Development of IoT Healthcare Platform Model for the Elderly using Bigdata and Artificial Intelligence

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Abstracts: The entry into an ultra-old society in South Korea, the remarkable development of medical technology as well as the recent emergence of the Fourth Industrial Revolution have contributed to the steady growth of the silver industry in line with the demand for healthy lives of the elderly. However, the silver industry of South Korea is still a rudimentary level. The existing older telecare product was sensor-based and was able to respond at or after the accident. However, there are limitations in preventing and predicting accidents. In particular, preventive healthcare is very important because even in small accidents, older people can be at great risk. We intend to build a healthcare platform based on IoT, against this backdrop. Based on previous studies, we try to build a new concept of architecture by collecting, storing and analyzing data to overcome the limitations of existing platforms. It's supposed to build cloud-based Bigdata storage that can collect and analyze real-time operating conditions for older people with cameras and mobile phones, and study algorithms for old-age care through Artificial Intelligence. This research would certainly give more safe accident prevention and health care for the elderly and the healthcare industry.

Keywords: Artificial Intelligence, Bigdata, Healthcare, Internet of Things, Platform.

1. INTRODUCTION

Recently, the size of the global elderly-friendly market has more than tripled over the past four years. With the entry into a low birth rate and aging society, the elderly population increases every year, and healthy living for the elderly is becoming very important. The purpose of this study is to design and develop a so-called '100-Year-Old Healthcare (Wehde, 2019) (Katsaliaki & Mustafee, 2011) (Lenz & Reichert, 2007) Platform (Parker & Van Alstyne, 2014) (O'Reilly, 2011) (Gawer, 2009)' using Internet of Things (IoT) (Madakam et al., 2015) (Yang et al., 2011), Artificial Intelligence (AI) (Ghafoor, Hussain, & Ahmad, 2023; Minsky, 1961) (McCarthy & Hayes, 1981), and Bigdata (Sagiroglu & Sinanc, 2013) (George et al., 2014) (Oh, 2015) (Jeong et al., 2020) (Kang & Jung, 2016) (Lee & Han, 2019) (Lee, 2020) technologies to reduce the accident rate of the elderly and solve major social issues. The core topics to be designed in this study can be summarized into three as follows. (1) By constructing an architecture that collects, stores, and analyzes elderly behavior, information on the status of the elderly (including patients) is collected in real time (camera, voice, etc.) to build a dataset. (2) By designing an AI algorithm that analyzes elderly behavior, it is intended to conveniently recognize images and voices of the elderly. (3) It is to develop a 365-Day+24-Hour Care Service Platform for elderly caregivers. Healthcare equipment, elderly emergency situations, elderly abnormal behavior analysis, health status analysis, and community services will always be managed on this platform. Recently, healthcare services around the world are evolving into artificial intelligence-based services beyond simple information management (Altakhayneh, 2022; Habib, Farooq, & Rizvi, 2022). By applying IoT, Bigdata analysis, and AI learning algorithms to existing products, it is possible to monitor the elderly in real time (Wang, & Wu, 2022). It is urgent to develop a next-generation (100-Year-Old Care) platform that can be pre-care by capturing risk signs.

2. RELATED WORKS

2.1. Internet of Things

It is a concept that emerged with the development of Information and Communication Technology (ICT). Literally, computer communication functions are attached to various objects to link them with smartphones. The term originated in 1999 when Kevin Ashton of MIT(Massachusetts Institute of Technology)'s Auto ID(Identification) Center predicted that the Internet on objects would develop using RFID(Radio Frequency ID) and sensors. As the name suggests, the IoT refers to a technology that goes beyond people-to-people communication and gives IP(Internet

