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Education

MOBILE SYSTEMS APPLIED TO DISTANCE EDUCATION

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ABSTRACT In order to deal with the covid-19 epidemic in the education field in general and in particular in the field of medical training. We present a contribution in the Innovative Educational Concepts. This solution based on an autonomous and teleoperated mobile robot. The remote control of the mobile system allow students to perform patient temperature sampling operations and perform tasks in inaccessible or dangerous environments such as x-ray radiology rooms.

KEYWORDS : Distance Education, Control Architecture, Software Architecture, Mobile System, X-rays.

INTRODUCTION

Experimentation is a very important part of education in engineering. This is also true for mechatronic engineering, which is a relatively new field, combining three engineering disciplines: mechanical engineering, electrical engineering and software engineering. The equipments needed for experiments in mechatronic are generally expensive. One solution for expensive equipments is sharing the available equipments with other universities around the world [1].

Two are the possibilities to realize it:
a) Remotely accessible student laboratory facilities - with the advent of the Internet and its rapidly spreading adoption in almost all spheres of society - have become feasible and are increasingly gaining popularity.

b) Virtual reality (VR) is a system which allows one or more users to move and react in a computer generated environment.

At present, several e-learning laboratories have been developed. It can be distinguish two categories of them:
c)Remote laboratories (Figure 1), which offer remote access to real laboratory equipment and instruments;

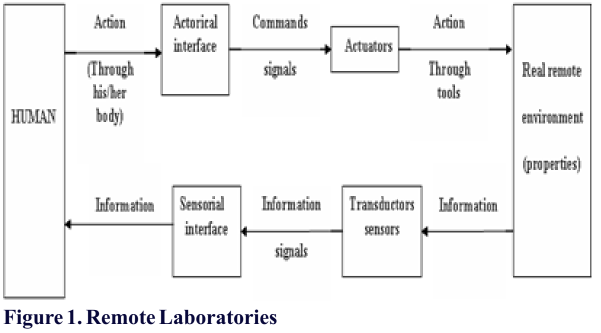

Figure 1. Remote Laboratories

d)Virtual laboratories (Figure 2), which offer access to a virtual environment using for this simulation software.

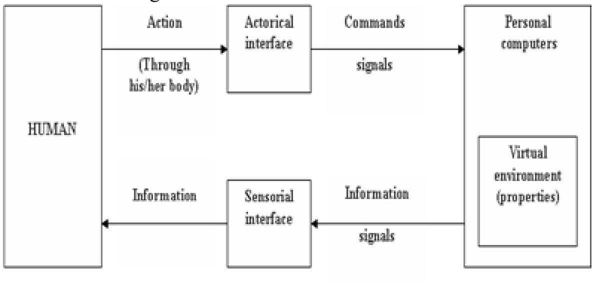

Figure 2. Virtual laboratories

Multi-agent Systems For Autonomous Control

The organization of a system - or its control architecture - determines its capacities to achieve autonomous tasks and to react to events [2]. The control architecture of an autonomous mobile system must have both decision-making and reactive capabilities: situations must be anticipated and the adequate actions decided by the mobile system accordingly, tasks must be instantiated and refined at execution time according to the actual context, and the mobile system must react in a timely fashion to events. This can be defined as a rational behavior, measured by the mobile system's effectiveness and robustness in carrying out tasks.

To meet this global requirement, the control system architecture should have the following properties [3]:
a) Programmability: a useful mobile system cannot be designed for a single environment or task, programmed in detail. It should be able to achieve multiple tasks described at an abstract level. The functions should be easily combined according to the task to be executed.
b) Autonomy and adaptability: the mobile system should be able to carry out its actions and to refine or modify the task and its own behavior according to the current goal and execution context as perceived.
c) Reactivity: the mobile system has to take into account events with time bounds compatible with the correct and efficient achievement of its goals (including its own safety). Consistent behavior: the reactions of the mobile system to events must be guided by the objectives of is task.
d) Robustness: the control architecture should be able to exploit the redundancy of the processing functions. Robustness will require the control to be decentralized to some extent.
e) Extensibility: integration of new functions and definition of new tasks should be easy. Learning capabilities are important to consider here: the architecture should make learning possible.

