A decision support system for medical emergencies of older adults in Taiwan

Hui-Min Hua
Department of Computer Science and Engineering,
College of Informatics, Yuan Ze University, Tao-Yuan, Taiwan
E: tinahmh@nkc.edu.tw

Baw-Jhiune Liu
Department of Computer Science and Engineering,
College of Informatics, Yuan Ze University, Tao-Yuan, Taiwan
E: bjliu@saturn.yzu.edu.tw

Tan-En Wang
Information Management Department,
Nan Kai Institute of Technology, Nantou, Taiwan
E: wangte@nkc.edu.tw

H-M. Hua, B-J. Liu, T-E. Wang. A decision support system for medical emergencies of older adults in Taiwan. Gerontechnology 2007; 6(3):169-174. Taiwan is experiencing the second highest rate of population ageing in the world, just behind Japan. Since only 2% of the older adults had access to acute medical care services in 2004, the government of Taiwan is pursuing plans to provide remote care. This contribution concerns work in progress in the design of mobile telecare based on a new decision support system (DSS) for transmitting data collected from older adults to health data centers and clinics in Taiwan. The support system provides assistance in planning for rescue personnel and vehicles after emergencies. Moreover, evaluation of disasters, the state of neighbouring resources, and the optimal route from disaster site to the nearest hospital are displayed. The platform is designed for monitoring and analysing vital signs and physiological parameters. Data are picked up by medical sensors and transmitted via the internet to monitoring systems in control centers to give healthcare workers an immediate and concise reading from their internet browsers so that they may supervise and provide appropriate emergent medical care. A second level of the support system incorporates geographic information systems (GIS) and provides both maps and text to support path finding for the rescue vehicles. This new DDS will facilitate a comprehensive emergency home-care for older Taiwanese.

Keywords: telecare, GIS, decision support system (DSS)

The over-65 population in Taiwan has increased from 6.9% in 1996 to 9.7% in 2005. In the same time period the population aging index, which is the ratio of number of older adults (65 years and over) and the younger population (0-14 years), increased from 34.0% to 52.1% (*Table 1*)[1]. According to the Council for Economic Planning and Development at Executive Yuan of Taiwan, the over-65 population in Taiwan will reach 14% of the total population by 2020 and over 20% by 2030. This will be the second highest rate of increase in the world, just behind Japan. Long-term care and home care, senior welfare, and technology for the aged are becoming important issues nowadays, and are all included in the health care system of Taiwan (*Table 2*)[2,3].

As the percentage of older adult adults continues to increase, the traditional oriental extended family has been gradually replaced by nuclear families and single older

Table 1. Selected countries by percentage of population 65 years and over in 1996, 2000 and 2005, with ageing index added; aging index = ratio of number of older adults (65 years and over) and the young (0-14 years of age)[1]

Countries	65 years and over (%)			Ageing index (%)		
	1996	2000	2005	1996	2000	2005
Philippines	3.5	3.7	4.0	9.2	10.0	11.3
Malaysia	3.9	4.1	4.6	9.2	10.0	11.3
India	4.2	4.4	4.9	12.0	13.1	15.0
South Africa	4.2	4.6	5.2	11.9	13.7	17.0
Mexico	4.5	5.0	5.6	12.8	14.8	18.1
Brazil	4.8	5.3	6.0	15.5	18.3	22.8
Thailand	5.6	6.5	7.8	21.5	26.9	34.6
South Korea	6.1	7.2	9.1	26.9	34.3	47.3
China	6.3	6.9	7.6	26.8	27.3	35.6
Singapore	6.4	6.8	8.2	28.3	32.7	41.2
Taiwan, R.O.C.	***7.9***	***8.6***	***9.7***	***34.0***	***40.9***	***52.1***
Argentina	9.9	10.2	10.6	35.0	37.8	41.3
New Zealand	11.5	11.7	12.3	50.0	51.6	57.7
Australia	12.2	12.4	13.1	56.5	59.5	67.1
Canada	12.2	12.7	13.2	60.5	66.0	73.4
United States	12.7	12.4	12.4	58.1	58.1	60.4
the Netherlands	13.3	13.6	14.2	72.3	73.1	78.1
Finland	14.4	15.0	16.0	76.0	82.2	92.8
Switzerland	14.6	15.1	14.7	83.4	87.4	93.1
France	15.1	15.8	16.2	76.9	82.9	87.3
Japan	15.1	17.3	20.0	96.6	119.1	145.8
Austria	15.3	15.5	16.6	87.5	92.4	105.9
Germany	15.6	16.4	19.3	96.9	105.4	136.2
United Kingdom	15.7	15.6	15.8	81.5	82.3	89.0
Spain	15.7	17.0	16.8	98.6	116.3	118.6
Norway	15.8	15.3	14.7	80.6	76.5	75.3
Italy	16.9	18.0	19.4	115.5	127.3	139.6
Sweden	17.4	17.3	17.3	92.9	93.9	100.3

