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# A study on the web-based intelligent self-diagnosis medical system

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ABSTRACT

U-Health is a representative realization method of ubiquitous IT and it is being embossed as an industry that can make our lives abundant. Through the u-Health, the diagnosis will go beyond the restriction of space, which is based on hospital, and be positioned as a universal value in a daily life by combining diagnosis and life naturally. The researcher would like to suggest systematical and intelligent medical diagnosis expert system that can give the effect same as the help from real experts with health check helper and scientific and objective knowledge that fit to the age and environment of changing. The system proposed in this paper suggests synthetic preventive health care methods by analyzing life style, food and nutritions beyond just finding the name of disease. This is intelligent medical expert system that suggests pre- and post-care and appropriate cure after analyzing one's own health condition on the basis of knowledge.



## 1. Introduction

In the future medical system, individual will continuously monitor his health status regardless of time and space and receive the service concerned to prevention, early diagnosis and effect control of chronic disease in real time. Moreover, medical staff can perform accurate diagnosis, treatment and post control conveniently because medical devices of health care organizations are connected via network.

It is expected that both of health care provider and user will reduce time and cost, medical environment will be changed from hospital-based one to citizen-based one and whole health care processes from prevention to diagnosis, treatment and post control will be developed equivalently.

For example, medical diagnosis expert system can analyze the disease of patients and inform appropriate curing method by receiving the symptoms of patients and other related facts. Expert system has been greatly progressed, and most of those are being used to replace or assist human experts.

Expert system consists of knowledge base, which saves special knowledge in human experts' brain in the form of fact and rule, and reasoning engine, which contains knowledge required to solve problems based on the knowledge base. Like this, the system consisting of knowledge base and reasoning engine is called knowledge base, and expert system is an example of knowledge-based system having special knowledge in the knowledge base. So, users can be provided with experts' opinion through reasoning process by implanting experience, knowledge and experts' decision-making process required to solve a problem and using it [1,2].

Section 1 described about the purpose and methods of the study on experts system development trend. Section 2 examined theoretical background on u-Health care such as the characteristics, classification of medical information system and the development trend. Section 3 proposed elements and development tools required to develop medical diagnosis expert system, knowledge expression, rule-based reasoning, case-based reasoning, and integrated reasoning based on rule and case reasoning method of expert system and its integrated model. The method of experiment and evaluation in Section 4, and the conclusion and future researches in Section 5.

## 2. Appearance background and service type of u-Health

### 2.1. Service type of u-Health

As disease type changes, new disease successively occurs and environmental risk increases, health care providers need to synthesize various health care information and construct rapid medical treatment system and health care user demands convenient, safe and high-quality service.

The developmental request has accelerated the appearance of u-Health. Health care authority is assisting u-Health politically in order to reduce people's cost for medical treatment from the national aspect, reinforce advanced medical care by informatizing medical organization and enlarging health care service to the disable, the old and the social stranger as well as general people.

The representative type of u-Health service can be classified by its purpose and application scope as shown in Table 1.

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**Table 1**
Representative types of u-Health service

| Participant | Prevention and health improvement | Medical treatment and post control |
|---|---|---|
| Internal informatization of heal care organization | Asset control system of medical organization using RFID, Creation of patient/target information system data | |
| Connection between health care organizations | Medical telematics<br>The system to use health information of insurance company | Electronic prescription service<br>Remote EDI service |
| Connection between health care organization and user | Health control postal service<br>On-line fitness service<br>Mobile health control service<br>The old and the weak protection service | Video consulting<br>Reservation and control agent service<br>Medical smart card service<br>Mobile nursing control service<br>UV emergency rescue service |

