RT 121

Fuzzy control: ball-on-beam

Description

- **linear, one-dimensional single-variable system with one input and one output**
- **fast, real-time control using microcontroller**
- **implementing fuzzy algorithms**
- **microcontroller-based development process for process control systems**

Fuzzy methods are particularly suitable for systems that mathematics cannot describe adequately or easily. Fuzzy algorithms can offer major advantages, as the control strategy is developed not on the basis of exact mathematical modelling, but on a linguistic description of the process. Additional input variables and the rule base can be easily added.

This experimental unit forms part of a series of teaching systems developed in collaboration with the **Department of Automation and Information Technology at the Harz University of Applied Studies and Research**.

The RT 121 provides an introduction to fast, digital real-time control by fuzzy methods. A ball-beam model acts as a mechanical single-variable system.

A fuzzy control is used to attempt to hold the ball in a specific position by tilting the beam, even when the position of the ball is modified by external influences.

The position of the ball is determined using a resistive measuring system. A potentiometer detects the inclination of the beam. These sensors supply crisp signals to the fuzzy controller, where the signals are transformed into fuzzy input values and inferenced before being transformed back into a crisp output value. A servo motor equipped with a drive rod modifies the inclination of the beam and acts as an actuator.

The control algorithms are initially written in the user-friendly development software FSH-Shell and then compiled to generate microcontroller code. The control strategy can be optimised at a later date.

A joystick can be used to control the system manually. This allows the degree of difficulty of the control process to be estimated very accurately.

Learning objectives/experiments

- introduction to the fundamentals of fuzzy control and microcontroller technology
- working with the development software FSH-Shell
- development of a simple fuzzy control for a single-variable system using the elements
  - fuzzification, rule base, inference, defuzzification
- implementation of fuzzy algorithms in the mechatronic system using microcontrollers
- optimising the algorithms on the mechatronic system using the online debugger

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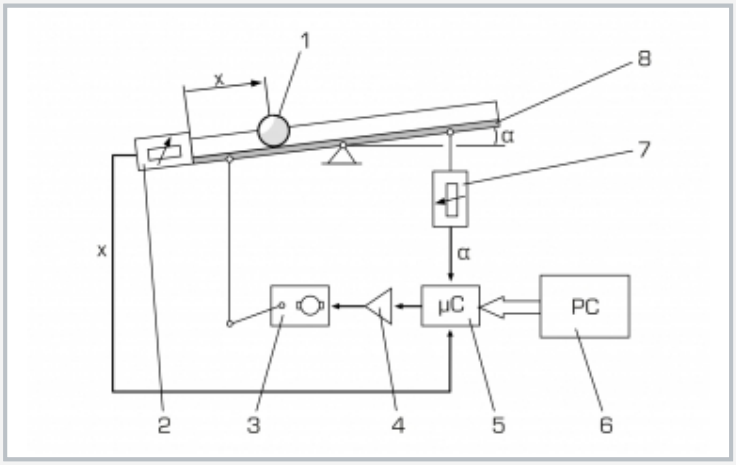
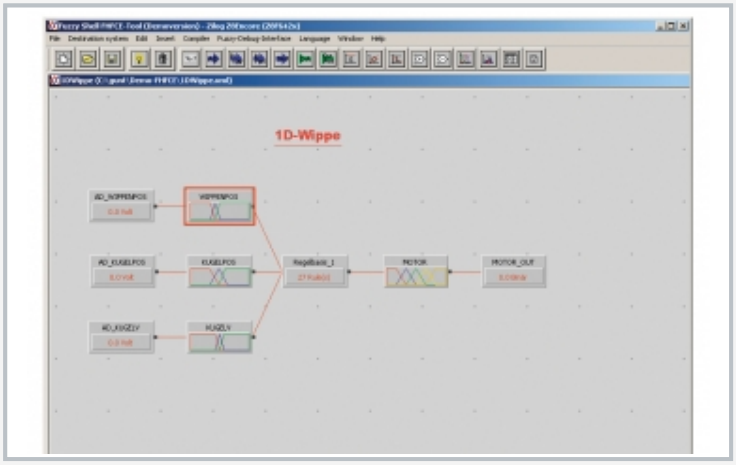
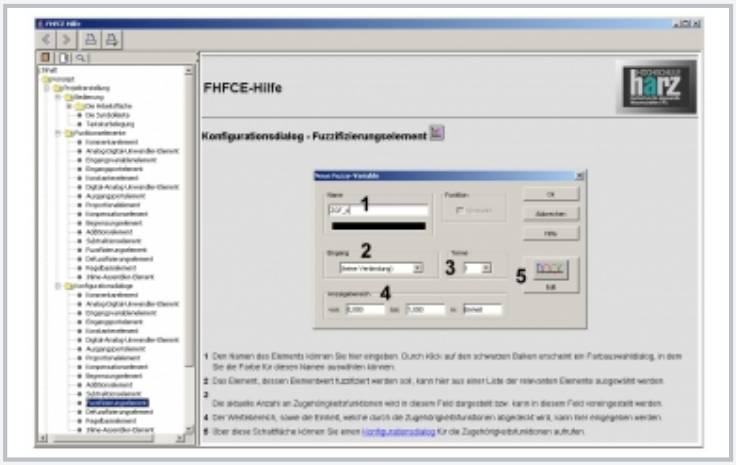


1 ball, 2 ball position sensor, 3 servo motor for beam drive, 4 amplifier, 5 microcontroller, 6 PC with development software, 7 beam inclination sensor, 8 beam



FSH-Shell development software: structure of a fuzzy control



FSH-Shell development software: help function

Specification

[1] introduction to fuzzy control and microcontroller technology
[2] ball-beam as mechanical single-variable system, SISO (Single Input – Single Output)
[3] switchable between fuzzy and manual mode
[4] servo motor for beam drive as actuator
[5] microcontroller with USB port as fuzzy controller
[6] FSH-Shell development software for design and optimisation of the fuzzy controller; software via USB under Windows 7, 8.1, 10
[7] resistive measuring system with film potentiometer as ball position sensor
[8] potentiometer as beam inclination sensor
[9] part of the structured teaching concept: level 1 – basics

Technical data

Beam, U-profile
- length: 500mm
- material: aluminium

Ball
- diameter: 25,4mm
- weight: 66g

Servo motor
- operating voltage: 5,0V
- actuation torque, interpolated: 206Ncm
- actuator velocity, interpolated: 0,18s/60°

Microcontroller
- 8bit microcontroller Zilog Z8Encore
- 12-fold ADC 8bit

Film potentiometer
- resistance value: 12,5kΩ ±30%
- electrical path: 500mm

230V, 50Hz, 1 phase
230V, 60Hz, 1 phase
120V, 60Hz, 1 phase
UL/CSA optional
LxWxH: 600x520x330mm
Weight: approx. 20kg

Required for operation

PC with Windows

Scope of delivery

1 experimental unit
1 FSH-Shell development software + USB cable
1 set of instructional material

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Optional accessories

020.30009	WP 300.09	Laboratory trolley