RT 124

Fuzzy control: carrier vehicle with inverted pendulum

Description

- **non-linear, single-dimensional multivariable system with strong coupling**
- **complex, mechanical system with two degrees of freedom**
- **fast, real-time control using microcontroller**
- **implementation of fuzzy algorithms**
- **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 vehicle with an inverted rod pendulum acts as a mechanical multivariable system. A fuzzy control moves the rod pendulum to the centre position, where it is held in position, and at the same time controls the position of the vehicle.

A rotary encoder determines the position of the vehicle from the rotation of its wheels. A rotary potentiometer detects the inclination of the pendulum.

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. This in turn activates an actuator, the drive motor on the vehicle. The control process is made more difficult by the fact that the vehicle can only move to a limited extent from its original position.

The RT 124 completes the learning contents from the RT 121 – RT 123 series. This experimental unit is very complex, as the controller has to activate an actuator using two input variables. The overall solution also has to be fine tuned properly.

The control algorithms are initially written and simulated 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

- design of an demanding fuzzy control for an unstable, coupled multivariable system (fundamentals from the experiments with the units RT 121 – RT 123 are required)
- superposition of pendulum stabilisation and position control of the vehicle
- comparison of different controller structures
- optimisation of rule base
- development of a strategy to decide what to do in case of conflicting requirements
- demanding optimisation of control response

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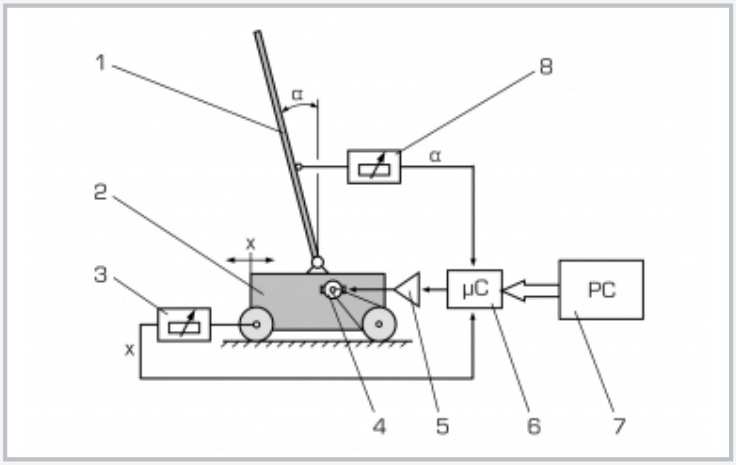
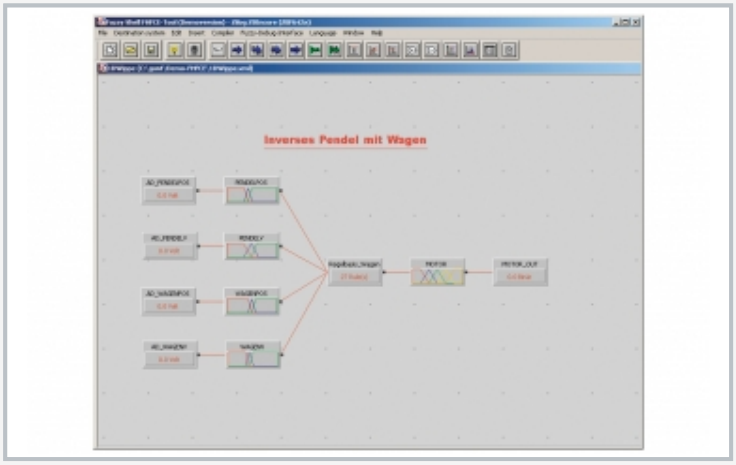
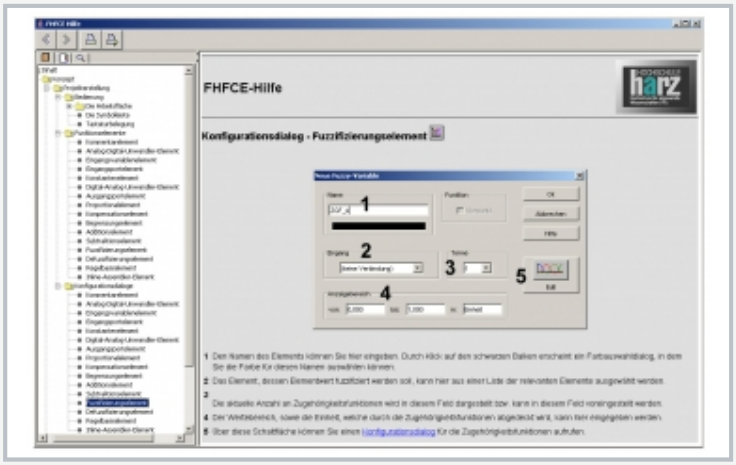


1 rod pendulum, 2 vehicle, 3 vehicle position sensor, 4 drive motor, 5 amplifier, 6 microcontroller, 7 PC with development system, 8 pendulum inclination sensor



FSH-Shell development software: structure of a fuzzy control



FSH-Shell development software: help function

Specification

[1] fine tuning of a fuzzy control system with strong coupling and use of microcontroller technology
[2] inverted rod pendulum with vehicle as mechanical multivariable system, MISO (Multiple Inputs – Single Output)
[3] switchable between fuzzy and manual mode
[4] motor to drive the vehicle as actuator
[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] rotary potentiometer as pendulum inclination sensor
[8] rotary encoder as vehicle position sensor
[9] permitted route of vehicle relative to starting position: adjustable
[10] part of the structured learning concept: level 3

Technical data

Vehicle
- max. tensile force: 12N

Rod pendulum
- length: 990mm
- weight: 0,1kg

Drive motor
- 12V

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

Rotary potentiometer
- resistance value 5kΩ; ±20%

Rotary encoder
- diameter of sensor wheel: D=40mm
- impulses per revolution: 50
- resolution: 2,51mm / impulse

230V, 50Hz, 1 phase
230V, 60Hz, 1 phase
120V, 60Hz, 1 phase
UL/CSA optional
LxWxH: 600x520x190mm (control unit)
Weight: approx. 20kg
LxWxH: 350x290x1080mm (vehicle)
Weight: approx. 2kg

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