Research on Cognitive Theory Model of Man-Machine Combination Pilot Based on Information Processing

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Abstract. The cockpit design of information integration have changed the role of pilot. The role of Pilot in flight changes from the operator to the monitor of flight data, which put forward higher requirements for the pilot's information processing ability. Pilots will receive a lot of information and they must make decisions in a short time. Due to the need to process a large amount of information under the time pressure, the cognitive load of pilots is increasing and the work performance is decreasing, which would affect flight safety. Thus, this paper have analyzed the characteristics of information acquisition and processing from the perspective of pilot and cockpit. And then, the information processing framework based on pilot cognitive characteristics has been established. Finally the pilot cognitive theoretical model and Man-machine combination precision cognitive system model was proposed. The model considered both human and aircraft information interaction, quantified the cognitive load of pilots from the perspective of information processing ability.

Keywords: Pilot cognition model · Cognitive behavior modelling · Pilot information processing · Cockpit

1 Introduction

With the development of engineering technology and airworthiness technology, the reliability of aircraft mechanical system is increasing, and the safety and reliability of aircraft equipment have been greatly improved during flight mission. The number of serious aviation accidents caused by the damage of aircraft structure, components and system equipment is decreasing year by year. At the same time, with the improvement of aircraft automatic control system and the realization of information integration cockpit design, the human-aircraft system in flight mission is becoming more and more complex, and the flight environment poses challenges to the pilot's response and decision-making in emergency situations. With the application of artificial intelligence technology, the role of the pilot has changed from the operator to the monitor, but the cockpit design of information integration also makes the pilot need to process a large amount of real-time data at the same time, which puts forward high requirements for the pilot's cognition and decision-making ability [1].

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Modern cognitive theory has absorbed the research achievements of system theory, information theory, cybernetics and computer science in the development process, and put forward the information processing model of human cognition, which regards human cognition as a process of information acquisition and processing. From the perspective of information processing, the cognitive mechanism and theory of man-machine combination can be classified into two categories: human cognitive characteristics and human-machine interaction cognitive characteristics.

In the operating environment, people are often processed under high cognitive load and state of emergency. For the research on cognitive characteristics of people under pressure and state of emergency. Sun [2] studied the hazard perception model of automobile drivers based on KAP theory. The cognitive structure equation of human danger perception is constructed, and the stress state is described objectively by combining demographic indicators such as driver age and gender, driving experience, visual search mode, traffic constraint cognition, risk attitude and other factors. Wu [3] through the study of complex information task error in the cognitive mechanism of interface. The integrated use of cognitive psychology, design science, experimental psychology, human factors engineering, and related theory and method of cognitive neuroscience and error source is put forward from the failure of tasks - factor to solve the complex information task interface design optimization problem. By establishing a mathematical model of misjudgment and misoperation in emergency situations, Huang [4] demonstrated the deficiencies and defects of the operator's cognitive behavior model in the existing human-machine system, and studied how to further optimize the human cognitive model after considering misprocessing.

The cognitive process research of specific display layout design is also the key issue of commander's human-computer interaction. By combining the memory mechanism of Chinese characters with long-term memory in working memory theory and intelligent methods such as point set topology, Liang [5] made an intelligent design for the cognitive processes such as character formation, literacy and character memorization and realized the mathematical explanation of the coding process. Wang [6] studied the design of digital interface information display, such as sensory perception, memory system, thinking and decision-making, and complete the action transmission of human machine. The core of HMI research is the coordination problem of human-machine relationship in a specific environment. Through excellent human-machine interface design, the effectiveness, efficiency, safety and comfort mechanism of human-machine interaction can be effectively solved.

The cognitive process of specific task types is an important application of human cognition. Liu [7] optimized the interface design of typical monitoring tasks in terms of visibility, cognition and experience by studying the information processing and storage methods of human brain. Shao [8] obtained the information display layout of pilot panel under warning and alarm tasks by analysing the coding rules of flight images and combining the cognitive theory of visual perception. Wu [9] studied the cognitive error mechanism for complex information tasks, providing theoretical improvements for subsequent cognitive optimization and interface optimization design. Li [10] solved the tasks related to the cognitive model of miners' safety behavior through intelligent technology, providing a method guidance from a cognitive perspective for monitoring

and patrol operations. The situation where the operator is overwhelmed and overburdened with information. The key of man-machine combination interaction is the display and processing method of all kinds of information which appears in normal man-machine interaction. The most important characteristic of complex human-machine combination interaction system is the information coupling of perception, decision and execution. The most important problem is to distinguish the machine-assisted human tasks from human tasks, and to solve and implement different task domains, that is, to analysis the characteristics of human and machine in the system, in order to determine the influencing factors of function allocation.

