



LabEx DigiCosme

Scilex – Task 2

November 9, 2020



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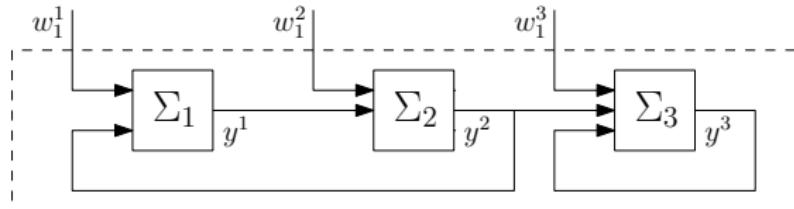
Task 2

Continuous and discrete systems: models and verification



- ▶ Mathematical modelling of **Cyber-physical systems** or **biological systems** involves different classes of mathematical models going from finite state automata to differential equations which may also involve distributed computations.
- ▶ The coupling of these classes of models requires a great care.
- ▶ All these elements make the application of formal methods challenging (for verification or controller synthesis)

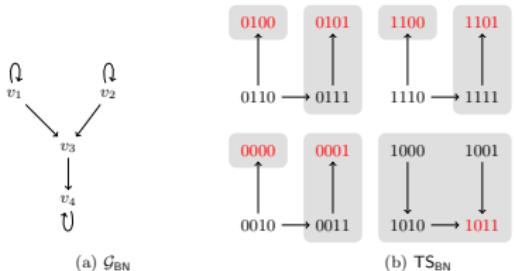
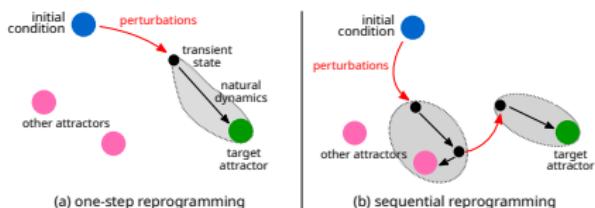
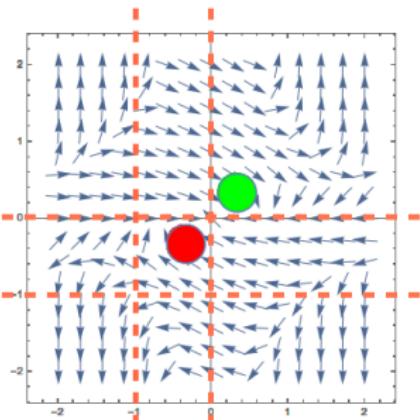
Interconnected systems¹



¹Figure from PhD Thesis of Adnane Saoud

Examples

- Predicate abstraction of continuous-time dynamical systems²
- Cell programming as Boolean Networks³



²Image from Sergio Mover

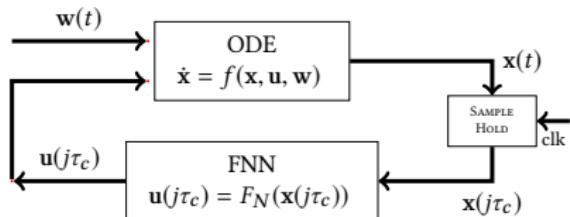
³Image from “Sequential Reprogramming of Boolean Networks Made Practical”.

Hot topic 1

Formal methods for neural network-based systems



Closed-loop CPS systems with Neural Network components⁴



Challenges

- ▶ Extension of reachability/SMT methods to deal with NN components
- ▶ Specification definition for NN components

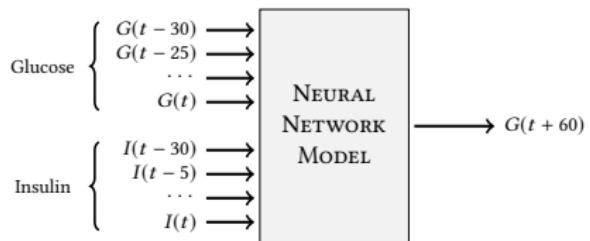
⁴From Reachability Analysis for Neural Feedback Systems using Regressive Polynomial Rule Inference, Kushner et al. HSCC 2019.



Hot topic 2

Data driven modeling of dynamical systems

Model prediction from data⁵



Challenges

- ▶ Lack of properties on modelled systems (Lipschitz, monotony, etc.)
- ▶ Conformance proof of NN model with respect to databases or real systems
- ▶ Adapt controller synthesis algorithms

⁵Conformance verification for neural network models of glucose-insulin dynamics, Kushner et al. HSCC 2020.

Opportunities



Cooperation with DataSense for learning-based systems to improve
explicability, verification, specification