Fuzzy Control: Inverted Pendulum

Technical Description

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 unstable "inverted pendulum" system acts as a mechanical single-variable system. The upright position of the pendulum is adjusted by two independent propeller drives and should be achieved quickly and if possible without overshooting. A fuzzy control will be developed and optimised for this purpose.

The inclination of the pendulum is measured by a potentiometer. The sensor supplies a crisp signal to the fuzzy controller, where the signal is transformed into a fuzzy input value and inferenced before being transformed back into a crisp output value. This output value controls the actuators, two propeller drives.

The learning contents of the experimental unit RT 121 are extended by RT 122 that is more complex because of its two independent drives. Conducting the experiment makes high demands on the system optimisation, as the two independent drives have to be tuned.

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.

The well-structured instructional material sets out the fundamentals and provides a step-by-step guide through the experiments.

Learning Objectives / Experiments

- Design of a fuzzy control for the unstable single-variable system: inverted pendulum (fundamentals from RT 121 are required)
- Working with the development software FSH-Shell
- Activating of two independent actuators that are coupled via the system
- Mastering of non-linearities in the system: inverted pendulum
- Mastering of non-linearities in the propeller drive
- Optimisation of
  * fuzzification
  * rule base
  * defuzzification with respect to stability
  * velocity
  * control quality

* Non-linear, one-dimensional single-variable system with two actuators
* Inverted pendulum with one input and two outputs
* Fast, real-time control using microcontroller
* Implementing fuzzy algorithms
* Microcontroller-based development process for process control systems
**Fuzzy Control: Inverted Pendulum**

1 inverted pendulum, 2 pendulum inclination sensor, 3 PC with development software, 4 microcontroller, 5 amplifier, 6 drive motors with propellers

**Specification**

1. Design and optimise fuzzy control systems using microcontroller technology
2. Inverted pendulum as mechanical single-variable system, SIMO (Single Input - Multiple Outputs)
3. 2 independent motors for propeller drive as actuators
4. Microcontroller with RS232 port as fuzzy controller
5. FSH-Shell development software for designing and optimising the fuzzy controller
6. Rotary potentiometer as pendulum inclination sensor
7. Part of the structured learning concept: level 2a

**Technical Data**

- **Inverted pendulum**
  - length: 780mm
  - counterweight: 1.89kg
- **2 drive motors**: 7.2V / 23A
- **Microcontroller**
  - 8bit microcontroller Zilog Z8Encore
  - 12-fold ADC 8bit
- **Software**: FSH-Shell, runs under Windows XP or Windows Vista
- **Rotary potentiometer**
  - resistance value 5kΩ +/- 20%

**Dimensions and Weight**

- **l x w x h**: 600x520x1200mm (with upright pendulum)
- **Weight**: approx. 36kg

**Connections**

- 230V, 50/60Hz, 1 phase or 120V, 60Hz/CSA, 1 phase

**Scope of Delivery**

- 1 experimental unit
- 1 RS232 cable
- 1 FSH-Shell development software
- 1 set of instructional material

**Order Details**

080.12200 RT 122 Fuzzy Control: Inverted Pendulum