MODULAR ROBOTIC SYSTEM - A CONCURRENT ENGINEERING APPROCH

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Abstract: The modularity of robotic subsystems is a big opportunity for robotics to compel recognition on the market as a viable and efficient alternative, thanks to the development of standardized modulus, especially, but also because of the robots' features-such as productivity and flexibility. The idea of this proposal roots in the structure of a personal computer. The winding and the upgrade of a pc is an extremely simple and quick process thanks to the standardization of the functional modulus. Extrapolating this idea to robots, and to robotic systems, in general, it is necessary the conceiving of a modular system, as far back as in the primary design faze. The modular system should be conceived as intelligent structures with a high degree of sensorial, communicational, functional and control autonomy. These elements are presented and experimented with functional models, for validation. The conclusions are formulated and future directions are targeted.

Key words: modular robots, standardization, plug and play structure, robotics.

1 Introduction

The reconfigurable robots structures are characterized by changeability, maintenance and increased adaptibility.

From kinematical and especially mechanical point of view, the idea to realize reconfigurable robotic structures, in modular format, even if at a first sight is enough hopeful and it could be characterized as a total solution, at a more careful analysis it prove its limitations.

The modular solutions ask for more Lego concept, through which the use of identically interconected entities has as a result the achievement of some complex structures.

The technological implementation of this concept has as a result experimental robotic structures, developped especially in the big laboratories of the american and japanese universities.

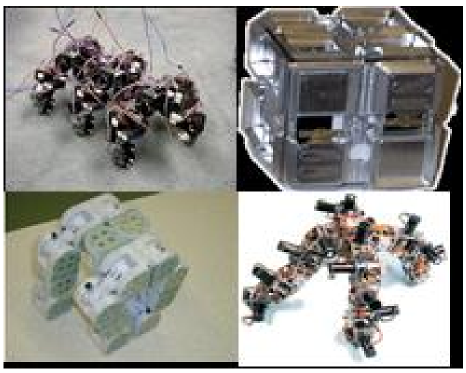

Fig. 1. Modular robotic structure experimentsTitle of figure (9 pt.)

The disadvantage of those systems is given by the redundancy due to the use of some more complex systems in respect with the fulfiled task has as a result not only an increased cost price toward the classical systems, but, contrary to the expectations, at a lower fiability and at an extremelly complex command and control structure.

The first steps in industrial implementation of the modularity concept, at functional level and at the maintenence level was realized by MOTOMAN. In figure 2 can be identified the imposed design direction for the last robotic revolutionary arhitectures, realized during 2006-2007.

Fig. 2. Motoman structurea (http://www.motoman.co.uk/IA20.htm)

2 Considerations regarding the modular industrial robotic structures

The command and control system of a reconfigurable modular robot can be watched as an informatic network composed from more modules equipped with calculus processores. Due to the characteristics of those robots, where the network structure is dynamical (can has different characteristics at different time intervals), can be realized many operations [Ivanescu and Florescu, 2007]:

- the differentiation of the modulus or the division of those role
- the modulus synchronization to generate a coherence motion
- the use of some command distributed methods of high level for taking decisions.

One of the solutions that can be adopted refers to the introduction of "hierarchically principle" inside the robot control system. Such of structure could has the following levels:

- the maintenance level of the system;
- the control level of the robot structure morphology;
- the control level of the motion;
- the decisional level.

Each level or process inside a level requires different resources to allow the communication between modules such as the case of communication speed or of the distance between modules. By analogy with biological systems, it can be told that alive systems has nervous systems nervoase such as different chemical substance which allow inter-cellular communication inter-celulară [Coman and Petrişor,2007; Bîzdoacă and Petrişor, 2007].

Same as in the animal case, robot system needs different types of communication devices and protocols with different properties, such peer-to-peer or master-slave type communications.

2.1 The algorithms characteristics

Like every functional device, the reconfigurable robots also have certain constructive limitations. The number of tasks that such a robot can accomplish depends on the number of modules existing in its structure, as well as the accomplished functions.

Another problem of the algorithms characteristics is represented by the modules conectivity [Bîzdoacă and Petrişor, 2007]. In the most approaches till now, the reconfigurable robotul was regarded as a grouped structure, with a fix number of modules. The robot limitations are naturally defined and the behavior is given for entire group. nevertheless, if it is consider the more general case in which are involved two robots which are join in a single robot, the system limitation can be predicted. The fundamental defnition of the robot system architecture must be extended to consider the all flexibility reconfigurable robot.

