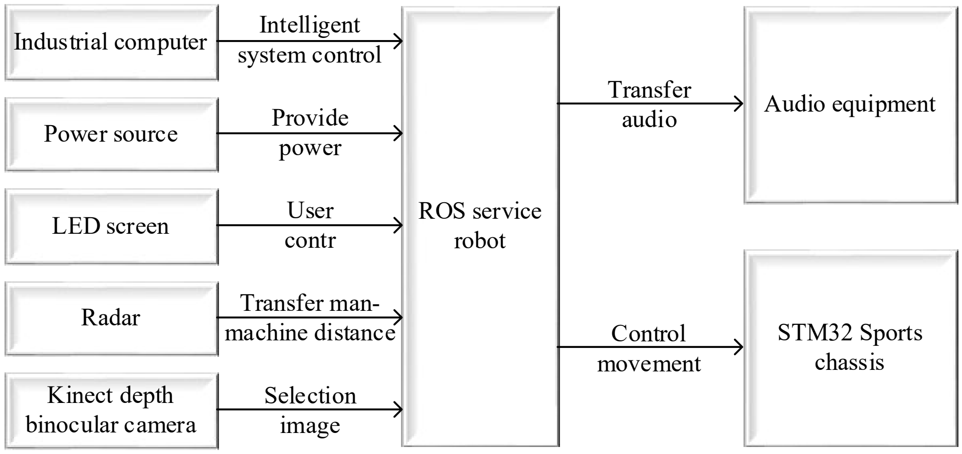

Fig. 1. ROS service robot hardware architecture

2.1.2. Overall system architecture design. The overall functional design of the system is shown in Figure 2. After the system is started, the ROS service robot will visually follow the guardianship target through the equipped Kinect depth camera, and always keep the distance and angle between the ROS service robot and the guardianship target within a certain range, and the fall detection will be carried out continuously while the ROS service robot is following the guardianship target, and if the detection result is that the guardianship target has not fallen down, the ROS service trolley will continue to follow and fall detection on the guardianship target. If the detection result is that the guardian target has not fallen, the ROS service trolley will continue to follow the guardian target and perform fall detection. If the detection result is that the guardian target has accidentally fallen, the ROS robot cart will call the automatic audio/video function module to initiate a request to set up an audio/video call with the guardian to broadcast the real-time situation to the guardian, so that the guardian can understand the situation at the first time and make the quickest rescue decision.

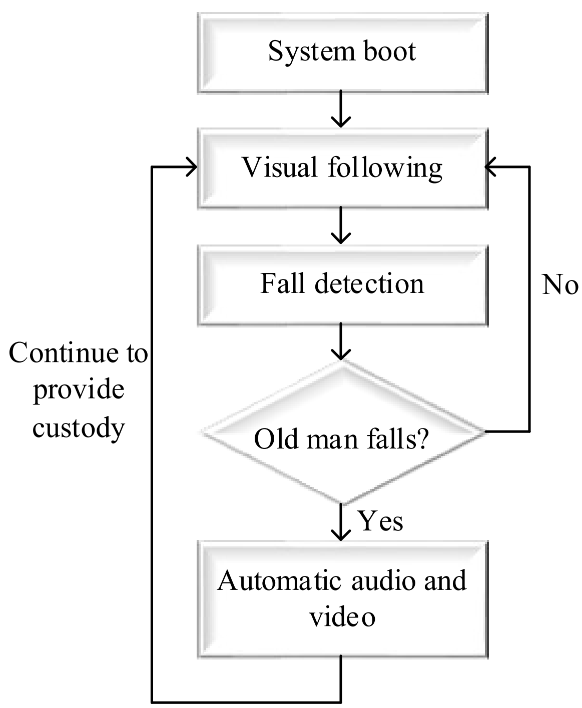

Fig. 2. Overall functional design of the system

2.2. *Visual following*

After starting the ROS service robot with this intelligent system, the system then automatically starts the Kinect depth binocular camera and reads the parameters of the depth binocular camera camera camera angle α, image width Imagewidth, image height Imageheight, with the human-machine distance threshold d set by the system. After that, the Kinect depth binocular camera passes the acquired grayscale image to the ROS service robot, and this system utilizes the current processed depth image in combination with the Skeletonize(image) function of the submodule morphology in the python function package skimage and the medial_axis (image, mask= None, return_distance=False) function to obtain the skeleton map of the current guardian target, and stabilize and smooth the current image. Where image is the image object, mask is the mask, default is None, if a mask is given, the skeleton algorithm is performed only for the pixel values within the mask, return_distance is a bool type value, default is False, if it is True, in addition to returning the skeleton, the distance transformed value is also returned at the same time [27]. After that, the system obtains the current man-machine distance Manmachine_distance by enabling the 2D radar, extracts the target center point, and obtains the target bearing Target_bearing (Targetbearing is the position of the center point located in the width of the image). Subsequently, determine whether the two equations Manmachine_distance=d_ and Target_bearing=$\frac{Image.width}{2}$ are valid, if not, drive the STM32 motion chassis to adjust the robot position according to the size of the two equations. The specific rules are as follows:

If Manmachinedistance<d, drive the STM32 motion chassis in the direction away from the guardian.

If Manmachinedistance > d, drive the STM32 motion chassis toward the guardian.

If Target_bearing< $\frac{Image.width}{2}$, drive the STM32 motion chassis in the left direction.

If Target_bearing> $\frac{Image.width}{2}$, the STM32 motion chassis is driven to turn right until Man_machine_distance=d_ and Target_bearing= $\frac{Image.width}{2}$ are both satisfied, and the visual following flow is shown in Figure 3.

