RT 123
Fuzzy Control: ball-on-plate

Description

- **linear, two-dimensional multivariable system with two actuators**
- **ball-plate model with two inputs and two outputs**
- **fast, real-time control using microcontroller**
- **implementing fuzzy algorithms**
- **two fuzzy controllers with weak coupling**
- **microcontroller-based development process for process control systems**

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**.

A ball-plate model acts as a weakly-coupled mechanical multivariable system. A fuzzy control is used to move the ball to a specific position quickly and with as little movement of the plate as possible, even when the position of the ball is modified by external influences.

The position of the ball is measured without feedback using a touch panel and the crisp signals sent to the fuzzy controller, where the signals are transformed into fuzzy input values and inferenced before being transformed back into a crisp output value. Two servo motors act as actuators during this process. The inclination of the plate is modified by the movements of the respective motors; these movements are transferred to the plate by the drive rod.

The learning contents of RT 123 are based on the fundamentals of RT 121. The RT 123 is a multivariable system with two separate fuzzy controllers, which can also be coupled. Optimisation of the system by fine tuning the parameters will be looked at in a later exercise.

The control algorithms are initially written in the user-friendly development software FSH-Shell, simulated 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

- design of a fuzzy control for a decoupled multivariable system (fundamentals from RT 121 are required)
- development of a model with two separate fuzzy controllers for each axis
- effect of the position and velocity of the ball on the control characteristic
- optimisation of control characteristic by additional coupling of the fuzzy controllers
- comparison of a fuzzy control with a manually controlled system

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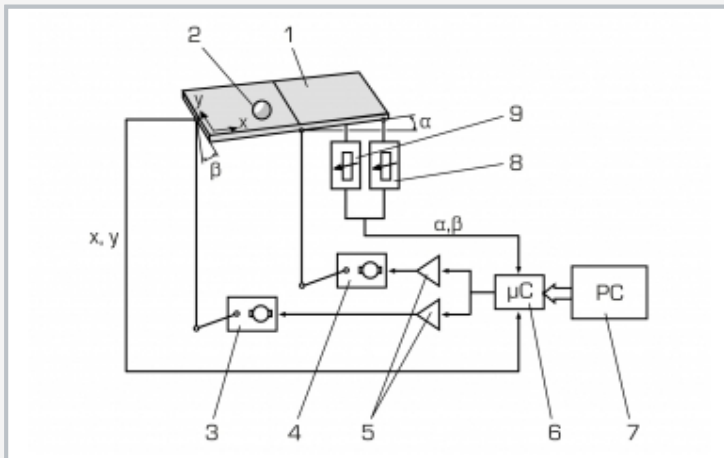
1 swivelling plate with touch panel to measure ball position, 2 ball, 3 swivel drive y-axis, 4 swivel drive x-axis, 5 amplifier, 6 microcontroller, 7 PC with development software, 8 plate inclination sensor y-axis, 9 plate inclination sensor x-axis
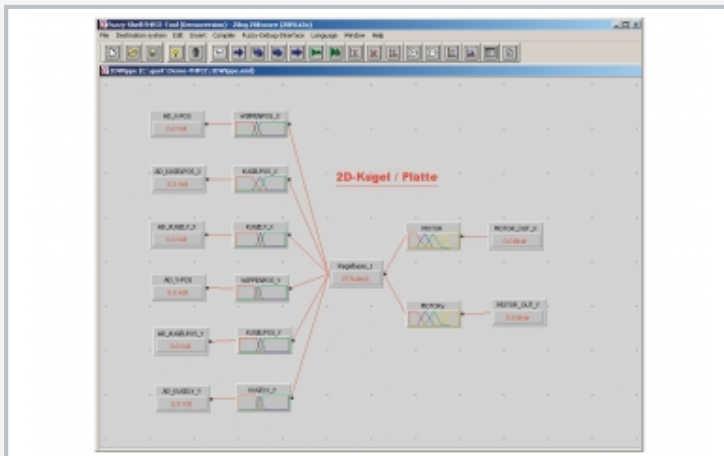
FSH-Shell development software: structure of a fuzzy control
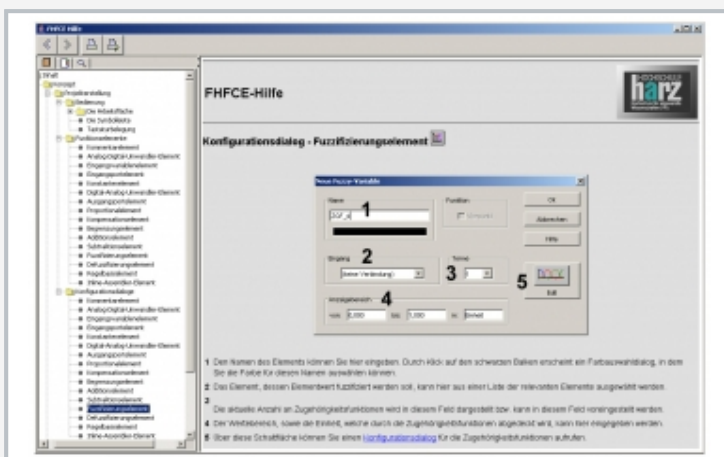
FSH-Shell development software: help function

Specification

[1] develop parallel fuzzy controls using microcontroller technology
[2] two-axis ball-plate system as mechanical multivariable system, MIMO (Multiple Inputs – Multiple Outputs)
[3] switchable between fuzzy and manual mode
[4] 2 servo motors used as actuators to swivel the plate
[5] microcontroller with USB port as fuzzy controller
[6] FSH-Shell development software for designing and optimising the fuzzy controller; software via USB under Windows 7, 8.1, 10
[7] resistive analog touch panel as ball position sensor
[8] potentiometer as plate inclination sensor
[9] part of the structured learning concept: level 2b

Technical data

Plate
■ LxW: 378x303mm

Ball
■ diameter: 35mm
■ weight: 174g

2 servo motors
■ operating voltage: 5,0V
■ actuation torque, interpolated: 206Ncm
■ actuator velocity, interpolated: 0,18s/60°

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

Touch panel
■ operating voltage: 5,5V
■ active area: 378,5x303mm

230V, 50Hz, 1 phase
230V, 60Hz, 1 phase
120V, 60Hz, 1 phase
UL/CSA optional
LxWxH: 600x520x300mm
Weight: approx. 24kg

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 |