International Journal of Computer Science and Information Technology
ISSN: 3005-9682 (Print), ISSN: 3005-7140 (Online) | Volume 6, Number 1, Year 2025
DOI: https://doi.org/10.62051/ijcsit.v6n1.08
Journal homepage: https://wepub.org/index.php/IJCSIT/index

Design and Implementation of Elderly Health Monitoring Glasses Based on Intelligent Vision

Fangfei Liu [1,*], Zeyuan Zhang [2], Xin Zhi [1], Hongyi Wang [1], Chunlei Yang [1]

[1] College of Information Engineering, Henan University of Science and Technology, Luoyang, China

[2] College of Software, Henan University of Science and Technology, Luoyang, China

*Corresponding Author: Fangfei Liu

ABSTRACT

With the acceleration of the aging process in China, the elderly generally face the double challenges of eyesight decline and health care. Traditional health monitoring devices require extra wear and are complex to operate, making it difficult to meet daily needs. Therefore, this study innovatively combined the health monitoring function with daily glasses, and proposed a design scheme of elderly health monitoring glasses based on intelligent vision. Through the deep integration of the micro sensor and intelligent algorithm, based on preserving the function of vision correction, the non-inductive monitoring of vital signs such as heart rate and blood oxygen is realized, and the multi-modal pose analysis technology is used to identify the fall behavior in real time and automatically trigger the emergency help mechanism. The system adopts lightweight structure and voice interaction design to ensure that elderly users "ready to wear and use" and effectively solve the pain points of "cumbersome operation" of traditional equipment. The program uses daily wearable devices as the carrier to build an invisible health management system, provide new ideas for smart elderly care, and significantly improve the safety and independence of life for the elderly.

KEYWORDS

Smart glasses; Health monitoring; Aging-friendly design; Senseless monitoring; Fall detection

1. INTRODUCTION

At present, our country has entered a deeply aging society [1]. According to the data of the National Bureau of Statistics, by the end of 2023, the elderly aged 60 and above accounted for 21.1%, with a scale of more than 280 million, among which the prevalence of chronic diseases was as high as 78%, and falling became the leading cause of accidental death of people over 65 years old.Elderly people generally face the dual needs of vision decline and health monitoring: long-term wearing of reading glasses to correct vision, and lack of convenient means of health monitoring. Traditional health monitoring equipment [2] is difficult to meet the needs of daily use due to complicated operation and extra wearing.

Although the existing research has realized multi-sensor fusion monitoring, it is still limited by the form constraints of independent wearable devices. For "Multi-device overlay wearing"; For this core pain point, this study innovatively selects glasses as the functional carrier, whose daily wear characteristics perfectly meet the needs of health monitoring, and realizes the design concept of "integration of health monitoring and vision correction". By deeply embedding micro-sensors and intelligent algorithms into the glasses frame, a new paradigm of accompanying health management is built.

This paper designs a kind of elderly health monitoring glasses based on intelligent vision. The smart glasses [3] have three core advantages:

Multi-functional integration: On the basis of preserving the optical correction function, the multi-mode sensor (vision, acceleration, humidity) is integrated [4] to realize the non-inductive monitoring of heart rate, blood oxygen and respiratory rate;

Intelligent fall detection: Multi-dimensional fall recognition model based on posture analysis [5] is adopted, combined with dynamic threshold adjustment strategies, to reduce the false positive rate and shorten the response time of triggering help;

Age-appropriate design: lightweight structure and voice interaction are adopted to ensure accessibility for elderly users;

2. OVERALL SYSTEM DESIGN

Based on the design concept of "function invisibility, interaction without influence and service accompaniment", this research builds a three-layer architecture system covering "data perception - intelligent analysis - user response". Through the collaborative design of multi-modal perception, intelligent algorithm and age-appropriate interaction, the natural integration of health monitoring and daily life scenes is realized.

