Efficient Maintenance Work and Transfer of Skills by Augmented Reality (AR) Tool

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Abstract

In recent years, there are increasing industry challenges stemming from the lack of technical skills due to the retirement of skilled workers, the decrease in the working population from the declining birthrate and aging population, and an increase of aging facilities. Given these issues, there is a correlating increase in demand for solutions to problems related to the transfer of technical expertise and efficient maintenance service work.

Using Augmented Reality (AR) technology, we, therefore, developed an AR function that supports our repair and maintenance service education and training for the transfer of engineer skills and expertise. The tools have the functions to show on equipment, in an overlaying manner via the cloud computing, the current operating status like sensor values, specification information, and manuals of the target equipment and inspection history. In addition, we fully introduced some of these AR technologies developed this time to a newly built in-house engineer education facility called "Manabi-ya". We realized the learning using AR technology tool for skills and expertise transfer.

1 Preface

Serious societal challenges in Japan, such as the declining birthrate and aging population, and the lack of technical skills due to the retirement of the skilled workers, engineers and technicians, have begun to present challenges for facility repair and maintenance service field. We witness not only a simple shortage of personnel, but also the challenge of the loss of the skills and expertise of skilled workers engineers and technicians without being transferred in the service engineering field.

As a countermeasure against such issues, we are working on a repair and maintenance service work support tool utilizing Information and Communication Technology (ICT). For example, we use the Internet of Things (IoT) technology to acquire detailed equipment operation data from various sensors that are retrofitted to the equipment. Based on the big data obtained from these devices, we are working toward the realization of the diagnosis of failure prediction and remaining product life using numerical analysis and Artificial Intelligence (AI).

This paper introduces our initiatives to support the repair and maintenance service work by using a tool with Augmented Reality (AR) technology, a latest technology.

2 Realization of Repair and Maintenance Service Work using AR Tool

2.1 What is AR?

AR is an acronym for Augmented Reality. AR is a technology that enhances the real world that humans perceives by computer-generated perceptual information. What creates the world that humans perceives all by computer-generated perceptual information, is called Virtual Reality (VR). Both are used in various fields. The AR has recently become popular in smartphone games and is making progress in its use in both hardware and software. Fig. 1 shows an example of AR. Since AR is a technology that targets the real world, it is expected to be applied to field service operations.

2.2 Issues

To use AR technology, the computer must be able to reliably recognize the location information of the real world and the target equipment. For this

Fig. 1 Example of AR

For an operation panel in the real world, an extended arrow mark is used to indicate the point where confirmation is needed. This function is based on AR technologies.

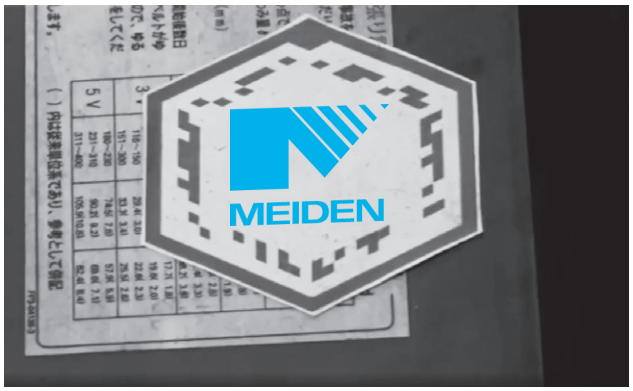

Fig. 2 Example of AR Marker

An extended display is given in the relative position, assuming that the setting position of this marker is the starting point. Although there is no designation in terms of size, the larger the display, the easier the recognition from a distant point.

reason, it is necessary to place a mark called an AR marker, for alignment in a space on or around the target repair and maintenance service equipment. The work of creating and installing the AR marker is difficult, as it becomes a barrier to the introduction of AR technology. In response, by unifying the shape of the AR marker, the challenge of creating the AR marker was reduced, and the seal was used to facilitate the retrofitting to the existing equipment. We are also considering incorporating AR markers into our products from the manufacturing process for our equipment. Fig. 2 shows an example of an AR marker.

There is also an issue that some engineers find it less convenient to use AR technology than conventional work methods. For this reason, we also paid attention to the User Experience (UX) such as the ease of operation in consideration of substituting the work method with AR technology.

Fig. 3 Image of AR Tool Utilization at Project Site

By using the AR technology effectively, an arrow mark is displayed in overlay mode so that the bolt position can be found easily during the inspection.

