Smart Bracelet Design and Function Improvement

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Abstract.

With the increasing development and popularity of smart wearable devices, smart bracelets have become one of the hottest smart devices today. Through a comparative analysis of existing products, this paper proposes improvement strategies in the three main directions of UI and module design, security, and handling of health issues to provide a product that is easier to use and meets the health needs of the elderly. For the direction of UI and module design, it is proposed to add the gesture recognition function and develop it in the direction of non-contact recognition based on the existing technology, and at the same time, use machine learning to achieve personalized recognition. Based on personalized module design, a GPS tracking device is installed to prevent users from being tracked, and a new network module is added to enable users to get in touch with others at a time when they encounter danger in remote areas. Improvement strategies in the security direction include data transmission, storage, and device security. The smart bracelet can use trusted computing for data encryption and storage by adding low-power core and optimizing the data transmission in three paths: local area network (LAN), public network (PN), and the cloud.

Regarding health problem processing, it is proposed to achieve fall prevention through scene recognition and optimize the fall detection function through user information. In addition, this paper takes UV irradiation as an example to point out that smart bracelet devices can be added with new indicator detection technology to prevent some diseases. At the same time, a full voice interaction system can be developed to meet the social needs of the elderly.

Keywords: smart bracelet; security; older people; module design; fall detection

1. Introduction

In today's era, smart bracelets have become the choice of more and more people. However, the vast majority of smart bracelet manufacturers are still using the logic of smartphones to make smart bracelets; in fact, the operation logic of smart bracelets and smartphones is completely different. And for older people, that means they have trouble understanding and using smart bracelets. At the same time, with the popularity of smart bracelets, people began to pursue personalization and stronger practicability, including urban environment and field environment at the same time (such as switchable communication modules, including LTE, WIFI, ZigBee, Starlink, etc.). People have also begun to notice that using smart bracelets can identify the surrounding risk factors, the upcoming risk prevention, the user's physical and mental health care, and the security risks of smart bracelets themselves. The criminal risk caused by the data leakage of smart bracelets is increasing, and manufacturers only pay attention to the data protection of smartphones while ignoring the data protection of smart bracelets. Therefore, people urgently need more secure bracelets to protect users' personal safety and privacy. At the same time, with the development of biosensors carried by smart bracelets, smart bracelets, a new type of wearable medical device, are widely used for the elderly. Still, today's smart bracelets are rarely designed or optimized for the elderly.

Currently, most smart bracelet research concentrates on using sensors to collect increasingly precise user body data; it largely overlooks the fundamental components of the bracelet, such as its design, functionality, user protection, and ease of use. The protection of users is not only the protection of body and mind but also the protection of user privacy. At the same time, the needs of the elderly as a large potential user group of smart bracelets are ignored. Protect the physical and mental health of users and prevent personal safety, including the user's own physical and mental detection and simple judgment, apnea, accidental falls, a variety of detection methods and treatment of heart problems, the prevention of criminal acts such as voyeurism, the detection of harmful rays, and give users some life advice. Discuss the huge issues of data security for today's smart bracelets, including the violation of privacy, the crime caused by a large number of data breaches, and the potential risk of crime. Some suggestions for improvement are also described, including solutions for local data security, data security in transit, data security in the cloud, and device loss through the TOR network, requirements for more secure transport protocols, and encryption modules at the hardware level as possible solutions. Finally, the paper discusses that the elderly, as major users of smart bracelets, can alleviate the waste of medical resources for the elderly in some areas and the lack of medical resources for the elderly in some areas by using new forms of interaction, including gesture control, more friendly disease prediction function, accident handling function, and life suggestion function for the elderly.

2. Gesture Recognition and Module Design

2.1 Gesture Recognition

Currently, few smart bracelets on sale in the market have the function of gesture recognition, and even if some of them have this function, there are few operations it can do for the user. Due to the size limitation of the bracelet dial, it is not as convenient for the user to perform some operations as other touchscreen devices, and this is where gesture recognition comes into its own. The convenience of a bracelet with gesture recognition is reflected in the more intuitive and seamless interaction between the user and the device.