2 Study on Cognitive Mechanism Based on Cognitive Characteristics of Pilots

2.1 Research on Cognitive Mechanism

The aircraft display and control system displays the task information, parameter information, auxiliary decision information, statistical summary information and status display information to the pilot by displaying layers, numbers, icons, images, texts, text tables and dialog boxes on the interface. Pilots use sensory processing to store information received by their senses in the form of visual or sound representations. Selective attention decision and control information is further strengthened and processed into short-term memory. Perception is produced by processing in the brain. Short-term memory is transformed into working memory and long-term memory through perceptual processing. At the same time, relevant experiences are extracted from long-term memory as working memory for perceptual processing. The pilot makes decisions through thinking and reasoning, and then gives instructions to the display control system, which feeds back new information to the pilot. The specific pilot cognitive mechanism is shown in Fig. 1.

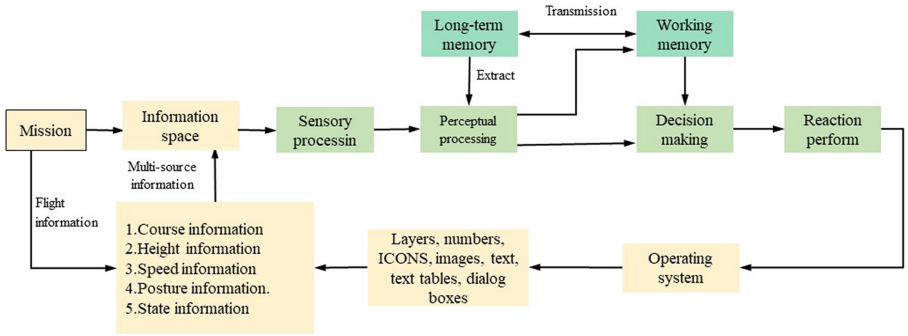

Fig. 1. Cognitive mechanism based on pilot characteristics

2.2 Core Cognitive Theory of Enhanced Cognition

Based on the cognitive mechanism and the different cognitive characteristics, man and machine are combined for cognition in the aspects of cognitive acquisition, analysis,

decision-making and action. The core cognitive theory of enhancing cognition is shown in Fig. 2.

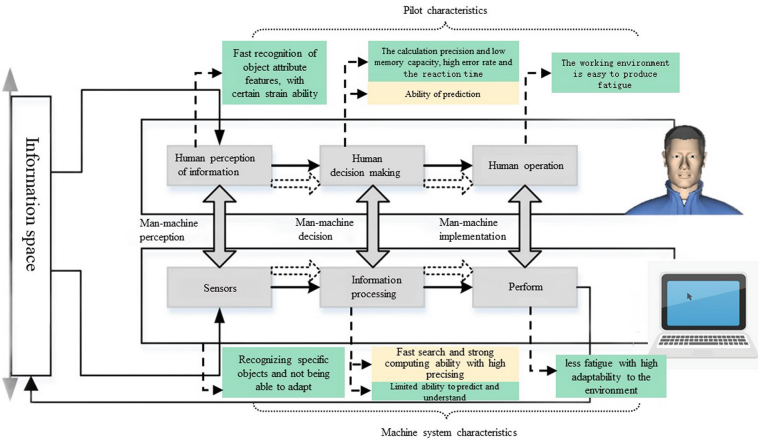

Fig. 2. Human computer combination cognitive enhancement

2.3 Natural, Efficient and Accurate Man-Machine Combination Cognition Mechanism

On the basis of man-machine combination cognition and machine system of multi-source information processing, machine system is disturbed to the environment monitoring and feedback processing. personal factors, experience of reasoning decision-making, and other functions, the influence of the adaptive algorithm based on pilot cognitive mechanism, the study of natural, efficient and accurate the man-machine combination of cognitive mechanism are shown in Fig. 3.

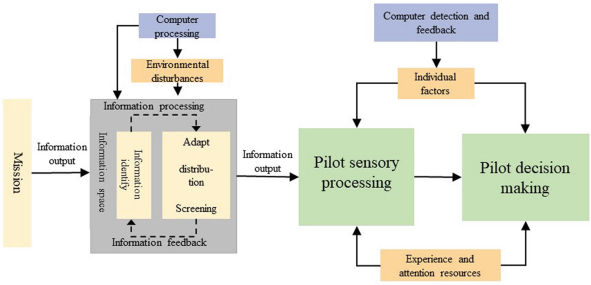

Fig. 3. Machine processing, monitoring and feedback

3 Human-Machine Combination Precision Cognitive Framework

3.1 Human-Machine Combination Precision Cognitive Framework

Based on the pilot's cognitive mechanism, the pilot's information processing model is constructed. The cognitive mechanism and information processing model, the cognitive framework of pilots are established. The human-machine combination precise cognitive framework is established by combining the machine system information processing rule base. The specific cognitive framework is shown in Fig. 4.