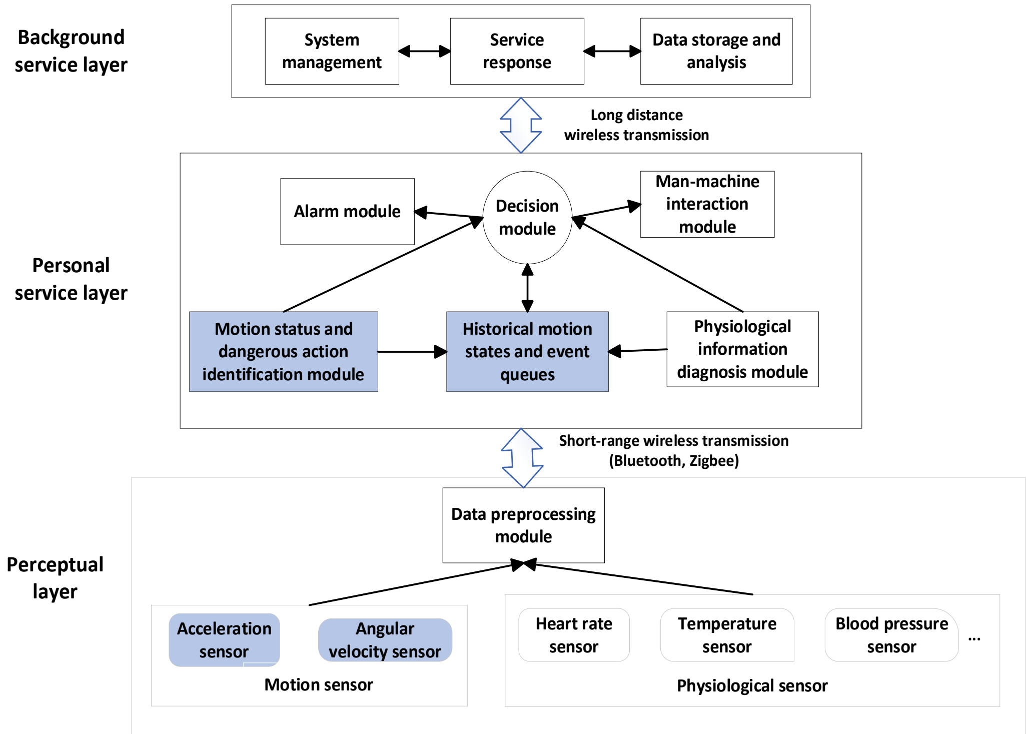

Figure 1. The Composition Structure Of Wearable Health Monitoring System

2.1. System Architecture Design

The system adopts the closed-loop architecture of "perception-decision-interaction", and functions at each level are as follows:

2.1.1. Sensing layer: multi-modal data acquisition

The sensing layer is composed of embedded sensor clusters, which realize the non-inductive collection of physiological and behavioral data without affecting the basic functions of the glasses:

Visual perception module: capture dynamic images of microvessels around the eye by micro-camera, extract basic physiological parameters such as heart rate and blood oxygen;

Motion perception module: integrated acceleration and gyroscope sensors [6], real-time monitoring of head posture and body movement trajectory;

Environment perception module: embedded temperature and humidity sensors to assist in identifying potential fall risk environments such as slippery ground and high temperature;

2.1.2. Processing layer: intelligent data analysis

The processing layer completes real-time assessment and risk warning of health status through edge computing [7] and multi-source data fusion algorithm [8]:

Physiological parameter analysis module: integration of visual signal and motion compensation algorithm to eliminate the interference of daily activities on vital signs monitoring;

Fall recognition module: Based on spatio-temporal feature extraction technology [9], multi-dimensional fall determination model is constructed by combining motion trajectory analysis (such as abrupt acceleration and attitude Angle change) and environmental parameters;

Dynamic threshold adjustment module: adaptively optimizes algorithm parameters according to user behavior patterns to reduce false positive rate;

2.1.3. Interaction layer: undisturbed feedback mechanism

The interactive layer uses a lightweight design concept to ensure that older users are "ready-to-use":

Voice interaction system: transmit health status alerts and fall alerts through bone conduction technology;

Intelligent warning mechanism: Level 1 warning (low risk) : micro-vibration reminder of mirror leg; Level 2 warning (medium risk): voice broadcast advice; Level 3 warning (high risk): automatically send location information to emergency contacts;

Low power consumption management module: based on event-triggered power control strategy, extend device battery life, and compress computing resource consumption through intermittent data acquisition and lightweight algorithm;

2.2. Modular Cooperative Logic

The system realizes functional linkage through two-way coupling of data flow and control flow:

2.2.1. Data Flow

The original data of the sensing layer (such as acceleration waveform, temperature and humidity reading) is transmitted to the processing layer through Bluetooth 5.0;

Adaptive filtering algorithm [10] was adopted in the processing layer to complete physiological parameter calculation and risk assessment;

The interactive layer triggers hierarchical warning according to the analysis results;

2.2.2. Control logic

Daily monitoring: collect physiological data periodically (every 10 minutes/time), and store health data locally for 24 hours;

Anomaly monitoring: When an anomaly is detected, start high-frequency data acquisition (100Hz sampling rate);

Emergency response: After confirming high-risk events, activate the NB-IoT module to send positioning distress signals;

2.2.3. Fault tolerance mechanism

Data verification: eliminate transmission errors through CRC verification and timestamp alignment;

Redundancy design: Key modules (such as fall detection) are verified by dual algorithms in parallel;

Security protection: hardware watchdog circuit to prevent system crash;

