Challenges in Achieving Long-term Autonomy

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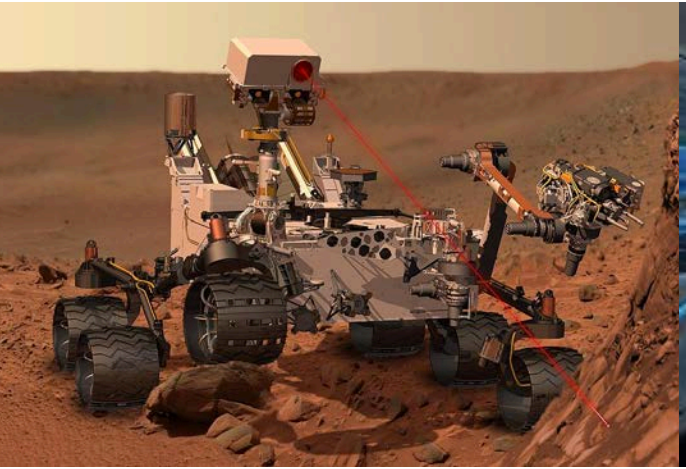
Instead of …

- Autonomy is NOT about doing the same thing over and over without human assistance.

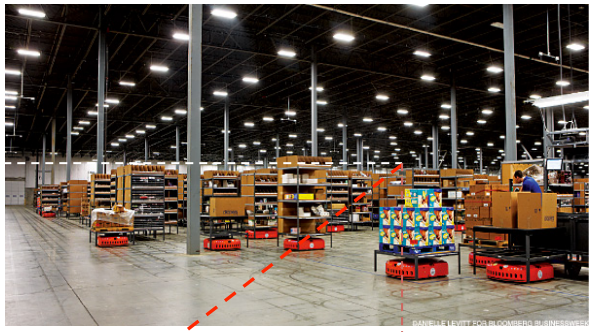
What we mean by long-term autonomy?

- The key difference is that autonomous systems need to work in “Open” real world that is highly uncertain and dynamic – need perception, reasoning, and adaptation.
- Long-term means that the operation time is much longer than the validity of a priori assumptions/information



Uncertain Dynamic environment

Uncertainty



IBM Watson

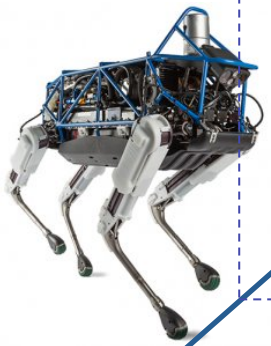
AlphaGo

Static/known environment

Small searching space → Large searching space

Single system → Multiple components → Distributed design

Scalability



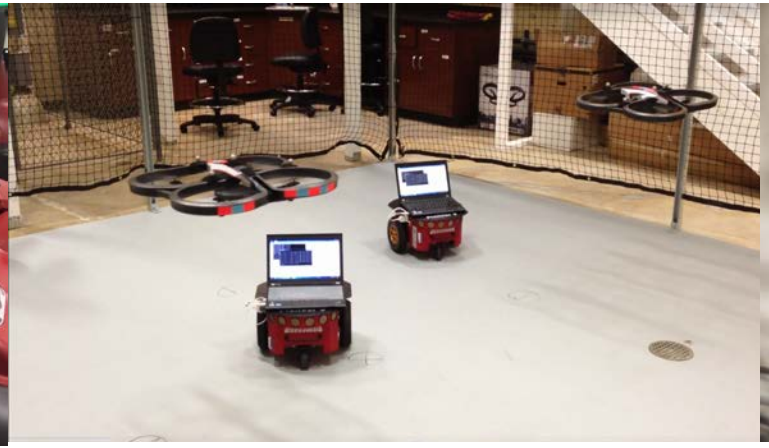
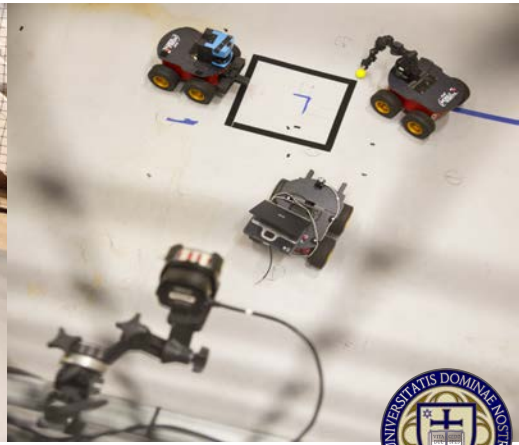
Simple dynamics
Simple task

