TECHNISCHE UNIVERSITÄT DRESDEN

AirMetro
Research Training Group
2947 at TU Dresden

T6: Robust Motion Trajectories

Development of Robust Motion trajectories under Consideration of Model and Data Uncertainty

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Motivation

The optimization of movement trajectories, taking into account polymorphic uncertainty, is the basis for:

— the optimization of energy consumption and time requirements,

— maintaining the high safety level of aviation.

The focus on robustness is essential due to the large variety of sources of uncertainty:

— natural variability of environmental conditions,
— uncertainty, incompleteness and inaccuracy of
  – sensor and geodata,
  – data from mobility surveys,
— available expert knowledge and
— microclimatic models.

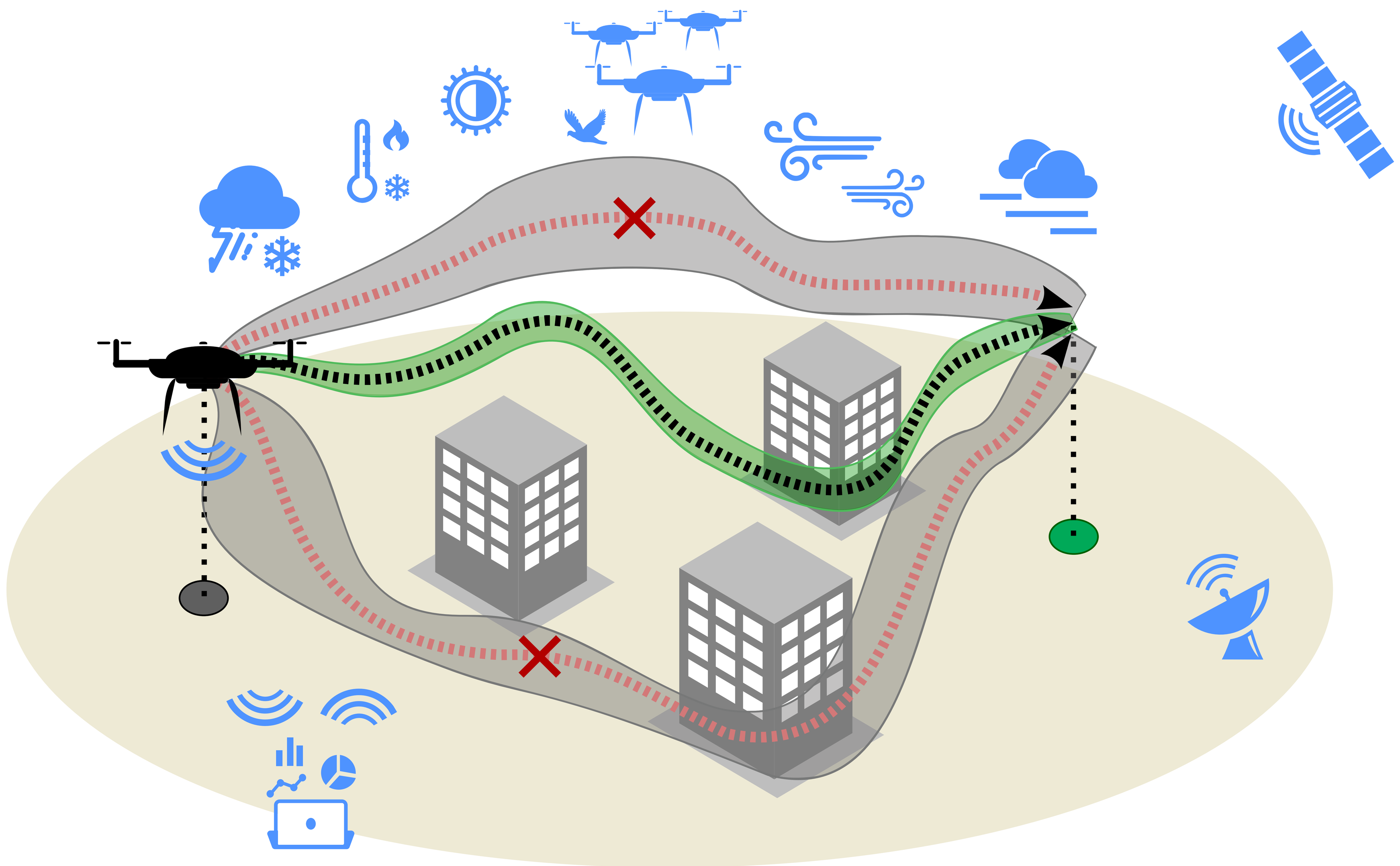

Figure 1: Optimization of trajectories by considering polymorphic uncertainty

Methods

The quantification of the uncertainty and the update of the movement trajectory in real time is carried out by:

— Application of Bayesian filters [1] to take into account time-varying aleatoric uncertain measurement data and simulation parameters (inherent, objective uncertainty),
— extension by additionally including epistemic fuzziness (e.g. measurement errors) and
— recursive quantification of polymorphically uncertain model parameters.

