

Autonomy Protocols: From Human Behavioral Modeling to Correct-by-Construction, Scalable Control

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Behçet Açıkmeşe, Mary Hayhoe,
Dana Ballard, Ufuk Topçu

UNIVERSITY of
WASHINGTON

Project Objective:

Develop scalable, automated methods for the synthesis of autonomy control protocols with provable correctness guarantees, incorporating insights from models of human behavior.

Novel empirical and mathematical insights on how humans manage complexity

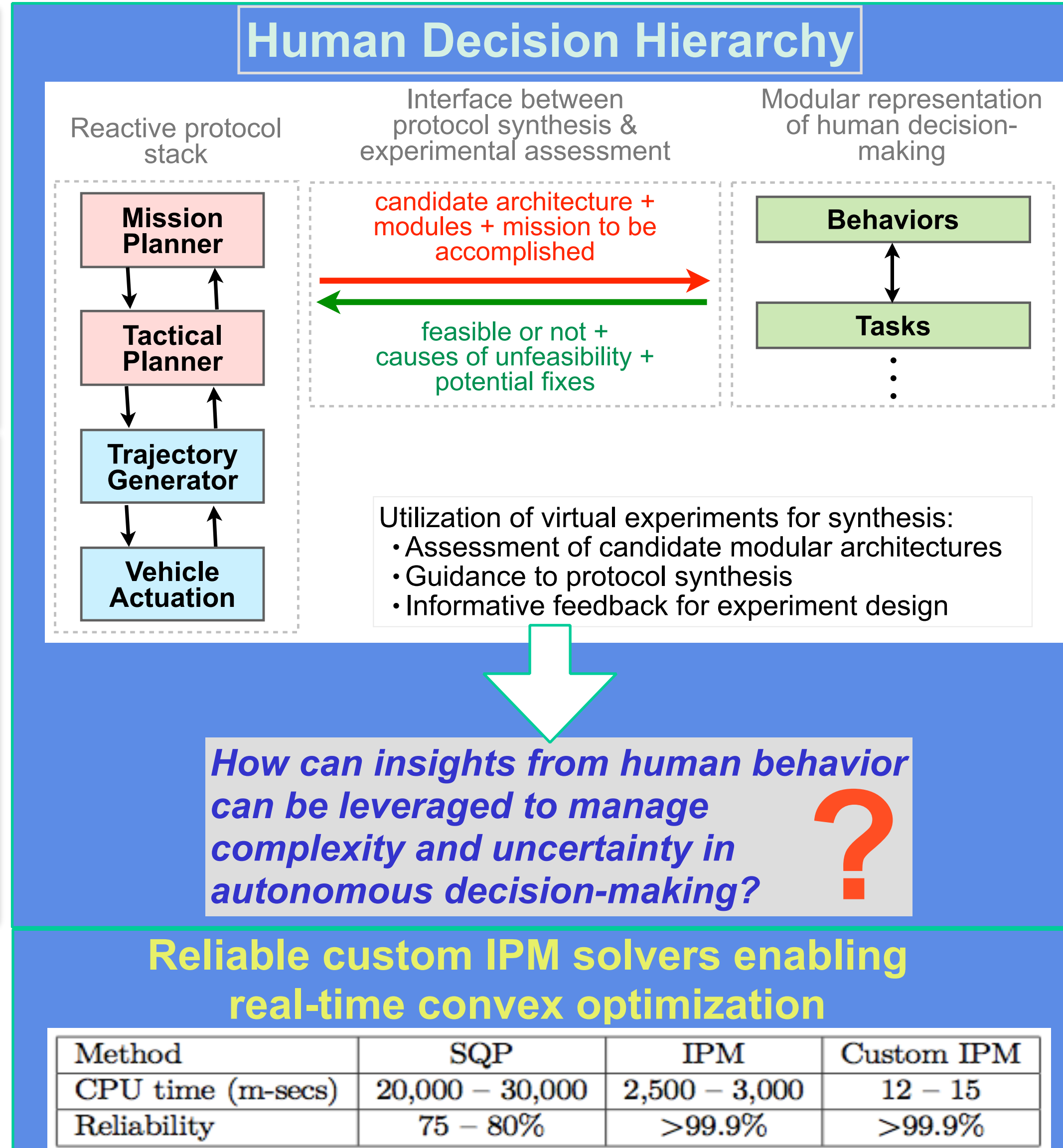
- guide architectural exploration for effective hierarchical decompositions
 - couple control and sensing/perception
- Decision-making hierarchies identified as "promising" by developing correct-by-synthesis protocols from
- formal temporal logic specifications for verifiability
 - customized real-time solution algorithms for constrained Optimal Control Problems (OCPs)