Protocol) addresses to objects and leads to communication between people and objects, or between objects and objects. A device that is operated remotely is often thought of as the IoT, which includes an Internet system set up on the device. Similar to ubiquitous, it became a more extended concept by absorbing its existing own communication system into the Internet system. The concept of the IoT is often called Machine to Machine (M2M), but the concept of M2M and IoT is slightly different. Roughly speaking, M2M is a rather technical and narrow term for the exchange of information between terminals, and it can be said that IoT is an ecosystem of M2M by expanding it to all possible electronic devices. The IoT tends to introduce the Internet to the activation of inter-object networks in more earnest, and its active aspect is highlighted. Meanwhile, M2M has a strong aspect limited to communication like remote controls and barcode readers, and is generally less active, if not all. Currently, the number of lines on the IoT in Korea is about 6.11 million, roughly divided into the following five applications. (1) Remote control: Monitoring or controlling the status of fixed devices such as remote meter reading, traffic, water, power, road facilities, etc. (2) Wireless payment: VAN(Value-Added Network) tasks such as food delivery man's portable credit card payment terminal (3) Vehicle control: location monitoring or control (4) Tablet PC(Personal Computer): Portable tablet device such as insurance salesperson, logistics management, site management, etc..

2.2. Existing Healthcare Platform

In 2019, the second-largest cause of death in South Korea for the elderly aged 65 or older was a fall accident. 65% of these falls occur in beds. Accordingly, many companies and research institutes have developed an AI-based fall prevention system to prevent and respond early to bed falls. Accordingly, 300,000 elderly data were learned for the first time in Korea, achieving a recognition rate of about 70%. In addition, edge computing and cloud computing were established to utilize real-time image information of phosphorus. However, this senior K(Korea)-Platform has several limitations. First of all, personal information processing for face recognition and learning algorithms for night fall recognition were insufficient. And, it did not become an advanced AI algorithm due to a mixture of perceptions of objects similar to each individual's shape. In addition, there was a lack of sufficient cloud testing for real-time video analysis and rapid action. Despite the South Korean government’s support efforts, the lack of professional manpower and insufficient R&D(Research and Development) investment due to the revitalization of small and medium-sized enterprises-oriented industries are prevalent. Currently, it can be concluded that the recognition efficiency of the elderly K-Platform is significantly reduced due to the occurrence of uneven video types and video clumps. Two problems were identified, such as performance degradation of a server that collects and stores relatively large image information. To solve this problem, I felt limited in building and testing edge computers and cloud architectures. In order to solve these difficulties, many companies have derived the primary results through their own previous studies on the development of artificial intelligence-based fall prevention systems for the elderly, but the quality and performance of the product are judged to be insufficient. It is necessary to secure a test bed for improvement and verify precise technology through cooperation in nursing homes. In addition, it is compulsory to secure market competitiveness of products through integrated development such as fall of the elderly, management of the elderly with dementia, and management of the elderly living alone.

3. STRATEGY PROPOSAL FOR HEALTHCARE

3.1. Major Goals

As the elderly population increases every year due to the entry into a low birth rate and aging society, healthy living for the elderly becomes very important, we intend to solve major social issues by reducing the accident rate by developing and distributing the 'Elderly 100-year-old care platform' using IoT, Bigdata, and AI technology. Detailed development objectives are as follows <Figure 1>. (1) Building an architecture for collecting, storing, and analyzing elderly behavior (2) Building Bigdata for elderly behavior (3) Developing AI algorithms for analyzing elderly behavior.

3.2. First Stage: Architecture Establishment

The first stage is to build a cloud-based collection, storage, and analysis architecture such as video and voice information for the elderly. It enables learning data composition with a Cloud-based Bigdata storage configuration

that can collect and store and analyze the operating state of the elderly in real time with cameras and mobile phones. Real-time video and voice are collected and stored in a cloud environment, and artificial intelligence algorithms use learned data to verify and determine risk status in real time (Almutairi, & Khan, 2022). Through this, the real-time detection function is activated in various environments such as hospitals and homes. This means that scalability, low cost, and high efficiency operation are possible by utilizing the cloud environment, and accident prevention is also possible. Firstly, it is necessary to produce an elderly joint recognition data set. Information on elderly clothes, elderly colors, elderly joints, human body movements, elderly joint angles, and elderly joint rotation is collected. The confirmed structured and unstructured data are tested using various techniques, and more than 30,000 video and image learning data are tested, and more than 50,000 voice learning data are tested. It also constructs an architecture that collects and analyzes real-time state information. Whether or not to build a cloud environment is the key to success, and the response processing speed is set within 3 seconds.