High-dimensional dynamics
Complex missions

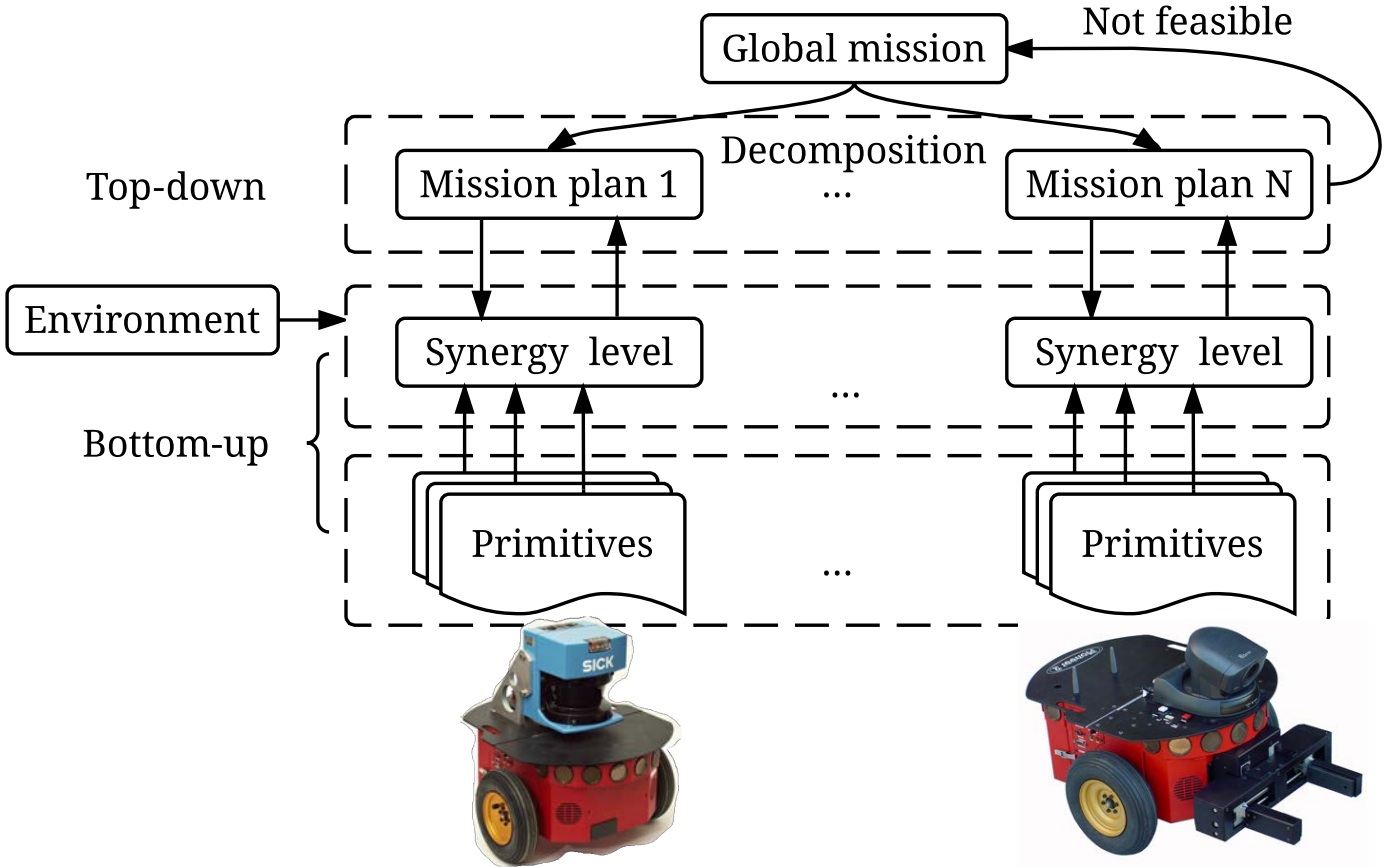
Complexity

DISCOVER Lab at Notre Dame

- In Discover Lab (Distributed Cooperative Systems Research Lab) at Notre Dame, we are using **multi-robot systems** and **human-machine collaboration** as working examples to study the design principles for engineered complex systems.
- We ask how to design intelligent physical systems with **provably correct performance** even in **uncertain, dynamic environments**.