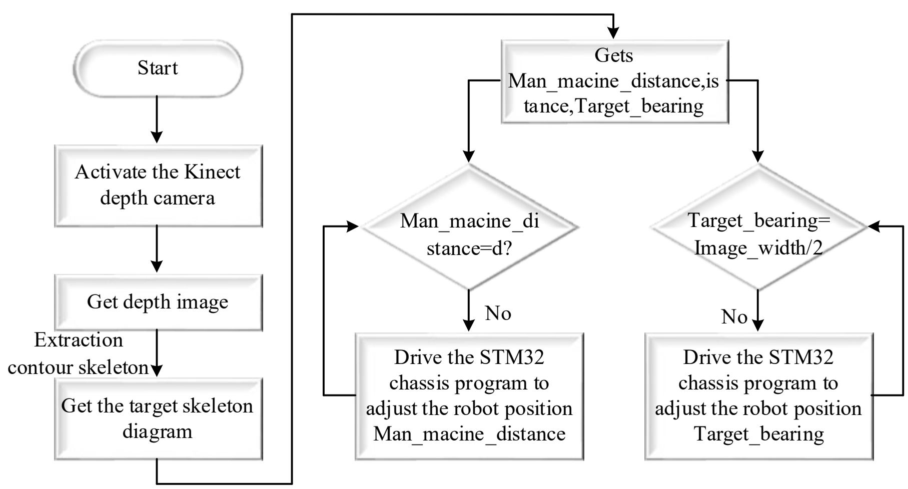

Fig. 3. Visual following process

2.3. *Framework of fall detection neural network construction system under hardware and software constraints*

The fall detection neural network construction system under hardware and software constraints proposed in this chapter is based on a fall dataset, which is collected by an FMCW millimeter wave radar in the 60 GHz regime, and a fall classification network is deployed on the radar board. The fall detection neural network construction method under hardware and software constraints proposed in this chapter is used to solve the above problem. While deploying the fall detection sensing network on the radar, it achieves a system performance that combines both robustness and high accuracy recognition. The block diagram of the neural network construction system is shown in Fig. 4, and this chapter investigates both building a streamlined network structure and improving network robustness. In terms of building a streamlined network structure, the structural framework of the network is searched using the network structure search technique. In terms of improving network robustness, the network adversarial learning technique is used to extract ubiquitous perceptual features for each network structure using the domain adversarial strategy, to bring out the optimal recognition capability of each network, and to evaluate the performance of each network structure, combining the searched network framework and the extracted eigenfeatures, and iteratively evaluating the optimal network using the simulated annealing strategy, and finally obtaining the robust and streamlined classification and recognition network.

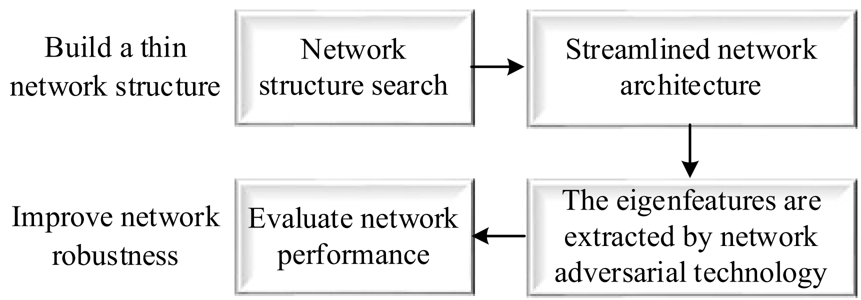

Fig. 4. Block diagram of neural network construction system

2.3.1. Search strategies under hardware and software constraints. The problem of designing a neural network structure is transformed into an optimization problem using a neural network structure algorithm. In a set search space, combinations of structures in the space are searched according to a certain search strategy, and finally a performance evaluation strategy is used to feedback the network performance and find the optimal neural network. Setting the network hyperparameter vector as λ, λ can represent the neural network structure A, and vector λ belongs to the search space of the network search algorithm R. At this time, the performance index of the neural network structure A can be measured by λ. Therefore, the problem of neural network structure design can be reduced to the problem of hyperparameter vector λ as follows:

$$\begin{aligned} &\lambda = \arg\min_{\lambda} L(A, D_{train}, D_{test}) \\ &s.t. \lambda \in R \end{aligned} \tag{1}$$

D_{train} denotes the training set, D_{test} denotes the test set, and $L(\cdot)$ denotes the loss function, which measures the network training effect.

The design of the network structure is converted into a search for optimal hyperparameters, λ including the individual structural parameters of the neural network. The search for network structure is reduced to the problem of finding the optimal hyperparameters. The search strategy used in the network structure search in this chapter is the simulated annealing algorithm. The simulated annealing algorithm is a method for searching the global optimal solution, which not only has the advantages of flexibility, easy implementation and faster operation speed, but also has the properties of asymptotic convergence, parallelism and robustness. Due to the introduction of stochastic probability in the search process, i.e., accepting a solution vector that is worse than the current one with a certain probability, which decreases gradually over time. Thus the method avoids falling into local optimal solutions and can jump out of the local optimal solution to find the global optimal solution. The stochastic probability is given in the following equation:

$$p = \exp(\frac{-\Delta E}{kT}) \tag{2}$$

where ΔE is the difference between the searched new solution and the current solution, k is Boltzmann's constant, and T is the variable that controls the iterative process. The process of optimization search using simulated annealing strategy is as follows:

1) In the first step, a neural network structure is randomly selected as the current solution in the search space.

2) Generate a random perturbation in the search space and select a new neural network structure as the new solution.

3) Calculate the objective function difference corresponding to the current solution and the new solution.

4) Judge whether the new solution is accepted or not. If the objective function difference is greater than 0, i.e., the performance of the new solution network is greater than that of the current solution, the new solution is directly updated as the current solution. If the objective function difference is less than or equal to 0, i.e., the performance of the new solution network is less than or equal to the current solution, then update the new solution as the current solution with probability p.

5) Continue to generate new solutions for iteration until the iteration stop condition is reached to stop iteration.

2.3.2. Performance Evaluation Strategies Based on Network Adversaries. Specifically, the network adversarial approach used in this chapter adds a domain discriminator to the conventional network classification, and the classifier shares a feature extractor with the action classifier. During the training of the training set, the feature extractor is made to learn domain-independent but action-information-related features by applying a penalty to the classifier for misjudging and a penalty to the domain discriminator for correctly classifying. The adversarial learning training approach weakens the extraction of non-robust features by the feature extractor for a specific scenario, and instead extracts action eigenfeatures so that the learned network is more generalized.

During training, two loss functions are defined, the fall detection binary classification loss function L_Y and the domain discriminator loss function L_D. For the fall detection binary classifier G_γ, the classification loss of the fall action is measured using the binary cross entropy (BCE) loss function as in the following equation:

$$L_Y(x, y) = BCE(sigmoid[G_Y(G_F(x))], y) \tag{3}$$

Among them:

$$BCE(p, y) = -(y \times \log(p) + (1-y) \times \log(1-p)) \tag{4}$$

x represents the input data and y is the action classification output.

