An Intelligent Homecare Emergency Service System for Elder Falling

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Abstract—**As aging people is growing quickly in many countries, the fall problem is formed a curial public health and clinical problem among elderly persons because fall is the prime cause for traumatic death and physical sequela of them. However, as many of the elders choose solitary life alone and because of the isolation, the emergency service model has faced two main challenges: first, how to discover the fall accident; and next, how to communicate the emergency service center. In this research, we propose an intelligent homecare emergency service system based on two intelligent technologies: artificial neural network and intelligent software agent. The fall detector that based on tri-axes accelerometer and back-propagation neural network classifier is implemented to detect the fall events automatically. On the other hand, an intelligent agent-based homecare emergency service system is developed to communicate the emergency service center and hospitals for requesting help. In the meantime, the basic and important health information related to the elder will be sent together with that request. Thus, the emergency service center can base on the elder's information to dispatch an available ambulance that takes the necessary medicines and equipment to the elder's house.**

Keywords—**Homecare, Elder falling, Back-propagation neural network, Fall detector, Multi-agent system, Emergency service system**

I. Introduction

As people age, their independence is threatened by a number of factors such as social isolation, illness, disease, and so on [1]. For many solitary elder, the most concern factor could be the falling [2]. Tinetti [3] reports that approximately 30% of persons over age 65 years fall each year, and the cost associated with the fall injury for elder is very expensive. Typically, a homecare emergency service model for elder falling comprises four essential activities: (1) to discover the fall event; (2) to communicate the emergency service center (also called call centre) or hospital for requesting an emergency service; (3) the emergency service center dispatches an ambulance to the elder's house; and (4) rescuing the elder. In this model, these essential cooperative activities are highly relies on human acting. However, there are more and more solitary elders of life alone in the elder communities. Hence, the typical emergency service model has faced two main challenges: how to discover the fall accident; and how to communicate the emergency service center for requesting the help. Therefore, an automatic and intelligent approach to implementing the emergency service for elder falling is important to today's society [1, 4].

The objective of this paper is to propose intelligent based approaches to facilitating the elder falling emergency services. Two intelligent technologies are explored in our research. First, the Back-propagation neural network technique is implemented in an intelligent fall detector to recognize the fall event. Next, the intelligent software agent technique is used to request an emergency service from emergency service center and the hospitals automatically. If an elder falling down, the intelligent fall detector can detect the accident and send a fall signal to the intelligent homecare emergency service system. While the system receives the signal, there is a mobile agent will carry the elder's basic information (such as name, address, etc.) and the health information (such as disease history, the medicines what the elder takes, etc.), and then move over the internet to the emergency service center and hospital for requesting help. Therefore, the elder can get better efficiency and quality of service. The system overview is shown in Fig. 1.

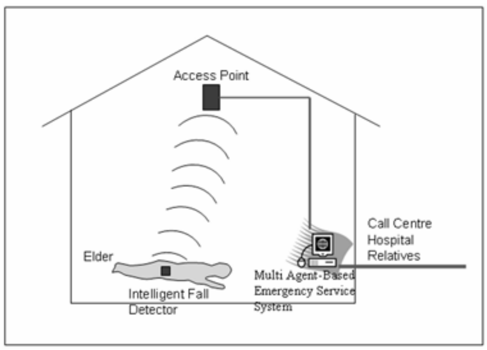

Fig. 1: The system overview of homecare emergency service for elder falling

II. THE NEURAL NETWORK-BASED FALL DETECTOR

To face the first challenge of elder falling emergency service model, we proposed that using neural network technique to facilitate the recognition of fall activity.

A. The architecture of intelligent fall detector

Recently, a number of researches that focus on the fall detection techniques were proposed in the literatures. For examples, Yamaguchi[5] placed the infrared sensors on the door of bathroom to detect the time spent in bathroom. Noury etc.[6] designed a small portable device that can measure the vertical acceleration, posture, and physiological vibrations. The principle of monitoring fall activity in our approach is to measure the three axes acceleration variation of the elder's body, and then recognized by a neural network classifier. The intelligent fall detector proposed here comprised two key components: an accelerometer module and a processing unit. Fig. 2 shows the functional block diagram for the intelligent fall detector. The accelerometer module senses the elder activities continuously, and outputs the signals (modulated by pulse width modulation) to the processor. The processing unit handles three activities: performs neural network-based classification to determine the fall activities; produces an alarm to indicate a fall event in happening; and initiates the wireless network module to transfer the event to agent-based emergency service system.

