

Design of the Modular Control Architecture for a Walking Robot

Mladen Stoilov Milushev and Todor Stoyanov Djamiykov

Abstract - Essential highlight of a new robot generation as mechatronics systems is using of movement basics taken from the nature. In the present paper is examined a modular architecture for control and information processing for such kind of robots. Especially here is considered a building of basic module as main entity of the architecture. The approach for architecture assembly is to create instances of basic module and realize of object-oriented connections in between depending on problem standing to solve. The presented paper suggests both approach and module for a synchronal control for the leg of a six-legged mobile robot.

Keywords – Mechatronic System, Biomechanics, Walking Robot, Fluidic Muscles, Modular Control

I. INTRODUCTION

Legged vehicles have a number of potential advantages over wheeled or tracked vehicles for locomotion over rough terrain. Six legged locomotion is the most popular legged locomotion concept because of the ability of static stable walking. The hexapods are often inspired by nature, two examples of such robots are Lauron [1] and Genghis [2]. Most of them are laboratory prototypes [3,4,], but there are also few walking machines built for specific applications. Our six-legged walking robot prototype **BiMoR** (Biologically Motivated Robot) is shown in Fig. 1. The actuating of one joint is achieved through two of the muscles under implication of the antagonistic connection principle [4]. Each of the legs is attached to the body in a 60° angle (Fig. 1).

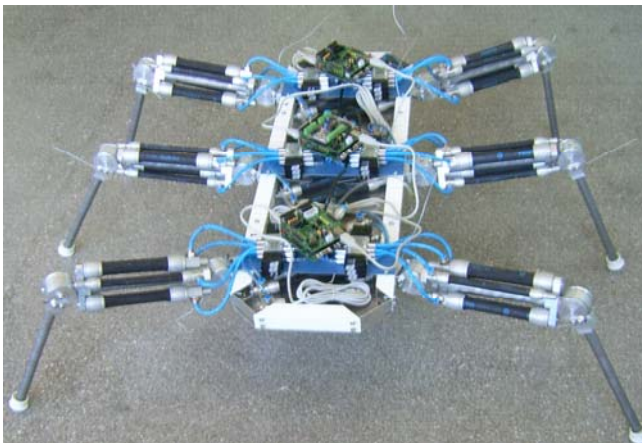


Fig.1 The six-legged robot prototype

M. Milushev is with the Department of Automation of Discrete Production Engineering, Faculty of Mechanical Engineering, Technical University - Sofia, 8 Kliment Ohridski blvd., 1000 Sofia, Bulgaria, e-mail: mcm@tu-sofia.bg

T. Djamiykov is with the Department of Electronics and Electronics Technologies, Faculty of Electronic Engineering and Technologies, Technical University - Sofia, 8 Kliment Ohridski blvd., 1000 Sofia, Bulgaria, e-mail: tsd@tu-sofia.bg

II. Control Architecture Choice

Depend upon the way they are presented throughout scientific literary sources [1],[2],[3], control concepts for mobile robots can be classified as:

- Analytical description;
- Rule-based control
- Behavior-oriented control
- Neural network-based control

Currently the approach towards mobile robots with behavior-oriented control is domineering. In turn behavior-oriented control concepts can be represented through reactive, deliberative or hybrid control. *Reactive* control systems put direct connection between sensor information and commands to the actuators, which allow robots to react immediately to environment changes. With *deliberative* systems the robot is capable of using the complete existing and current sensor information to plan its behavior, which is a rather complex one. *Hybrid* systems attempt to unite the benefits of both reactive and deliberate systems.

The hereby-suggested architecture (Fig.2) for a mobile robot control roots in the hybrid principle, which means to define the elementary behavior types along with the ways of combining them in order to achieve complex control architecture. The letter consists of four levels: joint, leg-module, body and moving robot. Each level contents intelligent units for interpretation of sensor information and for providing backup actions to the upper level.

The least functional unit is the joint. A control task on this level involves the managing of the pressure and force of the actuator working in antagonistic mode. Since the only alternating variable in the control loop is the fluid flowing in and out of the muscle, the valve takes up 3 positions: fill in-close up- let out. Integrating the reflexive entity on that level proves to be purposeful in regard of the contact force on the surface.