2.3. Invisible Design Innovation

In order to realize the deep integration of the health monitoring function and the glasses carrier, the system is optimized in the following aspects:

2.3.1. Hardware layout design

Space reuse strategy: The camera is embedded in the nasal bracket, and the mirror reflection principle is used to capture the signal around the eye; IMU sensor is built into the mirror leg hinge to reduce the impact of center of gravity deviation; The bone conduction module is integrated at the end of the mirror leg and fits into the vibration conduction area of the temporal bone;

Ergonomic design: The elastic hinge of the mirror leg supports 15° adaptive adjustment to adapt to different head circumference sizes; Sensor layout conforms to the head pressure distribution model (auricle load-bearing ratio > 60%);

2.3.2. Functional coupling design

Optical reuse: the lens coating layer integrates transparent electrodes to achieve physiological signal acquisition and vision correction function reuse;

Energy reuse: Use the opening and closing kinetic energy of the mirror leg for energy recovery to extend the battery life of the equipment;

Design for social acceptance

Appearance concealment: retain the traditional glasses shape, no exposed electronic components;

Privacy protection: data is stored locally encrypted and can be exported only after biometric authentication;

2.4. System Scalability Design

In order to meet the needs of future functional upgrades, the system reserves three expansion interfaces:

Hardware expansion interface: standard slots are reserved for mirror legs, supporting external sensors and other modules;

Algorithm upgrade interface: Open SDK for third parties to develop customized health analysis models;

Service interface: compatible with mainstream medical cloud platform to achieve data interconnection;

Through systematic architecture and modular innovation at the theoretical level, the design provides a complete theoretical framework for the subsequent technical implementation, while taking into account the technical feasibility and user acceptance, forming a complete closed loop from data perception to health services.

3. IMPLEMENTATION OF CORE FUNCTIONS

3.1. Non-inductive Monitoring System For Vital Signs

Based on photoelectric volume pulse wave (PPG) technology [11], a physiological parameter monitoring scheme suitable for optical glasses platform was proposed. The system is designed to integrate optical sensor group at the nose base of eyeglasses to realize non-invasive monitoring by detecting the blood flow changes of microvessels around the eye.

PPG monitoring on the lens carrier needs to consider the following key factors:

(1) Optical sensor configuration:

Dual wavelength measurement: 940nm near-infrared light (suitable for blood oxygen monitoring) and 530nm green light (suitable for heart rate detection);

Sensor layout: Reflector measurement is adopted at the nose bracket, and the distance between transmitter and receiver is recommended to be 3-5mm;

(2) Signal processing process:

In terms of signal processing, the system integrates the motion compensation algorithm and the improved Beer-Lambert law calculation method to ensure the accuracy of monitoring data.

Table 1. Expected Performance Indicators Of Vital Signs Monitoring

argument	Expected accuracy	Measurement principle
Heart rate	±3bpm	PPG peak detection
Blood oxygen saturation	±2%	Dual wavelength ratio method
Respiratory rate	±1 time/minute	PPG amplitude modulation analysis

3.2. Fall Detection System

This system adopts multi-dimensional analysis method to achieve fall detection function:

(1) Multi-feature fusion detection:

Time domain analysis: comprehensive acceleration and attitude Angle change characteristics;

Frequency domain analysis: energy feature extraction based on wavelet packet;

Environment perception: combined with auxiliary information such as ground material;

(2) Intelligent classification algorithm:

Adopt lightweight LSTM network model;

Input dimension: 6-axis motion data (acceleration + angular velocity);

Output: fall event probability assessment;