2.2 The necessity of some open systems

In the present robotic structures, the adoption of some standards which allow an implementation of strong connections between different components elements of the robotic structures is imposed. The benefits of the standards are such universal accepted so many organizations consider the standardization process an imperative process which must be implemented in a short time. So, there have beeing created working teams which have as objective the development of standards and in the same time they are assured that the products so created are in acordance with the operation standards at the respective time. In the case of robotics, working with standards is essentially, because the robot is a very complex structure which has electrical, mechanical elements as well as calculus devices closed to personal computers and not only.

The robots are some of the complex elements which are presented nowadays in industrial applications. Because the security is one of the principal characteristics of working in an industrial environment, is very important that the programms for controlling the robot or the succession of robots are well understanded by a large number of staff specialized in working in industrial environment.

The adaptibility of the interface to an interface standard, as well as the modularity process of very easy changing of different equipments is the major reason for which kinematic coupling standard realization is desired. An interface with a strong deterministic character and easy to be changed will has as a result a very performant characterization by means of a set of discrete parameters. Later, when this modul are used at a large scale, the set of discrete parameters which govern this modul will has as a result a standard reprezentation of the information, doing that, in this way the changing process to be more efficient.

A very important element for a kinematic coupling standard is represented by the characterization of the kinematic coupling performances. These parameters should describe in a universal and general valid way the performances of interfacing and applicability for all the standardized applications, and also the maximum independence which must exist between the performance parameters established from he beggining.

Tabel 1 presents both a set of primary design parameters and a set of secondary parameters.

Table 1. Primary and secondary Design Parameters

Performance parameter	**Primary design parameter**	**Secondary design parameter**
Repeatability	Coupling type, materials, surface finishing	Assembling process
Tiredness of repeatability	Operation conditions	
Interchanging	Interchanging tolerance	Load conditions
Load capacity	Coupling type, materials	Geometry (at coupling level0
Price	Production process and accuracy	Material, assembling and accuracy process

2.3 Plug and Play – PnP solution

Plug and Play concept refers to the possiblity of a user with a few technical knowledge to install and to disassemble hardware components without too much effort – Figure 4. So, with the help of identification techniques and of the configuration schemas implemented in hardware and in the opearting system, the user hasn't problems in founding IRQ free signals and I/O free ports. This thing is assumed by the operating system which will enumerate the identities and the capabilities of the devices attached to the system, and will allocate the proper resources for these. In principle, adding of a new device in the control architecture needs only to set up the device and to reset the computer. The benefits of PnP technology are obvious: facility in use, accepting of robotic systems on a large sqaure and and price reduction for tehnical support.

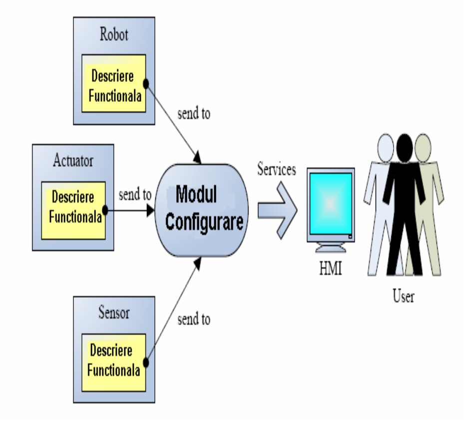

Fig. 3. Modular Plug and play communicational interface structure

From structural point of view, Plug and Play concept is applied for modular robotic structure by implementing of more leyers, similar with the organisation on layers of the operating protocols in internet network.

This organisation, extended at the level of robotic structures, is actually, the solution to succesfully realise the modular robotic structures.

The standaridization based on comunicational layers pointedly means, respecting of a minimal set of rules by all the plag and play network producers.

Extended this idea at the level of robotic structures means to realized modul drivers so that a minimum set of rules must respected. These rules allow the complete communication between modules and the central system which administrates the modular architecture or which allow the direct commnunication between modules.

Conclusions

The studies and the researches accomplished up today, have created an adequate base to continue the research and to realise experimental modules which highlight the potential of the modular approach in robots engineering. The experiments beeing unrolling start from the use of servoactuators from din Hitec familly, as well as Mitsubishi subsystems. Concomitantly, for a large approach will be studyed also the hydraulic and pneumatic structures of SMC Italy, romanian branch.

Present studies are based on the use of embeded systems – configurable inside mechatronics and robotics applications. The current experiments are based on the development platform FPGA based on Digilent systems and subsysteme and Microchip subsystems, together with the use of touch screen type systems as a user interface type support for command adaptive software. The implementation of this proposal is advanced, following that the results will be presented in the next papers.

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