The Supervisory Control System in a Moving-Actuator type Total Artificial Heart: Thought and Progress

*K. S. Om[†], J. M. Ahn[†], J. H. Lee[†], J. H. Choi[†], W. E. Kim[†], H. C. Kim[†], and B. G. Min[†]

*[†]Dept. of Biomedical Engineering, College of Engineering, Seoul National University
[†]Dept. of Biomedical Engineering, College of Medicine, Seoul National University

Abstract

In this paper we reviewed and stated the present state of our team's research of the moving-actuator type total artificial heart (MA-TAH). Especially, this paper showed new direction of researches. The integrated research of battery, telemetry, TET is required. And the real-time supervisory of the state of hemodynamic variables and MA-TAH is also needed. These requirement made us to think the supervisory control system (SCS). As functional abilities of the SCS require very high computational cost, the digital signal processor is an appropriate choice for our need.

- Glossary -

MA-TAH: Moving-Actuator type Total Artificial Heart
SCS: Supervisory Control System
TET: Transcutaneous Energy Transmission
LAP: Left Atrial Pressure
RAP: Right Atrial Pressure
PAP: Pulmonary Artery Pressure
AoP: Aortic Pressure
CO: Cardiac Output

I. Introduction

Supervisory control system (SCS) is a system for the maintenance and alarm processing during the operation of the moving-actuator type total artificial heart (MA-TAH). Moreover additional function of user interface is required.

MA-TAH under development at Seoul National University has achieved great progress and the need of integration of each researches is very high. We are going to integrate and testify the each research under the name of SCS before the end of this year.

SCS has the contrary properties, i.e., it isn't need for the temporary control and maintenance, but it is essential for the long-term control and maintenance. In the other view point, the planned SCS can be said as an expert system for the MA-TAH. Expert system is a successful field of the study of artificial intelligence. Prof. Edward Feigenbaum of Stanford University said an expert system is an intelligent computer program that uses knowledge and inference procedures to solve problems that are difficult enough to require significant human expertise for their solution. ... [1]. The emphasis of the studies of expert system has shifted from the hand-crafted expert systems - all the software components, as well as the knowledge base, were coded by their developers - to the intelligent expert systems such as the ones based on the neural networks and fuzzy logic [2][3][4][5]. Our plan is to use the fuzzy logic for the implementation of SCS. The basic idea of fuzzy logic lies in the human's linguistic variable processing, i.e., ' If ~ , then ~. " This idea is well suited for the our planned SCS. Fig. 1. shows the general architecture of rule based expert system. Some

of recent studies about the supervisory and diagnostic expert system are [6][7][8][9][10][11][12][13][14][15][16][17].

The broad functional abilities of the planned SCS is categorized by three part like as follows: 1) Maintenance processing part, 2) Alarm processing part, 3) User interface part. The detailed function of each part will be stated in the preceding sections.

II. Maintenance Processing

Maintenance processing part consists of three component like as follows:

1) Battery maintenance
2) Telemetry maintenance
3) TET (Transcutaneous Energy Transmission) maintenance

The TET is well studied by J. M. Ahn, and the battery and telemetry is on the way of exhaustive study by W. E. Kim and J. H. Lee respectively right now. The dead-line of the studies is set around the half of this year. Especially, our team tried the new ideas, e.g., laser diode for telemetry, and solar cell for energy source, distinguished from other team. The three researches are going to integrate under the one system of the SCS.

III. Alarm Processing

The alarms have three sources like as follows:

1) Hardware failure (motor, controller, line, and other hardware components)

2) State alarm (abnormal hemodynamic variables, abnormal and dangerous state of MA-TAH such as low battery, position mismatch of telemetry transmitter and receiver, etc). For this function, the cause-consequence alarm relationship trees must be settled [18].

For hemodynamic variabl alarm processing (LAP, RAP, PAP, AoP, CO), the hemodynamic variables estimation is needed, and it occupied a branch of the study of MA-TAH [19][20][21].

IV. User Interface

The thinkable display data is the hemodynamic variables, the conditions of the MA-TAH (battery, telemetry, controller, etc.), and alarm messages. We are considering the small LCD for the displayer. And for the special control and user control, additional devices are on the planing.

V. Conclusions and Recommendations

In this paper we reviewed and stated the present state of our team's research of the MA-TAH. Especially, this paper showed new direction of researches. The integrated research of battery, telemetry, TET is required. And the real-time supervisory of the state of hemodynamic variables and MA-TAH is also needed. These requirements made us to think the SCS. As functional abilities of the SCS require very high computational cost, the digital signal processor is an appropriate choice for our need.

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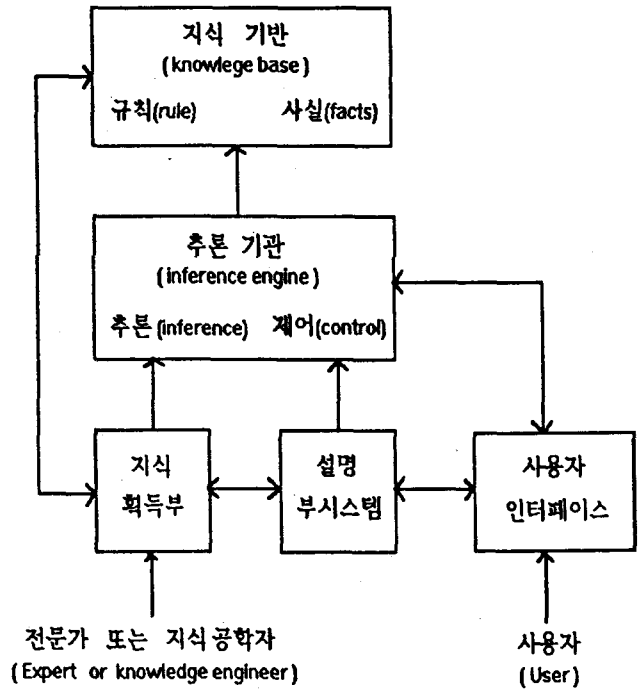

Fig. 1. Architecture of rule based expert system.