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Information Support for Annual Maintenance with Wearable Device

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Abstract

One of the way in which annual maintenance is improved is to support with wearable devices connected with network. Two basic key systems for advanced plant maintenance using Head Mounted Display(HMD) have been developed, which are “a communication support system between a foreman and workers” and “a remote cooperative system utilizing gazing point information”. The one enables a foreman to observe and instruct plural workers at the same time. And the other realizes a supporting function from a remote expert. The effectiveness of these prototype systems have been confirmed by basic laboratory experiments in the university.

1 Background

A concept of the satellite operation maintenance center could be a solution to decrease the total management cost of nuclear power plants. The satellite center is located apart from the control room of nuclear power plants, where the introduction of an advanced information system for operation and maintenance with the concept of augmented reality technology is the main subject of this paper. In this study we focus on improvement of annual maintenance work, which is supported with wearable devices connected with network.

The wearable devices workers will wear for conducting annual maintenance work, will need the following three functions; (1)navigation function by which maintenance worker can reach their work place through the labyrinth of nuclear power plant without straying, (2) support function which helps workers look for manual appropriate for their work, search past similar cases as the reference to their work to conduct without any mistake, and communicate smoothly with their foreman at the work place to supervise the subordinate workers by using mobile computer, and (3) support function by which experts located in the satellite center will help by giving appropriate instruction the workers to conduct their maintenance work accurately to compensate for the workers’ testing skills for solving difficult problems.

As the first step to realize the three functions above, two basic key systems using Head Mounted Display(HMD) have been developed, which are “a communication support system between a foreman and workers” and “a remote cooperative system utilizing gazing point information”.

2 A Communication support system between a foreman and workers

For the communication support between a foreman and workers, a new observation and instruction support system has been developed by utilizing a tablet PC and Augmented Reality technology. This support system enables a foreman to observe and instruct plural workers at the same time for machine-maintenance work. With this support system, a foreman can observe plural worker's field of views and make some instructions to the workers by superimposing the instructions over the worker's field of views.

In this system, as shown in Figure 1, the workers equip a CCD camera which captures the worker's filed of view, a mobile computer with wireless LAN, a microphone and a see-through HMD. And the foreman equips a microphone and a tablet PC with wireless LAN.

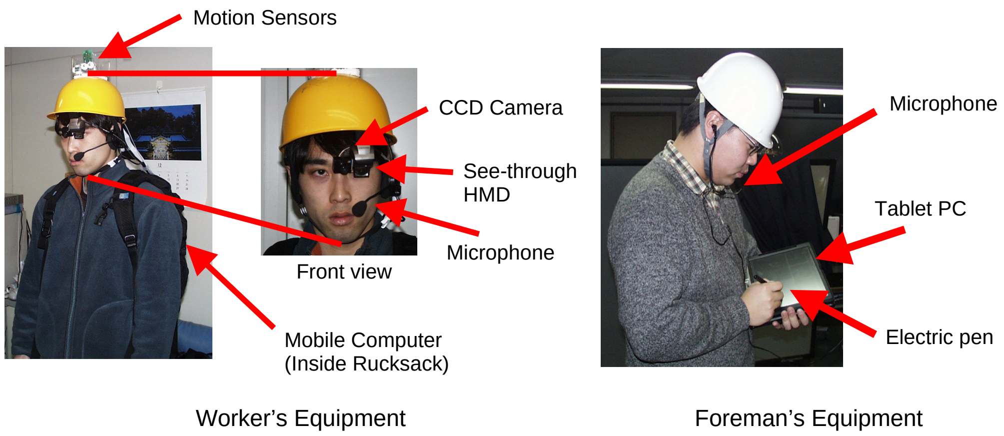

Figure1 Worker's and foreman's equipments.

The worker's filed of view images captured by the CCD camera mounted on the worker's helmet are transferred to the foreman's tablet PC via wireless LAN. As shown in Figure 2, the interface of the foreman's tablet PC consists of preview screens for observing the plural worker's field of views, an instruction screen for writing instructions to the workers and some operation buttons for controlling the support system.

The foreman can select a worker from preview screens and write some instructions such as arrows and comments over the worker's field of view with an electric pen. When the foreman pushes a send button after writing some instructions, the instructions are transferred to the workers who are equipped with a see-through HMD and superimposed upon the view of the workers.

On the worker's site, a function which estimates appropriate locations where the instructions should be superimposed has been developed in order that the locations of instructions where the foreman intends to display are properly aligned in the correct relative position even if the worker moves around the work place. With this function, the worker can understand some instructions from the foreman more intuitively such as important locations the worker should pay attention to.

In this study, in order to estimates appropriate locations, two measurement methods have been developed. One is the method that the appropriate locations are calculated based on the artificial markers located in the work site in advance. The other is the method that the appropriate locations are calculated based on the natural markers which are acquired from the feature point of work environment such as an edge of machine apparatus(Harris et al.,1988). These methods are used together according to the situation of the work environment. For example, in the case that the accurate measurement is required, the method using the artificial markers are applied. And in the case that it is difficult to locate some artificial markers around the work environment and the accurate measurement is not required, the method using the natural markers are applied.