For domain discriminator G_Y, the scene classification loss is measured using the cross-entropy (CE) loss function as follows:

$$L_D(x, d) = CE(softmax[G_D(G_F(x))], d) \tag{5}$$

Among them:

$$CE(p, d) = -\log(p_d) \tag{6}$$

x denotes the input data, d is the scene category label and denotes the input x is the data of scene d.

During the training process due to the design of the confrontation between the domain discriminator and thus the feature extractor, there is also a gradient inversion operation between these two tasks, and the gradient optimization direction for the action classifier is:

$$\frac{\partial L_Y(x,y)}{\partial \theta_Y} \tag{7}$$

For the domain discriminator, the gradient optimization direction is:

$$\frac{\partial L_D(x,d)}{\partial \theta_D} \tag{8}$$

So, the optimization direction of the feature extractor is:

$$-\lambda \frac{\partial L_D(x,d)}{\partial \theta_D} + \frac{\partial L_Y(x,y)}{\partial \theta_Y} \tag{9}$$

λ for adjustable hyperparameters.

In the test set, given the test data x, the action classification output is obtained using the trained feature extractor G_F and action classifier G_Y:

$$p = sigmoid[G_Y(G_F(x))] \tag{10}$$

Neural networks with cross-scene generalization capability is crucial for wireless sensing to be applied in real scenarios, this chapter proposes the idea of adversarial using $L_\gamma(x,y)$ to guide the feature extractor to learn the feature differences between fall actions and non-fall actions of the elderly, and $L_D(x,d)$ to guide the feature extractor to extract the deeper action features that are not dependent on the scene. This adversarial learning strategy ultimately makes the network robust and generalizable.

2.4. Neural network based abnormal power usage detection model

Electricity safety is an important part of home safety, and it is of great significance for the elderly, especially those who live alone, to analyze and detect abnormalities in the home environment's electricity use behavior, so as to discover and deal with dangerous situations in a timely manner. Through the energy meter data acquisition module in the sensing control layer, the measurement data of the meter can be read and uploaded to the timing database at the edge end, so as to obtain the timing data of electricity consumption in the home environment. In this paper, anomaly detection is carried out by using long and short-term memory recurrent neural network modeling for the timing data generated by the energy meter in the home environment.

2.4.1. Bi-LSTM network fundamentals. LSTM networks are a new neural network structure derived from RNNs, aiming to solve the common problem of gradient vanishing or explosion in RNNs. Specifically, LSTM networks introduce a new internal state c_t for passing information linearly and can output information to the external state h_t of the hidden layer in a nonlinear manner. Then:

$$c_t = f_t \odot c_{t-1} + i_t \odot \tilde{c}_t \tag{11}$$

$$h_t = o_t \odot \tanh(c_t) \tag{12}$$

Three gates are used in the model to control the information transfer paths, namely the forgetting gate $f_t \in [0,1]$, the input gate $i_t \in [0,1]$ and the output gate $o_t \in [0,1]$. These gates control the transfer of information by means of the product of vector elements $\odot$ [28]. In addition, the model computes the candidate states $\tilde{c}_t$ using the memory cells c_{t-1} of the previous moment and a nonlinear function:

$$\tilde{c}_t = \tanh(W_c x_t + U_c h_{t-1} + b_c) \tag{13}$$

This internal state can be controlled by a series of gating units, including Oblivion Gate f_t, Input

Gate o_t, and Output Gate i_t. Through the synergistic action of these gating units, the LSTM network can realize more flexible and accurate information processing:

$$i_t = \sigma(W_i x_t + U_i h_{t-1} + b_i) f_t = \sigma(W_f x_t + U_f h_{t-1} + b_f) o_t = \sigma(W_o x_t + U_o h_{t-1} + b_o) \tag{14}$$

In this model, $\sigma(\cdot)$ is a Logistic function which takes values in the range (0, 1). The external state h_{i-1} from the previous time step and the input x_i from the current time step are also used in the model, as well as some weights $* \in \{i, f, o, c\}$ represented by the network parameters W_s, U_s, b_s.

2.4.2. ResNet Fundamentals. ResNet is a very important architecture for deep learning that builds deep neural networks by adding "residual blocks". You want to approximate an objective function $h(x)$ using a nonlinear unit $f(x;\theta)$. By decomposing the objective function into a constant function x and a residual function $h(x)-x$. i.e.:

$$h(x) = x + (h(x) - x) \tag{15}$$

The optimization problem can be transformed into approximating the residual function $h(x)-x$ using the nonlinear unit $f(x;\theta)$ and approximating $h(x)$ with the constant function $f(x;\theta)+x$. This cross-layer connection allows the model to be trained more easily, prevents the problem of vanishing gradients that occurs in deeper networks, and facilitates the flow of information through the network.

2.4.3. AlexNet Fundamentals. AlexNet is a deep convolutional neural network model. The AlexNet model consists of eight convolutional layers and three fully connected layers.Techniques such as ReLU activation function, local response normalization, and Dropout are used in the model to reduce overfitting and improve generalization. Although AlexNet was originally designed for image classification tasks, it can also be applied to the task of feature extraction from time series data [29].

For time series data, time series data can be viewed as a two-dimensional matrix where one dimension is time and the other dimension is features. They are usually continuous meter-sample data with a certain time interval, and these data can be represented as time series. To extract useful features from these time series data, a convolution operation can be applied to the data at each time step. This means applying a convolution kernel (a set of weights) to each time step of the time series and moving the convolution kernel in a sliding window fashion to process the entire time series so that features of the time series data can be extracted as in a convolutional layer in a convolutional neural network.

The size and number of convolution kernels are very important when applying convolutional operations. By adjusting the size and number of convolution kernels, features at different time scales can be captured.