Next functional level is the leg-module that displays a

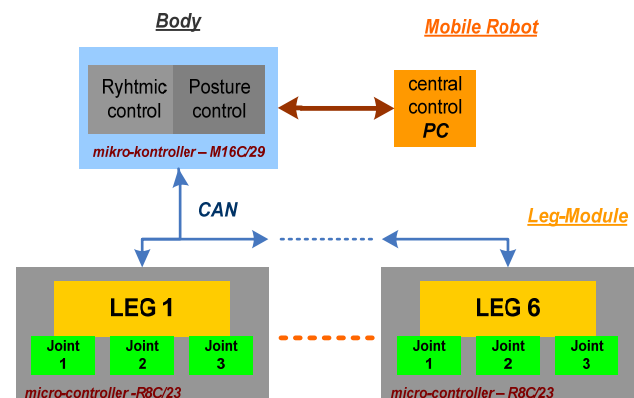


Fig. 2 Six feet structure with three joints

combination of the three joints. Control solutions here are focused on the originating and proceeding of information concerning the leg-module along with providing backup actions for the higher level and thus allowing the leg-module to be viewed as an independent entity. The accompanying integration of a reflexive unit would be appropriate with reference to the force of contact or collision alongside the movement direction. At this point proceeds the regulation of a communication link between the controllers for the leg and those for the body.

The body level is in charge of coordinating the legs in a way granting a static stability of different walking modes, e. g. tripod or tetrapod. Depending on the walk velocity the phase and speed for each of the legs are chosen (Rhythmic Control). Additional function on this level is the control of body alterations (Posture Control). All data required to control horizontal changes and body velocities are calculated using the valid joints angles dimensions or are valued on base of additional body sensor information.

The moving-robot-level performs the highest level of moving systems control. It accounts for the motion's trajectory set up and for body changes as the main control algorithm – coordinating sub-levels. The moving-robot-level should provide for a data exchange in order to:

- Obtain commands, e. g. move to a premeditated position through detection by the own sensors, or ;
- Communicate data about the robot's status quo.

III. HARDWARE PLATFORM AND COMPONENTS

There are many approaches for implementation of digital systems design: microprocessor and micro-controller based (or software), dedicated ASICs and FPGA-based solutions. Maximum flexibility can be reached with software specifications of the full system; however for highly parallel systems micro-controller based solutions are suitable.

The hierarchical modular control architecture of BiMoR is similar of walking machines CLAWAR [4] and BISAM [3]. A PC system at the top level of the hierarchy performs the main robotic tasks e.g. path planning, calculation of foot trajectories and communication with the environment (Man Machine Interface). On second level, M16C/29-



Fig. 3 The interface board with the plugged on micro-controller board.

microcontroller is connected with the PC system and is used for movement realization, sensor data acquisition and pre-computation. For the aim of execution the basic functions (Fig.3) of legs like closed-loop joint control (valve control, recording the signals of joint encoders) are installed six R8C/23-microcontrollers. On base level, each sensor and actuator is connected with the interface board to the micro-controller board. The M16C/29 and R8C/23 microcontrollers are installed in industrial controller boards and contain one Full CAN module, which can transmit and receive messages in both standard (11-bit) ID and extended (29-bit) ID formats. In detail, the control architecture for leg, consists the following dedicated components:

- Joint encoder- for the measurement of the joint angles special shaft encoders have been developed [5]. They are based on magnet-sensible transformer and provide the absolute position of a joint;
- Pressure sensor sensor - the pressure inside the air muscles is measured for generate a PWM signal for the control of the closed-loop control of the joint;
- Interface board- containing drivers for the control of up to 6 digital valves with 3 PWM channels. High precision amplifiers was implemented for joint encoders, pressure sensors and force sensor.

IV. CONCLUSION

The presented paper offers a structure intended at significant enhancement in the modularity of control for mobile robots, which use the principle of peristaltic motion through antagonistically functioning muscles. The system opens a possibility to widen the presence of reflexes during experiments, to combine them on different levels with reflex chains. With the described closed-loop control it is possible to move the machine slowly in a pentapod, tetrapod and tripod gait. For that, types of elementary behavior modes have to be defined as well as models for their combination.

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