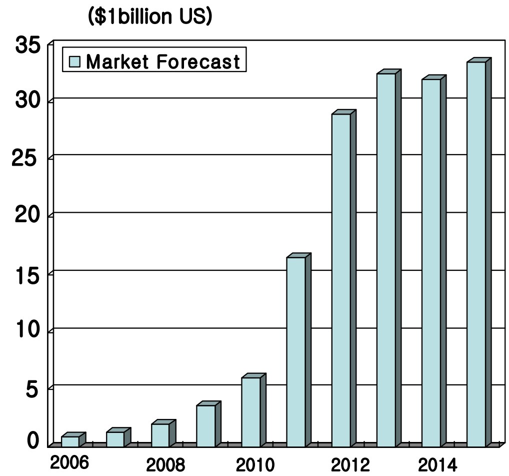

**Fig. 1.** Forrester Research, "forecast of health care".

*On-line fitness service*: It is the service that specialist prepares user schedule check, health status and training menu and provides training progress control or advice via on-line on the basis of them.

*Mobile health care service*: It is the service that provides health status and information service for health such as blood pressure and glycosuria via mobile network in real time.
*Reservation control agent system*: It is the system that searches and reserves proper hospital and doctor in several hospitals, depending on user's available time.
*Medical smart card service*: It is the medical service that enables individual to save basic medical information, make reservation of medical examination and save receipt and prescription history.
*Mobile nursing control service*: It is the service that provides nursing control effectively on the basis of mobile environment. It allows more diversified nursing controls and measures for emergency patients in the work environment, in which mobility and portability are improved.
*UV emergency rescue service*: It is the service that performs rescue instantly through wire and wireless emergency signal by using UV device in home and indoor when there is no people's movement [2,3,6].

### *2.2. Market forecast about Healthcare Information System of USA*

It is expected that home and mobile health care market focusing on the patient with chronic disease will grow rapidly in USA.

It is expected that home and mobile health care market of USA will rapidly grow from USD 970 million in 2006 to USD 5.7 billion in 2006 and USD 33.6 billion in 2015.

The scale of the worldwide patient with main chronic disease is 250 million people in glycosuria, 1 billion people in high blood pressure and 0.3 billion people in asthma. It is increasing because of food and environmental pollution.

Home and mobile health care service can be widely distributed in the organization with limited budget like senior care facility. In addition, large companies are actively entering into home and mobile health care business aiming at the patient with chronic disease. Moreover, the technology that can be applied to medical information system comes to the step of practical use. It is expected that more medical organizations will adopt the system and the scale of concerned market will increase by geometric progression in the next several years. You can predict in detail by referring to specific value of following graph (Fig. 1) [9].

## 3. Design and embodiment of intelligent medical information system

In the future, the general people, the patients, the old and the weak can check health status periodically at home or medical care organization through u-Health, which will be supplied via various wire or wireless communications and they can maintain high-level health through prior prevention.

The purpose of this study is to design the system that can evaluate patient's health status, predict disease and provide same effect as what doctor diagnoses and treats patient on the basis of patient information as well as doctor's special knowledge and main health index saved in knowledge base of intelligent medical information system. Health index, which is proper for the control of chronic disease, is searched and bio-sensor and device that can measure the health index such as blood pressure and blood sugar conveniently at any time and space are being developed. The bio-sensor and device are linked to intelligent medical information system and provide prevention, early diagnose and effective control of chronic disease in real time.

Moreover, the people, who suffer from various diseases but cannot visit hospital because of time restriction, can check and diagnose their healths and they can maintain health by monitoring their health statuses with intelligent medical information terminal.

People can measure enzyme values such as GOT and GPT through bio-sensor that measures the function of health diagnosis electrochemically and intelligent medical information terminal and receive specialist-level medical treatment service through health care diagnosis module.

In order to get the intended result, the inference used for intelligent medical information system suggests several methods as the processes to operate expressed knowledge [10]. In specialist system, there is a RBR (rule-based reasoning) treatment method that saves the knowledge of specialist in RB (rule-based) as a type of rule and solves the problem according to the saved rule.

