Intelligent Monitoring System Applied to Super Long Distance Telerobotic Tasks

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Communication Time Delay, Intelligent Monitoring, Knowledge Base, Small Capacity of Communication, Telerobotic System.

ABSTRACT

Time delay and small capacity of communication are the primary constraint in super long distance telerobotic systems such as astronautical robotic tasks. Intelligent telerobotics is thought to break this constraint. We aim to realize this super long distance telerobotic system with object handling knowledge base and intelligent monitoring. We will discuss about physical and technical factor for this purpose.

INTRODUCTION

Telerobots such as space telerobotic systems use both autonomous and direct human control (manual control) in execution of their tasks. Supervisory control is a well known concept applied to these hybrid systems. From the viewpoint of flexibility and human friendliness in telerobotic task execution, we have proposed a more cooperative way to effectively utilize both autonomous functions of the robot and direct maneuvering by the human operator and developed MEISTER system[1].

In the telerobotic task execution visual information, such as TV monitors, is most important for cooperation between robots on a remote site and a human operator on a local site. However, in order that TV monitor supports a human operator effectively, the monitor should display scenes relevant to task situation. In the conventional systems, a human operator must control camera direction and viewing angle (zooming) manually along with robot task control. It increases burden of the operator severely. Therefore we have proposed intelligent control system of monitoring camera for telerobotic task execution[2].

First we will describe the principle of the intelligent monitoring system briefly, second discuss special issues of telerobotics executed over super long distance, and then show possible extension of the current intelligent monitoring functions for the issues.

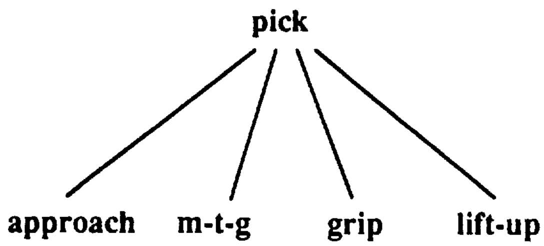
INTELLIGENT MONITORING

The MEISTER system has a collection of task oriented object models as the knowledge base[3]. Each model contains environmental data which work as a world model. Handling knowledge, both generic and specific, is described by methods attached to object classes.

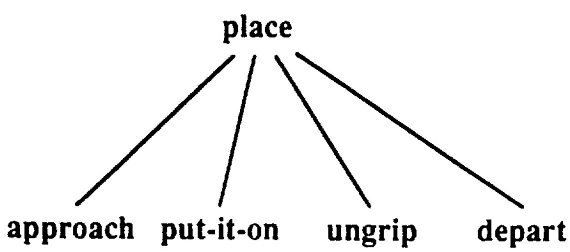
The human operator achieves cooperation by watching the robot motion through TV monitors. Whether the human operator can help robot effectively or not depends on whether or not the TV monitors display appropriate scenes of task executions. In the original MEISTER system, the human operator controls viewing-point (camera direction) and viewing-angle (zooming) of the camera manually. We found that this controlling operation is the busiest part of the operator's task. Considering the problem, we have introduced intelligent monitoring in telerobotic task execution[2]. We call 'intelligent' to mean that a robot autonomously reports to the operator selected information relevant to a given task.

The basic concept for the intelligent monitoring is based on the observation that we control our view according to what to see, when to see, how to see. These strategies seem to have deep relation with structure of manipulation tasks.

In the knowledge base of MEISTER, a pick operation is expanded into lower level motion commands such as 'approach,' 'm-t-g(move-to-grip),' 'grip,' and 'lift-up' motions depicted in Fig. 1. Differences in the meaning of these motions should correspond to different control strategies for monitoring action. This implies



(a) Expansion of "pick" operation.



(b) Expansion of "place" operation.

Fig. 1. Expansion of pick-place operation.

understanding the contents of the task and how the task is proceeding. We apply this concept to the control of viewing direction and the viewing angle of the monitoring cameras so that the human operator can receive appropriate information to cooperate with the robot. The details of the strategies of camerawork for each motion are as follows.

approach
In this motion the robot hand approaches an object. This is a kind of global motion. The hand moves straight to the destination with a certain speed. If an obstacle exists on the path, the operator should stop the robot or control the robot to avoid it. So in approach motion the monitoring camera should catch the whole area of the motion or follow the robot hand with viewing angle as wide as possible.

m-t-g(move-to-grip)
In this motion the robot hand moves to the grasping position of an object. It is a kind of guarded motion. Since the robot hand is already close to the object, the operator wants to look at the robot fingers and the object closely so that he or she can check their relative position. Therefore the camera should zoom in on the hand and the object.

grip
In this motion the robot hand does not change its position but its fingers close to hold the object. The aim of camera control is almost similar as the m-t-g motion. Further closing up helps the operator to confirm that the fingers hold the object successfully.

lift-up
The hand goes up into the free space to prepare next approach to another target. The camera should zoom out smoothly expecting this motion.

put-it-on
The hand sets the object in hand to the destination place. The camera should zoom in to cover the object in hand and the other one to which the former one will be assembled.

ungrip
The hand releases the object in hand. The camera is centered to fingers so that the operator can confirm that the object is successfully releases from the hand.

depart
This motion is similar to lift-up motion. The camera should zoom out smoothly covering current hand position and the point in the free space the hand goes to.

PROBLEMS TO BE ATTACKED

Time delay and small capacity of communication are the hardest constraint in super long distance telerobotic systems. Direct power or position feed back loop between local and remote sites is not realistic because the time delay will be a few ten seconds or a minute. We cannot construct an efficient servo loop between local and remote sites. The problems are summarized into two points.

