Towards to realization of adaptive individual life support system

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Abstract: In this paper, a model of adaptive individual life support system is proposed from the viewpoint of cybernetics. This model is derived based on the relation between human behavior and human action, static and dynamic in processing speed, and abstract/concrete. In applications, task and information of human which includes in this system analyzed by paying attention to cybernetics. This paper shows a few actual example of modeling by fundamental adaptive individual life support model such as medical diagnosis, health care and education support. Finally as an example, design and implementation are concretely carried out for health care support system. This is also a method to design a information support system which is involved in human.

Keywords: hierarchy human behavior, human action, adaptive human behavior model, life support, cybernetics

1. Introduction

In concerning human with mechanical system, there have been literatures on human machine interface for reducing human error, intuitively understanding and/or improving operation method after the way of training operator[1]. Most literatures have focused media conversion, e.g., from displaying messages on the computer screen to voice messages, animation etc, called graphical user interface[2]. The other hand, there have been applications of artificial intelligence, which targeted how express acquired knowledge. Even though the system with AI(Artificial Intelligence) technology, whole system does not seem to be approaching to human.

From the viewpoint of mechanical system being close to human, the importance has been pointed out supporting human life or work by gathering human behavior and analyzing. For example, Matsuoka[3] reported an emergency report system by collecting human behavior at home and analyzing gathered data. Aoki[4] reported that correspondence of regularity and irregularity is processed by pattern using HMM (Hidden Markov Model). Experimental results of Aoki is derived by following movement in one room and has not described two or more validity or extendibility in movement among rooms. Also change of people behavior affected by a day of the week, a season, etc. has not been into consideration.

Akamatsu[5] proposed a method to estimate tiredness caused by driving a car based on measuring movement of the body and the limbs. Computational data accumulation and interactive display for behavior understanding by Yairi[6][7] was proposed by visual and audio processing. As this system focuses otolaryngology, the proposed method difficulty applies the other filed.

These results are very important cases, but unfortunately framework of life support system based on human behavior understanding is not proposed, so it is difficult to apply another problems.

The concept of digital human by Kanade[8] is proposed and focuses only reproduction of human function. It has not mentioned about life support. Consequently to realize life support system in the relation between human and mechanical system, a general model is required.

In this paper, a scheme and a model for adaptive individual life support are proposed from the viewpoint of cybernetics. Next after discussion of applying the scheme and model into some actual cases, software design and implementation for health care system is shown.

2. Human life behavior and its scheme

In this section, aim of life support is defined as to provide secure life. For this, life support system is analyzed from the view point of cybernetics including human, machine and communication.

Human behavior to accomplish desired objective is composed of life actions and/or life behavior. This is similarity between computer machine instruction and micro-program. Furthermore each life behavior and action can be put into meaning.

Moreover human life behavior and action are influenced by mind and body condition. In this paper, mind and body condition is called by human internal state. Examples of this internal state are disease, tiredness, awaking and so on. External injury and physically handicapped etc also affect human life behavior and action. This is called external state in this paper.

When we try to perform life behavior, we carry out many actions. Our daily life behavior is represented as series or combination of the actions. These actions are generated by knowledge etc. From above discussion, a scheme of human life behavior is derived as shown figure 1.

3. Adaptive individual life support model

In this section, an adaptive individual life support model is proposed based on the discussion in previous section. Next, the effectiveness of proposed model is described by applying the proposed model into some actual cases.

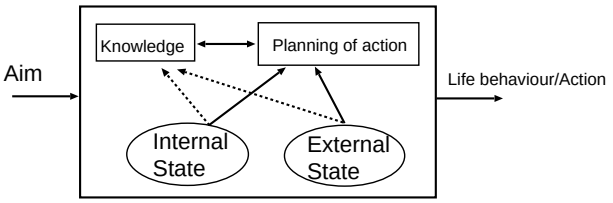

Fig. 1. Scheme of human life behavior

3.1. Life support model

Human has each individual life behavior and state. A person has state which depends on internal and external state, and this causes change of life behavior and action. For the reason, the support system is required to perform human behavior/action according to individual mental physical condition by observing mental and physical condition, life behavior and action. Accordingly, modeling to express mental and physical condition, and technology to observe human behavior, action and physical mental condition are required.