In addition to the existing recognition methods, such as detecting changes in the pressure of the hand on the screen and sensing the muscle movements of the hand wearing the smart bracelet, a much more convenient method can be developed in the future—non-contact gesture recognition. With non-contact gesture recognition, users can perform common operations such as answering a call, cutting a song, and checking a message. Simple gestures without touching the screen or using physical buttons make the operation more efficient and convenient. For another, apart from the gestures that come with the bracelet, users can also customize the gestures, which are recorded through the special camera of the smart bracelet. Then, the bracelet carries out gesture segmentation, gesture analysis, and machine learning, and finally, it completes the task that the user needs.

This improvement makes the bracelet more convenient to use in specific scenarios. For example, when exercising, users do not need to stop to unlock the screen or press the button but can access the exercise data or switch the exercise mode by simple gestures, which improves non-interference and safety during exercise. This intuitive gesture interaction not only conforms to ergonomic design but also provides users with a more natural and smooth experience, reflecting the urgency of improving the bracelet’s technology.

2.2 Module Design

In this era, people are increasingly pursuing personalization; thus, many commodities appear as customized models. Even if the price of personalized products is higher, many users will still choose to customize according to their preferences. In addition to the necessary modules, the smart bracelets are designed to meet the adjustment that each module can be added or subtracted according to the user‘s needs. In the meantime, this adjustment will greatly increase the practicality of the smart bracelet. Before getting the smart bracelet, users can choose the modules in their smart bracelet, including system software modules and hardware modules, to customize a unique bracelet. This paper devises the following two new modules which users can choose.

2.2.1 Privacy and Security Module

There have always been clandestine photo-taking or eavesdropping incidents in hotels, fitting rooms, public toilets, rented flats, etc. Some pinhole cameras are extremely hidden and hard to detect, which is very disturbing to many people. Therefore, adding infrared or wireless signal detectors to smart bracelets can prevent users from being illegally monitored and eavesdropped on. When users come to hotel rooms or fitting rooms in shopping malls, they can turn on the privacy and security module to detect and ensure the safety of their environment. In addition, some criminals will install GPS tracking devices on other people‘s cars; after adding a GPS detector to the smart bracelet, users can turn on this function when they are near their cars to eliminate the security risks in time and prevent being tracked.

2.2.2 Network module

In recent years, more and more people have liked wild adventure activities, but the signal in the wild is often weak. Thus, some accidents happen. Developing a new type of network module in smart bracelets can reduce the casualties of accidents to a certain extent; users can choose the network mode based on this module. On one hand, users can use the same mobile data traffic as now or connect to WiFi in the city. On the other hand, when users want to go to the wilderness or remote areas, they can assemble the satellite communication device matched with their smart bracelets in advance and switch the bracelet to the satellite communication mode. If they encounter dangers, even with no signal, they can call for help via satellite phone while sending their positioning. Moreover, this module is particularly useful for people working or living in remote areas. Except for the satellite phone and positioning function, users can also utilize satellite internet access, and the internet speed in this mode is much faster than that of mobile data traffic and WiFi.

3 Security

3.1 Data Security

3.1.1 Local Data Security

With the rapid development of smart bracelets, people are paying more and more attention to data security. Human biological data and information collected by smart bracelets in the surrounding environment have become a major new threat to personal safety and invasion of privacy [1]. At the same time, the loss of smart bracelets and the unsafe disposal of discarded smart bracelets is a major source of data leakage. For example, for human beings whose biological gender is female, the criminal can commit a crime at the weakest time of the victim through the menstrual prediction function of the smart bracelet, and the microphone and positioning system on the smart bracelet can also become the "accomplice" of human trafficking.

Therefore, the requirement for data confidentiality is imminent, and people urgently need an encryption method for the smart bracelet, encrypting the local data, and need to be invisible to avoid affecting the consumer experience. Now, trusted computing can solve many computer security problems and has been widely used in desktop computers, notebooks, smartphones, and other fields of methods; the standard is promoted by the computing and communication industry through the TCG.

The traditional method of trusted computing needs to add a separate chip called the Trusted Platform Module (TPM). However, adding a TPM chip independently for devices with power-sensitive and small space, such as smart bracelets, is not feasible. Therefore, the smart bracelet SOC needs an additional low-power core (independent of other cores). For example, Cortex A35 is based on an ARM64-bit Armv8-A instruction set. This is where additional low-power cores run security-related operations such as data encryption and decryption, key storage, and booting of the operating system.