adults in Taiwan. The percentage of older adults living with their children has decreased from 70.2% in 1986 to 64.3% in 1996 and the percentage of single elderly increased from 11.6% in 1986 to 13.7% in 2005 (*Figure 1*)[4]. Less than 2% of the older adults living alone had access to acute medical care services in 2004[2]. As a result the provision of necessary and appropriate care at the right time and place is a significant focus of the Government's social welfare policy for the aged which creates plans and projects to provide distant care for older adults. These plans involve the creation of comprehensive service systems to record blood pressure, heart rate and blood sugar for health centres[5]. However, to be effective the health centres should not receive unprocessed data that increase the work load of the medical staff, but instead receive processed information on health status and needed interventions.

Mobile communication and ADSL have become popular in Taiwan in the past 10 years, and the quality of this service has been improved[6,7], enough to make it useful for real-time emergency data transmission[8]. Using these advanced communication options our study aims at giving older adults access to acute medical care in their homes or other locations when emergencies such as heart attacks, falls or cerebro-vascular accidents happen. In this

Table 2. The healthcare system of Taiwan as defined by the Ministry of the Interior, Taiwan, R.O.C.

Preventive healthcare (Health promotion)
Health station
Health promotion and support, and disease prevention
Acute medical care (Medical care network)
Emergency care
Primary care institution
District hospital
Regional hospital
Medical centre
Rehabilitation and after-care service (Long term care)
Chronic disease hospital
Nursing home / Nursing care institution
Day care
Home care for the aged
Care of the home
In-home services
Social welfare and other social services

short communication on work in progress, a decision support system (DSS) is presented to cope with medical emergencies in 1-person households of older adults.

The system

The system's first component is a remote monitoring system installed in the home that analyses and monitors life signs and physiological parameters of the older adult, such as systolic and diastolic blood pressure, heart rate and pulse. The older adult's data are detected by medical sensors and instruments, and collected in a home based or mobile workstation. Collected information is checked continuously by a DSS and when a possible emergency is detected, the body of data is transmitted from the home or other location via internet to the hospital or health control centre using either a fixed (home care service) or a mobile (3G) data transfer method. The DSSs in the control center then can determine the appropriate analytical path for the data (*Figure 2*).

When emergencies such as heart attacks, falls or cerebro-vascular accidents in the older adult occur, alert signals from home service monitoring agents are sent to emergency contacts, medical staff, emergency hospitals and clinics and collaborating institutes. Physicians will be able to evaluate the information and render diagnoses at the time the emergency is happening. If required an alert message with the older adult's location would be sent to the ambulance station. The embedded GIS (geographic information system) will direct the rescue vehicles to the site of the emergency, and subsequently to the nearest hospital that is already prepared for the specific patient (*Figure 3*)[9].

