Interaction based Teleautonomous Control System

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Abstract

There has been a growing need for interaction between human operator and a remote system to perform a complex task in an unpredictable environment and to operate an important work at a remote distance. The interaction becomes an important parameter in the teleautonomous operation because it permits the operator to control the system at remote distance. As the environmental uncertainties to be applied are getting increased, so is the difference between the plan of the operator and the execution of the system increased. Since the operator may be difficult to know the latest information from frequently changing environment due to time-varying delays, remote system may be hard to control in accordance with the operator s command.

Interactive Teleautonomous Control System (ITCS) is an approach based on interactions at these environments. The ITCS can be regarded as a control system using the transmitted a system's intnetion. The interactive teleautonomous control does not mean the interaction from operators point of view only considering feedback environmental information and forward simulation but an interaction between the operator and the system that transmits or receives intentions. The proposed ITCS is based on the intention communication that transmits their intentions to each other. The ITCS can correctly control the system in accordance with the operator's intention. Using the intention communication, a systems intention is helpful to the operator. In the interactive teleautonomous control, the intention communication has to be provided by the interaction between the operator and the system.

I. Introduction

The term 'teleautonomous operation' or 'teleautomation' is used to emphasize the interactions of humans with remote, intelligent, partly autonomous systems of many forms [1]. In *the teleautonomous operation, an operator can* operate system that have a high degree of autonomy in the remote site. The commands of high-level operator commands and low-level system controller can work in a harmonized control method. Information about the systems environment is transmitted to the operators screen and the information enables the operator to control or steer. The system itself can also cope with the problem of urgency by using the information.

According to the Collins COBUILD dictionary, the word 'interact' is defined as when one thing interacts with another or two things interact, the two things affect each others behavior or condition. This meaning is suitable for the teleautonomous operation. In the existing teleautonomous operation, the operator receives varieties of information from the system in time-varying delays and then the operator transmits a command to the system using the information after the simulation. The process has no consideration for the autonomous execution of the system. The predict display works fine when an operator interacts with static objects such as robot manipulators [1]. However, the predict display entirely depends upon the quality of the robot and environment models available and the accuracy with which tasks must be performed.

The ITCS is the approach based on interactions where exist time-varying delays and frequently changing environment. The basic idea of the proposed system is to transmit what a system intends to do, to recognize the system's intention, and to control in accordance with it. The ITCS can be regarded as a control system using the transmitted intentions. The interactive teleautonomous control does not mean the interaction from operators point of view only considering feedback environmental information and forward simulation but means an interaction between the operator and the system that transmits or receives intentions.

II. System Description

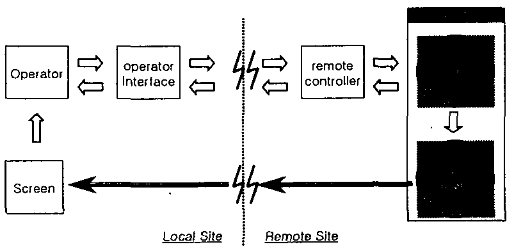

Fig. 3 the Architecture of the ITCS

Fig. 1 can schematically represent the architecture of the ITCS. Generally, the teleautonomous operation has shared control architecture. In shared control, a complex task is divided between the operator and the system. The operator in external loop performs the global control task. The local control task is performed in the internal loop by system's computer. As seen Fig. 1, it is composed of three major parts: an operator interface (OI), a screen and remote controller (RC). There are also two minor parts: an operator and system where there is the remote site.

The OI is shown of following Fig. 5. This displays the navigation of mobile robot. In the interface, an operator can easily judge that the mobile robots behavior performs a task execution accurately. When the operator knows the robot is difficult to perform a task, he can conveniently control the mobile robot through a mouse or joystick. The OI also shows the state of the mobile robot to understand the navigation. The RC uses dynamically feedback control law [2], which can asymptotically stabilize a system about a reference input (or an operators command). In addition, the remote controller may request state information and then re-plan stable execution via the requested information. In Fig. 5, the screen denotes the navigation of the mobile robot by the black line and the command of the operator by the red line. The screen also shows the state of the mobile robot.

The system steered exist in the uncertain environment. The environment applied has unpredicted events such as happening to moving or fixed obstacles and so on. It is very restrictive to assume that the environment is well known before a system executes. If an operator does not perfectly know, the execution of the system can be either inaccurate or unstable. The operator makes processes for the system's execution and informs environmental information to the system even though the environment applied is poorly known. However, after the mobile robot starts to navigation, it may inform its current state and next execution to the operator. The transmitted information is a great help to control the mobile robot. This proposed control system allows the mobile robot to navigate the unknown environment easily.

III. System's Intention

Here information to assist an operator controlling the system is defined as the system's intention. As previously explained, the its intention is composed of the current execution result and the next execution plan. The structure of the system's intnetion is illustrated in Fig. 2.

The system's intention has been sorted out in such a way that it is easy to know: the current position of the system and the next execution plan. However, the present time is not the current of literal meaning but the very time when the system transmitted information to operator at this time. Because there are time delays, it is past information when the operator received the current position among the system's intention. Besides, the system may now be executing the next process or the system may be going to follow the very next process right now. Namely, the next process may become the current process under navigation or the shortly next process.

```
typedef struct
{
   int n; //the number of sub-goals
   float ax[n], ay[n], ath[];
   // current robots position
   float nax[n], nay[n], nath[n];
      // next sub-goal position
   float elapse_time;
      // the elapsed time to the next sub-goal
   boolean event_vara;
     // whether a event occurs or not
   time_t; //transmitting time to the operator

} deasinfo;
```

Fig. 2 Structure of System's Intention

In order to control the system such as a mobile robot, the operator utilizes the current position as a reference and the next path as the criterion of a decision. The operator judges whether the robot follows commands or not. His decision has help from the robot's intention. The operator need not operate any manual steer provided the mobile robot follows commands. If not so, there is any necessity for the mobile robot to control. The operator analyses the current state, and the next execution; moreover, he makes a careful decision after consideration. The path of the mobile robot is modified with mouse or joystick. The modified path is sent to the robot. Because time delays exist there, the mobile robot must examine whether the current environment is safe or not before it takes the modified path. If there are no problems, the robot will navigate normally. If not, the robot will stop and report.