As an access for solving the bottleneck problem in the construction of specialist system, the method to create rule by inductive study of past case has been researched. There is a CBR (case-based reasoning) method that saves past case in CB (case-based) and solves problem by using it directly in inference. For synthetic inference, synthetic expression of knowledge is required. 'IF∼THEN∼' format of RBR (rule-based reasoning) and example of CBR (case-based reasoning) are used to be expressed as a format of 'IF∼SEARCH∼THEN∼' synthetically in knowledge [1,3].

Fig. 2 expresses synthetic inference system of existing RBR (rule-based reasoning) and CBR (case-based reasoning) briefly. In Fig. 2, the input value for inference is input from user interface to work area and RBR (rule-based reasoning) is processed. Whether conforming attribute value exists in RB (rule-based) is selected (IF∼). If it exists, the value, which is calculated after solving the collision of rule is decided as a final value (THEN∼). If the decisive solution is not made in RBR (rule-based reasoning), however, it can be calculated by operating CBR (case-based reasoning). After comparing input value to the case saved in CB and searching whether it corresponds to attribute value, if there is a case, which was searched in (IF∼SEARCH∼) CB (case-based), it becomes a decisive solution (THEN∼) but if there is no case, it is processed that there is no decisive solution. Because selection and searching can be treated as internal inference engine in Fig. 2, the synthetic inference of RBR (rule-based reasoning) and CBR (case-based reasoning) is more effective than its individual processing due to mutual complementary role.

We selected the characteristics of symptoms and causes as the evaluation criteria for similarity. We built the characteristics of each symptom in a hierarchical structure. In this structure, we reduced the seek time, as there were no unnecessary node, and measured the similarity in two steps to enhance the accuracy of the evaluation.

We entered the characteristics of each symptom as the string to retrieve the cases. And then we used a *K*-NN (Nearest Neighbor) algorithm to measure the similarity between the retrieved cases as shown in Fig. 3 [1,4,7], where $C^n$ was the stored case, $C$ was the entered case, $S_i$ was symptom, $C_i$ was cause, $W_i$ was the weight of each characteristic, and $V_c$, $V_{c^k}$ were the characteristic values of the entered and stored cases respectively. We measured the similarity based on symptoms as shown in Fig. 4, where $S$ was the entered symptom that had no characteristics, $S_A$ was the entered symptom that had characteristics, $S^k$ was the stored Symptom that had no characteristics, and $S_A^K$ was the stored symptom that had characteristics.

As shown in Fig. 4, if one of symptoms had no characteristics, the similarity was read as 0.5 (①), if both symptoms had same characteristics, the similarity was read as 1 (②), if both symptoms were same, and had no characteristics, the similarity was read as 1 (③), and if one had no characteristics, and another had different characteristics, the similarity was read as the value divided by the number of the stored symptom (④).

$C$ : Entered Case $\qquad$ $C^n$ : Entered Case

$$Case_i = (S_c, C_c)$$
$$S_i = Symptom$$
$$C_i = Cause$$
$$\min[sum_i\{W_i \mid V_i - Case_i \mid\}]$$
$$Sim(C, C^n) = \sum_c W(a) Sim_c\left(\frac{V_c(a)}{V_{c^k}(a)}\right)$$

**Fig. 3.** The measurement of similarity by *K*-NN algorithm.

$$S_A = 0 \vee S_A^n = 0 \qquad Sim_a = 0.5 \quad \text{------} \; ①$$
$$(S_A \neq 0 \wedge S_A^n \neq 0) \wedge S_A = S_A^n \qquad Sim_a = 1 \quad \text{-----} \; ②$$
$$(S_A = 0 \wedge S_A^n = 0) \wedge S = S^n \qquad Sim_a = 1 \quad \text{---} \; ③$$
$$(S_A \neq 0 \wedge S_A^n = 0) \wedge S_A \neq S_A^n \qquad Sim_a = \frac{1}{(S_A^n count)} \quad \text{---} \; ④$$

**Fig. 4.** The measurement of similarity based on symptoms.

## 4. Experiment and evaluation

### *4.1. Case-based reasoning for hybrid diagnosis*

According to increasing knowledge through developing a rule-based system, it is very important to efficiently store the method in the rule-based system. In this paper, in order to limit the amount of pattern by retrieved cases, we created case-based library with a tree structure as a symptom.