We note an interesting link between the desirable properties of intelligent control architecture for autonomous mobile systems and the behavior of agent-based systems:
a) Agent-based approaches to software and algorithm development have received a great deal of research attention in recent years and are becoming widely utilised in the construction of complex systems.
b) Agents use their own localised knowledge for decision-making, supplementing this with information gained by communication with other agents.
c) Remaining independent of any kind of centralised control while taking a local view of decisions gives rise to a tendency for robust behavior.
d)The distributed nature of such an approach also provides a degree of tolerance to faults, both those originating in the software/hardware system itself and in the wider environment.

It is for these reasons that we consider an agent-based system to be a suitable model on which to base an intelligent control architecture for complex systems requiring a large degree of autonomy.

Although widely used, multi-agent systems research has also lead to a number of definitions of agency. Once again, in some cases, these definitions are inconsistent. In our context, the terms agent or intelligent agent refer to a material or software entity with one or more independent threads of execution, and which is entirely responsible for its own input and output from/to the environment in which it is situated [4]. It is therefore autonomous. We assume that the agent has welldefined objectives or goals and exercises problem-solving behavior in pursuit of these goals; reacting in a timely fashion. It is this behavior that allows us to refer to the agent as intelligent. While being flexible problem solvers in their own right, the power of agents is only fully realised once multiple agents are combined and communicating. This is referred to as a multi-agent system (MAS). As agents are equipped with different abilities and different goals, each agent has a distinct sphere of influence within the environment in which all the agents are situated. These spheres of influence may overlap, defining a fundamental relationship between agents. Further relationships may be superimposed through the use of communication channels. A MAS, therefore, has all the basic properties of a complex system: autonomy, asynchronicity, concurrency, reactivity and extensibility.

System Architecture

The remote laboratories provide a live performance laboratory accessible via Internet, which can be used to cover the experimental issues in any tele-education system. Clearly as bandwidth increases and higher speed network access reaches users; these factors play an important role in user adoption of remote laboratories.

The concept of remote laboratories is defined as a mechatronic workspace for distance collaboration and experimentation in research or other creative activity, to generate and deliver results using distributed information and communication technologies. To implement a remote laboratory, a common Internet-based teleoperation model [5] is used as shown in figure3.

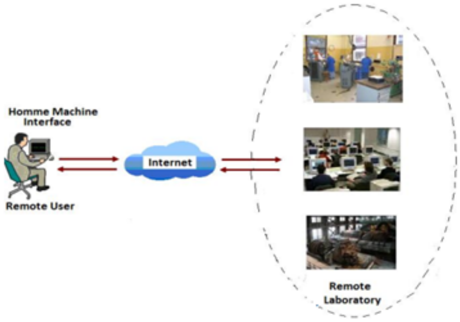

Figure 3. System Architecture

The Remote user, through his Internet navigator, addresses a http request to a Web server and downloads an application on his work station. A connection is then established towards the server in charge of the management of the mobile system to control. The user is then able to take the remote control of it. In parallel, other connections are also established towards multi-media servers broadcasting signals (video, sound) of the system to be controlled.

The Internet network (network without quality of service) limits the quantity of information that can be transmitted (bandwidth) and introduces delays which can make the remote control difficult or impossible. The solution proposed, through this work, to face the limitations of the Internet, is founded on the autonomy and the intelligence, based on multi-agents systems, granted to the mobile system in order to interact with its environment and to collaborate with the remote user. The need that consists in wanting to assign to the mobile system the maximum of autonomy and intelligence brought us to examine in the detail the choice of a remote control architecture [6].

