# Quantitative Metrics for Execution-Based Evaluation of Human-Aware Global Motion Planning
## HRI-2020

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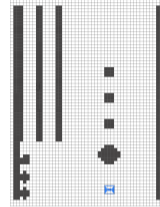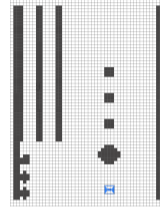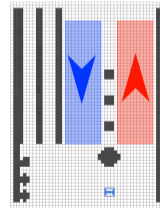
# Contents

# Motivation

Figure: Courtesy of SPENCER project

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Compliant motion

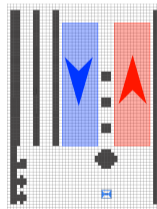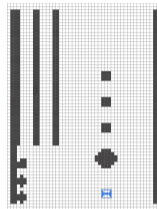Figure: Courtesy of SPENCER project

**Quantitative metrics** for **Execution-Based Evaluation** of **Human-aware Global Motion Planning**.

1. Human-aware $\rightarrow$ Maps of Dynamics (MoDs)
2. Global Motion Planning
3. Execution-based Evaluation
4. Quantitative metrics

# Related Work - Maps of Dynamics

# Maps of Dynamics (MoDs)

Quantitative metrics for Execution-Based Evaluation of <u>Human-aware</u> Global Motion Planning.

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- ▶ They are **spatially grounded**.

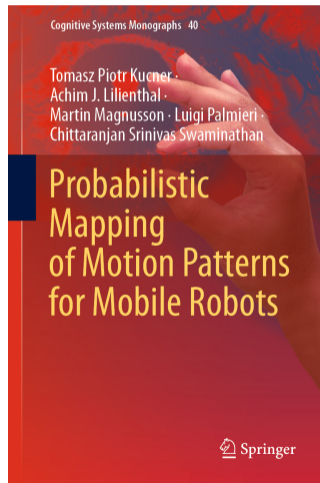# Maps of Dynamics (MoDs)

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- ▶ They are **spatially grounded**.
- ▶ Based on the representation, they may model velocities, paths or cell-transitions.
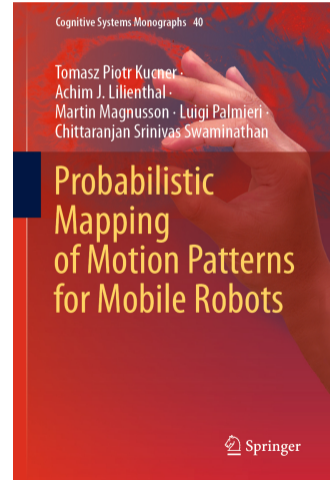
# MoD Example - Trajectory Mapping

Example: **Gaussian Mixture Model**[1]
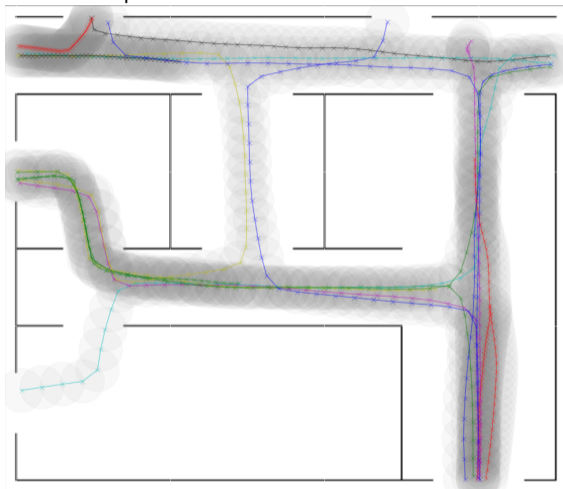


[1] Maren Bennewitz et al. "Learning Motion Patterns of People for Compliant Robot Motion". In: The International Journal of Robotics Research 24.1 (2005), pp. 31–48.

Example: **Circular-Linear Flow Fields (CLiFF-map)**[2]
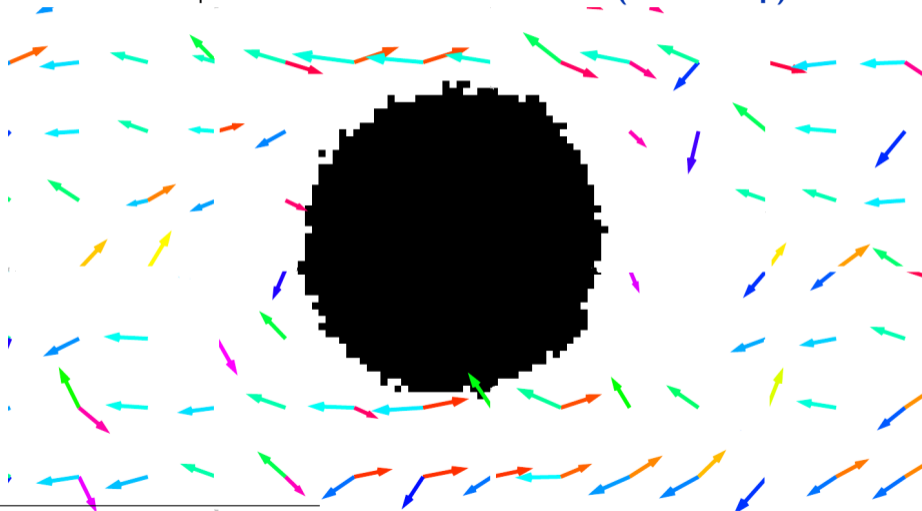


[2]Tomasz Piotr Kucner et al. "Enabling Flow Awareness for Mobile Robots in Partially Observable Environments". In: IEEE Robotics and Automation Letters 2.2 (2017), pp. 1093–1100.