Key Observations:

- Human decision-making is observed to have a modular hierarchical decomposition
- Modular Inverse Reinforcement Learning (RL) provides a systematic way to model human behavior
- Temporal Logic (TL) based mission/tactical planning systematically ensures "correctness" of autonomy
- Real-time optimization based motion control can implement mission plans in the physical domain
- Online abstractions of constrained motion control via reachability sets provide inter-layer consistency

Merging these capabilities under a single synthesis framework can enable a leap in autonomy by

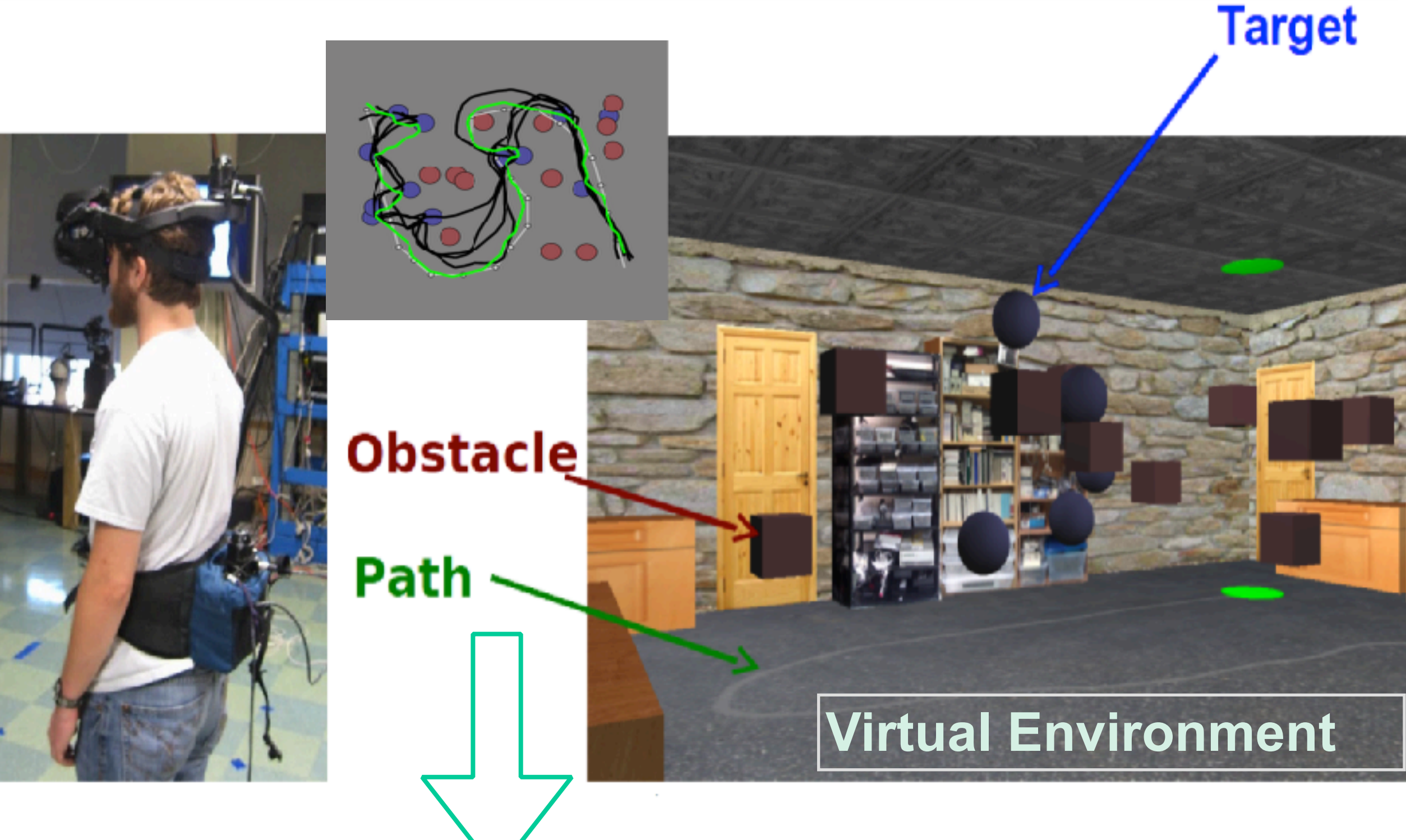
- Significantly increasing the fidelity of models used in decision-making
- Reducing the conservatism of the autonomy protocols without sacrificing tractability and correctness