2.4.4. Fundamentals of AdaBoost Classifier. AdaBoost is an integrated learning method that can build a strong classifier by combining multiple weak classifiers. Compared to a single classifier, AdaBoost is able to improve the classification accuracy and generalization ability.The basic idea of AdaBoost is to weight the previously misclassified samples in each iteration and retrain the classifier to focus more on these samples in the next iteration. In this way, each classifier is able to focus on the previous misclassified samples and improve the classification accuracy. The basic principle is as follows:

Assume that the training dataset is:

$$T = \{(x_1, y_1), (x_2, y_2), \cdots, (x_N, y_N)\} \tag{16}$$

It is a binary classification problem in which each sample has a corresponding feature $x_i \in X$ and a label $y_i \in \mathrm{Y} = \{-1, +1\}$. In order to obtain a strong classifier $G(x)$, the AdaBoost algorithm utilizes the training dataset to learn a set of weak classifiers D_m, of which $m = 1, 2, \cdots, M$, and linearly

combines them, and its basic process is shown below:
1) Initialize the sample weights, and for a training set, assign equal values to the weights of all samples:

$$D_1 = (w_{11}, \cdots, w_{1i}, \cdots, w_{1N}), w_{1i} = \frac{1}{N}, i = 1, 2, \cdots, N \tag{17}$$

2) Iterative training of weak classifiers, in which a weak classifier is trained using the current sample weights in each iteration.

(1) Training the training dataset with weight distribution D_m produces the basic classifier:

$$G_m(x): X \to \{-1, +1\} \tag{18}$$

(2) Use the current sample weights to train a weak classifier $G_m(x)$ and compute the classification error rate:

$$e_m = \sum_{i=1}^{N} P(G_m(x_i) \neq y_i) = \sum_{i=1}^{N} w_{mi} I(G_m(x_i) \neq y_i) \tag{19}$$

(3) Calculate the weight of each basic classifier $G_m(x)$ based on the classification error rate so that subsequent combinations of multiple weak classifiers can be weighted according to their classification accuracy:

$$\alpha_m = \frac{1}{2} \log \frac{1 - e_m}{e_m} \tag{20}$$

(4) Weak classifiers all classify the samples and then adjust the weight of each sample according to the accuracy of the classification, i.e., samples that are misclassified are given higher weights, while samples that are correctly classified are given lower weights:

$$D_{m+1} = (w_{m+1,1}, \cdots, w_{m+1,i}, \cdots, w_{m+1,N}) \tag{21}$$

$$w_{m+1,i} = \frac{w_{mi}}{Z_m} \exp(-\alpha_m y_i G_m(x_i)), \quad i = 1, 2, \cdots, N \tag{22}$$

Here, Z_m is the normalization factor:

$$Z_m = \sum_{i=1}^{N} w_{mi} \exp(-\alpha_m y_i G_m(x_i)) \tag{23}$$

It makes D_{m+1} a probability distribution.

3) Construct strong classifiers and repeat step b until a set maximum number of iterations is reached or the error rate is below a preset threshold. Then all the weak classifiers are combined weighted according to their classification accuracy:

$$f(x) = \sum_{m=1}^{M} \alpha_m G_m(x) \tag{24}$$

A strong classifier is finally obtained.

$$G(x) = sign(f(x)) = sign\left(\sum_{m=1}^{M} \alpha_m G_m(x) \right) \tag{25}$$

2.4.5. Neural Network Models for Mixed Multiple Time Scales. In accordance with the previously analyzed normal users and electricity theft users in the time scales of months and weeks, the electricity consumption data of normal users show strong correlation, while the electricity consumption data of electricity theft users show less correlation, this hybrid multi-timescale neural network model consists of four main components, which are described in detail as follows:

a) Electricity consumption data with day as the time scale, Bi-LSTM network is used to extract the global features of the users. b) The Bi-LSTM network is iterated in the opposite direction respectively, utilizing both forward and backward information to enhance the overall learning effect of the sequence. c) The relevant parameter settings of the Bi-LSTM network are shown in Table 1. d) The Bi-LSTM network is used to extract the global features of the users. e) The Bi-LSTM network is used to extract the global features of the users.

Table 1. Relevant parameter settings of Bi-LSTM networks

Type	Parameter setting
Enter the dimension input_size	1035
The number of cells in the hidden layer is hidden_size	128
LSTM layer num_layers	2
dropout	0.5
batch_first	True
bidirectional	True

Electricity consumption data in weekly time scale, ResNet is used to extract the weekly electricity consumption characteristics of the users.The relevant parameter settings of ResNet are shown in Table 2.

Table 2. Relevant parameter settings of ResNet

Type	Parameter setting
Enter the dimension input_size	7*148
The resnet layer num_layers	3
Num_filters of the convolution kernel	16, 8 and 4
The convolution kernel size kernel_size	3
Move step	1
Activation activation	relu

For the electricity consumption data with month as the time scale, AlexNet is used to extract the monthly electricity consumption features of the users.The relevant parameter settings of AlexNet are shown in Table 3.

Table 3. Relevant parameter settings of AlexNet

Type	Parameter setting
Enter the dimension input_size	30*34
Num_filters of the convolution kernel	8, 16, 32, 32 and 16
The convolution kernel size kernel_size	3
Move step	1
Activation activation	relu

For the fusion features of the extracted model, finally the AdaBoost classifier is used to binary classify the dataset, and the network model is trained and tested several times, and the final output of the classification and detection results.The relevant parameter settings of the AdaBoost classifier are shown in Table 4.

Table 4. Relevant parameter settings of AdaBoost classifier

Type	Parameter setting
Base_estimator	CART decision tree
The number of weak learner number n_estimators	50
Learning_rate	0.8
Algorithm algorithm	SAMME.R

3. Results and discussion

3.1. Analysis of the effectiveness of fall detection

3.1.1. Experimental data collection. A total of 8 volunteers participated in this experiment, 4 males and 4 females, all over 60 years old.The 8 volunteers performed 5 normal behaviors and 2 different types of fall behaviors, of which the normal behaviors included walking, standing, etc., and the fall behaviors included forward fall and sideways fall, and the description of the experimental behaviors is shown in Table 5. Each volunteer performed the cycle of normal behaviors listed in the table 2 times and 3 times for different types of fall behaviors, totaling 115 behaviors, 95 normal behaviors and 20 fall behaviors.

Table 5. Experimental behavior description

Categories	Behavior	Explanation
Normal behavior	Walk	Walking posture
	Standing	/
	Sitting position	Including sitting, sitting, and starting
	Squatting	Including from crouching, maintaining squat, to the station
	Stooping	Including bending, bending, reaching the line
Fall down	Forward fall	Fall from the walking state
	Lateral fall	Fall from standing

3.1.2. Test results and analysis. In order to verify the feasibility of the fall coefficient f for fall judgment, a certain fragment of the experimental data was studied, the video clip contains the process of walking, standing, walking to forward fall, the curve of f change in the fall process is shown in Fig. 5, from the 228th frame to the 255th frame is the behavior of the fall, from the figure it can be seen that f reaches the threshold three times in the fall process, and it only needs to reach the threshold once during the fall can be be recognized as a fall, so the fall can be successfully detected by using the method of this paper.

