Redundancy in Sensors, Control and Planning of a Robotic System for Space Telerobotics

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Abstract

This paper discusses the analysis and development of a manipulator redundant in structure and sensor devices controlled by a distributed multiprocessor architecture.
The goal has been the realization of a modular structure of the manipulator with evident aspects of flexibility and transportability.
The distributed control structure, thanks to his modularity and flexibility could be integrated in the future into an operative structure aimed to space telerobotics.
The architecture is applied to the 6 DOF manipulator Gilberto, developed at Department of Mechanics, Politecnico di Milano.

1. Introduction

The experimental activity of research and development has been originated by the precise need of improvement and integration of different indipendent projects already advanced in Department of Mechanics, Politecnico di Milano described as follows:

1) Development of 6 DOF robot with voice control system
2) Development of a dexterous hand provided with sensors and advanced control capabilities
3) Development of vision systems, with single and multiple cameras, for pattern recognition and objects analysis
4) Study of an expert system oriented to obstacle avoidance and path optimization
5) Application of a simulator for assembly problems solving

In this first phase the activity consisted in the optimization of a traditional manipulator with 6 DOF and his upgrading into a flexible structure provided with a hierarchical hardware control structure and relative software in order to make feasible real time control with a sufficient level of precision and throughput.
This work was mainly concerned with analisys and first development of a modular architecture both from hardware and software point of view.

2. Structure requirements

Thinking to the tipical needs of telemanipulator applications, it has been decided to organize the global control structure on a hierachical multilayered basis for software, and on a distributed structure for the hardware.
The goal is to obtain the following caracteristics:

- modularity
- expandibilty
- chance of increase parallelism degree without global changes of the existing structure.

3. The system architecture

The system is provided with an operator site for the handling and supervision of the system, that is on line with the control architecture of the manipulator.
At this level the operator is provided with interactive devices like microphone for voice control, several monitors connected to lower level units and the keyboard.
The control unit is a personal computer provided with a 80386 microprocessor.
From this level the operator can operate the whole system and receive a continuos feedback of the system status.
The processing unit has been also thought as gateway to external operating unit providing other activities that need task execution from the robot cell.
The main unit is connected by a standard serial bus to the manipulator supervisor, a computer unit provided with a 65816 microprocessor.
This lower level unit is oriented to control and handling of third level units, on the basis of tasks requested from the operator site unit.
The third and lowest level is the one that provide the operative units, called MPx, mainly provided with eight bit microprocessor.
The MP1 unit is oriented to real time control of manipulator, data monitoring, handling of manipulator initialization and shutdown.
The MP2 unit is dedicated to the voice control.
It performs voice analysis and commands handling for task execution.
Recently a third unit based on a 16 bit microprocessor and provided with a mathematic coprocessor has been connected to the system, which will be used for on-line computation of kinematics and dinamics. At the present time, these two tasks are demanded to the mainpulator supervisor.
The following step is the integration of a unit for handling of a vision system already experimented on a stand alone unit. The

vision system has been already developed, is operating on a 80386 microprocessor based unit, and is the one described in introduction.

4. The software system

The software utilized on the system is the one written for the lower simple task on single MPx units, and the real time operative system especially developed for the multilayered architecture.
The real time system is modular in its structure, and is provided with all of the services essential to a multitasking system. Any lower level unit is provided with the communication protocols and rules for exchanging data and functions, as the higher control unit is provided with dispatching and priority functions for the handling of subtask executed by the lower units.
At the present time the system is programmed in traditional high level languages like Basic or C. The applications written in such languages can use real time operating system services by way of function call mechanism; the next step will be the developement of a language oriented to handle the system and a new user interface.

5. Conclusions

This work is just the first attempt to subdivide whole control system into subsytems provided with local autonomy, communicating through well-defined protocols, for the optimized and flexible handling of the various subtasks that can be individuated in complex teleoperator operations.
At this moment it is on development the connection to the system of a second manipulator, precisely an IBM SCARA robot.
At the present the system is provided with high level control software for friendly interaction with the operator, for autonomous task planning and operation.
The future activity will consist in development of dedicated language for the system programming and of an interface between a transputer network already installed into a 80386 based computer and the existing architecture.
The aim, besidrs the obvious aspects of modularity and easy-expandibility tipical of an open system, is to map a highly complex system, such as a teleoperator control unit, into a network of specialized subsystems which can be developed and optimized independently and in a transparent way to the whole system.

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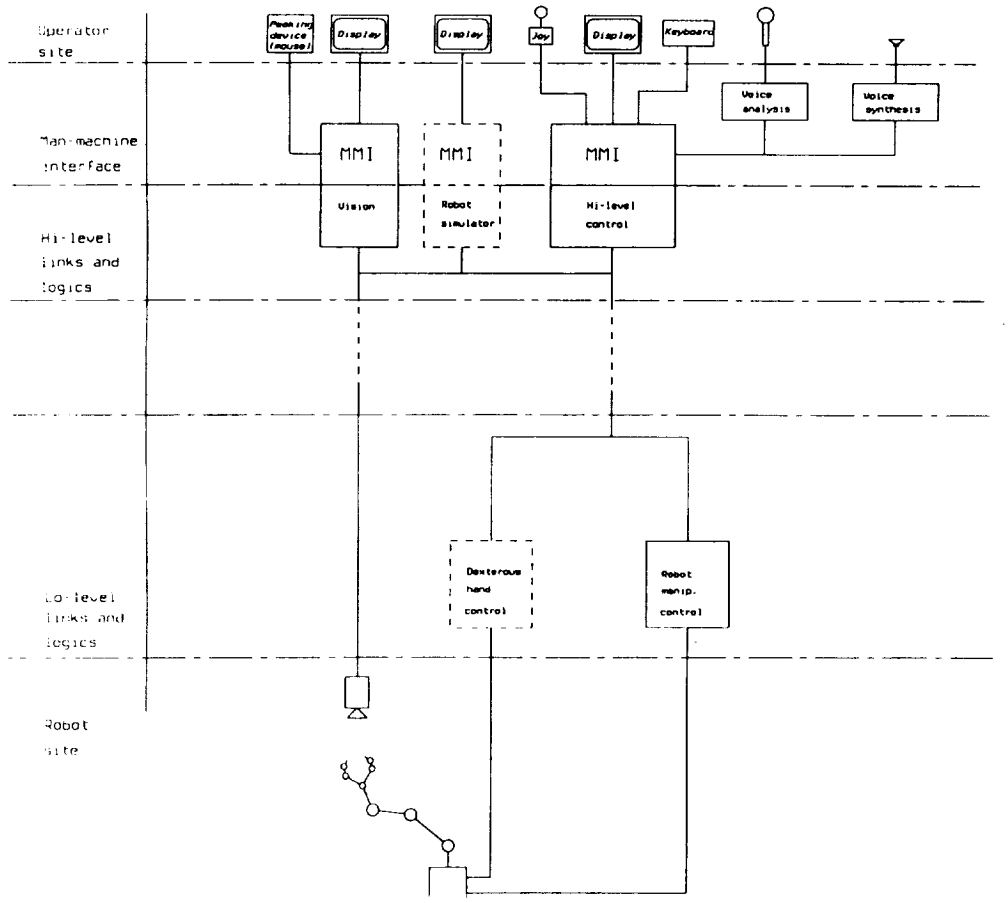

SENSOR-BASED PLANNING