2.3 Application to Repair and Maintenance Service Work

To refer to related information such as specifications of equipment to be maintained, past maintenance history, inspection status, and drawings at the site, much project-related documentation may be needed on site. Even if such documentation is digitized and information can be referenced on tablet device, much knowledge and time are required to search for the desired information. Since AR technology is used by linking it to the actual product, it can be uniquely identified without searching for information on the target equipment. One may work while also referring to the necessary information when needed, and a reduction in work time can be expected. In addition, required expertise and features specific to the target equipment can be managed together with location information. It is, therefore, one of the measures to prevent the loss of field service expertise due to the retirement of skilled workers engineers and technicians.

Fig. 3 shows an image of an AR tool utilization at a project site. When using an AR device such as a smartphone or tablet that runs either iOS or Android, it is operated by holding it in hand, but it is difficult to perform maintenance work with both hands while using the AR function. It is, therefore, recommended to use a glass-type AR device that allows one to work with both hands while using the

Fig. 4 Image of Glass-Type AR Device (HoloLens)

An image of AR-based inspection is shown by using a glass type AR device (HoloLens).

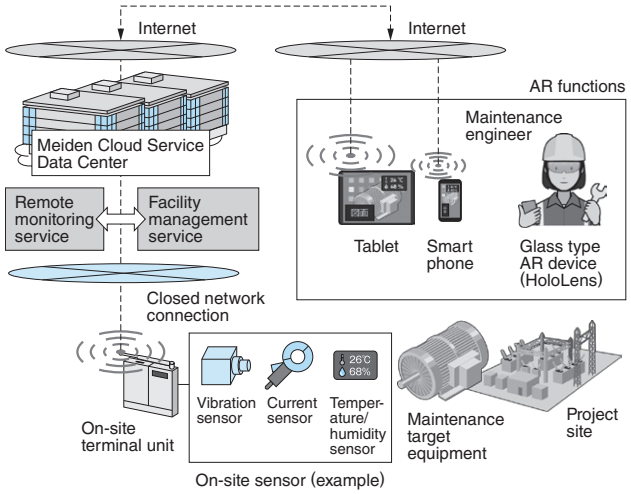

Fig. 5 System Configuration

A configuration of this system including that of cloud service is shown. An image of sensors and the project site is just one example and general-purpose sensors can be connected in our various project sites.

AR function. Fig. 4 shows an image of a glass-type AR device (HoloLens) in use. In the future, we will consider the application of an AR device integrated with a helmet, for example, with due consideration to the practicality in the service field.

3 Linking with Cloud Services

3.1 Managing and Accumulating On-Site Information in Cloud

Since 2016, we have been providing our Meiden Cloud Service, which has remote monitoring and facility management functions using IoT technology. In fiscal 2019, we developed an AR function linked with our facility management service. With this function, equipment ledger information, maintenance history, inspection information, and related documents can be managed by linking them with the real world such as actual equipment and project sites. A field service engineer can easily check the information of the target equipment by holding the AR device over the AR marker installed on the device. By introducing AR technology, information such as technical expertise collected at the site will be managed and accumulated in the cloud and sharing between field service engineers will be realized.

3.2 System Configuration

Fig. 5 shows the system configuration. Each component is as follows.

(1) On-site terminal unit

Using IoT technology, it collects equipment operation data from various sensors installed in the equipment and sends it to the cloud. The on-site terminal unit and the cloud are connected by a closed network connection.

(2) Remote monitoring service

It aggregates operation data of electrical equipment and mechanical equipment collected from on-site terminal units on the cloud to visualize the operation status. One can check using a smart device, such as a tablet that runs either iOS or Android.

(3) Facility management service

The facility management service manages customer equipment information, instruction manuals, and completed books in the cloud, and supports maintenance services such as repairs and inspections.

3.3 AR Function

The AR function communicates with the cloud and displays the information required for maintenance by superimposing it on the image of the actual machine. The information to be displayed can be registered at any position in the space by an engineer who uses the AR function. In addition to comments, equipment ledgers, inspection information, and sensor values in the space, it can also register electronic files such as photos, videos, sounds, and documents in the space. The AR function is used by activating it from the AR button displayed on the information display screen of the target equipment or the input screen of inspection items. Fig. 6 shows

Fig. 6 AR Function Call Screen for Facility Management Service

Left: This shows an image for AR function call from a facility ledger reference screen.
Right: This shows an image of an AR function call from an inspection record screen.