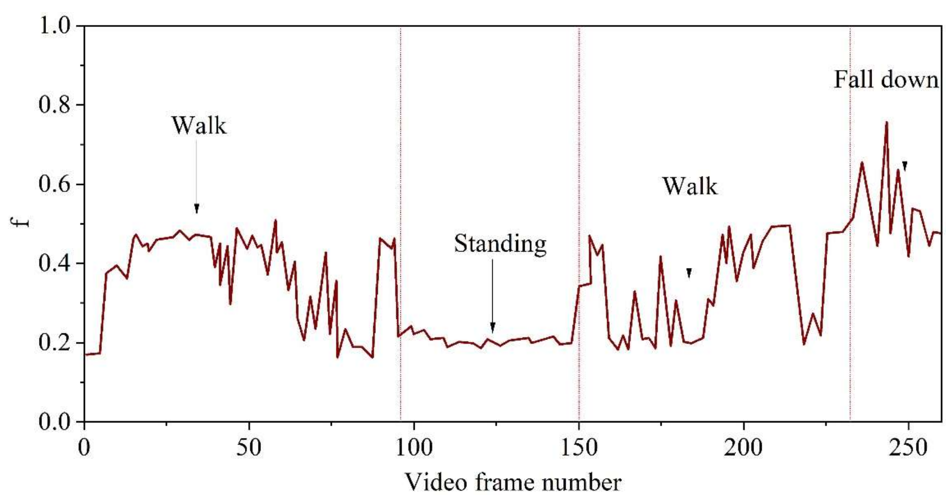

Fig. 5. The fall process f curve

The results of the fall detection comparison experiment are shown in Table 6. The table shows the experimental results of the proposed method compared with some other commonly used classifiers, including Support Vector Machine (SVM), Naive Bayes (NB), k-nearest neighbors (KNN) and decision tree (DT), using 130 video files in the "Coffee_room_01", "Coffee_room_02", "Home_01" and "Home_02" folders in the Le2i dataset as training data. Where SVM uses grid search to determine the parameters of the model using Gaussian kernel function with σ taking the value of 0.01 and penalty coefficient C of 1000.The value of k in KNN was tried from 1 to 20 and finally k was selected as 5. From the table, it can be seen that the method proposed in this paper has a better ability to recognize the falling behavior with Ac of 94.29% and outperforms the other classifiers (AcSVM=93.8%. AcNB=86.96%. AcKNN=91.09%. AcDT=93.27%). In the testing process, it was found that SVM is less prone to misjudgment, but in contrast it is prone to under-detection of fall behavior.The NB algorithm is mainly based on the classical Bayesian formula for derivation, which has good mathematical principles, and the NB algorithm relies on the assumption of independence.The KNN is non-supervised learning and has a higher complexity.The DT can find out the importance of the features, and it is able to effectively exclude situations such as sedentary sitting, but the overall effect is is not as good as the method proposed in this paper. The method designed in this paper takes into account the characteristics of its features when a fall occurs and therefore performs better.

Table 6. The fall detection compares the results of the experiment

	Sensitivity(%)	Precision(%)	Specificity(%)	Accuracy(%)	Error rate(%)
SVM	88.3	95.73	97.37	93.8	6.08
NB	90.94	78.6	86.68	86.96	12.29
KNN	85.54	93.89	96.02	91.09	8.4
DT	91.17	91.69	94.78	93.27	6.14
Ours	89.22	95.56	97.95	94.29	5.12

The comparison of fall detection accuracy is shown in Table 7. The table demonstrates some comparisons between this paper's fall detection method and other fall detection methods, from the table, the Ac value of this paper's method is 96.6%, which is 7.1%, 3.9% and 2% higher than the Ac values of the other three algorithms respectively. Therefore the results obtained from the experiments using the method of this paper can meet the needs of detecting the fall behavior of the elderly in daily life.

Table 7. Comparison of the accuracy of fall detection

Methods used	Ac (%)
The accelerometer is determined by the threshold method	89.5
The two value image is analyzed by neural network	92.7
Analyze the historical images of sports	94.6
Search strategy	96.6

This section of the test experiment continues to fall behavior and daily behavior of two parts, so the test results are also divided into two parts, in the fall behavior test is the most important is the detection rate, that is, the occurrence of fall alarm, if the detection rate is not high, often fall without alarm, then the reliability and practicality of the algorithm will be greatly reduced. What is more important in daily behavior is the false alarm rate, i.e., the system also alarms when no fall occurs, and false alarms will affect the user's user experience. After testing, each test action a total of 50 times, the test results of the fall behavior is shown in Table 8, the test results can be concluded that the check accuracy rate of about 99%, can accurately fall detection, and simulation experiment results match, but still in the test environment for the prescribed action of the fall test, the actual application may reduce the accuracy.

Table 8. Fall test results

Fall category	Alarm number	Alarm number	Alarm number
Fall forward	60	100%	0%
Fall back	60	100%	0%
Side fall	60	100%	0%
Fall down on a chair	58	97%	3%
faint	60	100%	0%

The results of the daily behavior test are shown in Table 9, normal walking and jogging, standing up and sitting down and other daily behaviors that are not particularly large in the frequency rate of action, no false alarms occurred, only when the user has a large movement, occasional false alarms will occur. The main focus of the fall detection group belongs to the elderly group, the elderly group in general is not a large number of movements and strenuous exercise, so the false alarm rate of the system is in a relatively ideal range, the user will not be affected by the higher false alarm rate of the reason for the use of the system experience.

