Nuclear Power Plant Operator Auxiliary Robot System

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Abstract. The potential problems on nuclear power plant when being operated by nuclear power plant (NPP) operators are discussed in the paper. The solution related to artificial intelligence (AI) is suggested. When using auxiliary robot system to support NPP operators to operate NPP, the relevant technologies and solutions are analyzed. The application of auxiliary robot system can be developed to other industries operation on operators support.

1. Introduction

The failure rate led by human beings occupies over 50% among full power operation NPP accidents and over 70% among low power operation NPP accidents; The number is over 70% among offshore oil exploration accidents; The misjudgments of pilot lead to commercial air crash occupy at least 50% [1].

So performance evaluation (PE) of people is focused by researchers and management team for a long time. PE is a formal and structural system to judge and evaluate the relevant attribution, behavior and result. Furthermore, PE can be used to evaluate the productivity of related people and judge he or she whether can perform better or more efficiently [2].

With artificial intelligence (AI) development in past a few years, expert system (ES) became an active application domain. ES had been widely utilized in medicine, geography, engineering design, education and army etc. ES can obtain conclusion based on experience and knowledge of experts. The combination between these conclusions and relevant optimization technology like fuzzy sets etc. can be more practical in the application [3].

NPP operator is one of key factors to keep NPP safe operation. It is very important to evaluate working performance objectively. At the same time, making use of relevant techniques and auxiliary methods to support and monitor NPP operators also become the ensuring of NPP safe operation.

2. Current operation model

At present the control of NPP control room and breakdown handling are completed by NPP operators. The relevant operation is relied on the mutual verification among operators. When breakdown and alarm appearing, NPP operators need to process based on related procedures prompting. However, the procedures are very numerous and tedious. The handling time and processing efficiency of NPP operators are needed to be improved.

In AI domain, ES is being explored and utilized in NPP through many ways. The majority of applications are related to fault diagnosis, human error evaluation, human reliability analysis and auxiliary operation etc. [4, 5]. Some small expert systems developed are used to process the training of NPP operators and other problems [6]. The application of AI and relevant technologies is crucial to the success of NPP and safe operation through knowing the impact of ES to NPP.
Though current ES application and auxiliary system can prompt the trend of NPP and the operation direction to NPP operators, the actual operation still needs to be done by NPP operators based on relevant procedures and hint information. Because of huge and tedious operation procedures, the efficiency of searching and finding becomes a problem. The process can be improved and supported by current technical means.

3. **Auxiliary system for NPP operators in control room**

   Auxiliary system for NPP control room is to make use of smart service robot and control room ceiling which space could be utilized to supply smart and high efficient auxiliary service to NPP operators. The objective is to help NPP operators finish relevant NPP operation rapidly.

   The creative point of the system is to use cooperation between the monitor of service robot and the screen of NPP control room ceiling to support NPP operators realizing right operation through auxiliary guidance. The implementation is to run two different systems through computer system of service robot. One system is used to display operation guidance on NPP control room ceiling screen based on collecting operation data of control room; the other system is used to display relevant contents of procedures on monitor to assist NPP operators to make decision auxiliary based on the same data collection. Then the monitor can give alarm when abnormal operation of NPP operators appearing.

3.1. **The solution of auxiliary system for NPP operators in control room**

   Currently NPP operators are responsible for the relevant operation in control room. When appearing breakdown or alarm, NPP operators need to look up relevant procedures based on the guidance of breakdown and alarm. Through the requirement of related procedure, NPP operators give action. The method will lead to the delay of time and efficiency.

   In order to solve the current issue, the system will give solution through two aspects. On one hand, when the signal of breakdown or alarm appearing, the relevant operation guidance according to related procedure will be given on the screen of control room ceiling to NPP operators and the animation will also be given to guide NPP operators to do operation; On the other hand, the relevant handling of related contents of procedure will be displayed on the monitor of service robot. Based on the contents NPP operators will give their operation judgments. Thus comparing to NPP operators searching relevant procedures manually based on the signal of breakdown and alarm, time will be saved greatly and efficiency will also be improved very much.

3.2. **The implementation of auxiliary system for NPP operators in control room**

   Firstly the auxiliary system for NPP operators in control room is very convenient and directly perceived through utilizing the space of control room ceiling to collect signal and guide operation; Secondly it is high efficient and directly perceived to use the monitor of service robot as searching and displaying device of procedure and give follow-up abnormal alarm of NPP operators if having.

   The camera and display of data collection on control room ceiling is showed as figure 1. Display background is connected with the computer system of service robot.

   Service robot locates beside NPP operators. The data information of operation on NPP operators can be obtained by pick-up head through best way. The data will be input and handled in computer. The service robot and structure are showed in figure 2.

   The characteristic of service robot is its controller part. The relevant technique includes our independent intellectual technology. Drive control integration is used to controller. The technology can save power and efficiency is high. The controller has low cost and low power consumption [7].

   The principles and procedures of auxiliary system for NPP operators in control room are as below:

   1) The data collected by the pick-up head of service robot and the camera installed on control room ceiling is input computer system of service robot;

   2) When alarm and breakdown signal of operation of NPP operators appearing, the monitor of service robot will display relevant procedure to the related alarm and breakdown signal for NPP operators to read, judge and process in shortest time. The method will save much manual time to search procedure. At the same time, the suggested operation procedure and animation
will be displayed on the screen of control room ceiling for NPP operators to take action. The process need to save procedure information in the database so as to visit, search and evaluated at any time [8];

3) NPP operators make decision for next action based on their judgment to procedure and reference guidance. Because ES has its limitations like wrong knowledge included, difficulty of knowledge obtained from suitable experts, difficulty that describing the knowledge in computer model, lack of learning ability of computer and etc. [9] It is necessary for NPP operators to make final decision;

4) Service robot will give judgment based on the next operation of NPP operators. If abnormity appears, alarm will be supplied. Thus NPP operators will make final decision again based on the explanation of ES decision for reference [10].

![Figure 1. Data collecting pick-up head and screen on control room ceiling](image-url)
4. Conclusion

China is a big country on nuclear electricity. At present over 40 reactors are operated. About 20 reactors are being built. More and more reactors will be built in the future. The safety of nuclear electricity has to be solved as an important project. China government has long term development strategy on nuclear energy. According to energy development plan from 2014 to 2020, till 2020 China nuclear energy will have 58 billion watts generating capability. At mean time there are over 30 billion watts nuclear energy being built. So the safe application of nuclear electricity needs to be solved as soon as possible [11].

![Image of service robot structure]

**Figure 2.** Structure of service robot

The method introduced in the paper will improve operation efficiency of NPP operators under the precondition that the operation of NPP operators is not affected. The method makes use of smart service robot based on AI to do auxiliary guidance to NPP operators. The necessary guidance will be shown through the NPP control room remained space. Thus NPP control operation can be realized through NPP operator auxiliary system efficiently.

The auxiliary robot system on NPP operators is a useful tool for NPP operators to improve NPP operation. It will display most optimized result from database based on AI method. The final decision right will belong to NPP operators. The system is a tool to support NPP operators to operate. It is not mean to replace NPP operators. With more and more NPPs built and operated, the systems related to AI will more widely used to keep NPP safe operation. The research method in the paper can be used to other type power plant operation of operators.
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