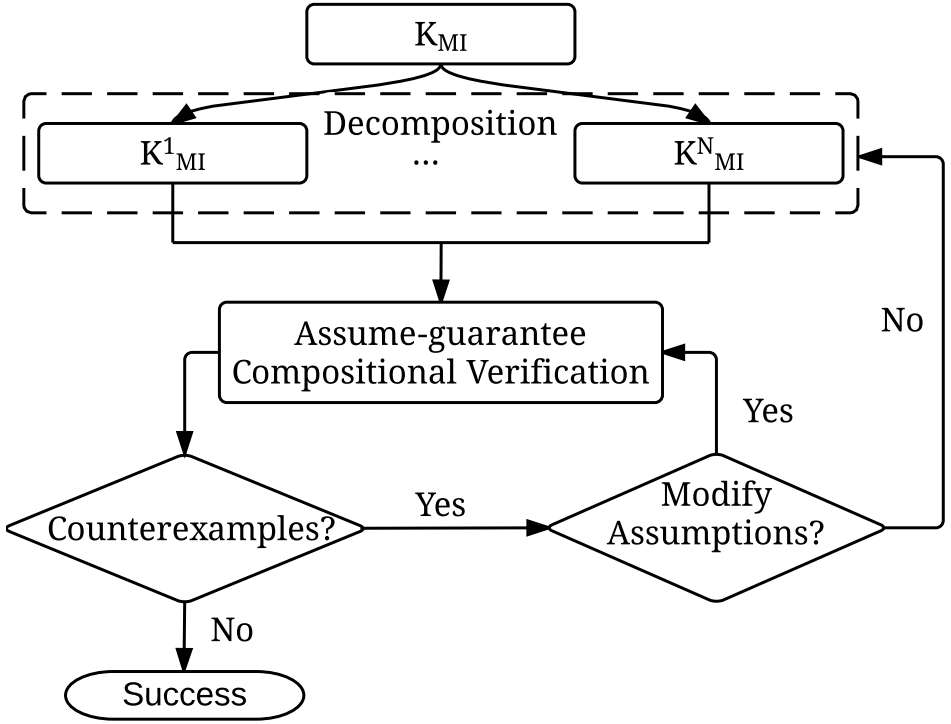




Combine top-down and bottom-up design



Top-down Task Decomposition

- Given team mission as formal specifications
- Need to decompose the global mission into individual robot tasks.
- Automatic reconfigure if the situation changes



