Human Machine Interface with Augmented Reality for the Network Based Mobile Robot

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Abstract. The human-machine interface is an essential part of intelligent robotic system. Through the human-machine interface, human being can interact with the robot. Especially, in tele-robotics environment, the human-machine interface can be developed with remarkable extended functionality. In this paper, we propose a human-machine interface with augmented reality for the network based mobile robot. Generally, we can take some meaningful information from human's motion such as movement of head or fingers. So, it is very useful to take these motions as input for systems. We synchronize head motion of human being and the camera motion of the mobile robot using visual information. So user of the mobile robot can monitor environment of the mobile robot as eyesight of mobile robot. Then we use gesture recognition for control the mobile robot. In the implemented framework, the user can monitor what happens in environment as eyesight of mobile robot and control the mobile robot easily and intuitively by using gesture.

Keywords: Human-machine interface.

1 Introduction

Many researchers have been tried to make the robot more intelligent and serviceable. Consequently, the robot system is widely used in various fields and become more important in our daily life. But, up to now, most robotic systems are not fully intelligence and this leads to needs of human-machine interface. Various researches on human machine interface are conducted. And now, human machine interface forms an essential part of successful robotic system.

Since the advent of computer network or internet, it changes extensively the whole industry as well as human being's lifestyle. Robot system should be included in these trends. Many robot developers are carrying out research on fusion of computer network and robot with their own methodology and have been paid attention to human machine interface especially.

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In this paper, human-machine interface(HMI) with augmented reality makes easier to control the mobile robot. Also, user can monitor an environment of the mobile robot with wide range of field of view by using the HMI. Therefore, the HMI makes control of the mobile robot comfortable and powerful. So, The HMI leads to more intelligent robotic system.

In section 2, we introduce our system framework. In section 3, we describe human-machine interface on our system framework. Section 4 describes an experimental environment. We conclude in section 5.

2 Network Framework for Network Based Mobile Robot

2.1 System Architecture

Figure 1 shows interaction between human and mobile robot through the network and human-machine interface. In this system, all resource such as vision system, mobile robot and processing unit are connected via network. A vision data from the mobile robot is processed by using diverse algorithms, and the output from the process is used for the mobile robot action, decision making or augmented reality visualization. To make the mobile robot intelligent, it requires tremendous amount of computing power, in particular, when the action has to be made in the real time basis. But, in networked environment, the mobile robot can perform its tasks more easily and intelligent by sharing resources around it. The key point of this system is to relieve the burden of the processor within the mobile robot, and so any intensive computation is carried out in other processing units such as PC, which is distributed on the network.

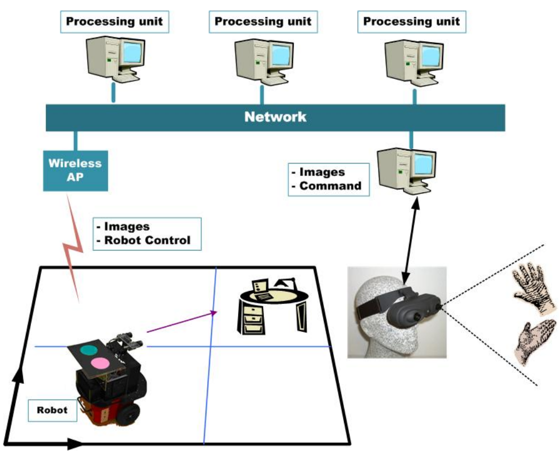


Fig. 1. System overview

In this system, the mobile robot is equipped with low performance PC, which functionality is restricted to only sensory data collection and the mobile robot control. Display device such as HMD (head mounted display) is convenient to use as interface with many system because it can easily build virtual or augmented reality environment. Many researchers have been studies the possibility of HMD device as human-machine interface [1][2][3][4][5][6][7]. In Fig 1, by displaying all information through HMD, user can interact with the mobile robot more easily and intelligently. In this system, a pan and a tilt position of a camera of the mobile robot and human head are synchronized. So, user can see what mobile robot see or what is happening in environment. Therefore the user gives command to the mobile robot through display screen of HMD and gesture recognition system. In the present work, simple but intuitive interface of human-machine interface has designed.

