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【論文の内容の要旨】

Currently, there are many petrochemical foundation products and petrochemical derivatives being both produced and used in chemical plants. These products are indispensable in many industrial fields, such as Japanese plastic product manufacturing, automobile and electronics manufacturing, and rubber product manufacturing, among others. Because chemical plants are part of capital-intensive industries, their automation and labor-saving strategies are advanced, and the involvement of skilled workers is decreasing. Notably, many substances that are handled in chemical plants have potential hazards, such as flammability, explosiveness, toxicity, and corrosiveness. Accidents in chemical plants are caused by hazardous substances, equipment failures, and human factors. According to statistical data, approximately 40% of accidents are due to human factors, including misrecognition, incorrect operation, contact mistakes, etc. Chemical plant workers are generally responsible for their specific work places, while board operators, who work cooperatively with field operators, are in charge of monitoring and remotely controlling equipment, such as valves and pumps, from control rooms. In distance cooperative work, operators often succumb to misrecognition, conduct erroneous operations, make contact mistakes, etc., which are regarded as human factors. Thus, sharing plant information is important for making quick and appropriate decisions.

This study focused on how the proposed system prevents human errors. In this thesis, the proposed system is described in six chapters:

Chapter 1 introduces the current state of and problems with technology concerning the prevention of accidents in the operation of chemical plants as well as disaster prevention at the time of the accident. This chapter then describes both the purpose of this research and the composition of this thesis.

In Chapter 2, a summary of the related study, including experiences regarding work support and information sharing systems in chemical plants, is presented. A method for inheritance and sharing information through the advancement of information technology is also examined.

Chapter 3 considers the work information presentation system, which is intended to prevent human errors via image processing techniques. The operator captures the target equipment using the tablet PC's camera. Template matching, which is an image processing technique, is used to specify the target equipment, such as valves, which are reflected in real-time images. Because different kinds of equipment have the same type of setting in a narrow space, the operator needs to capture the background that is shifted to the photographed image for accurate recognition. The system also uses the background image's features to identify the target equipment. In addition, a method for standardizing and revising the operation procedure manual was prepared, per the concept of 6W2H, to cope with unskilled operators. In the case example, it became possible to identify different types of machinery and equipment. The use of standardized operation manuals also helped reduce erroneous operation by unskilled operators.

Chapter 4 describes the instructional information system using image recognition (IR) and augmented reality (AR) technologies for the prevention of operator errors. With only template matching technology, it is difficult to distinguish different types of machine equipment with 100% accuracy. Therefore, this study proposes a method for improving the discrimination accuracy of machine equipment by combining IR and AR technologies. Furthermore, it presents a function that can record the field operator's work history in the database and an information sharing function that provides work information via the server. The case examples indicate that it is possible to prevent misjudgment of different types of machine equipment.

Notably, the operation history is automatically stored in the system's database. The accumulated work information is important for safety management and can be shared and utilized by all workers. With the proposed system, the field operator can recognize work target equipment via IR/AR technology, and the system displays the correct work procedures to site workers. The field operator can accurately check the work target equipment and work procedures onsite with this system as well, which can be beneficial for securing the safety of onsite workers as well as for preventing erroneous operation and judgment.

Chapter 5 explains an information sharing system that aims to enhance the safety of distance cooperative work. This system has functions to support both board operators and field operators at work sites. The system also allows for the sharing of real-time on-site images, along with work information that is necessary for operation. In addition to instruction information by a human voice from the control room to the site worker, correct work information is transmitted by a simple text display. Field operators can utilize two-way communication to obtain direction from the control room with the Yes-No button. In the chemical plant, a dynamic simulator has been installed that predicts the machine's behavior by inputting the present condition of the operator at the site and the operation amount of the facility. Therefore, in addition to facility operation procedures, information on the equipment's state is grasped in the control room, and information on behaviors that are predicted by the simulator is presented to the field operators. The system refers sensor data and displays plant information to the field operator on his/her tablet PC. The case example showed that the onsite operator can share the above information with board operators and thus carry out cooperative work both safely and securely.

To conclude this thesis, Chapter 6 summarizes the presented study on distance cooperative work support and work information sharing systems for multiple workers in chemical plants and states that the results are expected to prevent accidents that are caused by human factors in chemical plants.