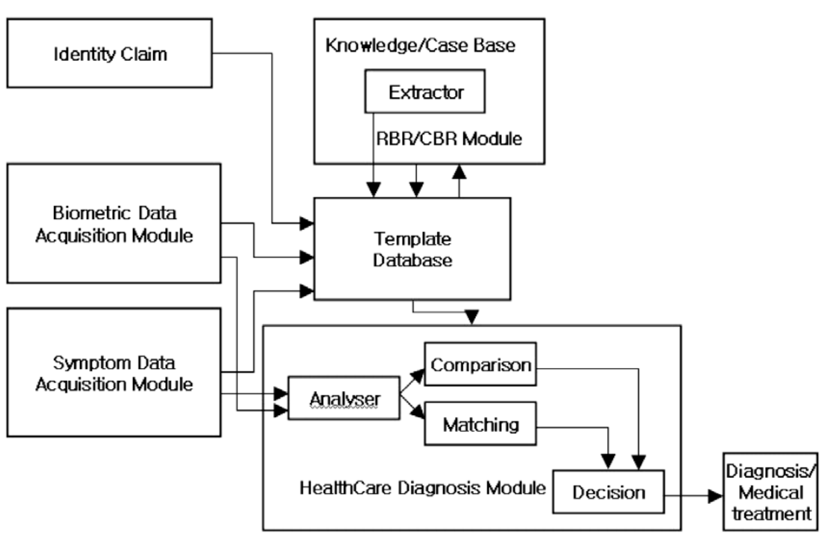


**Fig. 2.** Intelligent medical information system on the basis of hybrid inference engine.

The feature of symptom and cause is attributed on one tuple, including ***Key_Symptom*** and ***Key_Cause*** in Relation Database (***RDB***) and ***Key_Symptom*** and ***Key_Cause*** has attribute of tuple on ***Test_Cause***. The researcher measured the similarity by inputting symptom of each case and characteristic of cause as strings and using the engine of Hybrid Module. In experiment, several characteristics of causes and symptoms can be input and each characteristic can be input by selecting trigger. In case-based inference, characteristic of symptom is used for measuring similarity and characteristic of cause is used for measuring accuracy.

After searching for the saved case of each symptom, the researcher measured accuracy as follows through the causes of searched cases. $D_C^n$ is a cause of saved case and $D_C$ is a cause of input case. In order to diagnose patient's disease, accuracy is examined by analyzing characteristic of symptom, measuring similarity and examining the relationship with the cause of similar case. In Formula (1), when causes are same, 1 is added to measurement value of the case

$$\begin{aligned}&\text{If } D_C^n = D_C\\&\text{Then Count} = \text{Count} + 1\end{aligned} \tag{1}$$

Accuracy of the problem is measured by deciding that inference is successful when it is determined that the accuracy of cause of case is higher than critical value.

### 4.2. Evaluation

In experiment, rule-based inference model, case-based inference model and hybrid inference model are compared and analyzed.