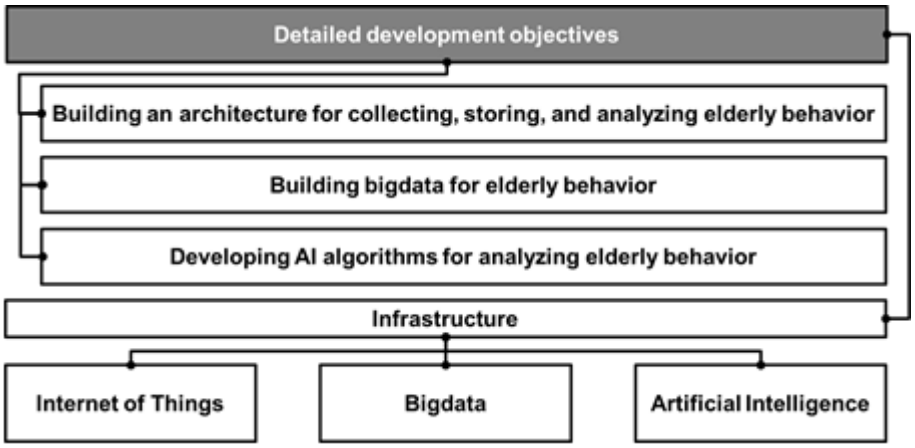

Figure 1. Goals for Healthcare platform.

3.3. Second Stage: AI Algorithm Development

The second stage is the development of elderly behavior (video) and voice recognition AI algorithms. We utilize OpenPose of CNN(Convolutional Neural Network), an artificial intelligence algorithm, to analyze elderly joint detachment, joint rotation, and joint angle, and to analyze dangerous speech using SOLA/STT(Speech-to-Text) of RNN(Recurrent Neural Network), an AI algorithm. This means joint object, angle, and rotation learning, and becomes the basis of voice recognition learning for the elderly. The elderly object recognition and the elderly voice data characteristic information collection takes a method of recognizing clothes, colors, etc., and notifying in advance when a specific boundary value is deviated in consideration of each individual's joint angle and rotation. The image and voice recognition rate are set at more than 90%. Through this, it is possible to expect the possibility of detecting and responding to risk factors in advance, relatively inexpensive on-site installation costs, and the possibility of statistics and analysis of risk factors. The development of image recognition artificial intelligence algorithms using CNN aims to achieve an object recognition rate of 95% or more, a joint recognition rate of 95% or more, and a human motion recognition rate of 85% or more. The development of speech recognition artificial intelligence algorithms using RNN aims to have a voice recognition rate of 89% or higher, a dialect recognition rate of 89% or higher, and a sound height recognition rate of 89% or higher.

3.4. Third Stage: Service Platform Establishment

The third stage is the production of a 365-Day+24-Hour care service platform for the elderly. It is to develop an integrated elderly health care platform that can check risks, request rescue, and check health care equipment on its own by using an elderly-friendly app. It should be designed in a form that can provide services such as personal health check, risk notification, and health equipment purchase using a smartphone app, and immediately notify the elderly such as statistical analysis when they find risk patterns. This means that integrated care for the elderly is possible, and it will contribute to improving the quality of life for the elderly. Above all, basic information on the elderly (age, gender, name, medical history, etc.) is developed in a friendly manner. UI/UX(User Interface and User

Experience) user-friendly methodology should be applied to design an elderly-friendly app screen. In addition, when a dangerous signal is received from a cloud data server, it is notified through a user app and a guardian app. Risk signal reception sets a target value within 3 seconds and determines whether to execute an artificial intelligence algorithm in a cloud environment. It also develops a social communication service that enables conversation or chatting between registered elderly people, which allows the elderly to decide to execute customized chat. In addition, it develops a service that allows the elderly to inquire about health care equipment and directly trade them, allowing them to choose between direct purchase and rental purchase.

4. DETAILED DESIGN FOR HEALTHCARE PLATFORM

4.1. Major Design

The specific design for the elderly healthcare platform is divided into three stages as follows <Figure 2> and <Figure 3>. Detailed design work for each major stage is expressed in detail in the next section.