Suppose that life support is to assist human life behavior and human life action to object(house, moving, operation of equipment etc) following the given goal (ex, QOL), life support model can be derived from the viewpoint of cybernetics as shown figure2.

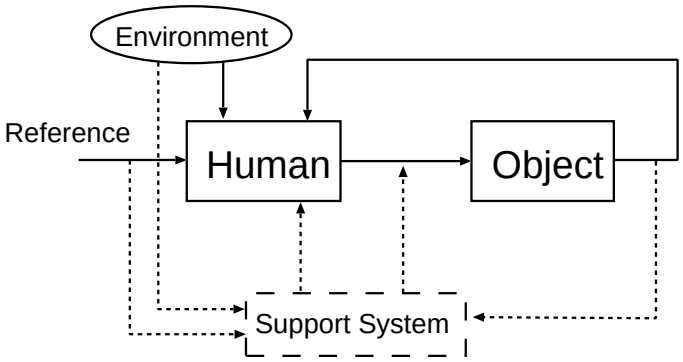

Fig. 2. Life Support Model

3.2. Hierarchical human behavior

In the above example of brushing teeth, it is one of life behavior with the aim of removing the some clung to teeth and preventing teeth from decaying. Since human has knowledge on the aim and way of brushing teeth, human generates a procedure for brushing teeth as follows picking teeth brush up, picking toothpaste up, opening the cap of toothpaste and putting some paste on the brush, finally brushing teeth. Teeth brush as a life behavior can be regarded to compose of above life actions. That is; life behavior is composed of some kind of life actions. Furthermore, human generates life actions program to perform the life behavior. Also teeth brush, opening cap etc each action themselves is carried out by real time control from the viewpoint of control theory, and continuously. Generating program is carried out by sample.

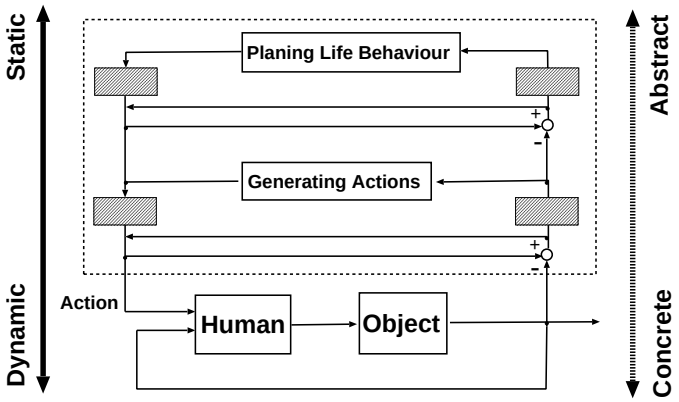

Fig. 3. Multi Layer Model of Life Support

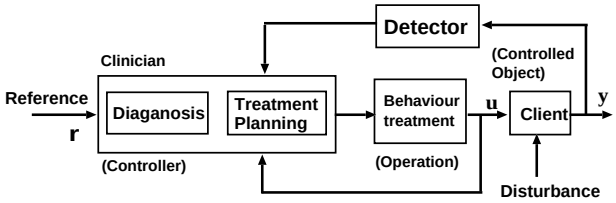

Fig. 4. Medical Consultation Model

3.3. Applying the modeling method into actual examples

In this section, applying the modeling method into actual cases is described.

3.3.1 Supporting medical consultation

Physician estimates the state of patient using the data from patient and clinical laboratory data and inspection. Finally physician identifies the disease of patient. Then physician makes a medical treatment plan after discussion on the subject with the patient and/or family. After that, the physician makes a detail treatment plan. The treatment has two types. The one is to provide directly treatment to the patient. The other is to provide indirectly to the patient's treatment, for example through nursing staff. In this case physician gives an instruction to nursing staff then nurse staff carries out the instruction. There may be a case that physician gives a description to patient and/or gives some advice to family. The family then cares for the patient. Physician should confirm that treatment is given to the patient.

Some time later physician evaluates the effect of treatment given to client and improves the treatment plan. Above-mentioned tasks of physician is similar to an feedback control system configuration, a patient as a controlled object, healthy as target and manipulated variables are medical treatment with cybernetics. Details for Medical diagnosis support system is available from reference[9].