The researcher measured operation processes of different models in same environment and accuracy within actual error margin by using actual data sets of 150 patients. Regarding rule-based inference model and case-based inference model, the rule, which is proper for each characteristic, is applied and regarding hybrid model, which is suggested by the study, accuracy measurement module, in which the relationship between similarity of symptom and cause is analyzed, is added (Tables 2–4)

$$\begin{aligned}&\text{Rate of diagnosis}\\&\quad= \text{Number of examined diseases/Number of entire diseases}\end{aligned} \tag{2}$$

$$\begin{aligned}&\text{Accuracy of diagnosis}\\&\quad= \text{Similarity of disease symptom}\\&\qquad+ \text{Similarity of disease cause}\end{aligned} \tag{3}$$

The result of experiment above shows that in rule-based model, the probability to diagnose disease decreases gradually as the number of experiment increases. It also shows that in the exceptional case that excludes the rule defined by the limit of rule-based model, the number increases when diagnosis is not available and in case-based model, the rate of diagnosis does not decrease as the number of experiment increases but inaccuracy increases. The hybrid model, which is suggested by the study shows lower capacity than that of rule-based model in a matter of time but it can maintain certain capacity in a mater of the rate of diagnosis and accuracy although the number of experiment increases. Synthetically, it is found that the hybrid model, which is suggested by the study, is most proper for diagnosis system, in which accuracy and stability become important factors.

**Table 2**
Experiment result of rule-based model

| Evaluation item | Number of data sets | | | |
|---|---|---|---|---|
| | 10 | 20 | 40 | 80 |
| Time (average of three times) (s) | 0.78 | 0.88 | 1.10 | 1.59 |
| Rate of diagnosis (rate) | 0.95 | 0.90 | 0.83 | 0.59 |
| Accuracy of diagnosis (aod) | 1.95 | 1.92 | 1.93 | 1.90 |

**Table 3**
Experiment result of case-based model

| Evaluation item | Number of data sets | | | |
|---|---|---|---|---|
| | 10 | 20 | 40 | 80 |
| Time (average of three times) (s) | 1.08 | 1.28 | 1.73 | 2.71 |
| Rate of diagnosis (rate) | 0.98 | 0.96 | 0.91 | 0.90 |
| Accuracy of diagnosis (aod) | 1.75 | 1.70 | 1.60 | 1.33 |

**Table 4**
Experiment result of hybrid model

| Evaluation item | Number of data sets | | | |
|---|---|---|---|---|
| | 10 | 20 | 40 | 80 |
| Time (average of three times) (s) | 0.85 | 0.96 | 1.2 | 1.73 |
| Rate of diagnosis (rate) | 0.97 | 0.96 | 0.92 | 0.92 |
| Accuracy of diagnosis (aod) | 1.91 | 1.89 | 1.88 | 1.85 |

## 5. Conclusion and future research

In this paper, technical investigation and analysis were carried out from the perspective of engineer in relation to the new change in the medical IT business market which has been rapidly expanding, as well as the expert system, and analyzed the utility, achievement and economic value related to the new business market.

In Rule-based Reasoning Side, first, we stored the information in a hierarchical structural and applied the appropriate rule. Second, we proposed an explanation function to represent a rule-based processing method. Third, we proposed diagnosis procedure and accurate responsibility using user queries and artificial technology.

In case-based Reasoning Side, first, we presented a case-based hierarchy structure. Second, as the amount of knowledge increased, we improved efficient retrieval time over a general retrieval method and supplemented disadvantage of search. In addition, case of correctness through similarity inquiry and cause of inquired similarity case [5,8,11,12].

By applying hybrid diagnosis, we improve reliability about solved problem. Moreover, we increase case of expansion as create new cases with selected characteristics and result of diagnosis.

Moreover, this study proposed the intelligent self-diagnosis medical system based on new knowledge base, by integrating the rule-based inference and case-based inference.

And this study also proposed the measure to overcome the shortcomings of the existing expert system, so as to ensure that individual patients check their health on a frequent basis with the same effect of being helped by expert.

Future studies need to focus on the function which enables the patients to check their health more accurately using various information from various sensors, and the advanced customized assisting function that helps with the management of health-related schedule in daily lives, as well as the provision of various information.

This model aims to resolve the shortcomings of rule-based inference by storing the problem related to exceptional situation which cannot be generalized as a rule, as well as the problem with the expandability in rule-based inference, as a case for case-based inference.

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