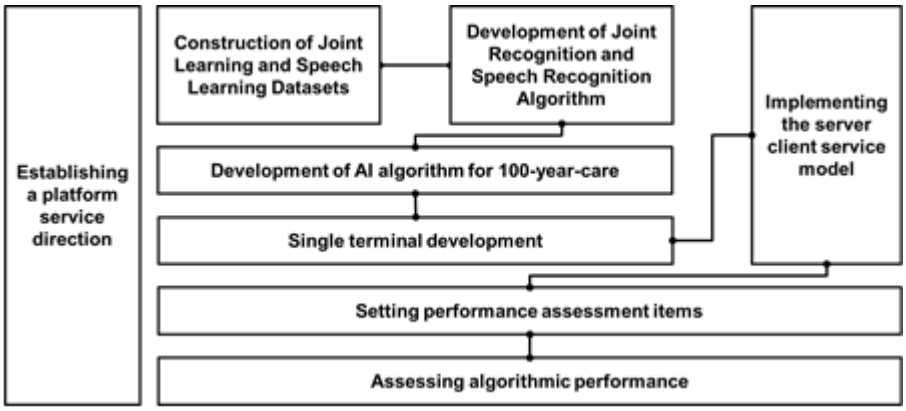

Figure 2. Design stage 1 for healthcare platform.

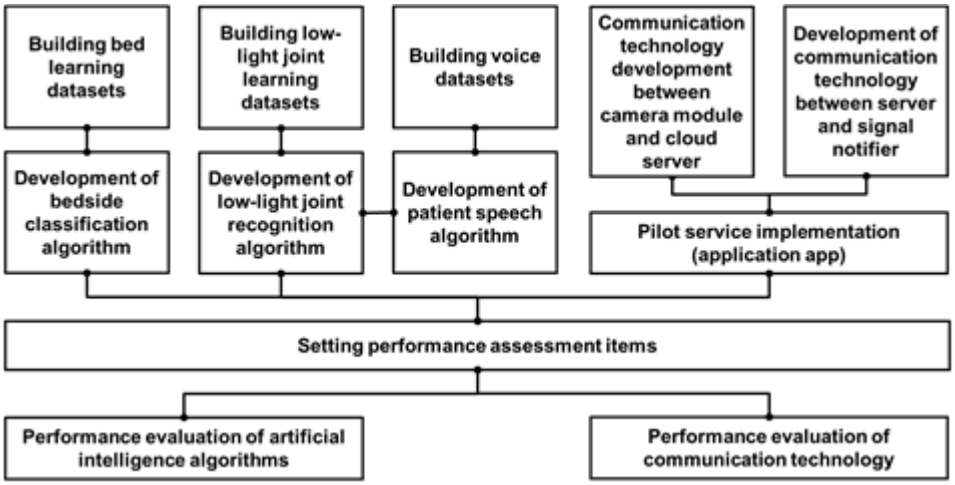

Figure 3. Design stage 2 for healthcare platform.

4.2. First Design: Architecture Establishment

(1) Collection and production of elderly joint recognition data sets: In this work, the image collected first is sliced into an image. Confidence Maps and Affinity Fields are distinguished for each body part in each image. Confidence Maps is used to determine the location of a person's joint in an image. Affinity Fields is used to identify the owner of the joint extracted from the image. Eyes, nose, and ears determine the direction of the face, chest, shoulders, elbows, and wrists determine the direction of the upper body, and pelvis, knees, and ankles determine the direction of the lower body. By vectorizing into Skeleton of the elderly, we analyze and classify the characteristics of the risk/unsafety behavior group of the elderly through the characteristic vector of behavior through the SVM(Surround

View Monitor) classification model. Collect data on the location and angle of joints during dangerous behavior in the elderly.

(2) Collection and production of voice information data sets for the elderly: It is extracted by dividing the frequency domain and the time domain from the collected voice. SNR(Signal-to-Noise Ratio) technology removes noise from speech waveforms. The Feature value of the elderly voice is extracted from the waveform and the pattern is classified through the feature vector. After pattern recognition, phonemes, syllables, and words are reconstructed to distinguish key words (e.g., help me, save me).