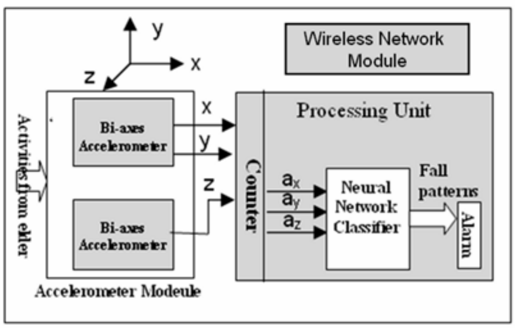

Fig. 2: The block diagram for intelligent fall detector

B. The structure of neural network classifier

Artificial neural network technique performs the fall confidence pattern recognition. There are two phases in neural network: learning phase and recalling phase. In the learning phase, a supervised learning algorithm is adapted to train the neural network from positive examples and negative examples. The learning rule for adjusting the weights and biases of the network is based on the back-propagation training algorithm. By an iterative training process, the connective weights and bias in the neural network can be refined to fit the generation of expect output. Thus, the input activities of elder can be classified or predicted by the trained neural network in the recalling phase (also called predicate phase). The structure of the back-propagation network model (see Fig. 3) comprises four layers: one input layer, two hidden layer, and one output layer. The input layer which consists of three neurons reads data from the three axes accelerations. The hidden layer consists of two layers which arranged as 10 neurons and 7 neurons respectively. The output layer represents the fall patterns, i.e. fall, and not fall.

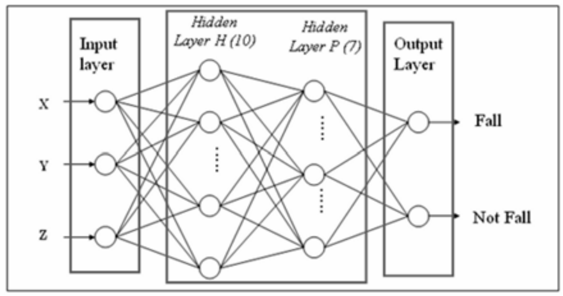

Fig. 3: The structure of the back-propagation neural network classifier

When the "fall" pattern is recognized, it will trigger an alarm to indicate the accident to nearby persons. If the detector alarmed with a wrong detection or the fall is light, the elder can reset the detector to disable the signal in 20 seconds. If the fall detector does not be reset, the fall signal will be sent to the agent-based emergency service system via the wireless network. Thus, the multi-agent system can initiate the emergency service procedures immediately.

III. THE MULTI-AGENT SYSTEM FOR EMERGENCY SERVICE

The emergency service system architecture proposed in this paper is based on a multi-agent integration. An agent is defined as an autonomous software entity that receives inputs and interacts with its environment, performing tasks in the pursuit of a set of goals [7, 8]. In our application, agents are the players in an emergency service platform and each one adopts some role. Fig. 4 shows the multi-agent system architecture. The intelligent agents are introduced as follows:

- Host agent: This is a stationary agent who is responsible to inform the relatives of the elder, and to send a mobile agent that carries the elder's basic information and health information to the emergency service center and hospital when the elder falling down.

- Mobile agent: This agent can move from a host computer to others over the internet. Its responsibilities are to request two main emergency services: (1) to apply to the emergency service center for requesting an emergency service help. The basic elder information (such as name, address, etc) and health information (such as suffered the cardiovascular disease, etc) can offer the emergency medical technicians (EMT) to do the best preparation; and (2) to continue move to the pre-identified hospital for informing the emergency department employees and the doctors to prepare the necessary procedures for that elder. In our application, the priorities of the pre-identified hospitals are decided by the elder himself or herself. If the first pre-identified hospital can not provide the emergency service, the mobile agent will automatically move to the next pre-identified hospital.
- Helper agent: This agent plays the controller role on the emergency service center. In many countries, the ambulance dispatching operation is managed by the people in emergency service center. When the helper agent receives the request from mobile agent, he will dispatch an available ambulance to help the elder. The elder's information provided by mobile agent can facilitate the EMT and ambulance to equip the appropriate equipments.
- Hospital agent: This agent is also a kind of stationary agent who working at the emergency department of hospital. Each hospital has its own hospital agent. The main responsibility of hospital agent is to response the request from mobile agent. The hospital agent will to look over the availability of emergency department. For examples, the available bed or the appropriate clinical doctors. If there is no such appropriate resource, the hospital agent will reject the request of mobile agent, and then the mobile agent can move to the next hospital.

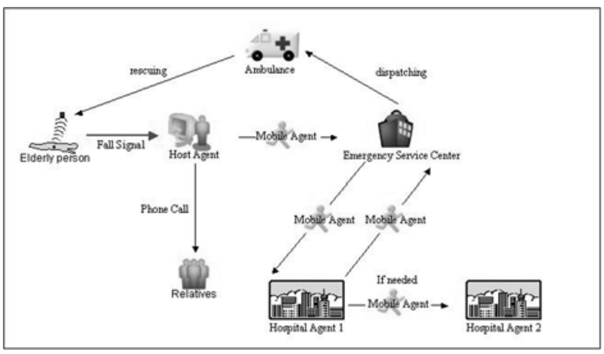

Fig. 4: The architecture of multi-agent system for requesting emergency services.