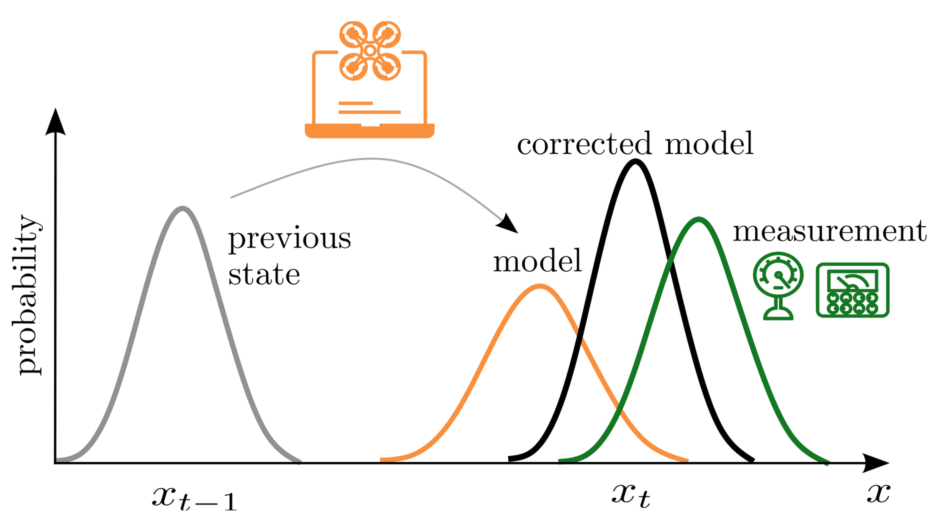

Figure 2: Scheme Bayesian filters

Results

Enabling the consideration of polymorphic fuzziness in combination with the use of extended Bayesian filters:

— Consideration of all available information,
— realistic uncertainty quantification of the simulation parameters [3], [4], [5],
— robustness evaluation [2] of the calculated trajectories and
— Adaptative adjustment of the trajectory in real time based on new data/measurements.

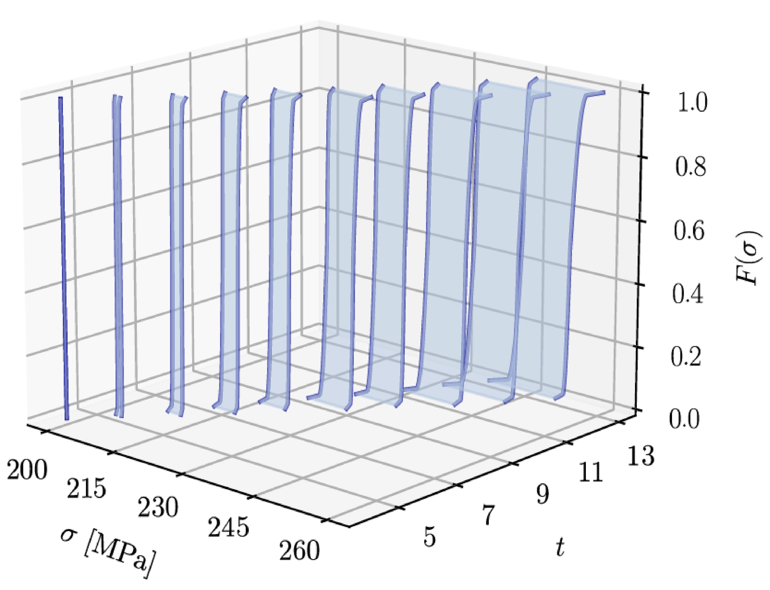

Figure 3: Time-dependent polymorphic fuzzy quantity, modelled by p-boxes [5]

Networking in the RTG

The following collaborations are planned for the determination and application of robust movement trajectories:

— Uncertainty quantification in the context of trajectory simulation (T10).

Required input variables are:

— Pre-processed position data from sensor and geodata (T5, T8),
— data from mobility surveys (T11) and
— predictions from microclimatic models (T7).

Literature:

[1] Banerjee, P.; Corbetta, M.: In-Time UAV Flight-Trajectory Estimation and Tracking Using Bayesian Filters. IEEE Aerospace Conference (2020), 1-9

[2] Schietzold, F. N.; Leichsenring, F.; Götz, M.; Graf, W.; Kaliske, M.: Robustness versus Performance-Nested Inherence of Objectives in Optimization with Polymorphic Uncertain Parameters. Advances in Engineering Software 156 (2021)

[3] Götz, M.; Graf, W.; Kaliske, M.: Enhanced uncertain structural analysis with time- and spatial-dependent (functional) fuzzy results. Mechanical Systems and Signal Processing 119 (2019), 23-38

[4] Zschocke, S.; Leichsenring, F.; Graf, W.; Kaliske, M.: A concept for data-driven computational mechanics in the presence of polymorphic uncertain properties. Engineering Structures 267 (2022), 114672

[5] Zschocke, S.; Graf, W.; Kaliske, M.: Polymorphic Uncertain Structural Analysis: Challenges in Data-Driven Inelasticity. Proceedings in Applied Mathematics & Mechanics 22 (2022), e202200023

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