In addition to the above function, a function has been developed to capture images of the worker's view by using stereo-matching algorithms for measuring the three dimensional shape of equipments located in the work place. This function makes it possible to estimate the three dimensional locations of the instructions where the foreman intends to display even if the instructions written on the display of mobile computer are in two dimensions.

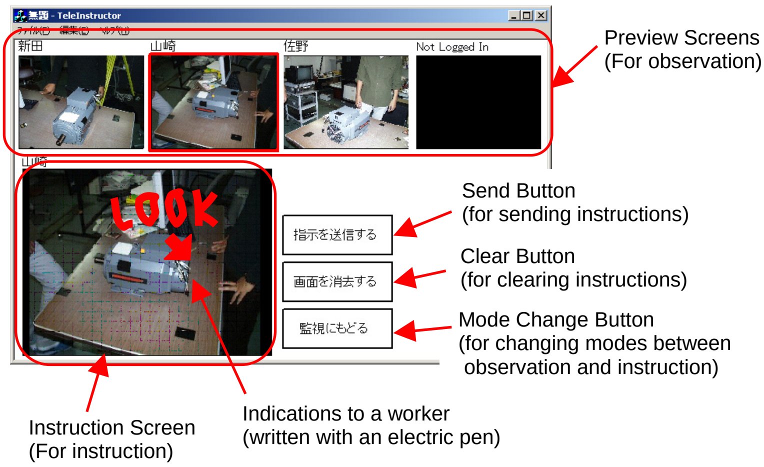

Figure 2 Foreman's Interface.

3 A remote cooperative system utilizing gazing point information

3.1 System configuration

A cooperative system utilizing gazing point has been developed. The system consists of two terminals. One is for the plant workers and the other is for the expert at the remote site such as satellite centre. The terminal for the plant worker consists of Eye-Sensing HMD (ES-HMD) (Fukushima et al.,2001), two PCs, headset, etc. as shown in Fig.3. The ES-HMD monitors worker's eyes by CMOS cameras and calculates gazing point by one PC. The other PC captures the view image of plant worker through a CCD camera which is fixed on ES-HMD. The terminal for expert receives the view image and the plant worker's gazing point via network and display where the plant worker is gazing in the view image as shown in Fig.4. The expert can know where the worker is gazing and detect what the worker thinks in combination with conversation information. And the expert direct which point the worker should pay particular attention to and what to do for supporting the worker's difficult task of the machine maintenance and testing.

Figure 3: Worker with AR devices

Figure 4: Interface for expert (+: worker's gazing point, O: indicating point by expert)

3.2 Experiment for System Evaluation

An experiment for system evaluation was conducted. As a test site a boiling thermal-hydraulic test loop was used. Participants are one expert and 3 workers. The expert is a researcher who use the loop and 3workers are students of university who have no particular knowledge of the loop. Task in the experiment that workers do are injection of fluid to the loop, adjustment of flow rate and draining of the fluid. The experiment were conducted 9 times (3 times by each person) as shown in table 1. In the table "AR indication" means using the function of display of superimposed indication on HMD and "gazing point" means using gazing point information for expert to understand the situation of workers.

Table 1: Experimental Condition for workers

Number of experiment	Participant A	Participant B	Participant C

1	Using AR Indication & gazing point	Using AR Indication	Not use
2	Using Indication	Using AR Indication & gazing point	Using AR Indication & gazing point
3	Not use	Not use	Using AR Indication

Table 2 shows the result of subjective evaluation of the system by questionnaire. From that result this system is bad to work, but it is useful. So to make this system useful and usable, the system must be improved to be miniaturized to wear and move easily.

Table 2: Subjective Evaluation of the System by Participants as Workers

(-2:very bad, -1:bad, 0: neutral, 1:good, 2:very good)

Division	item	Participant A	Participant B	Participant C	Ave.
Ease of work	Ease of walk	1	-1	1	0.33
	Ease of looking around work space	-1	2	-2	-0.33
	Ease of moving hands	2	2	2	2
	Ease of moving neck	0	-1	-1	-0.67
	Restriction of visibility	-1	2	-1	0
	Brightness of view	-2	-1	-2	-1.67
Understandability of Indication	Using AR Indication	2	2	2	2
	Using Audio	2	2	-1	1
	Using Character	Not used	Not used	Not used	-
Communication of intension	Using Audio	2	2	1	1.67
	Using gazing point	0	2	2	1.33
Whole System	Usefulness of the system	2	0	2	1.33
	Usefulness of the gazing point	2	2	1	1.67
	Usefulness of Audio	1	2	2	1.67
	Usefulness of Character	Not used	Not used	Not used	-

4 Conclusion

Two basic key systems for advanced plant maintenance using Head Mounted Display(HMD) have been developed, which are "a communication support system between a foreman and workers" and "a remote cooperative system utilizing gazing point information". The effectiveness of these prototype systems have been confirmed by basic laboratory experiments. The next step will be to conduct more realistic system development to be used in the training centre of machine maintenance workers for nuclear power plant.

References

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