Remote Control Architecture

Control Architecture

Humans are sophisticated autonomous agents that are able to function in complex environments through a combination of reactive behavior and deliberative reasoning. Motivated by this observation, we propose a hybrid control architecture, called EAAS [7] for EAS (Equipe Architecture des Systèmes) Architecture for Autonomous System. Our architecture combines a behavior-based reactive component and a logic-based deliberative component. EAAS is useful in advanced mobile systems that require or can benefit from highly autonomous operation in unknown environment, time-varying surroundings, such as in space robotics and planetary exploration systems, where large distances and communication infrastructure limitations render human teleoperation exceedingly difficult.

The proposed generic architecture consists in associating a deliberative approach for the high part and a reactive approach for the low part. The deliberative part or hierarchical agent allows decision-making and actions planning thanks to the use of the agent selection of actions (Figure 4). This last is composed of three levels: pilot, navigator and path planner.

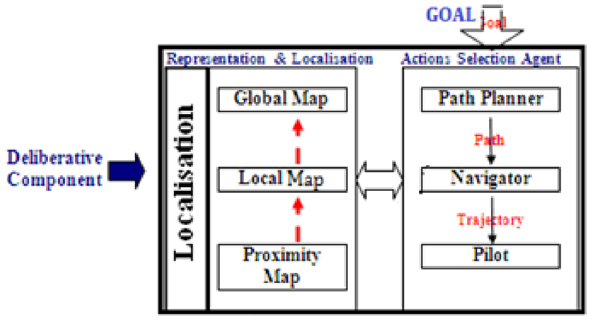

Figure 4. Actions Selection Agent

The pilot generates the setting points needed for action agent, based on a trajectory provided as an input. This trajectory is expressed in a different frame (e.g. Cartesian frame) from that of the setting points. This trajectory describes, in time, the position, kinematics and/or dynamic parameters of the mobile system in its workspace. The pilot function is to convert these trajectories into setting points to be performed by the action agent. The navigator generates the trajectories for the pilot based on data received from the upper level. These input data are of a geometrical type, still in a Cartesian frame, but not necessarily in the mobile system frame. Moreover, these data do not integrate dynamics or kinematics aspects; contrary to the trajectory, there is not a strict definition of the velocity, the acceleration or the force versus time. These input data are called path – continuous or discontinuous – in cartesian frame. The navigator must translate a path into a trajectory. The path planner generates the path using as input the goal, the mobile system localization and the global map of the environment.

The reactive part of our architecture, based on couples of agents perception / action, allows the mobile system to react facing the unforeseen events (Figure 5).

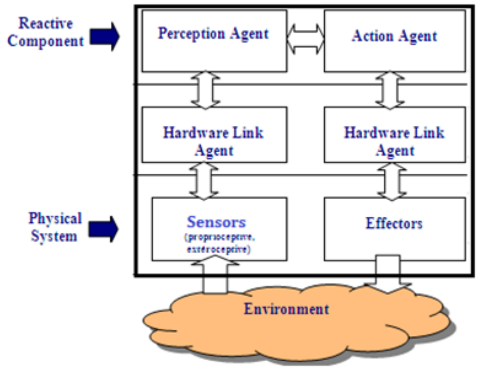

Figure 5. Reactive Part Of The EAAS Architecture

Remote Control Software Architecture

A Software architecture has been defined to make remote control of mobile systems possible. Our software architecture is based on a set of independent agents running in parallel. On the left side of figure 6, the server side is represented. It is basically composed of three main agents: "Connection Manager" which manages the different connected clients according to a Control Algorithm. This one is chosen by the designer of the system depending on the application: master/slave, priority, timeout... The "Media" agent communicates with the camera in order to broadcast signals (video, images) of the mobile system in its environment. The "SMA EAAS" (EAS Architecture for Autonomous Systems) which represents our control architecture. EAAS architecture is a hybrid control architecture including a deliberative part (Actions Selection Agent) and a reactive part. The reactive part is based on direct link between the sensors (Perception Agent) and the effectors (Action Agent).