2.2 Middleware for Network Based Mobile Robot

Generally, developing robot software are known as complex, tedious and error-prone task. Moreover, if the robot software is distributed over a network, its development imposes several additional problems such as concurrency issue, time delay and potential network failure. Hence, various methods for processing sensory data, controlling the robot and interfacing with the human must be integrated well-engineered piece of software. To resolve above-mentioned problems and increase efficiency of the proposed framework, developing service by using middleware layers is needed.

CORBA is a widely recognized middleware standard for heterogeneous and distributed systems [8]. By using CORBA's object model and its representation in the IDL (Interface Description Language), developers can implement network-based systems easily and transparently. In our system, we used the public domain implementation of CORBA, called ACE/TAO, as a middleware for the proposed system.

3 Services Based System Architecture for Human-Robot Interaction

We implement some services, which is key components of proposed system. Each service, which is implemented as CORBA object, has own specialized and cognitive task such as data streaming service, pattern matching and tracking service, gesture recognition service, human-machine interface service and so on.

3.1 Data Streaming Service

In Fig. 1, many services are distributed in the network, and can be connected to each other via various network media. Each service needs a different kind of data according to its property and purpose. Especially, image acquired from vision system can be used in diverse algorithm, pattern matching, tracking, gesture recognition, human-machine interface and so on. These tasks need the image data acquired from the mobile robot or the camera which is front of the HMD. To support these tasks efficiently, the image streaming service, that is basic service of all services, is implemented. In our work, designing a flexible and efficient image streaming service is very important because bottleneck or time delay in image streaming service will make the entire system unstable. Fig. 2 shows streaming service interfaces implemented in this paper.

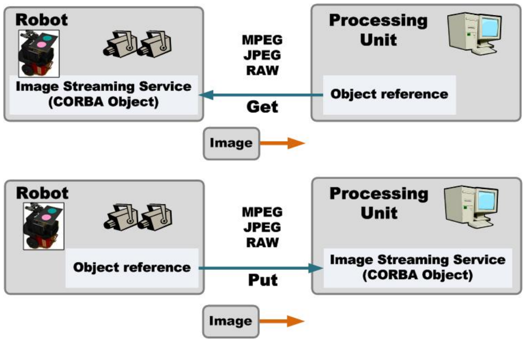


Fig. 2. Streaming service interfaces for different data type

The image streaming service has two simple but important methods, `Put` and `Get`, as illustrated in Fig. 2. In the case of `Get` method, processing unit is able to retrieve image from the mobile robot on its demand. In otherwise case, if processing unit needs every image on time, it can be done by using `Put`. In this system, we adopt image compression such as MPEG and JPEG to the image streaming service because the size of image data is very larger than other sensory data and network bandwidth is limited.

3.2 Pattern Matching and Tracking Service

We propose synchronization scheme between pan, tilt position of a camera on the mobile robot and pan, tilt position of a camera which is front of the HMD to ensure wide range of field of view. Fig. 3 shows the synchronization process. Pattern matching and tracking service receives an image from camera which is front of the HMD, then calculate motion factor of HMD. If motion factor is calculated, pattern

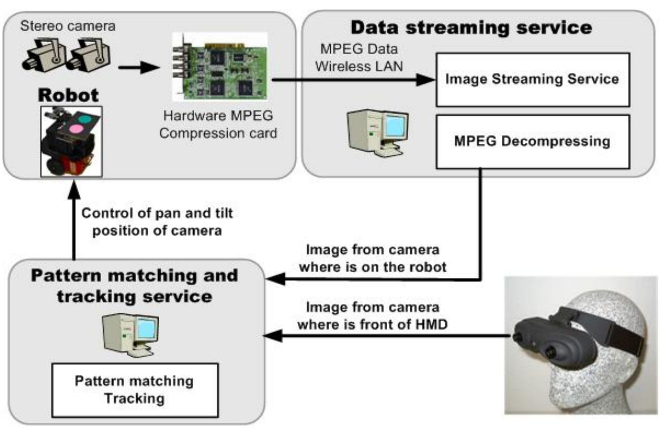


Fig. 3. Pattern matching and tracking service

matching and tracking service receives images from data streaming service and calculate motion factor of images from camera on the mobile robot. If there are difference between its motion factors, pattern matching and tracking service try to synchronize those motion factors by controlling pan, tile position of a camera on the mobile robot. We simply applied visual servoing technique.