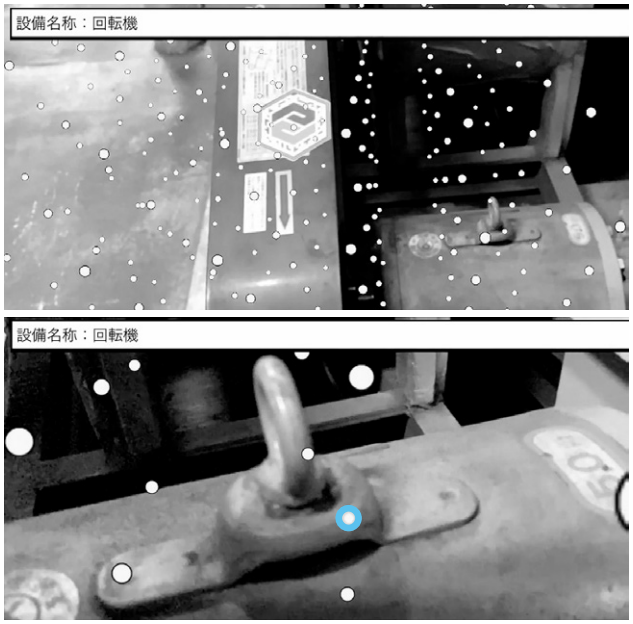

Fig. 7 Image of Registering Information with AR at Arbitrary Position in Space

Upper row: This shows buttons indicated by mesh-state dots distributed at the same distance.
Lower row: This shows the state in which the spatial position for which information is to be registered, is selected.

the AR function call screen for the facility management service. By pressing the AR button on the screen, the dedicated application installed on the on-site terminal unit is activated and the AR mode is set. Fig. 7 shows an image of registering information with AR at an arbitrary position in the space. In the registration mode, buttons for specifying the display position are displayed in a mesh in the space displayed through the screen. The engineer can

Fig. 8 Example of Arranging Reference Button of Equipment Ledger in Space

Upper row: This shows an image of ledger-information reference button allocation in space of the relevant facility.
Lower row: This shows an example of a window display about ledger information of the related facility.

assign the desired information to the desired position by selecting any button among the buttons displayed on the message.

3.4 Display Image

The display image displays examples and usage examples of information that can be referenced and registered using the AR function. Fig. 8 shows an example of arranging the reference button of the equipment ledger in the space. At the spatial position where the information is registered, a word balloon indicating that the information is registered is displayed. By selecting this word balloon, the contents of the registered information will be displayed in a window. Once the AR marker is recognized, its position in space is retained even if the AR marker is not within the angle of view of the camera. Fig. 9 shows an example of related documentation reference button allocation for a facility ledger, and Fig. 10 shows an example of the photo arrangement. The registered information is managed in the cloud and can be shared with other engineers. Fig. 11 shows an example of inputting inspection results using the AR function. With the AR function, input screens for each inspection item can be registered in the space. This makes it possible to superimpose the meter to be read and the inspection

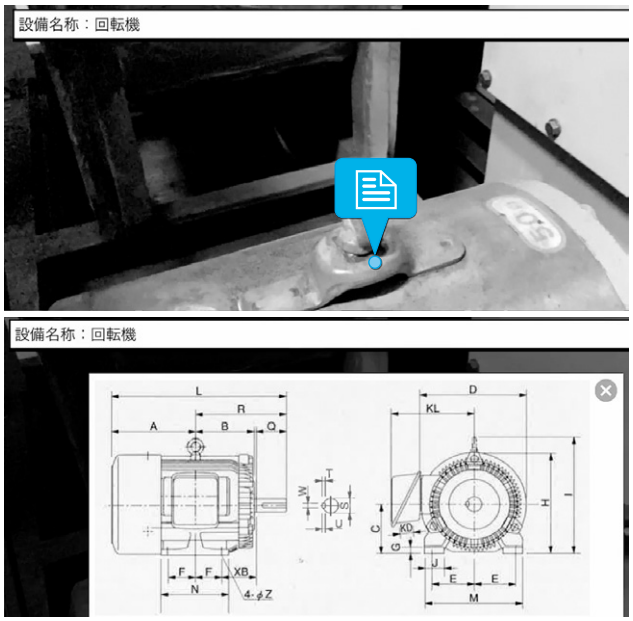

Fig. 9 Example of Related Documentation Reference Button Allocation for Facility Ledger

Upper row: This shows an example of arranging a reference button for a document associated with the ledger of the equipment in the space.
Lower row: This shows an example of displaying the drawing information registered in the ledger of related equipment in a window.