This low-power core, independent of other cores, is always kept on, has independent L2 and L3 caches, and is in ECC mode. Running SW-TPM (software TPM) on this core can achieve the encryption effect without consuming too much power [2].

For all sensitive operations, 2FA(two-factor authentication) verification is necessary. According to one study, 2FA has an interception success rate of more than 90% against known attackers [3].

Remote erase and lock functions are implemented with a separate security core and TPM running to prevent unauthorized access when the bracelet is lost or stolen.

3.1.2 Transmission data security

Smart bracelets usually use Bluetooth and WiFi to transmit data in the LAN(local area network) but generally use insecure transmission protocols. There are still many smart bracelets using Bluetooth 4.1 and WPA2 protocol; this means that Key Reinstallation Attacks and offline dictionary attacks are difficult to resist, so the risk of data transmission is greatly increased [4]. Therefore, for the new smart bracelet, WPA3 and Bluetooth 5. x should be supported to reduce the risk of data transmission. At the same time, technologies such as LAN isolation and VLAN (Virtual Local Area Network) can be used to restrict the access of devices on the LAN to each other at will to increase security, also by regularly forcing updates to the firmware and software of the smart bracelet to remedy known vulnerabilities and improve the overall security of the system.

Many of the applications and functions (such as physiological data synchronization) in the built-in system of a large number of smart bracelets are actually implemented in the browser, and many of them still use the old HTTP protocol; this means that such data is vulnerable to compromise, tampering, traffic hijacking, phishing attacks, and more. Therefore, mandatory HTTPS for smart bracelets is needed to solve the shortcomings of the HTTP plaintext protocol [5]. Add SSL/TLS protocol based on HTTP, rely on an SSL certificate to verify the server's identity, and establish an "SSL" channel between the client and the server to ensure the safety of data transportation. At the same time, the sensitive information in the transmission data is identified, and the data is deleted when the transmission security confidence is too low by using a secure communication protocol, such as a VPN (Virtual Private Network), to encrypt and obfuscate data traffic, especially when communicating over an insecure public network. At the same time, access to the Internet is through the Tor network to protect data security and user privacy.

3.1.3 Cloud Data Security

Now, most smart bracelet manufacturers do not have any encryption for the data itself, which means the data is transparent to the manufacturer [6]. This means that the user has to bear the risk of the vendor's data breach and the potential moral hazard to the vendor's staff (snooping on the user's data). Therefore, the AES-256 and SHA-512 algorithms should encrypt the bracelet data when uploaded to the smartphone and the cloud server. The original encryption key should be stored in the TPM of the smart bracelet and smartphone, and the original key should only be known by the user. The manufacturer cannot decrypt the data stored in the cloud at the manufacturer to ensure security.

3.2 Equipment Safety

Smart bracelets are still a big problem with today's battery technology. Therefore, users usually need to pick up the smart bracelet at least once every two days to charge its battery, which usually leads to the user not finding the smart bracelet. The ubiquitous problem of losing smart bracelets can be found by using GPS and WiFi based positioning technology under high battery capacity, using a privacy-secure finding system based on BLE (Bluetooth Low Power) with high battery remaining and open API(Application Programming Interface) and allowing access to other API to ensure availability in the vast majority of cases [7, 8].

4 The Research and Protection of the Elderly

4.1 Handling of Accidental Falls

In recent years, many elderly people have been seriously injured or even died because of accidental falls. Therefore, fall prevention and detection is the main research direction of many scholars worldwide. Given the smart bracelet's handling of falls as accidental, this paper will propose the following improvement directions.

4.1.1 The prevention of fall behavior

This paper initially divides the factors that lead to fall events into environmental and personal factors. The environmental factors refer to the scenes where the frequency of fall events is high, such as bathrooms and staircases. In contrast, the behavioral factors refer to the action behaviors of the faller before the fall occurs.

Therefore, this paper proposes that the smart bracelet of the future should have the following features: The device can assess the risk through scene recognition and send reminders to the wearer through the device to increase the degree of alertness and reduce the possibility of falls. In the bathroom scenario, for example, the smart bracelet can detect the humidity of the air. When the device recognizes that the wearer is in an environment with high humidity, it can send a reminder to the wearer.