IV. THE COMMUNICATION PROTOCOLS AND TYPES OF ELDER INFORMATION

A. The communication protocols between software agents

The Aglets Software Development Kit (ASDK, IBM Inc.) is adapted to implement the proposed multi-agent system. Aglets exploit a communication system based on message passing: two agents that want to communicate each other have to exchange a message. Fig. 5 shows the general communication architecture of the mobile agents. This architecture is designed as MVC (model view controller) architecture. The supported communication protocols in our application include three basic types: synchronization, asynchronization, and broadcasting mode. The network interface component is responsible to transmit or receive messages to/from other agents. The component of information and data stores the related information of the particular elder, which will be passed to emergency service center and hospitals when the mobile agent has arrived to the goal target. We will discuss the detailed content of elder information in next subsection.

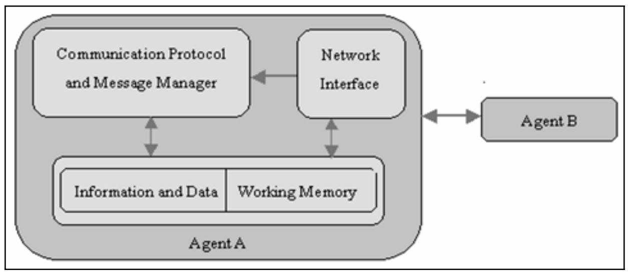

Fig. 5: The communication architecture of mobile agent

B. The information types passed by mobile agent

One of the main responsibilities of mobile agent is to pass the important information of the elder to the predict destination, i.e. emergency service center and hospitals. We believe that as early as possible to provide the patient's information for emergency service center and hospitals can improve the emergency service quality and can increase the survival opportunities for patient [9]. Because of that the EMT can take appropriate equipments or even the medicines for that elder patient, and as the meantime, the emergency department of hospital can prepare the bed, nurses, doctors, or medicines, anything what can help the elder.

As mentioned above, we identified three classes of elder information what will be carried by mobile agent. In order to facilitate the information can be accepted by different hospitals, we adapt the standard HL7 message specification as the format of the information [10] (see Fig. 6).

```
MSH|^~\&|||emergency healthcare||||ORU^R01|||2.4
    PID|||G123456789^^^TWNTHU^^HL7_0363||
    Yung^Cheng-Jie||19821021|M|||No.7-1,
    Huashan Rd.^^Su-Yao Township^Yilan
    County^270||039965432
NTE|disease history||nephrosis
NTE|disease history||lung disease
NTE|long-term take medicine||epilepsy
NTE|family disease history||hypertension
NTE|family disease history||diabetes
NTE|family disease history||leukemia
NTE|health habit||drinking|always
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Fig. 6: The elder information is formatted in HL7 standard.

The first class of information is related to the basic personal information. These information include the elder's name, personal identity number (or social security number), birthday, sex, weight, home address, and telephone, etc. This information can help the EMT to find the target elder. The secondary class of information includes the basic information related to the elder's health status, such as the current disease situation, disease history of the family, the critical medicines to take, etc. This information can help the EMT and the pre-identified emergency department of hospital to prepare the appropriate equipments and medicines. The third class of information is related to the advanced health information, such as the real time heart monitoring device, blood pressure monitoring device, etc. This information can help the clinical doctors at emergency department of hospital to do the best treatment and therapy for the elder. For example, Fig. 7 shows the ECG diagram displayed on the clinician's top-desk computer.

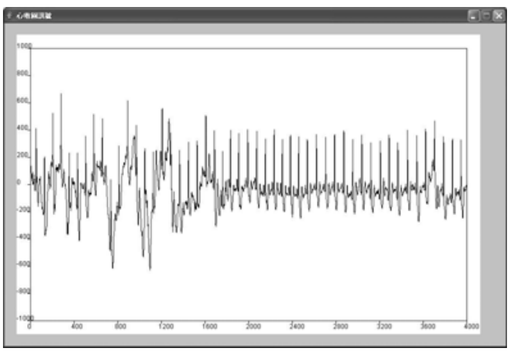

Fig. 7: The ECG diagram can redrew on the screen of the clinician's computer

V. Conclusions

In this paper, we present that applied neural network and software agent techniques to facilitate the elder falling emergency service. Neural network technique is used to recognize the fall event, and the software agent technique is used to inform the emergency service center and hospital. There are three main contributions of this approach: (1) the neural network-based fall detector provides the more accurate fall detection for solitary elders; (2) the intelligent agent-based emergency service system can automatically communicate the emergency center for requesting help; and (3) the important information related to the elder can early pass to the emergency service center and the hospitals for improving the emergency service quality.

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