3.3.2 Heath care support

In order to construct a health care and life support model, we discuss the medical task and task of nursing. The person to be cared and supported, who lives alone at own home, is called client in this paper. If the client has sick and/or has been cared, clinician or nursing staff visits periodically

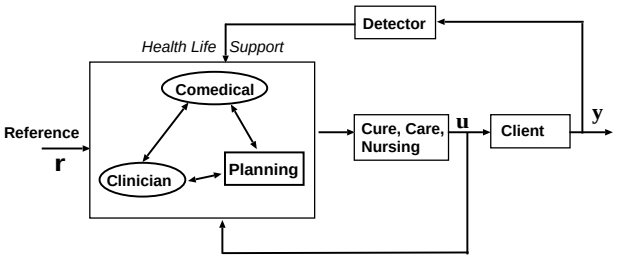

Fig. 5. Health care life support model

the client. They observe health condition and life situation of the client. Then they give some therapy and/or nurse to the person. When the client gets in touch with a medical institution or welfare institution, the institution sends clinician and/or nursing staff to the person. At this time, if the nursing staff finds some physical problem of the person, the nursing staff get in tough with clinician. These task is recognized to recover the health condition of the person, so clinician and/or nursing staff give some input to the person for recovering the health condition as a controller in the control theory.

Of course when pharmacist give the medicine to the person, the pharmacist guides the person to have effectively medicine. The family who live close to the person or neighbors visit often the person for finding problems or nursing. Like this, clinician, nursing staff, neighbors and/or their family look after the person with cooperative.

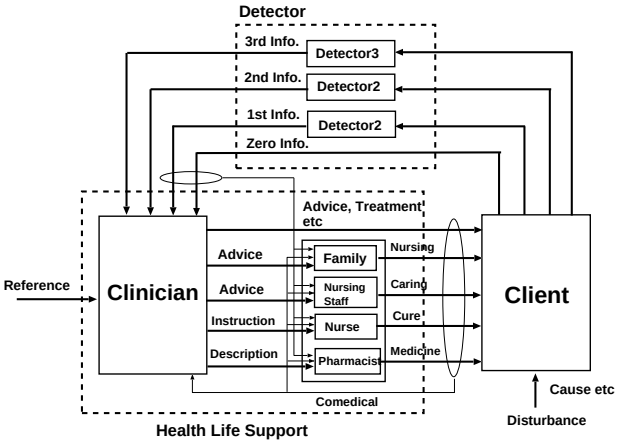

Fig. 6. Task and Information at Medical Consultation

3.3.3 Finding an irregular life behavior

Judging regularity of client life behavior is regarded as system identification in the health care life support model. It is not only very important to create a modeling of client but also to improve quality of life of client. For this reason, behavior/action which are analyzed about people's domestic action and pointed out that it could express by the limited automaton in which people's life action carries out probability changes. Figure 7 express this explanation. In the figure, $P(S(i), P(j))$ shows the probability of state transition from state $S(i)$ to $S(j)$. Next, an algorithm using HMM to judges whether the life action is habitual or not has been proposed.

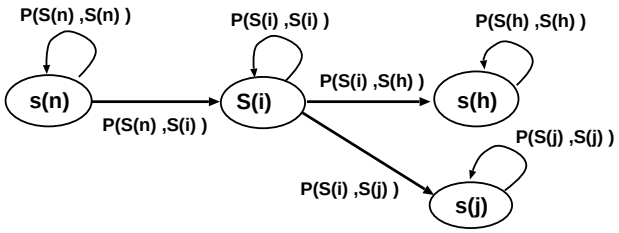

Fig. 7. Life behavior state transition

Then some of the authors show effectiveness of the algorithm with experimental results.

3.3.4 Education support

At a class, teacher try to transfer knowledge student by explanation etc, and put assessment into practice to student by such as examination, inquiry etc. Accordingly the assessment, teacher explain again same topic otherwise teacher proceeds a unit forward. From the viewpoint of cybernetics, teacher is regarded as a controller and student is regarded as a controlled object. Moreover, Lecture at class room considered to be real time processing. Teachers also define outcomes and objectives for each subject. Real time processing is not required to this matter. Processing speed to develop syllabus and/or lecture program requires less than defining outcomes and objectives.