# MoD Example - Spatial configuration changes

Example: **Spatio-temporal Flow Map (STeF-map)**[3]



11:00 h

[3]Sergi Molina et al. "Modelling and predicting rhythmic flow patterns in dynamic environments". In: Annual Conference Towards Autonomous Robotic Systems. Springer. 2018, pp. 135–146.

# MoD Example - Spatial configuration changes

Example: **Spatio-temporal Flow Map (STeF-map)**[4]



15:00 h

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# MoD Example - Spatial configuration changes

Example: **Spatio-temporal Flow Map (STeF-map)**[5]



19:00 h

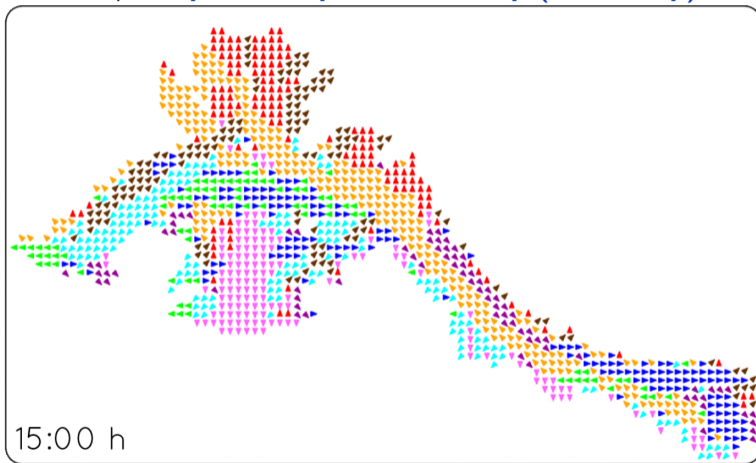[5]Sergi Molina et al. "Modelling and predicting rhythmic flow patterns in dynamic environments". In: Annual Conference Towards Autonomous Robotic Systems. Springer. 2018, pp. 135–146.

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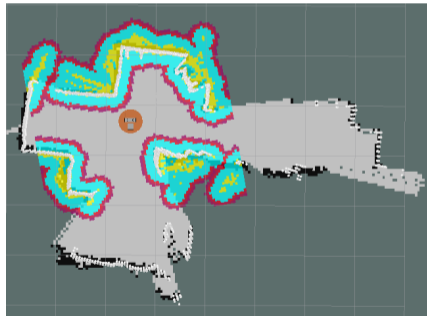
# Global motion planning

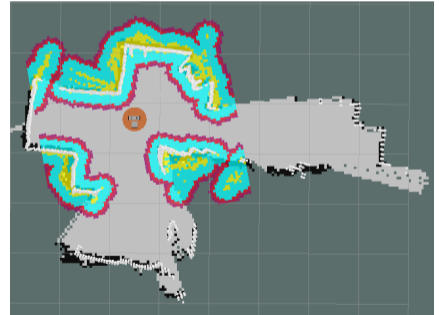Quantitative metrics for Execution-Based Evaluation of Human-aware Global Motion Planning.

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▶ Add additional cost component due to MoDs to motion planner.

# Down-The-CLiFF[6]



Compliant motion
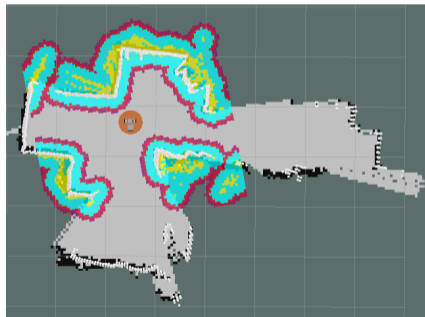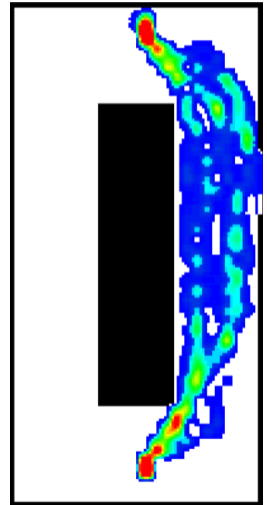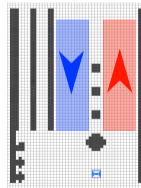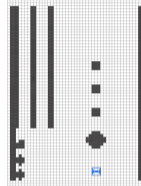
[6] Chittaranjan S Swaminathan et al. "Down The CLiFF: Flow-aware Trajectory Planning under Motion Pattern Uncertainty". In: IEEE International Conference on Intelligent Robotics (IROS), 2018. IEEE. 2018, pp. 6176–6181.

# MoDs and Motion Planning - Research Gap

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    - Many works that evaluate human-aware planning assume that the robot can track all humans in the entire environment.
- We still need to identify the relative advantages of different MoDs w.r.t motion planning.
- **This also means we need to have quantitative metrics for assessing the differences.**

# Our contribution

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- ▶ Framework based on multi-robot coordination → to replay recorded pedestrian trajectories while the robot executes its plan.

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  - ▶ Interaction → when a robot is front of a person or vice versa.

# How does it look?

Video

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