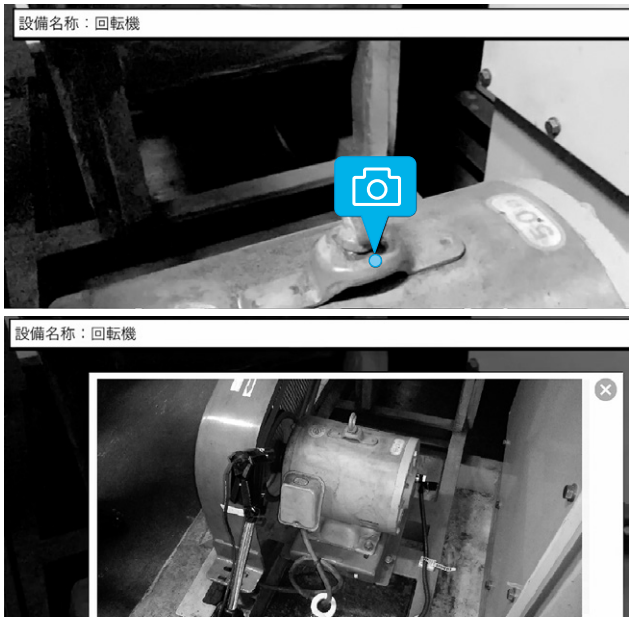

Fig. 10 Example of Photo Arrangement

Upper row: This shows an example of a photo taken on the spot and registered.
Lower row: An example of a window display is shown for the registered photo.

points to be visually inspected on the target equipment. As shown in Fig. 11, by selecting the balloon displayed at the spatial position, the inspection

Fig. 11 Example of Inputting Inspection Results Using AR Function

Left: An example is shown for an inspection value input button allocation at the inspection spot of the relevant facility in space.
Center: An example of a window display is shown for the inspection value input.
Right: An image is shown about a call-up after the use of AR function and a return to the original screen.

Fig. 12 Example of Registering Comments of Target Equipment

Left: An example is shown about comment input and registration on the spot.
Center: An example of a window display is shown about the registered comment.
Right: An example of a balloon icon is shown as seen from afar.

value input window is displayed, and the inspection result can be input and registered. It supports the inspection work of inspectors who are unfamiliar with the project site. Fig. 12 shows an example of registering comments of the target equipment. One can register notes about the target equipment and items to be handed over to another field service engineer, and the beginning of the comment is displayed in the balloon. For example, if a comment that calls for danger or caution is registered, the content can be shared among multiple field service engineers at a glance. Fig. 13 shows an example of the displaying sensor values. The operation data of the on-site equipment collected by the remote monitoring service can be displayed by superimposing it on the target equipment.

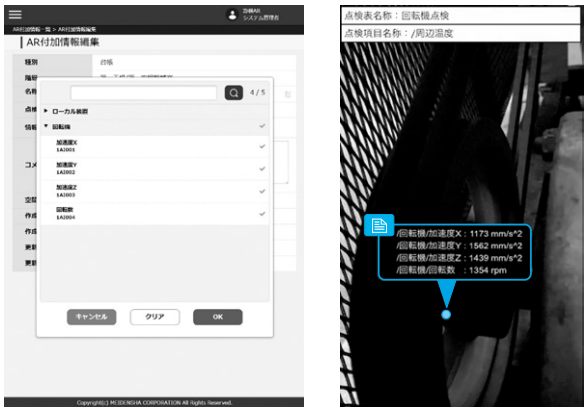

Fig. 13 Example of Displaying Sensor Values

Left: An image of a screen is shown about the registration of related sensor values.
Right: An example of a display is shown about the related registration sensor values.

4 Utilization of AR Technology for Training

An engineer training facility to support the skill improvement of repair and maintenance service workers has been newly built. At this facility called “Manabi-ya”, we set up a dedicated room that introduces the latest ICT, AR, and VR technologies, and some of the AR functions that we developed this time. As a result, we created an environment where maintenance technology can be learned without an actual machine and enhanced the in-house training that is unique to AR technology. For example, before the introduction of this facility, lectures were the focus and hands-on experience learning that involved the destruction of the actual machine, such as erroneous operation, was difficult. If, however, AR or VR technology is used, workers can repeatedly destroy virtual equipment that has been realistically reproduced, so they can experience erroneous operations in a virtual space.

5 Postscript

By utilizing AR technology, we have developed a function that supports the efficiency of on-site repair and maintenance service work. In addition, by introducing the developed functions into an in-house educational facility called “Manabi-ya”, we have created an environment that supports the skill improvement of repair maintenance service workers.

We will continue to contribute to the improvement of our repair and maintenance service work by further improving the AR function and actively introducing new ICT technologies.