The right side of the figure represents the client side. Agents are loaded in a web navigator. The "Remote Client" corresponds to a graphical user interface which allows the user to send orders to the mobile system and receive information about the environment. “Sender” and “Receiver” agents are used to allow the communication between the client and the server. “Pinger” and “Ponger” agents are used to observe dynamically the network. If the connexion is accepted, the “Connection Manager” will inform the “Local Client” agent which achieves the interface with the “SMA EAAS” to transmit orders transmission to the mobile system.

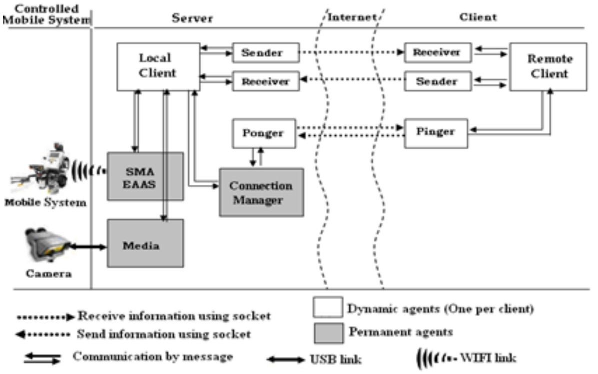

Figure 6. Remote Control Software Architecture Proposed

Realization

The mobile system used in our application is a Lego robot. Lego Mindstorms [8] is a development kit for manufacturing a robot using Lego blocks, and is gaining widespread acceptance in the field of technical education. By using a Mindstorm, a robot can be manufactured for various purposes and functions. It is beginning to be considered as a component of experimental equipment in robotics research. The Lego mobile robot (Figure 7) is powered by three reversible motors coupled to wheels and equipped with four sensors: sonar sensor, sound sensor, light sensor and touch sensor. The data produced by these sensors are used by perception agent to build a global map of the Lego robot environment's. This global map, the goal and the Lego robot localisation are used by the actions selection agent to define a plan of actions to achieve its mission. The Lego robot is equipped with Bluetooth connection that permits the communication with the application server and facilitates its displacement in the environment in order to reach its objective. The mobile system measure the temperature using an LM35 sensor and an Arduino board.

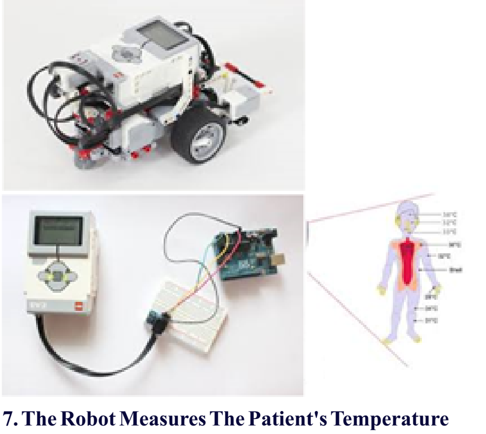

Figure 7. The Robot Measures The Patient's Temperature

The mobile robot can be deployed in the X-ray room to replace the doctor and nurse to avoid the risks related to X-rays.

Figure 8. The X-ray Room

X-rays are a type of radiation called electromagnetic waves. X-ray imaging creates pictures of the inside of your body. The images show the parts of your body in different shades of black and white. This is because different tissues absorb different amounts of radiation. Calcium in bones absorbs x-rays the most, so bones look white. Fat and other soft tissues absorb less and look gray. Air absorbs the least, so lungs look black.

The most familiar use of x-rays is checking for fractures (broken bones), but x-rays are also used in other ways. For example, chest x-rays can spot pneumonia. Mammograms use x-rays to look for breast cancer.

CONCLUSION

In this paper, we have presented a solution for distance education applied to the medical field. In the next paper we plan to use powerful robots with other types of sensors and application. This work requires more development in terms of control architecture and software architecture. We are also working on a mobile remote control application.

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