Thrust-I: Modeling of human sensory-motor decisions and empirical assessment of the candidate decision-making architectures

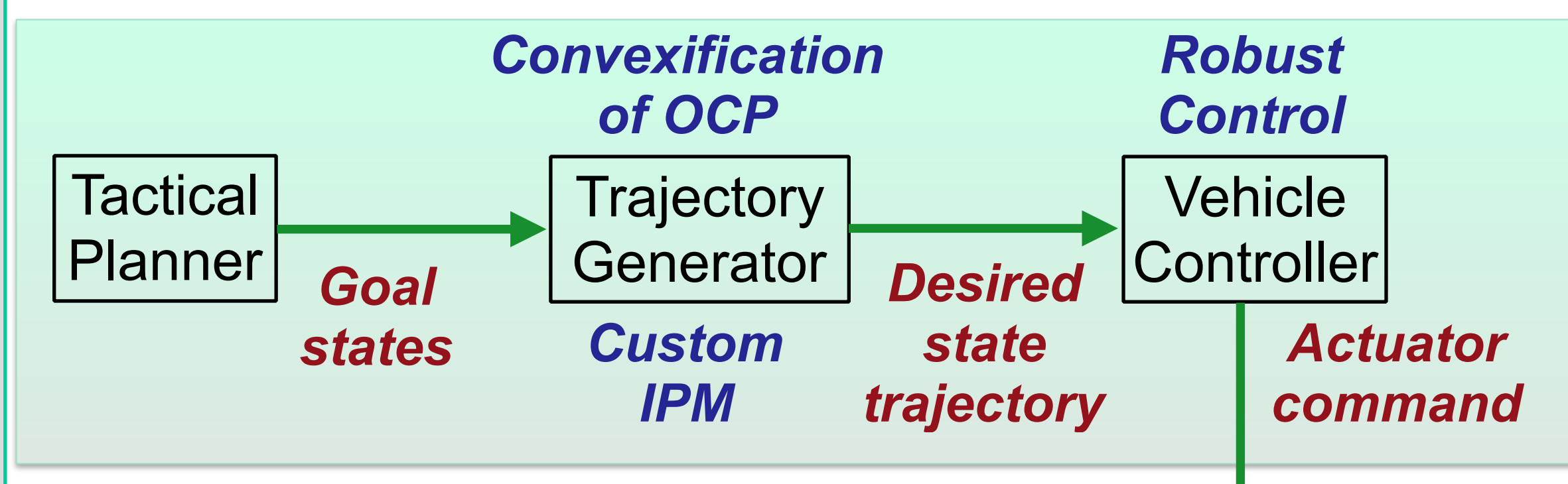
- How do humans decompose decision-making?
- How do we represent this decomposition?

