Verification of Building Stability using Reachability Analysis

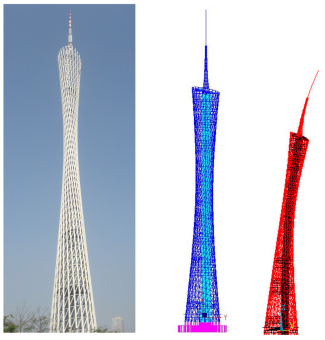
Technical University of Munich

Department of Informatics

Chair of Robotics, Artificial Intelligence and Real-time Systems

Background

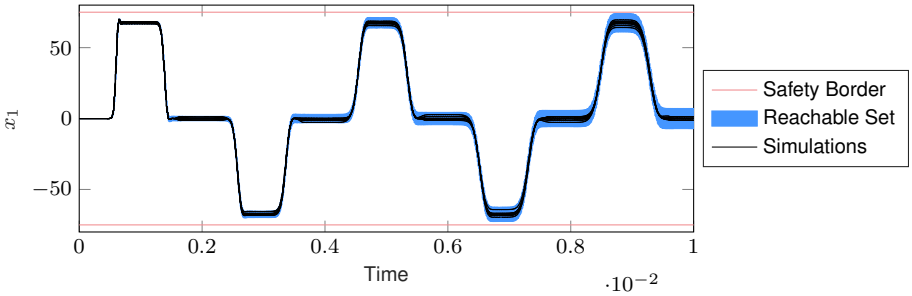
Large buildings such as towers and bridges are constantly exposed to natural forces, most notably wind and seismic activity. Their ability to withstand these forces is extremely safety critical, as a collapse of such buildings poses direct risks to critical infrastructure and human lives.



An extreme example of such safety risks are nuclear power plants [4], where failure of certain safety guarantees may result in global catastrophes.

Description

Reachability Analysis aims to verify all possible behaviors of a system by determining all states reachable from a given initial position. This is achieved by propagating continuous sets along the solutions of the differential equations modeling system dynamics.



We aim to apply this technique to the verification of building safety, both for completely uncontrolled buildings [2], as well as to structures including some actuators governed by a controller [3]. For reachability analysis, we use the existing algorithms in our toolbox CORA [1].

Tasks

- Literature review over relevant and feasible benchmarks
- Implement identified benchmarks into the CORA format [1]
- Define suitable safety specifications should they not arise from the literature
- Perform experimental evaluations on the created benchmarks via the CORA toolbox
- Report your results

[1] https://cora.in.tum.de/

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Advisor:
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Research project:
ConVeY

Type:
MA

Research area:
Formal Verification, Continuous/Hybrid Dynamics, Reachability Analysis

Programming language:
MATLAB

Required skills:
Good mathematical background, fundamental programming experience

Language:
English, German

Date of submission:
27. Juni 2025

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References

[1] Matthias Althoff. An introduction to cora 2015. In *ARCH@ CPSWeek*, pages 120–151, 2015.

[2] YQ Ni, W Lin, WH Chen, JM Ko, et al. Shm benchmark for high-rise structures: a reduced-order finite element model and field measurement data. *Smart Structures and Systems*, 10(4):411–426, 2012.

[3] Y Ohtori, RE Christenson, BF Spencer Jr, and SJ Dyke. Benchmark control problems for seismically excited nonlinear buildings. *Journal of engineering mechanics*, 130(4):366–385, 2004.

[4] Shohei Onitsuka, Tadashi Iijima, Tomonori Yamada, and Shinobu Yoshimura. Seismic analysis of nuclear power plants by using three-dimensional finite element models: a review. *Journal of Nuclear Science and Technology*, 56(1):1–16, 2019.

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