Table 9. Daily behavior test results

Behavior category	Alarm number	Error rate
Normal walking	0	0%
jogging	1	2%
Run fast	0	0%
Up and down stair	0	0%
Stand up and sit	0	0%

3.2. Analysis of the effect of monitoring abnormalities in electricity consumption

In this section, two months of data collected from an elderly person's home environment through an energy meter is selected, which contains five characteristics: voltage, current, power, power factor, and ambient temperature. Due to factors such as device communication errors and network transmission delays, the frequency of data collection is about 10 to 15 seconds per bar, generating about 5 to 6 records per minute. In order to standardize the sampling frequency of the data and reduce the chance error, the data were resampled at the average value per minute. After the resampling is completed, the missing values of a certain minute need to be processed. In order to ensure the continuity of the data, and taking into account the smoothness of the change of the electricity consumption data, the missing values of a single moment are filled with the values of the previous moment. After data cleaning the original training data 85168 items were obtained with a time scale of 1 minute. The graph of active power change per minute over two months is shown in Fig. 6. The graph of active power per minute variation over three days is shown in Fig. 7. As can be seen from the figure, the trend of daily power consumption is relatively similar, and the peaks of power consumption mainly appear around 9:00 a.m., 12:00 p.m., and 18:00 p.m. to 23:00 p.m., which corresponds to the daily life of the elderly people, who get up to wash and eat breakfast, lunch, as well as dinner, and boil water for bathing.

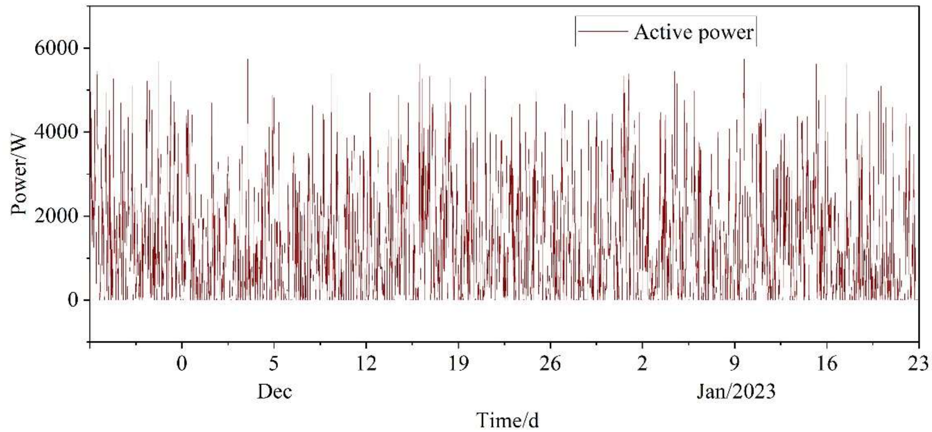

Fig. 6. The graph of power per minute in two months

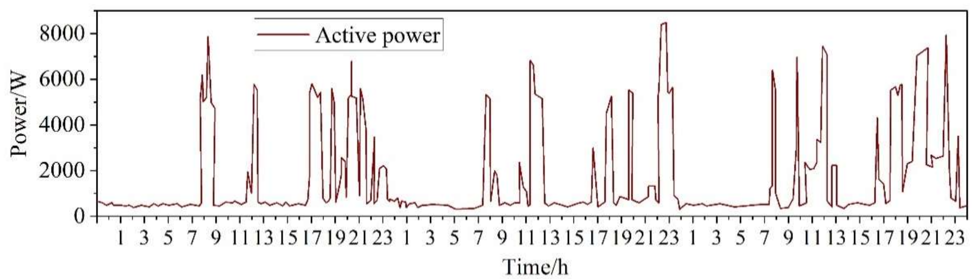

Fig. 7. Every minute change graph in three days

The experiment uses 60% of the data for training, 20% of the data for validation, and 20% of the data for testing, sets the epoch of training to 30 rounds, and sets the batch_size to 128. The variation of the loss curve for model training is shown in Figure 8.

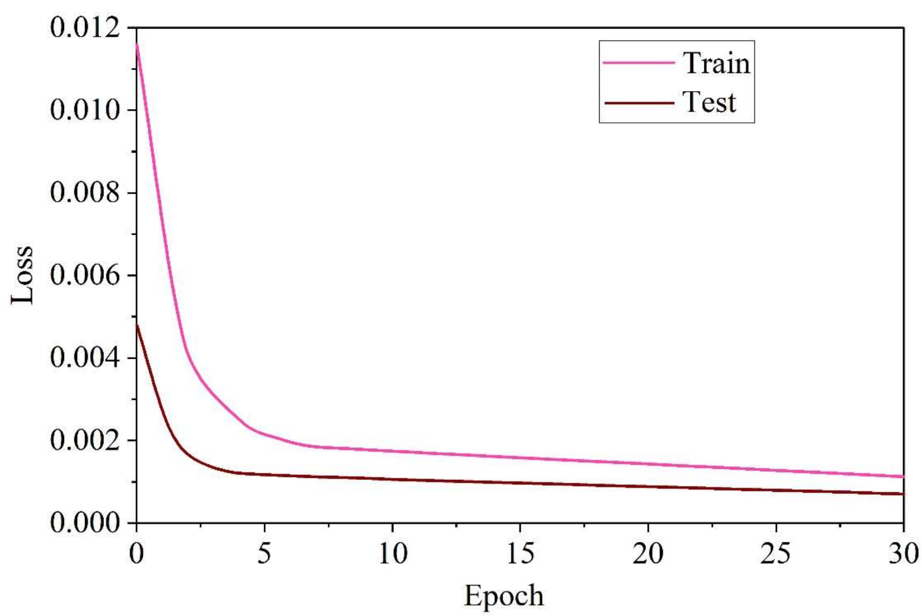

Fig. 8. LSTM power forecast model loss curve

The data in the test set were predicted using the model and the raw values of the data were obtained by inverse normalization, and the predicted and true values were evaluated with the following results: the root mean square error RMSE was 162.5, the mean error MAE was 24.8, and the mean absolute percentage error MAPE was 18.5%. The true values and model predicted values for a total of 1450 minutes in a 24-hour day in the test set were randomly selected to plot the curves, and the comparison between the true values and predicted values for a certain consecutive 24-hour time period in the test set is shown in Figure 9. From the figure, it can be seen that the curves of the true values and predicted values are more compatible.