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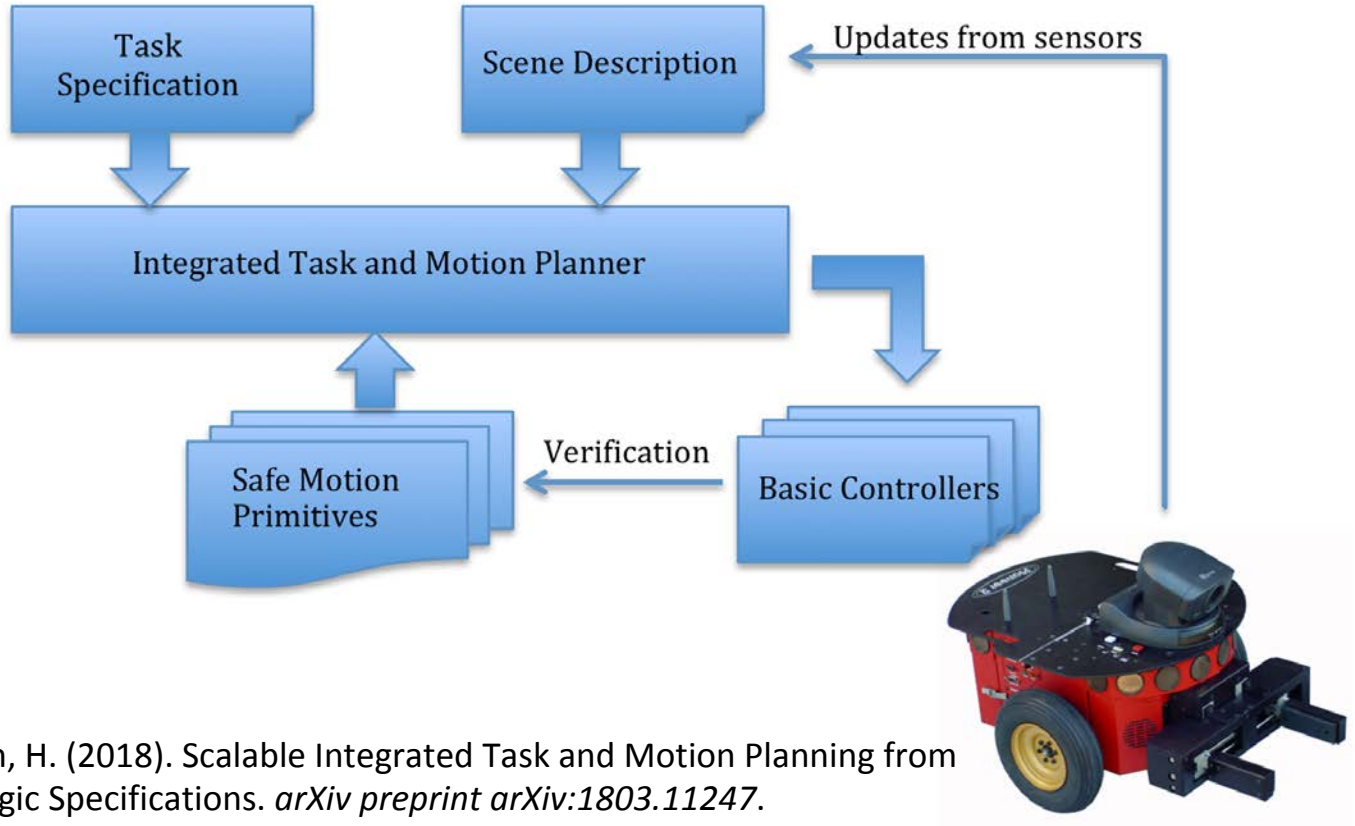
Integrated Task and Motion planning



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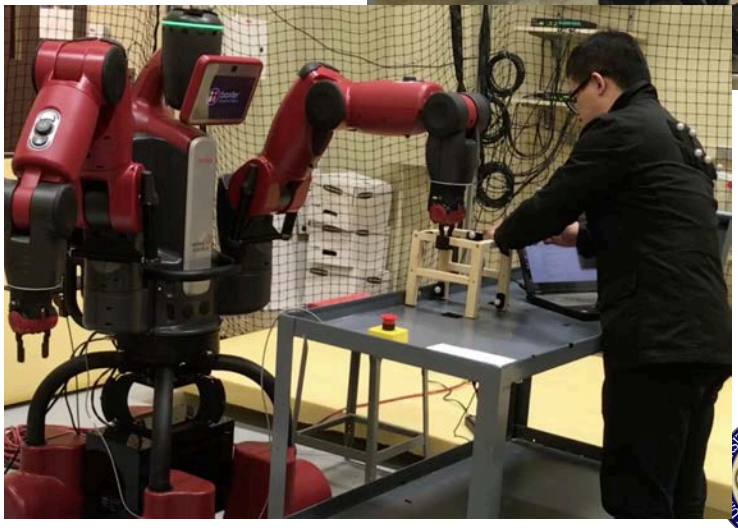
Human-machine collaboration

Distinct from the majority of existing work, which focused on human-machine interface, or human-aware motion planning, we are interested in

- ❑ **Mission planning:** Human-machine collaboration to achieve high-level missions in a provably correct manner
- ❑ **Integrated task and motion planning:** joint manipulation



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Post-modern control era

Uncertainty: Not just disturbances or noises, Uncertainties are everywhere due to unanticipated and dynamically changing real-world situations

Complexity: Complex missions that may not be captured by optimization, stability or regulation problems

Scalability: Beyond single-loop feedback control