Universität Siegen

Adaptive Fuzzy Control for Transfer Channels in Particle Accelerators

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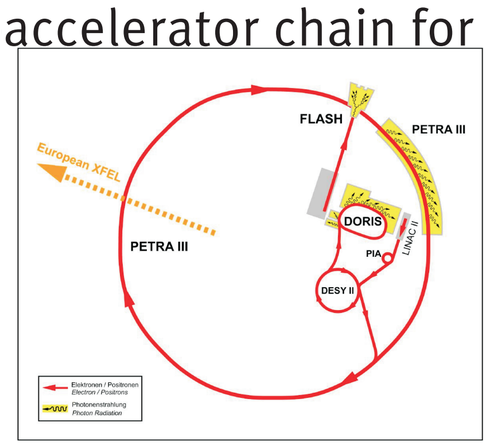
Key points

- Evolving Takagi-Sugeno fuzzy model
- Learning via fuzzy-rule-based structure design and parameter identification of the rules consequents
- Evolves over time as data samples arrive from the data stream
- Applies high-dimensional projected stream clustering (HPStream algorithm): Continuous refinement of the set of projected dimensions during the progression of the stream

Area of application

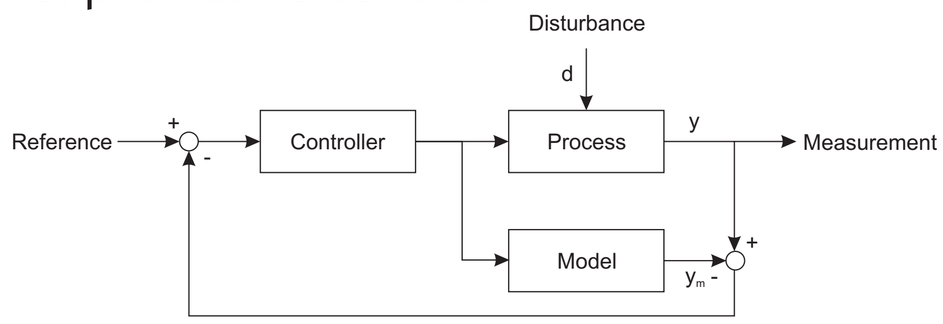
- 450 MeV electron/positron transfer line PIA to DESY II (pre-accelerator chain for PETRA III)



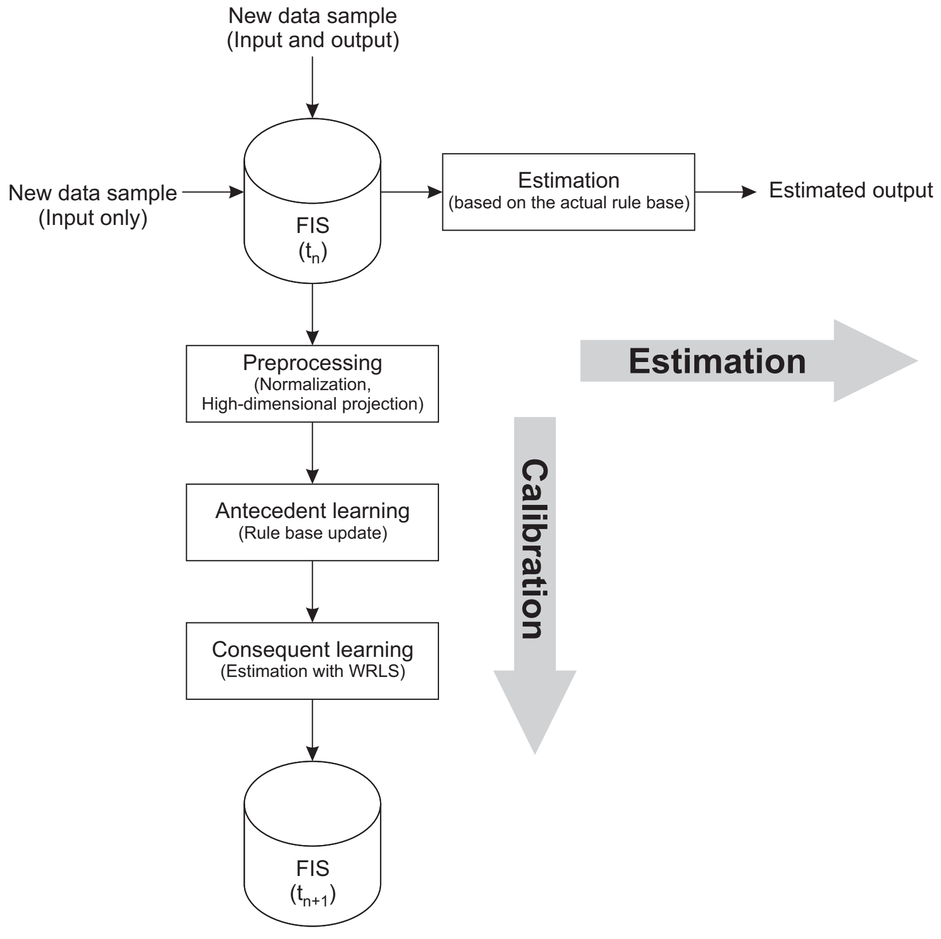
- Tests parasiticaly to the regular operation at beam transfer frequency of 6 Hz
- Integrated into the TINE-based accelerator control system via MATLAB codes

Overall controller structure

- Model predictive control



Algorithm flowchart



Takagi-Sugeno fuzzy model

- Rule base

$$R_i\text{: If } \vec{x} \text{ is } A_i \text{ then } \hat{y}_i = \hat{\mathrm{f}}_i(\vec{x}); \qquad i = 1, \ldots, C. \tag{1}$$

- Fuzzy system

$$\hat{\mathrm{f}}(\vec{x}) = \hat{y} = \sum_{i=1}^{C} l_i \Psi_i(\vec{x}) \tag{2}$$

- Gaussian membership functions

$$\Psi_i(\vec{x}) = \frac{\exp\left(-\frac{1}{2}\sum_{j=1}^{p}\frac{(x_j - c_{ij})^2}{\sigma_{ij}^2}\right)}{\sum_{k=1}^{C}\exp\left(-\frac{1}{2}\sum_{j=1}^{p}\frac{(x_j - c_{kj})^2}{\sigma_{kj}^2}\right)} \tag{3}$$

- Consequent functions

$$l_i = w_{i0} + w_{i1}x_1 + \cdots + w_{ip}x_p, \tag{4}$$

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