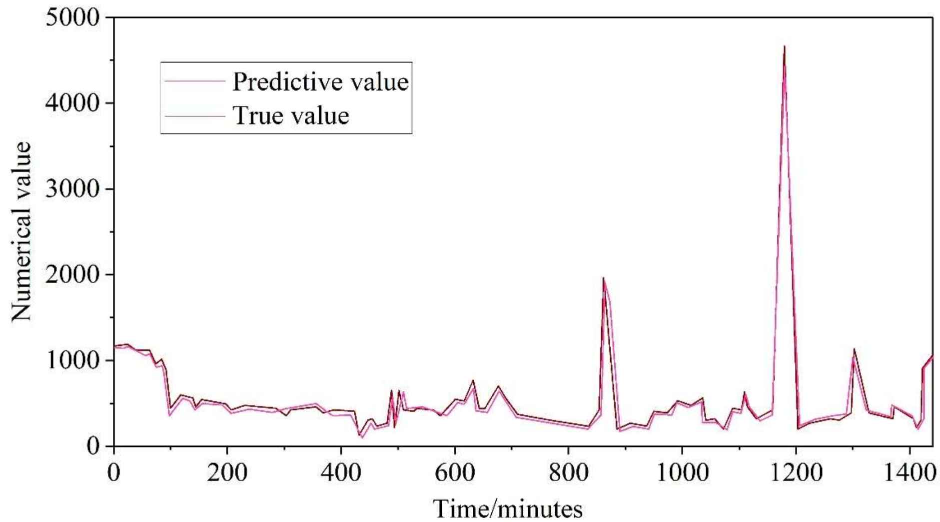

Fig. 9. The comparison between the real value and the predicted value

A segment of elderly home electricity usage monitoring data different from the training, validation and test sets, which contains certain abnormal electricity usage conditions, is re-drawn to determine anomalies in the active power consumption index. Setting to contain 3 consecutive anomalies, the system determines that the time period may have anomalies. Randomly select the active power of 2 consecutive days, and randomly select the abnormal detection results of 2 consecutive days as shown in Figure 10. As can be seen from the figure, an abnormal power rise occurs in the time period from 2:30 a.m. to 3:30 a.m. within the first day, which is correctly identified and labeled, and an abnormal power rise occurs in the time period from 10:00 a.m. to 11:00 a.m. during the daytime, which is also correctly identified and labeled. The next day, an abnormal power increase between 23:00 and 00:00 was also recognized. The reason for the above incidents is that high-power electric water heaters or hairdryers in the homes of elderly people were turned on incorrectly at incorrect times. However, at the same time, some of the power data points generated by the use of appliances during normal time periods have also been labeled as anomalous points. This is because high-power appliances do not have a slow power change process when they are turned on, and the model does not fit the data well for data with a large amount of sudden changes. Therefore, the design uses the following method to further filter the detected anomalies to reduce the false alarm rate of the system: when the system detects an anomaly, it reads the data before and after the time point for 5 minutes in the past week from the database, averages the values, and compares them with the data points that have been labeled as anomalies, and if the difference is more than 500W, it determines that the point is an anomaly, and pushes the anomaly information to the user to Notify the user to troubleshoot the anomaly.

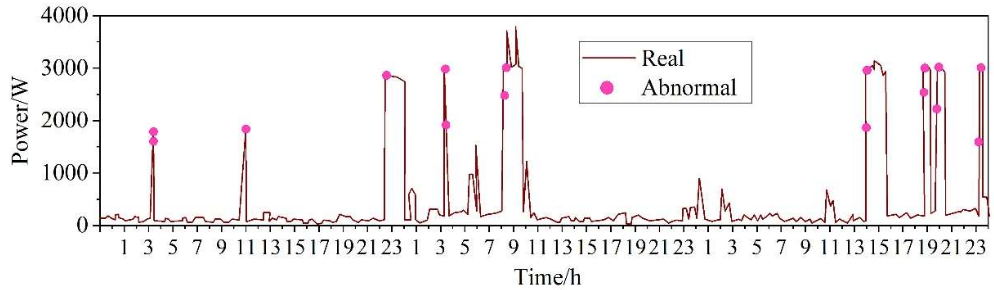

Fig. 10. Random sampling of two consecutive days of abnormal detection

3.3. Analysis of the quality of life and well-being of older persons

In this section, 600 elderly people (365 men and 235 women) in a community were selected for empirical testing, and a questionnaire was used to explore the impact of using the methods of this paper on the quality of life and well-being of the elderly. The questionnaire and results (%) of the study on the quality of life and well-being of the elderly are shown in Table 10. (1 represents "I can slow down the pace of life and be able to stay away from the mundane chores of daily life", 2 represents "I am more and more socially adaptable to getting along with others", 3 represents "I am willing to buy a ROS-based service robot when conditions permit", 4 represents "my medical expenses are significantly less than my peers", 5 represents "I am satisfied with the safety and security of my life", 6 represents "I often feel that my personality and marital status are more compatible and comfortable", and 7 represents " 8 means "I am satisfied with my financial situation and that of my family", 9 means "I appreciate the growth process and quality of life of my children", 10 means "I am very distressed about my health", 11 means "I often find it difficult to form friendships with others", 12 means "I am getting better and better in my relationships and communication with family members", 13 means "I feel as if most people have more friends than I do", 14 means " I feel very happy when I am with my family", 15 represents "I have a harmonious relationship with my neighbors and partners, and I never feel lonely", 16 represents "I can enjoy all kinds of social security, especially medical insurance and social security", 17 represents "I am more satisfied with my economic income and management status compared with others", 18 represents "I can quickly adjust my emotions and cheer up when encountering unpleasant things", 19 represents "I feel that I am old and have a good old age, and I am more and more satisfied with the quality of life", 20 represents " I know what I've done in my life and what it means.")

Based on the subjective opinions of the 600 elderly people surveyed, we analyze and discuss the main contents of the evaluation index system for the quality of life and happiness index of the elderly, which consists of seven target levels and several indicator levels, as follows.

1) Healthy quality of life. The survey shows that 365 male elderly people's self-identification of their health status is 18.46% excellent, 26.64% good, and 19.83% in general condition. 235 female elderly people's self-identification of their health status is 32.17% excellent, 16.64% good, and 18.88% in general condition. However, 15.69%, 14.12%, and 5.26% of male and 15.48%, 12.22%, and 4.61% of female older adults were distressed about their health status to varying degrees.

2) Economic Quality of Life. 82.11% of male respondents and 84.28% of female respondents in the survey were satisfied with their own and their family's economic situation. Therefore, it is necessary to further explore the status and role of economic quality of life in the study of physical activity and the quality of life and happiness index of the elderly, in order to better promote the synergistic development of physical activity and economic and social endeavors.