Commanding Level

An operator needs to command to robots with some high level robot language. If the commands which are sent from a local site to a remote site are much abstract, amount of communication will be decreased.

On the other hand too high level commands are not sufficient to let an operator and robots execute tasks cooperatively and such a telerobotic system is not effective. Therefore it is also an important theme to determine command level corresponding to the degree of time delay of communication.

Information Selection

The operator should achieve not only commanding the robot but also watching the task environment with monitoring camera and various sensors in order to cooperate with the robot to execute tasks. So bi-directional communication is necessary between a local site of an operator and a remote site of robots.

However not only time delay but also capacity of comunication are under constraint in super long distance telerobotic systems. It is not expected that all information can flow incontinently from the remote site to the local site. The remote system itself needs to select the information important to cooperate for the operator and send it to local site.

MONITORING FUNCTIONS

Basic strategies of intelligent monitoring described in the previous chapter will not be sufficient for the communication channel constraints problem. We propose following extensions for it.

snapshot function
Selecting and sending only important scenes when all the images can not be sent. Selection of viewing angles and viewing ranges in a sequence of task execution should be also included.

simulation function
Showing graphically simulated task procedure to give expected images of task status between the snapshots. These expected images help the operator to prepare response when the next new scene is displayed.

confirmation function
Confirming task status on each step using comparison of expected and real image on remote site. Though this is not directly monitoring, it can be seemed as an extension of monitoring of task procedure by robot itself.

recording of whole video
Storing whole scenes on remote site and send it to local site without any omission after the execution for analyzing errors later. This is a kind of telemetry.

EXPERIMENT PLAN

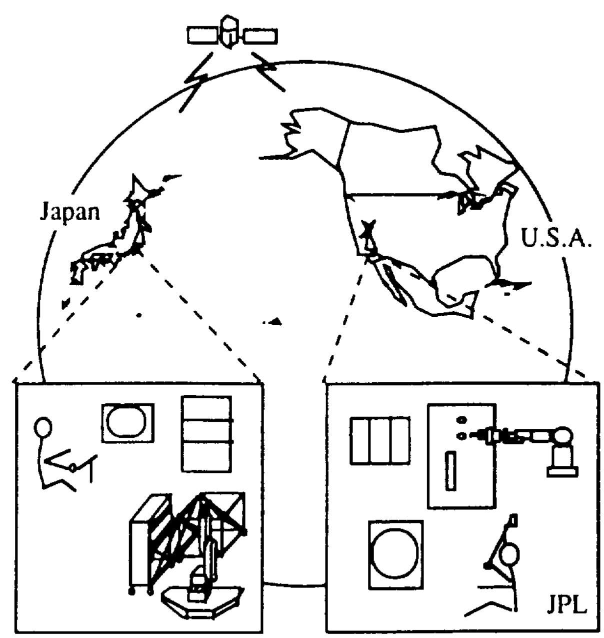


Fig. 2. Over pacific telerobotic operation.

Research topics described in this paper are for the collaborative research of ETL and JPL. In the collaborative research we plan to operate mutual telerobot testbeds (Fig. 2).

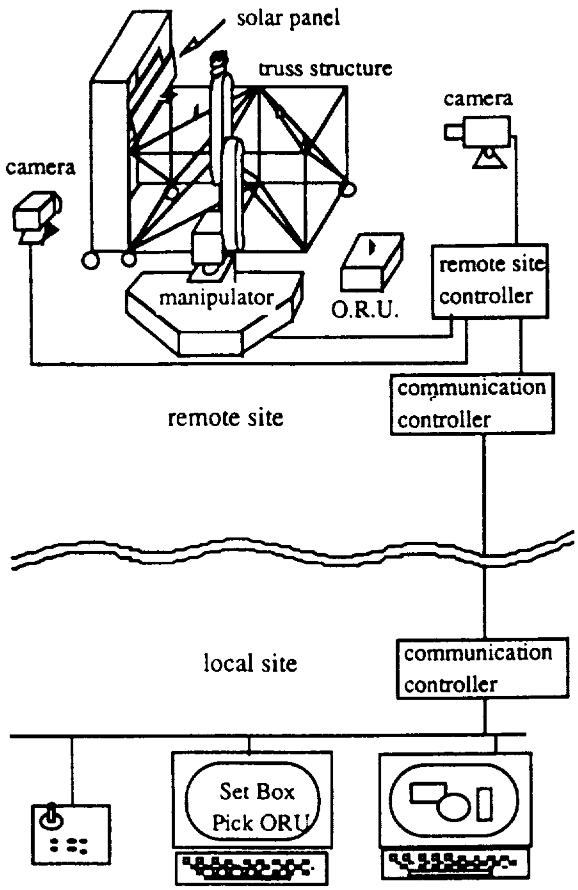


Fig. 3. Testbed plan at ETL.

The outline structure of the experimental telerobot testbed under construction at ETL is illustrated in Fig. 3.

Remote site subsystem includes a manipulator to execute task and monitoring camera(s) to monitor it. An image processing board is used to grab video images for monitoring, compress it to send to the local site.

Local site subsystem includes an interface for object handling knowledge-base and graphics on UNIX workstations. Direct control device such as joy-stick or master-manipulator will be also included for emergent intervention.

For connection line between local and remote sites, we plan to try several ways such as inter-network, ordinary telephone-line with ISDN and/or conventional modem connection. These are to study about influence of quality of communication to telerobotic task execution.

CONCLUDING REMARKS

We discussed problems of super-long distance telerobotics, and plan to extend and apply the intelligent monitoring system. KHI (Kawasaki Heavy Industry Co.) collaborates with us to construct the testbed for this experiment. Detail of the construction of the testbed is presented in another paper.

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