Modular decomposition to subtasks requiring specific information



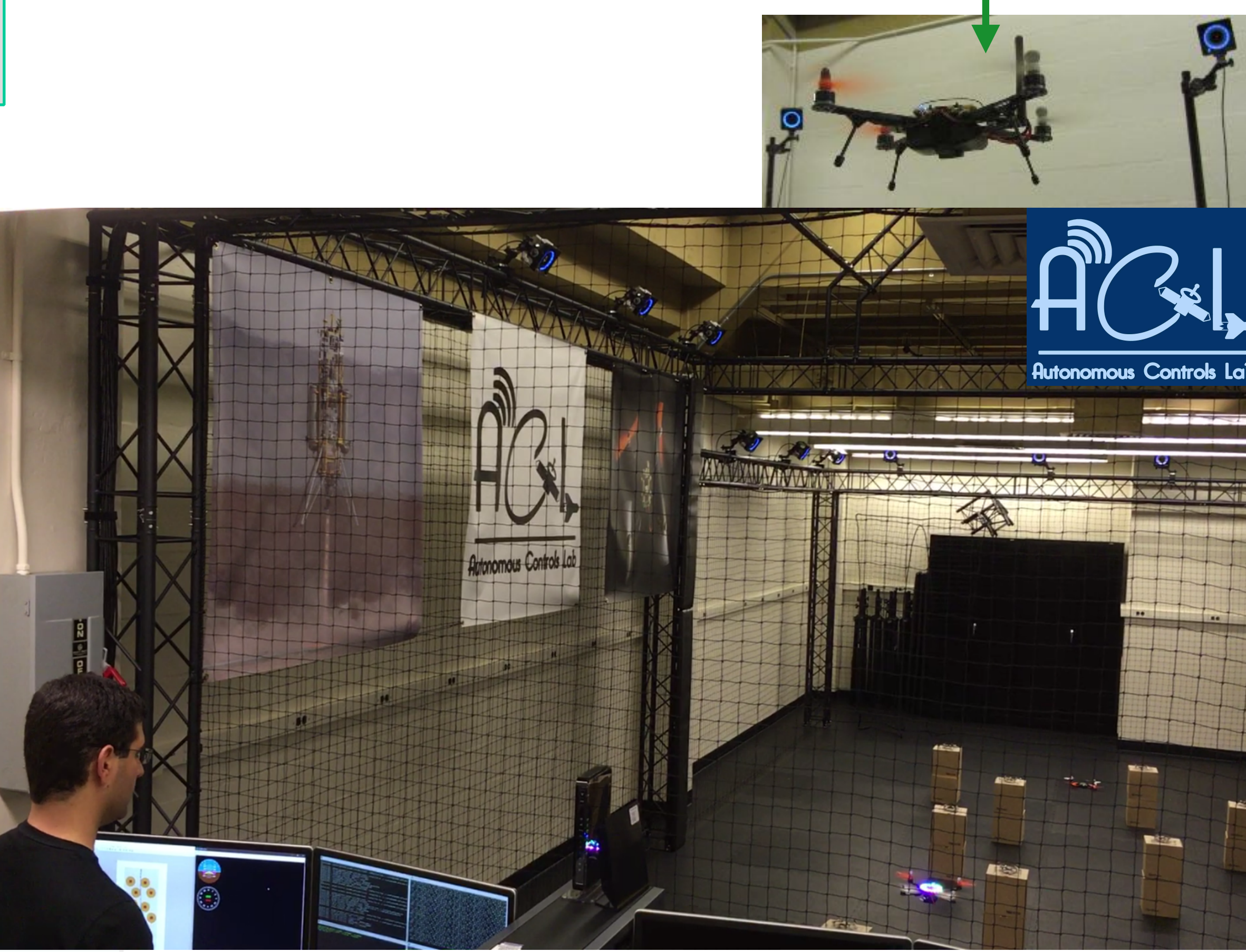
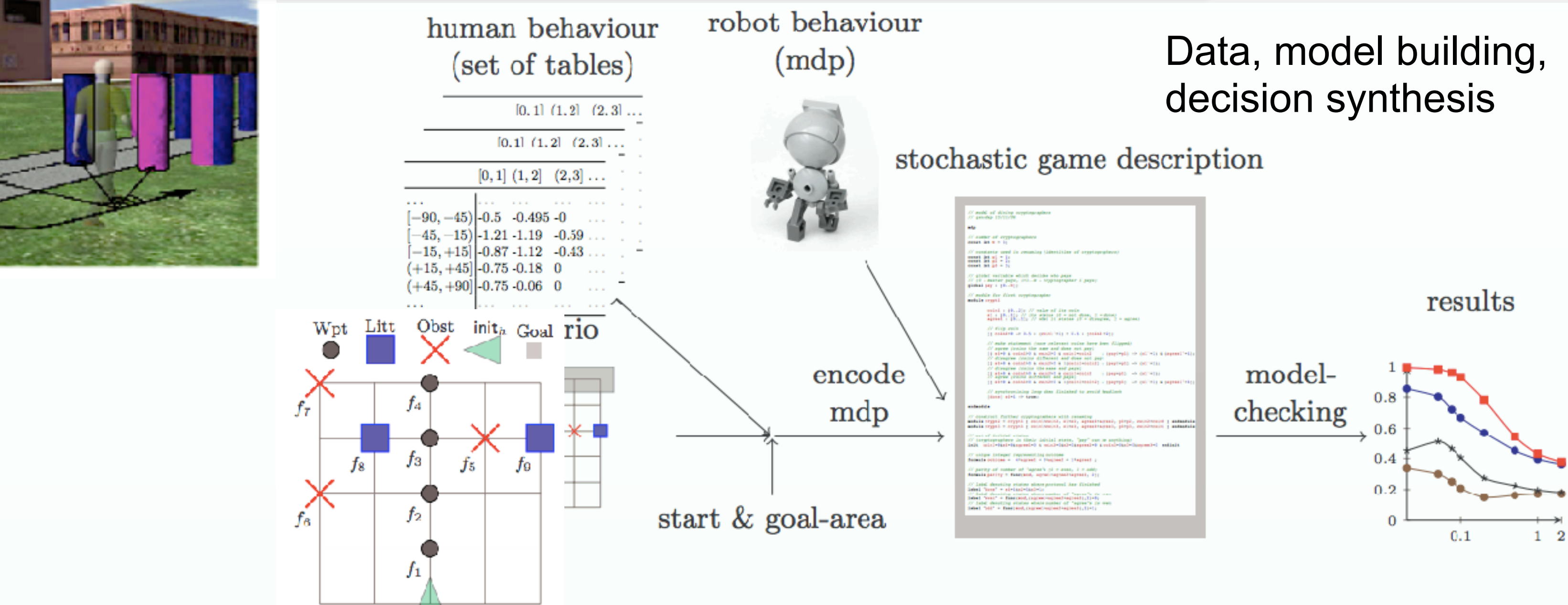
Thrust-III: Reliable run-time computational engines for motion planning and abstraction

- How can we incorporate uncertainty and constraints?
- How can this process be abstracted?
- How can the computations be done in real-time?



Thrust-II: Integrating architectural insights into decision-making

- How can synthesis problems be generated?
 - Models and constraints
 - Specifications and information flow
- How can we ensure inter-layer consistency?



Broader Impact

- Autonomy is a capability with stand-alone applications such as UAVs
 - Also embedded into numerous other instantiations of cyber-physical system
- We target:
- the gap between current autonomy capabilities and the levels at which they can impact our use of resources
 - the lack of systematic design methodologies toward highly capable and scalable autonomy protocols

