

Biochemical Reaction Networks with Fuzzy Kinetic Parameters in *Snoopy*

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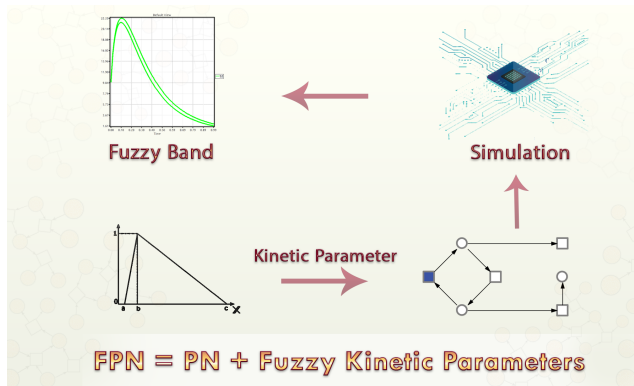
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- 1 The Problem
- 2 Fuzzy Logic
- 3 *FPN* Simulation
- 4 Test cases?

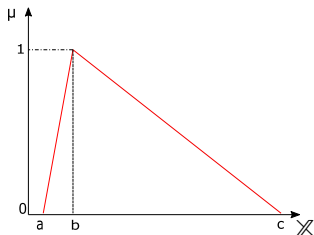




- Parametric uncertainty is one of the issues in modelling and simulation of biochemical reaction networks.
- This uncertainty usually comes from unavailable or imprecise parameters due to:
 - Some environmental factors,
 - Lack of exact knowledge.
- Stochastic methods are not always appropriate to deal with these situations.
- Giving an uncertain band of all outputs of interest might be an alternative method.



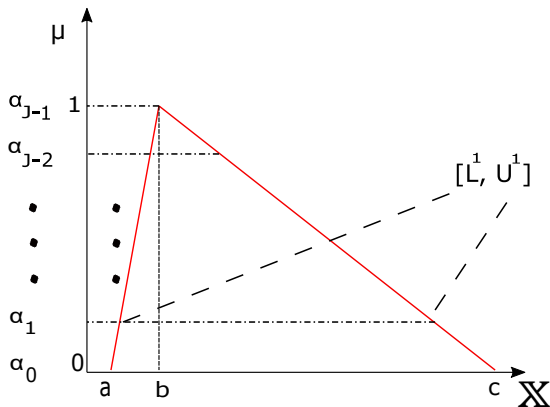
- **A fuzzy set** is defined on a universal set \mathbb{X} by its membership function which only takes real values in the closed (unit) interval $[0, 1]$, thus specifying a membership degree for each element of the universal set.
- **A fuzzy number** is a special (convex and normalized) fuzzy set with the universal set \mathbb{X} given by the set of real numbers.



a : pessimistic value
b : the most possible value
c : optimistic value



- **The α -cut** of a fuzzy set at a given membership degree $\alpha \in [0, 1]$ consists of a crisp subset of \mathbb{X} , in which each element has a membership degree greater than or equal to the given α level.





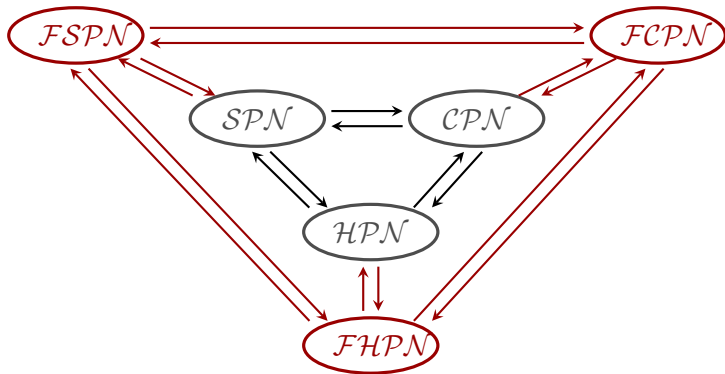
Extending Petri nets by fuzzy kinetic parameters yields fuzzy quantitative Petri nets (\mathcal{FPN}), for example:

- $CPN \Rightarrow FCPN$
- $SPN \Rightarrow FSPN$
- $HPN \Rightarrow FHPN$

In \mathcal{FPN} , a kinetic parameter can either be represented as

- a crisp number as usual, or
- a fuzzy number, if the parameter cannot be measured or estimated precisely.

Export relations between \mathcal{PN} and \mathcal{FPN} in Snoopy





- Decompose all fuzzy kinetic parameters into α -cuts.
- Discretise each α -cut and obtain samples (crisp values).
- For each α -cut do
 - For each sample combination do
 - $SPN/CPN/HPN$ simulation.

- For each variable of interest repeat the following steps
 - Obtain its output band over time.
 - Compose its α -cuts to obtain its membership function over time.



- *Snoopy* is a powerful modelling and simulation tool for various types of Petri nets.
- *Snoopy* has been developed by former staff members and numerous student projects at Brandenburg Technical University (BTU), chair Data Structures and Software Dependability.
- *Snoopy* now supports modelling and simulation of \mathcal{FPN} .

Questions?