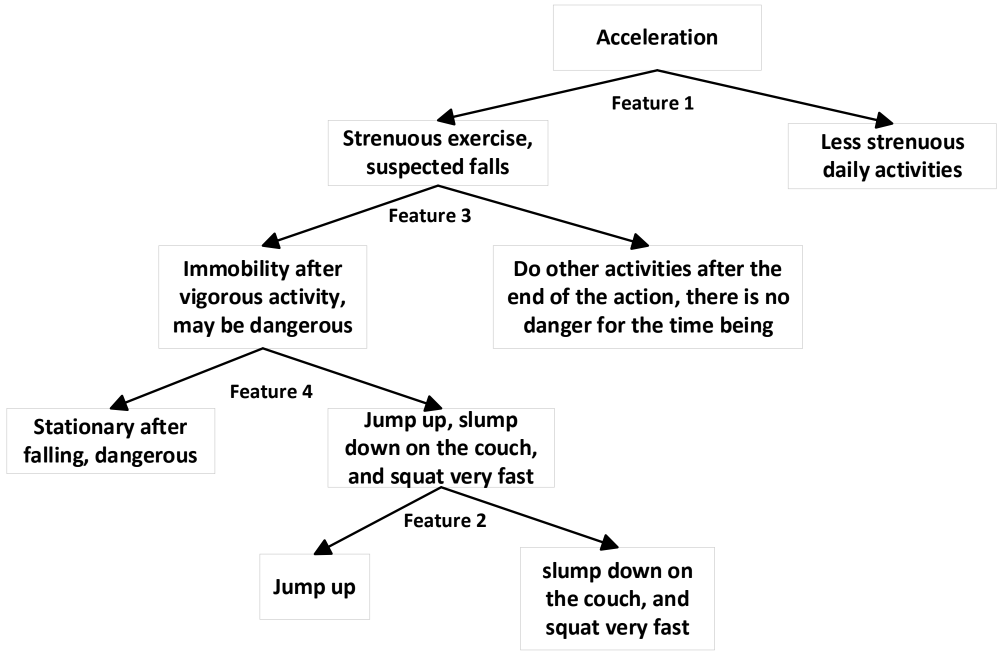

Figure 2. Fall Recognition Algorithm

3.3. Interaction And Security System

(1) Hierarchical response mechanism

Low risk: tactile vibration reminder

Medium risk: voice warning warning

High risk: Automatic emergency help

(2) Efficient energy management

Using dynamic voltage Frequency adjustment (DVFS) technology:

Dynamic power regulation: divided into normal mode and low power mode;

Event-driven data acquisition;

Multi-mode intelligent switching;

(3) Security and privacy protection

End-to-end data encryption (AES-256/TLS);

Biometric authentication mechanism;

4. SUMMARY

In this paper, an innovative design scheme of health monitoring glasses system based on intelligent vision technology is proposed. The physiological monitoring function is seamlessly integrated into the traditional glasses frame through the multi-mode sensor fusion technology, which realizes the non-inductive health monitoring while completely retaining the vision correction function. The system uses an innovative spatio-temporal feature fusion algorithm to achieve accurate fall recognition. Combining lightweight edge computing architecture and voice interaction design, it provides a convenient experience of "wear and use" for elderly users.This study breaks through the limitations of traditional health monitoring devices in terms of wearing comfort and ease of use, and opens up a new paradigm of "technology for aging".

Looking forward to the future, with the continuous optimization of monitoring algorithms and the development of new sensing technologies, the system is expected to be deeply integrated with the smart elderly care platform to provide more perfect solutions for the health care needs of the aging society. This technology path is not only suitable for elderly health monitoring, but also provides an important reference for the design of wearable devices for other special populations.

ACKNOWLEDGEMENTS

This work was supported in part by the Student Research Training Program of Henan University of Science and Technology (No. 2024147). We are very grateful to these grants provided.

REFERENCES

[1] Xiang Xin, Wang Yi. Current situation, characteristics, causes and countermeasures of population aging in China [J]. Chinese Journal of Gerontology, 201, 41(18):4149-4152. (in Chinese)

[2] Li Nan, Xu Lei, Liu Liyan, et al. Application research of wearable devices for health monitoring of the elderly [J]. Knitting Industry, 2022, (06):60-63.

[3] Chen Sutong, Hou Chengyi, Li Yaogang, et al. The present situation and the tendency of the development of intelligent glasses [J]. Journal of glass enamel and glasses, 2021, 49 (07): 29-36. DOI: 10.13588 / j.carol carroll nki g.e. 2096-7608.2021.07.005.

[4] Zhao Shifan. Research on smart wearable design for the elderly based on multi-modal interaction [D]. Jiangnan university, 2024. DOI: 10.27169 /, dc nki. Gwqgu. 2024.000471.

[5] Li Na. Research on wearable health monitoring system based on human motion status recognition [D]. Beijing University of Technology, 2013.

[6] Wu Tian-hao. Elderly fall recognition based on 3-axis acceleration sensor and gyroscope [D]. Beijing University of Technology, 2013.

[7] Shi Weisong, Sun Hui, Cao Jie, et al. Edge Computing: A new computing model in the Internet of Everything era [J]. Journal of Computer Research and Development, 2017, 54(05):907-924.

[8] Qi Youjie, Wang Qi. Review [J]. Journal of multi-source data fusion algorithm and space electronic countermeasure, 2017 (6): 37-41. DOI: 10.16328 / j.h tdz8511.2017.06.009.

[9] Sun X J. Research on Human behavior recognition technology based on spatiotemporal feature fusion network [D]. Shandong university, 2022. DOI: 10.27272 /, dc nki. Gshdu. 2022.003163.

[10] LI Yi. Research on Adaptive Filtering and Filtering Algorithm [D]. Northwestern Polytechnical University, 2003.

[11] Wang Yuejun. Respiratory rate monitoring based on photoelectric volume pulse wave [D]. Beijing Institute of Technology, 2015.