If above discussion is applied to the adaptive life behavior model, human is teacher and object is student respectively in figure 3. Furthermore a e-Learning system design would be explained by an education support model which can be derived based on this discussion[10].

4. Information System for Health Care

This section describes designing of health care information system based upon above the health care and life support model.

4.1. Information System Design

The health care and life support system is regarded as setting up feedback system to share/transfer the information among client, clinician and comedical in the case of some problem of client happening. This paper defines the health care information system as follows. When an irregular habitual life behavior and abnormal health condition is detected, the system confirms safety of client. And the system sends a message to clinician, nursing staff and/or neighbors depending on answer of client. In addition the system provides health advice from clinician to client.

Consequently the system has following specifications in order to perform above mentioned.

1. Obtaining the information of client
2. Transferring the information of client
3. Finding problem of client
4. Confirming client safety
5. Informing urgency to co-medical, clinician
6. Providing health care advice

The fourth and the fifth mean the collaboration among client, comedical and clinician. Finally the health care life

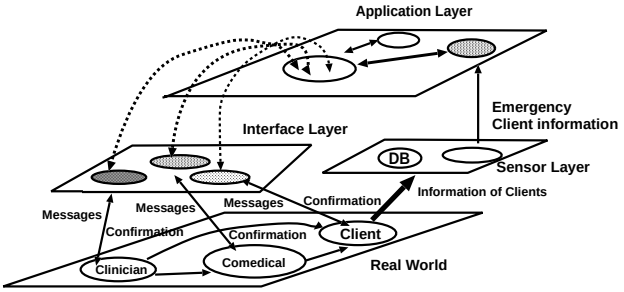

Fig. 8. Layer Structure for health care

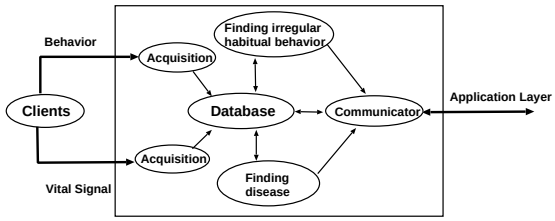

Fig. 9. Sensor layer

support system can be designed using layer structure shown by figure 8.

4.2. Layer Structure

This section describes the relations among layers and functions of each layers.

4.2.1 Real World

The object of this system are clients, clinicians and comedical including client's family and/or neighbors.

4.2.2 Sensor Layer

The sensor layer is to gather information of client and to find urgency of client[11]. If sensor layer finds an urgency of client, the sensor layer sends a message to application layer. The message has ID of client and urgency level that client needs clinician or not, needs nursing staff or not and so on. In addition the sensor layer provides health care record to clinician via application layer. This system focuses life information (Zero order), pulse and body temperature as the third order.

4.2.3 Application Layer

Application layer searches contacts of family doctor, comedical and/or client corresponding to urgency level for sending a message. With the search results application layer sends a message to interface layer. Application layer continues to send a message in order to the reply from receiver. If nobody replies, the system call an ambulance.

The application layer requests information of client to sensor layer after receiving a message of "Request : providing information of client". The application layer transfers the data to appropriate interface layer.

4.2.4 User Interface Layer

1. Clinician Interface
   Clinician interface informs urgency of client and transfers reply from clinician to the application layer. Clinician inputs the process into the system via the clinician interface. Clinician is able to retrieve health record of client.
2. Comedical Interface
   Urgency of client is informed to registered comedical via the co-medical interface. Comedical who received a message has to inform the condition of client and/or result of treatment to the system via the comedical interface. Also comedical retrieves health advice from the system that clinician has provided, and comedical guides client to keep health condition.
3. Client Interface(Interactive Response System)
   Client interface sends a message to confirm safety. Client can reply "No problem", "need help", "need clinician" or no answer. The client interface informs content of reply to the system.
4. System Administrator Interface
   The system administrator interface provides functions of system administrating such as registration, removing, modifying user(client, clinician, nursing staff, neighbors).

