PROCEEDINGS

53. IWK

Internationales Wissenschaftliches Kolloquium
International Scientific Colloquium

Faculty of
Mechanical Engineering

PROSPECTS IN MECHANICAL ENGINEERING

8 - 12 September 2008

www.tu-ilmenau.de

TECHNISCHE UNIVERSITÄT
ILMENAU

Published by
Impressum

Publisher Herausgeber	Der Rektor der Technischen Universität Ilmenau Univ.-Prof. Dr. rer. nat. habil. Dr. h. c. Prof. h. c. Peter Scharff
Editor Redaktion	Referat Marketing und Studentische Angelegenheiten Andrea Schneider
	Fakultät für Maschinenbau Univ.-Prof. Dr.-Ing. habil. Peter Kurz, Univ.-Prof. Dr.-Ing. habil. Rainer Grünwald, Univ.-Prof. Dr.-Ing. habil. Prof. h. c. Dr. h. c. mult. Gerd Jäger, Dr.-Ing Beate Schlütter, Dipl.-Ing. Silke Stauche
Editorial Deadline Redaktionsschluss	17. August 2008
Publishing House Verlag	Verlag ISLE, Betriebsstätte des ISLE e.V. Werner-von-Siemens-Str. 16, 98693 Ilmenau

CD-ROM-Version:

Implementation Realisierung	Technische Universität Ilmenau Christian Weigel, Helge Drumm
Production Herstellung	CDA Datenträger Albrechts GmbH, 98529 Suhl/Albrechts

ISBN: 978-3-938843-40-6 (CD-ROM-Version)

Online-Version:

Implementation Realisierung	Universitätsbibliothek Ilmenau ilmedia Postfach 10 05 65 98684 Ilmenau

Home / Index:
http://www.db-thueringen.de/servlets/DocumentServlet?id=17534

53rd Internationales Wissenschaftliches Kolloquium
Technische Universität Ilmenau
08 – 12 September 2008

V. Zerbe/ M. Milushev

MODULAR CONTROL FOR A JOINT BASED ON ANTAGONISTIC PNEUMATIC MOTIONING

INTELLIGENT MECHANICS IN ROBOTICS

Pneumatic Muscles as Actuators

Unlike electric drivers causing rotation movements when actuating a joint, fluidic muscles generate instead linear translations through extending and contraction. Hence, the realization of the one-joint-actuator (Fig. 1) proceeds by way of a pair of antagonistically connected muscles called protagonist and antagonist. The fluidic muscles MAS-20 produced by the company FESTO are selected as actuators for the walking robot. They provide for a contraction up to 73% and extension up to 103% of their initial length. As valves two 5/3 high speed switching valves of the company FESTO are used. The activating of one valve fills the first muscle from the regulated supply of clean air while the other muscle is being exhausted. The second valve acts vice versa. Thus in regard of the air stream each muscle is secured three conditions – in-close-out. The realization of a leg in accordance with this principle is shown in Fig. 2.

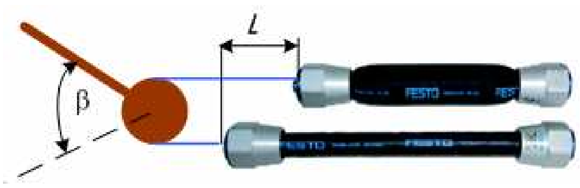

Fig.1. Mechanic structure of a joint

Fig.2. Leg construction

Control Architecture

The hierarchical modular control architecture is described in [6] and is similar to that of other walking machines [2, 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. At the second level the EVBR8C/23 produced by RENASAS microcontrollers execute the basic functions like data acquisition and processing through timely synchronization of the necessary joint angle positions and providing service activities to the upper level thus allowing to regard the leg as an autonomous unit. Here belongs the communication link between the body and leg controllers. At the base level each sensor and actuator is connected directly to the closed-loop joint control. The task is to control the actuator in a way allowing the realization of the prearranged joint rotation angle.

Closed-Loop Control of the Joint and Electronic Components

The task of controlling a muscle-joint integrates the subtasks of controlling the joint angle through the air flowing in and out of the muscle. The control architecture's structure is shown in Fig. 3. The sensor input provides the instant joint angle, which is compared with the given one. In case of occurring differences one of valve coils for rotation is activated in order to equal the values of current with the given angles. A PWM channel of the controllers is used to generate a 23 Hz signal for controlling the respective

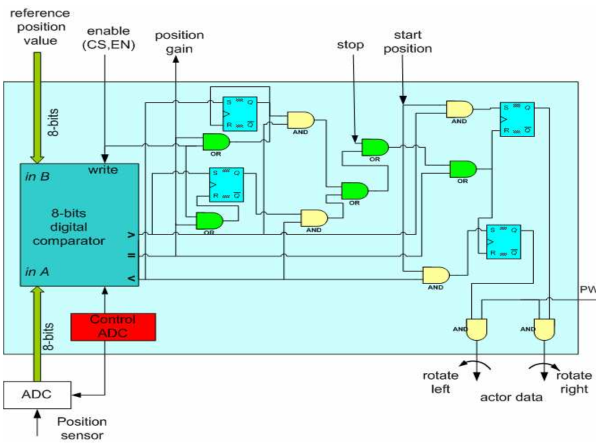

Fig. 3. Block diagram for implementing a joint control


Fig.4. FPGA modul

valve. The structure encompasses additional logic aimed at servicing the other control signals and synchronization with ADC.

For a hardware realization of the structure as well as in order to put module architectures into use the evaluation model using FPGA by Xilinx- XC95144XL (Fig.4.) has been set up. The module's capacity allows implementation of the three described structures, correspondingly for all three leg joints. Through coupling or through valves divided into two sections on each circuit board the peripheral will be connected: one section has six semiconductor switches for the coil valves and the second one has the sensors and ADC.

Experiments and Further Work

Since the only manipulative variable of the control loop are the airflow into and out of the muscle, the first step would be to generate the basic control scheme for the leg's joint. At the moment new control algorithms, which include a dynamic muscle model are tested. Further, the whole conception will be improved in order to define the types of elementary behavior of each joint and the manner in which to combine those types for setting up the complex control architecture for the leg and the two walking phases (return and power phase).

Acknowledgement

This work was supported by ВУ–ТН–201/2006 Contract entitled "Research of a Modular Architecture for the Control of Mechatronic Elastic Multi-Link Devices".

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