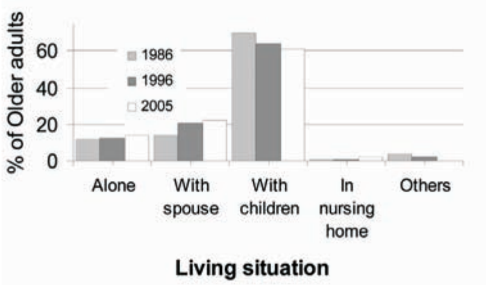

Figure 1. Living arrangements among older adults 65 years or older in Taiwan in 1986, 1996 and 2005[1]

Decision support

The DSS is an integrated system which incorporates information management and analysis modes. The DSS in our design is divided into four modes: (i) classification, (ii) cluster, (iii) association, and (iii) Gini type data processing. Classification systems are displayed as decision trees; the classification defines the collected vital signs into classes such as blood pressure, heart rate, and glycated haemoglobin based on a comparison of the online measures with values contained in the older adult's records and preset levels determined by physicians who define when a medical emergency exists. The decision tree model uses accumulated vital signs data to build rules to classify cases with maximum accuracy (*Appendix A*).

The DDS also consists of two levels: The first contains data objects which may be

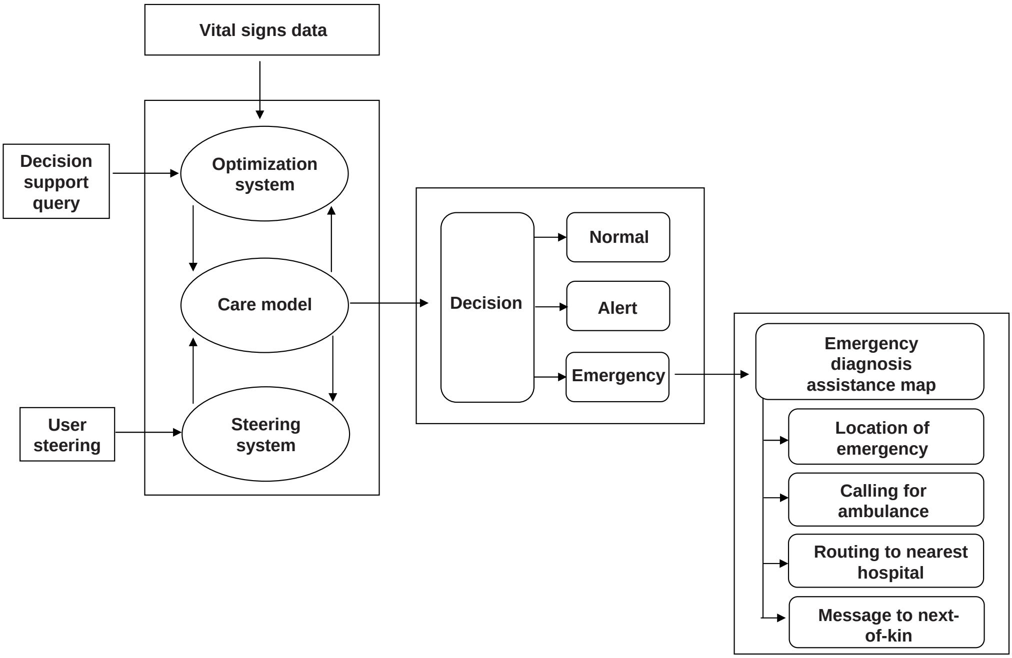

Figure 2. The structure of decision support systems platform. On the top the data sensed from the older adult arrive from the home based or mobile module (work station); subsequently the information extracted from the data is transferred to the decision module in the same workstation, and in case of an emergency situation the emergency module at the distant health care centre is activated and all necessary measures are taken

provided by the 3G mobile telecare system and objects of decision and path analysis modes for internal analysis. The second level incorporates geographic information systems (GIS) to provide maps and text.

3G mobile system

3G mobile telecare systems can provide fast clinical image transfer under emergency circumstances. Medical staff in hospitals and clinics may access the older adult's data from mobile devices during the emergency. These data include life signs and clinical images, which may be sent in real-time to give physicians precious seconds while making clinical decisions that may save lives. Both the aged and medical professionals can communicate via 3G telecom phone system during rescue procedures.

Embedded GIS

All home care service clients are catalogued in GIS databases and their locations visually represented on a map. Once an emergency has occurred, warning signals are activated by DSS correspondingly and the client's patient history records would come online. Coincident with the presentation of the client's data is the evaluation of the disaster condition (should one be present), the status of nearby resources, and the optimal paths to the client's location which are presented by DSS in graphical mode to facilitate human decision-making and reduce errors.