4.3. Software Designing and Implementation

This section describes the software desgin of health care life support system based on UML(Unified Modeling Language).

4.3.1 Use Case and Sequence Diagram

The use case view shows functionality of the system as perceived by outside users, called actor. This system consists of three use cases.

1. Sharing information
   health care advice
   retrieve information of client
2. Emergency jobs
   receiving urgency message from sensor system,
   informing urgency of client to clinician, co-medical
   confirming the safety of client
3. Administration
   adding/removing users
   modifying users

Each use case shows the views by figure12, figure13, figure14.

Here two sequence diagrams for showing a set messages arranged in time sequence are shown as figure10 and figure11.

4.3.2 Use case description

Normally Use Case Description defines a functionality of use case. This is a simple and consistent specification about how the actor and the use case (the system) interact. Some of use case description for explaining briefly the system behaviour. An example of use case for client safety is as follows.

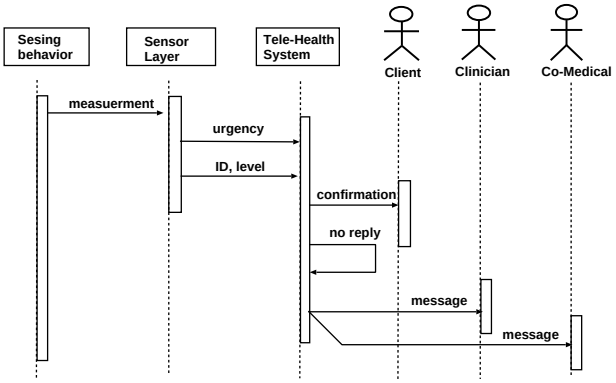

Fig. 10. Sequence Diagram : No response of client

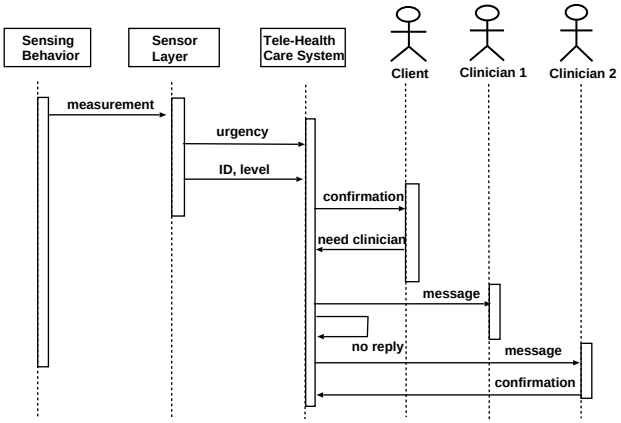

Fig. 11. Sequence Diagram : No response from a clinician

Confirming safety of client

Use Case:
Problem happening::confirmation(ID:0011)

Summary:
When the system finds a problem of client, the system sends a message to client for confirming safety of client.

Actor:
Client

Preconditions:
A problem happens to client. Sensor layer sends a message to Application layer.

Descriptions:

Basic Flow

1. Application layer sends a message of confirming safety to client via user interface.
   - Handy terminal of client shows the message.
2. The client sends a reply to the system.

Exception flow in sequence 2

If the client is not able to send a reply to the system with some reason,

1. In the case of the system receives a reply from the client in specified duration, the system call another clinician or a comedical.

Exceptions:
Communication error

Postconditions:
Communication line is set up between client and clinician and/or comedical.

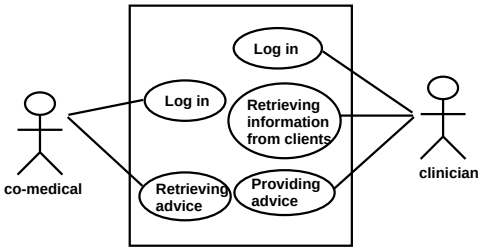

Fig. 12. Use Case View : Sharing information

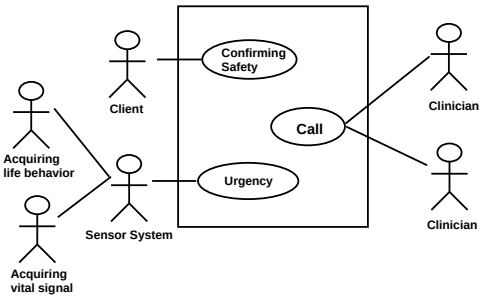

Fig. 13. Use Case View : Finding emergency

4.3.3 Sequence Diagram

A sequence diagram shows a dynamic collaboration between a number of objects. The importance aspect of this diagram is to show a sequence of message sent between the objects. Here one sequence diagrams for showing a set messages arranged in time sequence are shown as figure15.