Ⅳ. Experiments

Fig. 3 Experimental Environment & Pioneer 1

To experiment, the mobile robot Pioneer 1 is used. The Pioneer is based on a commercially available mobile platform [3]. The Pioneer has basic components as followings: Two drive wheels and a rear caster, Two drive motors with gearboxes and encoders, and Seven ultrasonic sonar transducers embedded in front and sides of the Pioneer 1 console. Top speed in forward or reverse is 0.9 m/s. Rotational speed is 300 $\deg/s$. The Pioneer has seven ultrasonic sonar transducers to provide objects detection and range information. The sonar positions are fixed-one on each side and five forward facing-and attached to the inside of the console. The serial port is a standard DB9 receptacle for RS232-compatible serial data communication between the Pioneer microcontroller and an external computer.

Saphira is architecture for mobile robot control. It was originally developed for the research robot Flakey [4] at SRI International. To operate my robot the Pioneer 1 with Saphira, C++ programs is programmed through Mirosofts Visual C/C++ in the MS Windows 2000 NT system.

It is experimented in my laboratory corridor as Fig. 3. A typical experiment setup is depicted in Fig. 4. To begin with, it is supposed that an experimental condition as follows: a poorly known and frequently changing environment, time - varying delays between an operator and the Pioneer (no noise in transmission line), and no slop and slide but flat in the indoor.

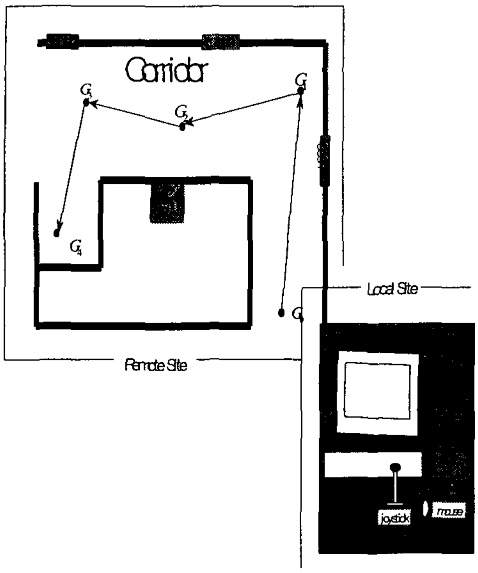

Fig. 4 Experimental Setup

In order to show the effect of the decision assistance information, we experimented as shown in Fig. 4. The Pioneer starts at the sub-task G_0. Just before departure, the Pioneer transmits its intention to the operator. Pioneers intention is made of the current state, the next path toward the next sub-task G_1, and the elapsed time. The Pioneer regularly informs its information at every sub-task G_j. And finally it reaches the sub-task G_4. Consequently, the Pioneer itself successfully finishes the task that goes from the G_1 to the G_4.

V. Conclusion

Using the decision assistance information, a new control method for a teleautonomous operation, was introduced. The role of the decision assistance information was explained by means of the experiment for mobile robot, the Pioneer 1. This information had advantages over the control of the Pioneer. The operator is reduced a burden for unexpected events in the frequently changing environment through the decision assistance information. The Pioneer autonomously carried out some task in time-varying delays.

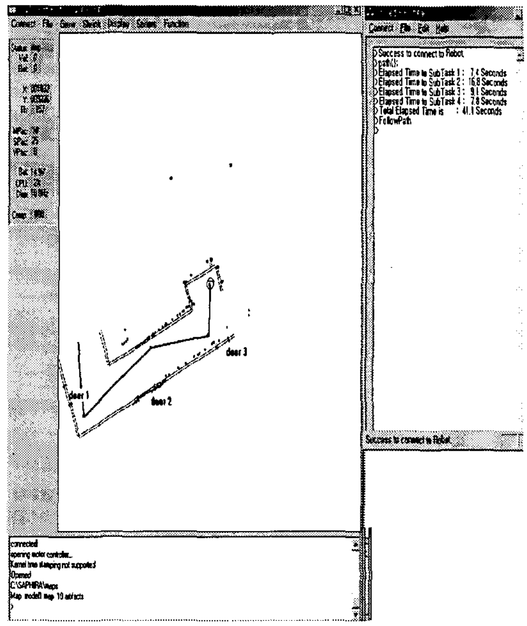

Fig. 5 Experimental Result

Reference

[1][1]Lynn Conway, Richard A. Volz, and Michael W. Walker, Teleautonomous Systems: Projecting and Coordinating Intelligent Action at a Distance , IEEE Transaction on Robotics and Automation, Vol. 6, No. 2, pp.146-158, April 1990 ITU-T Recommendation. Q.768, "Signalling Interface between ISC and ISDN Satellite Subnetwork," 1995. 10.

[2]Sung-Ryul Lee, Control of Car-like Wheeled Mobile Robot using Feedback Linearization , a Master Thesis, the Graduate School of Yonsei Univ., December 1997

[3] http://www.activemedia.com :Pioneer 1 Manual

[4] http://www.ai.sri.com/people/flakey