3.3 Gesture Recognition Service and Human-Machine Interface Service

Fig. 4 shows data flow of gesture recognition service and human-machine interface service. Gesture recognition service converts gesture of the user to command that is

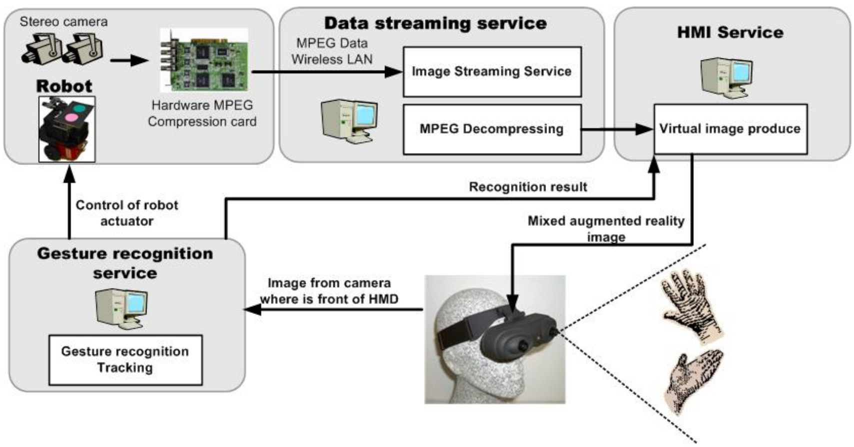


Fig. 4. Gesture recognition service and human-machine interface service

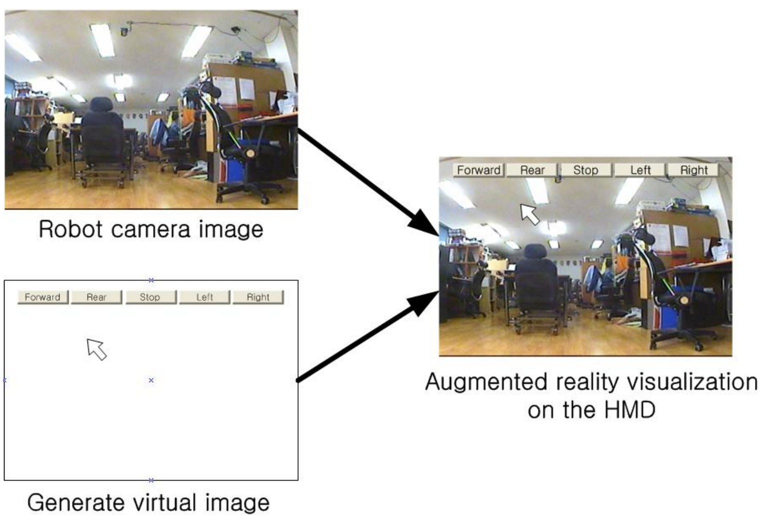


Fig. 5. Generation HMD image by human-machine interface service

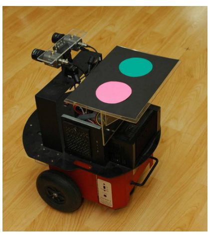
sent to the mobile robot. Gesture recognition receives image from the camera which is front of the HMD, then gesture recognition service try to find the user's hand position and try to recognize gesture in the image. If the recognition is success, gesture recognition service converts gesture to a command then send it to the mobile robot. Human-machine interface service produces a composite image using an image from the mobile robot and recognized result from the gesture recognition service then the composite image is displayed on the HMD.