4.4. Collaboration Diagram

A collaboration diagram shows a dynamic collaboration and shows the objects and their relationships. The collaboration diagram is drawn as an object diagram, where a number of objects are shown along with their relationships using the notation in the class/object diagram. Message arrows are drawn between the objects to show the flow of message between the objects.

4.5. Collaboration Diagram

A collaboration diagram shows a dynamic collaboration and shows the objects and their relationships. The collaboration diagram is drawn as an object diagram, where a number of objects are shown along with their relationships using the notation in the class/object diagram. Message arrows

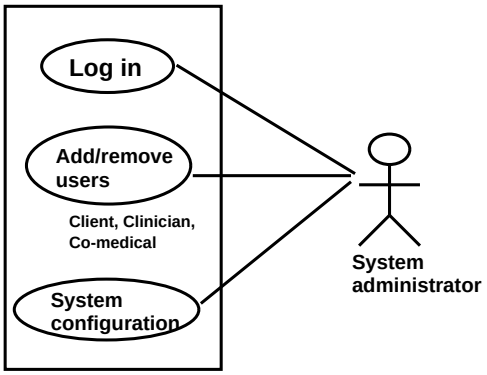

Fig. 14. Use Case View : Administration

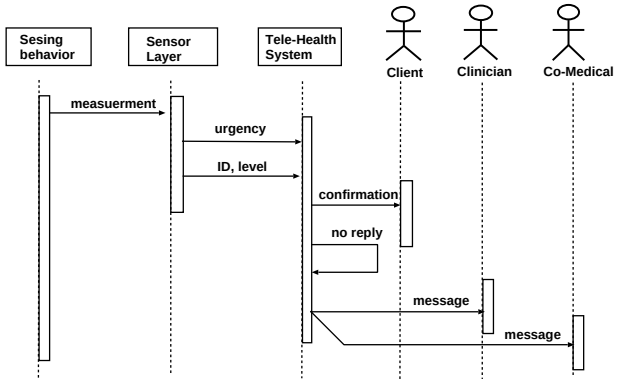

Fig. 15. Sequence Diagram : No response of client

are drawn between the objects to show the flow of message between the objects.

4.5.1 Implementation

The software system has been developed on the Vine Linux as similar as RedHat. All source programs have been developed by Java using JDK1.3. PostgreSQL has used for creating database.

The software system for application layer consists of about sixty classes, each class is about 100 statements. The software system for application has verified by behavior as same as designed scenario.

The developed softwares for user interface work on cellular phone terminal as an i-mode application. Japanese telephone line companies give various service to customer. For example, NTT DoCoMo provides phone, e-mail, packet data communication service, intelligent traffic guidance system and so on. Cellular phone accepts Java Program. User interface layer and sensor layer communicate the main system with TCP/IP. The classes in the main part communicate each another with sending/receiving message supported by Linux. Thus any layer can be located anywhere on the network.

5. Discussion and Conclusion

This paper pointed out the importance of research on the model which is adaptive to individual life behavior. Actually the model for life support has been proposed from the view point of cybernetics. Proposed method describes that feedback system setup on demand. Next the model has shown to be applicable to various life behaviour such as educational support, medical diagnosis and health care support.

Next, software design was described by giving design and implementation of health care life support system as an example. First health care life support model was derived by analyzing tasks and information of health care support from the view point of cybernetics. Next, information system was realized by multilayer structured which consists of user interface layer, sensor layer and application layer based on proposed the model. The software system supports client, clinician and comedical to collaborate among them and share the information. Each software system were implemented by way of object oriented method and UML. Details of software implementation are described by references.

The proposed modeling method and design of information system is to advocate a methodology of system design including human in the system.

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