Discussion

Our design automatically transfers the older adult's vital signs data to a decision support query and users steering, which can define the measurement ranges for the variable according to the situation. This project will make great use of the international 110 communication platform E1/T1, Cell ID, and logic link control (LLC) to dispatch staff, follow up on their status, and locate their transmissions so that staff transit time can be reduced. The safety of both accident stricken persons and victims of crime will be improved preserving social well-being and security. Dialling the e-110 number allows us to locate the older adult's current position, but it is not yet linked to health centres, which may result in fatal delays of emergency treatment.

Our design combines medical equipment, mobile phones, internet and the e-110 line to provide the most effective information exchange and facilitate a comprehensive emergency home-care system for the older adult. The National Police Agency of the Ministry of the Interior has budgeted NT$ 133,000,000 (about 7 million euro) for a three-year project of '110-e services and commands systems' starting in 2007. The implementation of this newly designed support system for medical emergencies in Taiwan is expected in the near future.

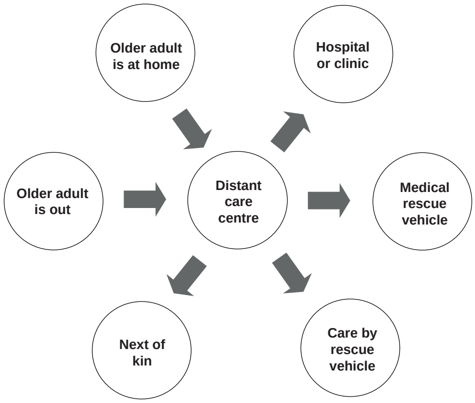

Figure 3. Data transfer diagram of the home care service system. The care control centre in the middle may receive information from both home-based work stations and mobile work stations, and dispatches messages to selected hospitals and clinics, rescue vehicles with mobile emergency facilities, clients that are cared for by rescue vehicles, and family or friends that have to be notified in case of emergencies

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Appendix A: DSS details

The DSS validates models in a cluster analysis with normal, alert and emergency as outcomes. The decisions are based on association rule analysis. Three-level data sets, called ***normal***, ***alert*** and ***emergent***, are regarded as dependent variables; systolic blood pressure, diastolic blood pressure, heart rate, body temperature, age, season, disease history, agenda, and outdoor temperature are regarded as independent variables[10,11].

A decision tree of DSS is based on Gini type function. Gini is a measure based on squared probabilities of membership for each target category in the node of DSS. It reaches its minimum (zero) when all cases in the node fall into a single target category. The Gini index at node *t, g(t)*, is defined as

$$g(t)=\sum_{j\neq i} p(j|t)p(i|t)$$

where *i* and *j* are categories of the target variable.

There are two types involved of Gini type data processing which are continuous and binary. For continuous target variables, the least squared deviation (LSD) impurity measure is used. The LSD measure *R(t)* is simply the (weighted) within-node variance for node *t*, and it is equal to the resubstitution estimate of risk for the node[10,11]. It is defined as

$$R(t)=\frac{1}{N_w(t)}\sum_{i\in t} w_n f_n (y_i-\bar{y}(t)^2$$

where R is the weighted number of cases in node *t*, w_n is the value of the weighting variable for case *i* (if any), f_n is the value of the frequency variable (if any), y_i is the value of the target variable, and *y(t)* is the (weighted) mean for node *t*. The LSD criterion function for split *s* at node *t* is defined as

$$\phi(s,t)=R(t)-p_L R(t_L)-p_R R(tR)$$

The binary index is based on splitting the target categories into two superclasses, and then finding the best split on the predictor variable based on those two superclasses. The binary criterion function for split *s* at node *t* is defined as

$$\phi(s,t)=\frac{P_L P_R}{4}\left[\sum_j | p(j|t_L)-p(j|t_R)|\right]^2$$

where t_L and t_R are the nodes created by the split *s*. The split *s* is chosen as the split that maximises this criterion. This value, weighted by the proportion of all cases in node *t*, is the value reported as 'improvement' in the tree.