(3) Test available structured and unstructured data using a variety of techniques: It analyzes and predicts using collected image, voice, and text data. The Random Forest prediction model developed using Feature Selection was tested. The SVM prediction model was tested using Feature Selection. Without using Feature Selection, a deep learning prediction model was tested.

(4) Real-time state information collection, analysis architecture configuration diagram: It constitutes GPU(Graphic Process Unit-based HW(Hardware), joint recognition, and face recognition S/W. It transmits learning data at the time of abnormal behavior to a cloud environment composed of edge computing. It transmits information to various media such as roaming detectors and cell phones. Personal information data (face information, age information) among the user's learning data are classified and processed as volatile data.

4.3. Second Design: AI Algorithm Development

(1) Development of AI algorithm for elderly motion and posture recognition: The collected image is sliced and constructed as an image. Confidence Maps and Affinity Fields are distinguished for each body part in each image. Confidence Maps and Affinity Fields are bisected to estimate the posture by recognizing the bones between joints and joints that distinguish the owner. If the accuracy estimated by comparing the angle of the joint and the distance between the location information and the bed boundary during the previously entered dangerous behavior is more than a certain level, the behavior is considered dangerous behavior. The number of hidden layers and various images are learned to increase accuracy while increasing the number.

(2) Development of AI algorithm for elderly object recognition: The collected image is sliced and constructed as an image. A CNN Feature map is generated using a CNN algorithm. A feature vector of uniform size is extracted from the RoI(Region of Interest) pooling layer. By inputting the feature vector into the fully connected layer, the object recognition information and the object's bounding box position are output to the output layer. The types of characteristics are identification of the elderly, clothes, colors, meals, and bedtime. We learn by increasing the number of hidden layers and the number of various images.

(3) Development of AI algorithm for the elderly: Collect elderly danger voice signals. It goes through preprocessing such as noise removal. The firing speed is adjusted by cutting a frame that has a certain size in the original signal, copying it to the corresponding frame, and overlapping it to obtain the next frame. Structural signals are determined through reserved words, word matching rates, and pitch levels set in advance through the sound model. The types of features are linguistic dictionaries, dialects, and pitch. It learns to increase accuracy while increasing the number of hidden layers and the number of various voice data.

4.4. Third Design: Service Platform Establishment

The development of the 100-Year-Old Care application for the elderly is designed in the following order. Basic information on the elderly (age, gender, name, medical history) is input. When a dangerous signal is received from a cloud data server, it is notified through a user app and a guardian app. It develops a social communication service that enables conversation or chatting between registered elderly people. It develops a service that allows the elderly to inquire about healthcare equipment and directly trade them.

5. CONCLUSIONS

So far, we have looked at the design and construction of IoT platforms for elderly health. This R&D performance can be expected to have a business effect in terms of science and technology. By maximizing the use of artificial intelligence, Korea can strengthen its status as an AI healthcare country. By establishing itself as a leading country in the application of core technologies in the fourth industrial revolution in the healthcare field, it is possible to revitalize infrastructure technology-linked businesses such as Bigdata, AI, and IoT. In industrial and social aspects, social issues can be solved. By contributing to the solution of the fall problem of the elderly in a low birth rate and ultra-aging society, the number of deaths and injuries can be reduced. In addition, by laying the foundation for total care for the welfare of the elderly, new jobs in the healthcare field can be created. The new healthcare industry for the elderly population, which increases every year, is increasing, and it is possible to cultivate new manpower with relatively low entry barriers and high added value projects. If this study is commercialized, as this healthcare business expands, it is possible to create a new workforce for field management personnel. To this end, it is possible to strengthen work process education for new personnel, increase knowledge sharing opportunities by holding seminars to improve new manpower skills, and consider education support at the national level to foster professionals.

6. ACKNOWLEDGMENTS

Funding for this paper was provided by Namseoul University.

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DOI: https://doi.org/10.15379/ijmst.v10i1.1435