Fig. 5 shows that the human-machine interface service generates image that is displayed on the HMD.

4 Implementation

4.1 Hardware System

Figure 6 shows hardware system of our implementation of the proposed system.



(a) Robot (Pioneer 2 DX)

(b) HMD (ARvision-3D HMD)

Fig. 6. Test hardware system

The mobile robot system, Pioneer 2 DX, is equipped with stereo camera, MPEG hardware encoder and industrial PC. It can carry out basic behaviors such as navigation and obstacle avoidance as well as capturing stereo image. The display system, ARvision-3D HMD, has 2x SVGA micro displays with 18 bit color depth. The HMD includes stereo camera with 2 independent channels. To execute many services mentioned in this paper, we use four PCs. All hardware systems are connected with each other via wired or wireless LAN interface.

4.2 Test Scenario of Interaction Between Human-Machine Interface Service and Mobile Robot

Through proposed system, the user can monitor the mobile robot environment with wide range of field of view by just turns his head. When the user turns his head, the camera on the mobile robot is following the user's head motion. So the user can monitor outside of the current field of view as shown in Fig. 7.

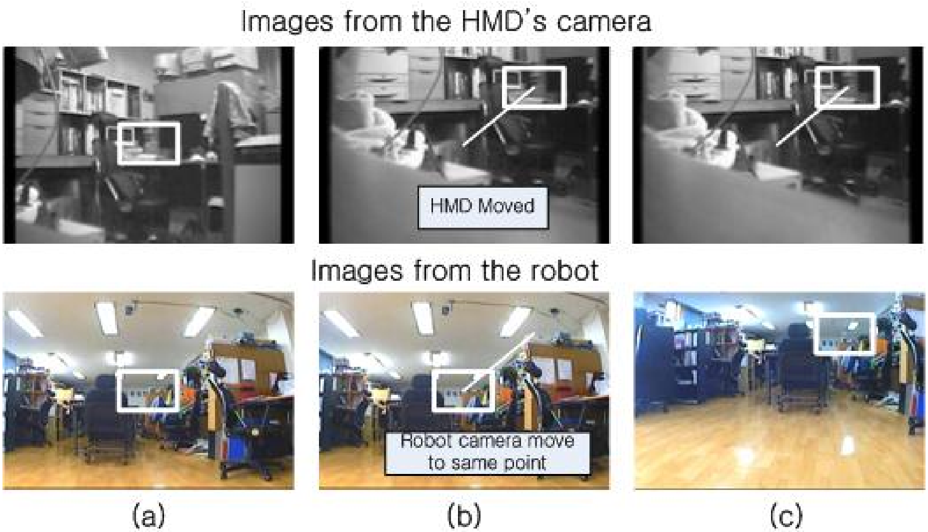


Fig. 7. Camera control of the mobile robot by head motion

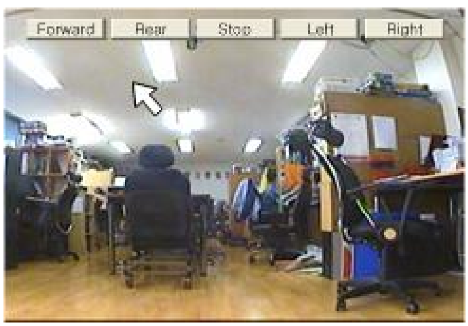


Fig. 8. Human-machine interface with augmented reality

If the user wants to control the mobile robot more precisely, the user uses their hand then a pointer will be shown in the HMD. The user moves his hands, the pointer follow the user's hand motion then the user select some interface button as shown in Fig. 8.

5 Conclusions

In this paper, we have designed and implemented a human-machine interface with augmented reality for the network based mobile robot. From test scenario using implemented human-machine interface, we verify that human and mobile robot interaction is done easily and intuitively through our interface. The human machine interface is important because it compensate with lack of robot intelligence. Consequently, designing a good human robot interface is the key to the successful robot system.

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