3) Family quality of life. Physical exercise is beneficial to the elderly in relieving aging pressure, eliminating mental fatigue, releasing bad emotions, and obtaining physical relaxation and psychological pleasure. 81.68% of the male elderly and 88.03% of the female elderly experienced that participating in their favorite and good at physical exercise activities on a regular basis can give them

a wonderful sense of pleasure and psychological satisfaction, harmonize their relationship with their partners and parents, and form affinity and cooperation with other people. They can also form the habit of being friendly and cooperative with others, laying a good foundation for acquiring and maintaining a higher quality of family life, and feel especially happy when they return home to be with their families.

4) Quality of social life. 89.55% of the male elderly and 92.5% of the female elderly in the survey are able to enjoy all kinds of social security, especially health insurance and social security.

5) Quality of Cultural Life. 97.04% of the male elderly and 97.96% of the female elderly are getting better and better at social adaptation in getting along with others, and the cultural life of the elderly is getting richer and richer.

6) Personal Value Realization. In the survey, 23.76% of the male elderly and 22.11% of the female elderly I often feel that it is difficult for me to establish friendships with others, which should be of great concern to us. The aging elderly often think of "who will take care of the future" problem, in the face of reality, they realize that they must care for themselves, strengthen the sense of self-reliance, enhance the ability to take care of themselves, in order to achieve health and longevity, this health needs is the common wish of all the elderly. Elderly people should be given timely guidance and assistance in adjusting their psychological state through scientific physical exercise activities and in becoming masters of their emotions.

7) Sense of Identity and Belonging. 83.98% of the male elderly and 85.19% of the female elderly are able to adjust their moods and cheer up their spirits quickly when they encounter unpleasant things after participating in regular physical exercise activities, and 83.94% of the male elderly and 91.45% of the female elderly never feel lonely when they have a good relationship with their neighbors and partners. However, 30.79% of men and 29.8% of women still feel as if most people have more friends than me.

Table 10. Study questionnaire and results of the old life quality and happiness index

Subjective happiness	Gender	Very disagree	Disagree	A little bit disagree	Kind of agree	Agree	Very agree
(1)	Man	0	2.3	5.15	25.2	50.05	17.3
	Female	0.39	2.88	2.75	16.98	53.6	23.4
(2)	Man	0	0	2.96	12.41	47.4	37.23
	Female	0.2	0	1.84	30.85	48.45	18.66
(3)	Man	5.09	6.32	7.85	28.44	41.56	10.74
	Female	0	2.08	5.62	29.46	38.84	24
(4)	Man	1.53	7.39	10.14	12.97	44.9	23.07
	Female	3.26	3.81	17.9	22.68	34.52	17.83
(5)	Man	5.27	8.92	12.43	13	48.24	12.14
	Female	2.38	3.2	11.09	14.36	54.83	14.14
(6)	Man	8.62	5.87	6.74	11.87	39.94	26.96
	Female	8.75	0.96	2.01	23.1	51.95	13.23
(7)	Man	3.2	4.99	5.9	24.1	53.72	8.09
	Female	8.59	5.49	6.68	19.88	53.84	5.52
(8)	Man	7.75	4.74	5.4	21.18	41.69	19.24
	Female	6.77	2.65	6.3	22.99	39.27	22.02
(9)	Man	9.29	4.73	6.51	12.35	39.81	27.31
	Female	7.04	5.1	9.97	23	30.48	24.41
(10)	Man	18.46	26.64	19.83	15.69	14.12	5.26
	Female	32.17	16.64	18.88	15.48	12.22	4.61
(11)	Man	26.87	33.09	16.28	11.32	8.95	3.49
	Female	39.71	21.44	16.74	12.78	5.11	4.22
(12)	Man	4.52	6	8.78	17.02	33.42	30.26
	Female	2.56	5.11	6.81	22.97	37.8	24.75
(13)	Man	30.81	22.03	16.37	13.73	9.72	7.34
	Female	25.85	22.73	21.62	16.08	11.43	2.29
(14)	Man	8.06	5.42	4.84	10.79	33.05	37.84
	Female	5.11	3.1	3.76	19.94	40.21	27.88
(15)	Man	2.9	4.15	9.01	13.62	50.12	20.2
	Female	4.13	2.03	2.39	17.86	52.76	20.83
(16)	Man	1.6	4.41	4.44	7.74	66.45	15.36
	Female	4.38	1.59	1.53	12.79	59.79	19.92
(17)	Man	6.22	3.04	3.42	14.66	56.01	16.65
	Female	3.62	2.57	3.07	11.78	55.97	22.99
(18)	Man	7.91	3.61	4.5	10.18	57.85	15.95
	Female	3.16	4.7	6.95	15.07	54.41	15.71
(19)	Man	8.68	7.12	5.15	18.75	50.93	9.37
	Female	2.57	3.29	1.02	23.34	56	13.78
(20)	Man	10.38	2.59	5.52	12.42	58.43	10.66
	Female	3.72	2.04	2.76	30.07	43.27	18.14

With the advent of an ageing society and the continuous improvement of human civilization, people are paying more and more attention to the quality of existence, the quality of life and the happiness index. A long and healthy life and quality of life are important cornerstones for measuring and evaluating the happiness index in old age. AI intelligent machines can effectively assist the elderly to enhance their functions and physical fitness, help slow down the aging process of the human body, promote the elderly “higher life, happier and stronger”, and also help promote the quality of life and happiness index of the elderly.

4. Conclusion

In this paper, we combine the fall detection algorithm and abnormal power usage detection algorithm to construct a ROS intelligent robot based on visual following and apply it in the daily life of the elderly in order to improve the quality of life and happiness of the elderly.

By using the system of this paper to identify two daily behaviors of the elderly fall behavior and abnormal power consumption, it is found that the detection rate of the fall behavior of the elderly by using the system of this paper is about 99%, and the detection error rate of the daily behavior test of the elderly is only 0.2%, which can be obtained that the method of this paper can effectively detect the fall situation of the elderly, and the results of the test are in line with the expectations, which proves the practicability of the method.

The quality of life and well-being of the elderly were analyzed at seven levels. In terms of the quality of healthy life, 45.1% of the male elderly believed that their physical health was better after applying the system proposed in this paper. At the level of cultural quality of life, more than 97% of older adults believe that their social adaptability in getting along with others is getting better and their cultural life is getting richer. Overall, the quality of life and happiness of the elderly are improved after using the system proposed in this paper.

The elderly care system based on ROS service robot proposed in this paper can improve the quality of life and happiness of the elderly, and also solves the social pain point problem of elderly care to a certain extent with good results.

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