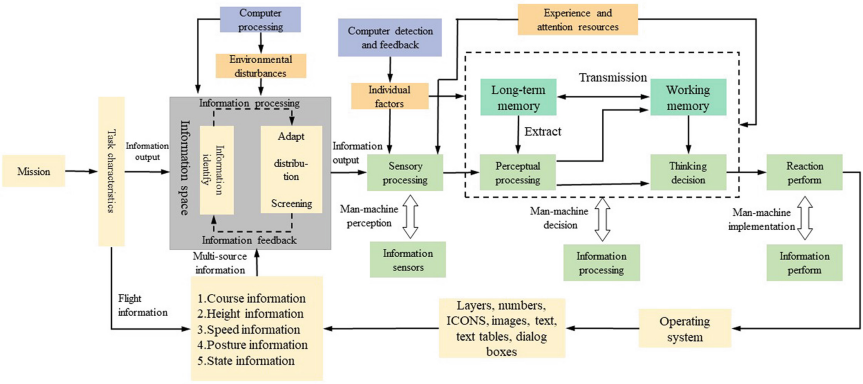

Fig. 4. Man-machine combination precision cognitive framework

3.2 Model Construction, Simulation and Effectiveness Evaluation of Human-Machine Combination Precision Cognition System

The man-machine combination precision cognition system model uses Matlab and Simulink as development tools. Based on intelligent control theory and man-machine combination precision cognition framework, neural network, machine learning and ATA module are adopted to screen and predict the information required for pilot's cognition. Monitor and feedback the physiological, psychological, micro-expression and other indicators of human body are used to establish the human-machine integrated cognitive system model. The simulation system is consisted of development environment and operation environment. The development environment includes the establishment of information knowledge base, the determination of neural network structure, the selection of training samples, neural network learning and training of samples. The operating environment is used to control the controlled object, including human-machine perception information input, information synthesis and task allocation, inference machine, neural network, knowledge discovery, knowledge base adjustment, human-machine combination intelligent voting processing. Finally, the effectiveness evaluation system of simulation results is embedded in the simulation platform to evaluate the efficiency of the model, as shown in Fig. 5.

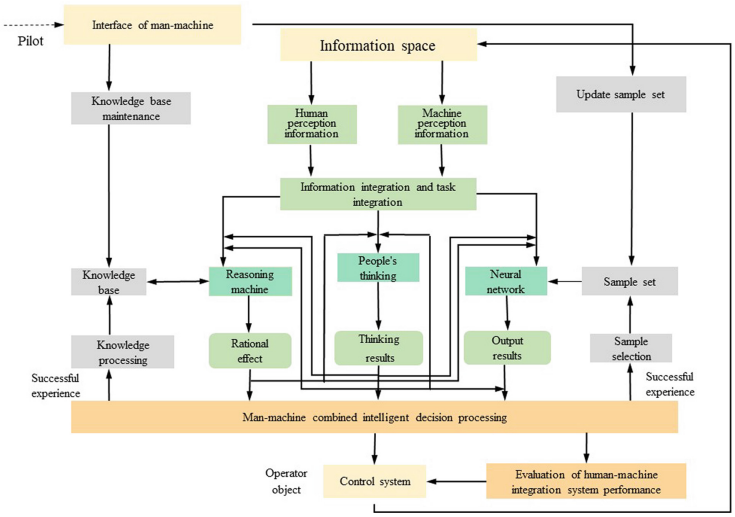

Fig. 5. Man-machine combination precision cognitive system model

4 Conclusion

This paper pay attention to the study of the pilot's information processing capability during the mission. Based on the theory of pilot model and the framework of intelligent control system, this paper proposed Man-machine combination precision cognitive system model. At first, the task information and environmental information that can affect human-machine cognition process under specific task scenarios are selected to construct information space. Based on this information space, the characteristics of machine information acquisition and processing has been studied, which providing theoretical basis for the necessity of man-machine combination cognition research. Combined with the information processing of the machine, the cognitive mechanism model could describe the cognitive ability of the operator in the task. Then the efficient man-machine combination precision cognition mechanism is studied. The paper constructs a cognitive framework based on the cognitive mechanism of pilot. By studying the human-computer combination cognitive process and machine-aided information acquisition, expression, processing and decision transmission, an efficient human-computer combination accurate cognitive model is constructed. The monitoring and extraction of physiological data, the simulation of cognitive model and efficiency evaluation are realized on the experimental platform.

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