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DEVELOPMENT AND TEST OF THE WALKING ROBOT "ANTON"

1. Introduction

This work presents the actual state of the work in the robotic area of RobotsLab group. RobotsLab group is the team of the young researchers created in cooperation work between the Virtual Engineering department in Fraunhofer IFF and the institute of Electrical Power Systems of OvG-University Magdeburg. In the last 7 years the numbers of legged robots (see Figure 1) were developed. Their mechanical structure and control system were improved. These improvements touch such question as the mechanical construction and the locomotion control system as well as the embedded control system. Recently investigations of improved robot tasks are concerned with multilegged robot locomotion over an impassable road or a strongly complex terrain such as earthquake affected area, mountain regions, high ledges, ditches, trenches.

Figure 1. Developed robots constructions in the period 2003-2007 year (SLAIR1, SLAIR2 and ANTON).

The control system of the full or part of autonomous legged robot is almost controlled by embedded system. Commonly the embedded systems are designed to control complex plants such as engines, satellites, vehicles, spacecrafts, and of course CLAWAR. They generally require a high level of complexity within the embedded system to manage the complexity of the plant under control.

2. Modular six-legged robot "ANTON"

In accordance with the requirements discussed above a multilegged robot with articulated body "ANTON" (see Figure 1, right) has been developed. The robot mechanics, sensor system and control system guaranty an additional flexibility in the body, to measure and control the support reactions as well as to control and forecast the robot motion stability. The real-time communication bridge based on industrial Ethernet protocol EtherCAT was developed. The robot construction has three modular segments linked to each other through two DOF joints and 6 legs. Each shoulder includes one articulated body segment linked with two 3-DOF-insectomorphic legs. The robot drives are servomotors, with maximal power 2.8W in knee and 8.68W in other joints. The sensor system of the robot consists of components that are standard for mobile robots and that make it possible to achieve autonomous robot functions in an environment.

2.1. *Hardware control system.*

Control system with real-time decentralized data gathering and processing builds the kernel of robot system and makes possible development of control algorithms with help of hybrid simulation. The control system has been already reached the industry level and based on the industry real-time communication EtherCAT. The developed hardware (see Figure 2) consists of NetX communication processor from Hilscher and FPGA.

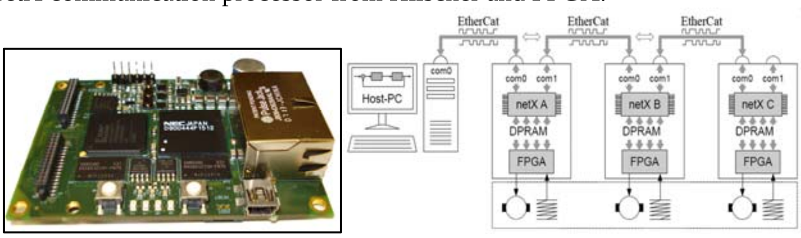

Figure 2. Flexible communication system based on netX processors.

Such communication system allows using of important technique in the robotic area as hybrid simulation technique. Starting with the SiL simulation, where the developed control system in Matlab/Simulink has the possibility to communicate with the real legged robot, the control system has acquired a new level so-called Rapid Control Prototyping.

2.2. *Software control system.*

The hierarchically organized modular control structure [3] is completely located on PC-side that implements additionally the interaction with user and produces the control signal for robot drives as well as monitors all actuators and sensors of the robot. The robot-side is implemented by fast and flexible FPGA, includes the hardware abstraction layer (HAL) for drive and sensors. The real-time connection between two parts is made via proposed netX® [2] based communication system. The PC-side hierarchical control system [3] has a three control levels: Action, Primitive and Servo levels. Each of them is for own task responsible. The action level represents the level of references: references for locomotion tasks and references for manipulation tasks. The primitive level ensures a regular walking pattern in accordance with parameters which comes from the action level. This level can be divided in four parts: step cycle generation, compliance control, COM stabilization and force and position feedback. The last level, servo level, is for the realization of the position control of servo DC drives responsible. The whole control process is sampled with the sample time of T_{sample}=1 ms.

3. Experimental results.

This chapter deals with the experimental results during robot movement. Firstly, the position control system is discussed and the experimental results of position control by robot movement are shown. The distributions of the forces during the robot movement are shown at the end of the chapter (see Figure 4).

Position control of servo DC drives is shown in Fig. 3. For the velocity loop a PI controller is utilized and for the angle loop a P controller is selected.

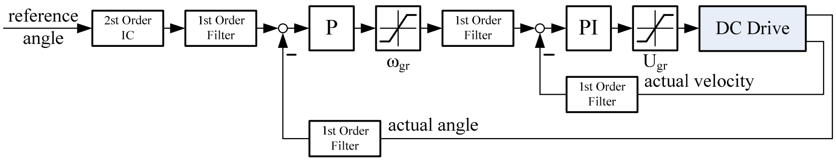

Figure 3. Cascade position control system of servo DC drive.

Experimental results of the position controlled DC motors of one of the legs, during the robot movements, are shown in Fig. 3. The results of simulation and the results of real experiments are practically identical. The maximal position error is less than 5 grads in the dynamic and is absent in the static mode.

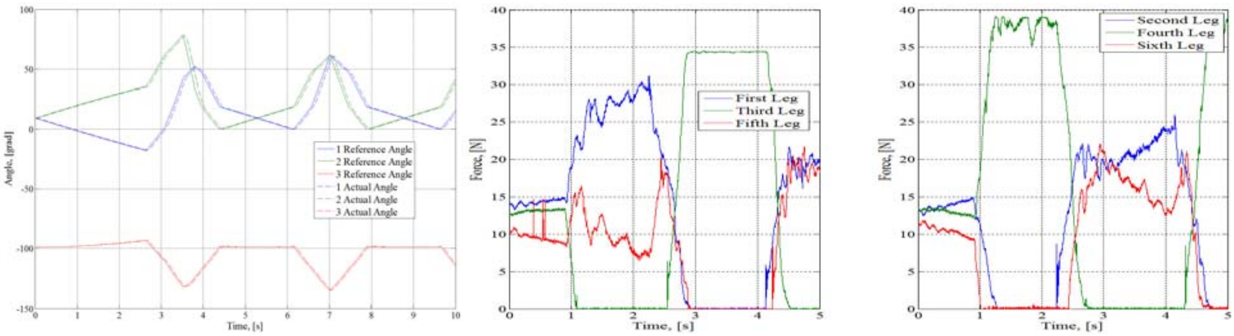

Figure 4. Experimental results of the position control and force distribution by robot movement with tripod gait.

References

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