4.1.2 Fall detection

The fall detection technologies applied worldwide mainly include sound frequency signal recognition, image recognition, and sensor recognition. Among them, the sensor recognition technology is the one that is used in most of the smart bracelet devices [9]. Most products today use acceleration sensors; establishing coordinate axes in the three-bit space detects acceleration in each direction. After that, different kinds of thresholds are set up to confirm whether or not a fall has occurred, and the threshold-setting methods used in the existing research include calculating the combined acceleration, calculating the angle of stance by utilizing the relationship between acceleration in each direction, and gravity, and so on [10,11].

This type of detection through accelerometers improves the accuracy of the inspection, and many researchers have done extensive experiments with their techniques to come up with the most accurate threshold ranges. the subjects selected for these experiments were nearly average in all their physical indicators. As a result, the threshold settings used in the fall detection function of smart bracelet products on the market today do not apply to all users, to the extent that this function is not as accurate as it could be for some users. This paper offers the following direction for follow-up research to address this problem:

Through machine learning, the relationship between the optimal threshold and the wearer's physical indicators is analyzed so that the smart bracelet can determine the appropriate threshold through the user's indicator, which can improve the accuracy of the fall detection function when used for each user and achieve product personalization.

Meanwhile, for inpatient users, the smart bracelet can be optimized for fall detection in different scenarios based on the patient's specific situation through big data statistics. Scenarios include getting in and out of bed, riding a wheelchair, and changing body position while toileting.

4.2 Smart Bracelets and Physical and Mental Health

Recently, the number of older people using information technology products has increased rapidly [12]. Surveys show that the use of digital health technology among people aged 65 and above has increased to 25% in 2014. Elderly people can wear smart bracelet devices to monitor physiological data in real time so that they can be detected and receive treatment when their bodies are abnormal. In this paper, we believe that smart bracelet devices have the following directions for extended development.

4.2.1 Physical health

Smart bracelet devices have been applied to the daily care of some chronic diseases, such as diabetes, hypertension, heart disease, etc. There are also studies showing that some of the functions of smart bracelets can be applied to the treatment of some rare diseases, such as the literature shows that the respiratory function training function of smart bracelet devices can be used for the treatment of patients with obstructive sleep apnea syndrome [13]. Future research could expand on more indexing techniques so that they can be applied to treating and caring for a wider range of diseases.

For example, it has been shown that UV exposure can reduce the incidence of common diseases such as diabetes and cardiovascular disease [14]. The smart bracelet can make a suitable sun exposure plan for the user according to the intensity of external ultraviolet rays and play a role in disease prevention. At the same time, long-term UV exposure will also damage the human body, such as skin photoaging, skin cancer, cataracts, etc. Therefore, the smart bracelet can also be used to prevent UV diseases through the detection of UV technology; when the UV intensity is detected to be beyond the acceptable range of human skin or when the exposure time is too long, it will remind the user to protect themselves from the sun.

4.2.2 Mental health

For elderly people, using bracelets to keep track of their daily lives and maintain a positive mood is also one of the reasons they use smart bracelet devices. Nowadays, many elderly people are not well integrated into the contemporary social environment under the rapid development of information technology and are unable to skillfully use smartphones for socializing, which makes the daily life of many elderly people in recent years receive a great degree of restriction. Based on this problem, several researchers have devoted themselves to studying intelligent interaction systems for the elderly in recent years, such as the VR application chat system in the literature. In the future, these technologies can be applied to smart bracelet devices, using big data analysis to customize personalized full-voice interaction systems for elderly users to meet the social needs of the elderly. At the same time, different chat modules can be designed to provide psychological guidance for the users according to their psychological condition, so that it can prevent psychological diseases in the elderly.

5 Conclusion

This research found that the smart bracelets currently sold on the market still have problems that need to be improved in some aspects. Firstly, the gesture recognition function is incomplete and has few operations that can be realized. In the meantime, users are paying much attention to the practicality of the bracelet, and the existing bracelet modules do not satisfy users‘ needs for privacy and network. Secondly, data leakage can easily lead to various problems, even life-threatening, which makes users trust smart bracelets less. Nowadays, it is difficult to retrieve smart bracelets after they are lost, which may also lead to the leakage of private information. Thirdly, there is a lack of bracelets for the older people in the market. At present, bracelets on sale do not have the function of detecting falls among seniors, nor do they have the function of preventing physical and mental illnesses.

This research proposes suggestions to improve the above three aspects. First and foremost, developing non-contact gesture recognition for smart bracelets will give users a better interaction experience. This paper also recommends customizing the smart bracelet and suggests the development of two new modules—the privacy and security module and the network module. These two modules can effectively prevent users from being tapped, listened to, and tracked and provide better communication. Moreover, this paper proposes specific encryption suggestions for the security of local data, data transmission, and cloud data. Even if the smart bracelet is lost, the user can find it through GPS and WiFi to prevent the information from being stolen. Last but not least, this paper suggests preventing falls of older users through scene recognition and optimizing the detection of different individual situations and specific scenes through machine learning. Meanwhile, this paper also proposes designing the UV detection function of the smart bracelet to reduce the incidence of diabetes and other diseases and adding a full-voice interaction system to the smart bracelet to prevent mental illnesses in older users.

This research provides directions for future improvements of smart bracelets in three areas: gesture recognition and module design, data security and device safety, and protection of the elderly, suggesting some specific methods. This paper does not fully consider the feasibility of some technologies and whether they can be applied to the smart bracelet. Users' needs have been changing over time, and all aspects of the technology can be improved in the future to enhance the user interaction experience.

Authors Contribution

All the authors contributed equally, and their names were listed alphabetically.

References

[1] Wilkowska W, Ziefle M. Privacy and data security in E-health: Requirements from the user's perspective. Health Informatics Journal. 2012;18(3):191-201.

[2] Najwa Aaraj, Anand Raghunathan, and Niraj K. Jha. 2009. Analysis and design of a hardware/software trusted platform module for embedded systems. ACM Trans. Embed. Comput. Syst.,12008,8(1):3-8.

[3] Reynolds J, Samarin N, Barnes J, et al. Empirical measurement of systemic usability. Useni Security Symposium, 2020,20: 127-143.

[4] Appel M, Guenther I S. WPA 3-Improvements over WPA 2 or broken again[J]. Network, 2020, 7.

[5] Durumeric Z, Ma Z, Springall D, et al. The security impact

of HTTPS Interception[C]//NDSS. 2017.
[6] Aldossary S, Allen W. Data security, privacy, availability and integrity in cloud computing: issues and current solutions[J]. International Journal of Advanced Computer Science and Applications, 2016, 7.
[7] Manikanta Kotaru, Kiran Joshi, Dinesh Bharadia, and Sachin Katti. Decimeter level localization using WiFi. SIGCOMM Comput. Commun,2015,45(4), 269–282.
[8] Sun Xiaowen, Sun Ziwen, Qin Fang. Research on human fall detection based on threshold and pso-svm[J].Computer Engineering,2016,42(5):317-321
[9] QU Junsuo, QIAO Ning, SHI. Haonan, SU Chang, Razi Abolfazl. Convolutional neural network for human behavior recognition based on smart bracelet[J].Journal of Intelligent & Fuzzy Systems,2020,38(5):5615-5626.
[10] Wang Rong, Zhang Yun, Chen Jianxin.Design and implement a fall detection system using a tri-axis accelerometer[J].Journal of Computer Applications,2012,32(5):1450-1452,1456.
[11] Jeng MeiYuan,Yeh TsuMing,Pai FanYun. Analyzing Older adults' perceived values of using smart bracelets by means-end chain[J].Healthcare,2020,8(4):494.
[12] Cao Xia, Zhou Xiaoli, Xue Mingyue, Li Xiaolong. Effect of Respiratory function training based on smart bracelet on patients with obstructive sleep apnea syndrome[J].Prac Cardiac Cereb Pneum Vasc Dis,2023,31(8):119-123+127.
[13] Zhu Qianqian, Zhu Zhi kai, Yao Sheng hong. Research Progress on roles of ultraviolet irradiation in diseases[J].Journal of Environmental and Occupational Medicine,2023,40(7):848-853.
[14] Yan Chao. Design and Implementation of chat system for elderly virtual reality Application[D].Huazhong University of Science and Technology, 2019.