Leveraging Quadrupedal Robots in Heterogeneous Multi-Robot Teaming with Run-Time Disturbances

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Motivation

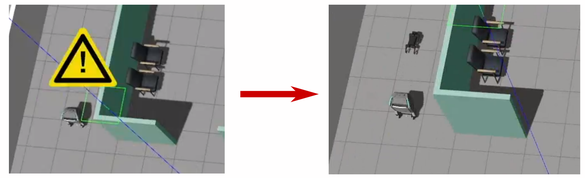
1. We leverage linear temporal logic (LTL) to synthesis tasks that can be specified by human understandable language and incorporate temporal constraints. The correct-by-construction nature guarantees that the task will be achieved when the plan is executed accordingly.

2. The LTL specification can be applied to the entire multi-agent system. Existing approaches allocate the overall task to each robot. However, during real execution, run-time disturbance is hard to avoid. This work aims to address run-time disturbance in both local and global levels.

Results

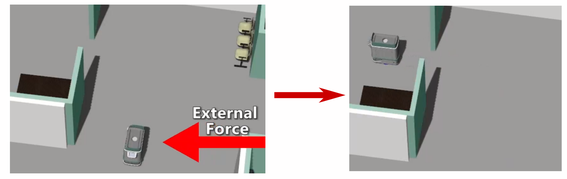
We explicitly consider our types of disturbances:
1. Loss of balance
2. Critical failure
3. Unexpected state change
4. Environmental change
   (any changes that can be mapped to the transition system change)

Example 1: global reallocation due to critical failure



robot malfunction — A1 takes over the task

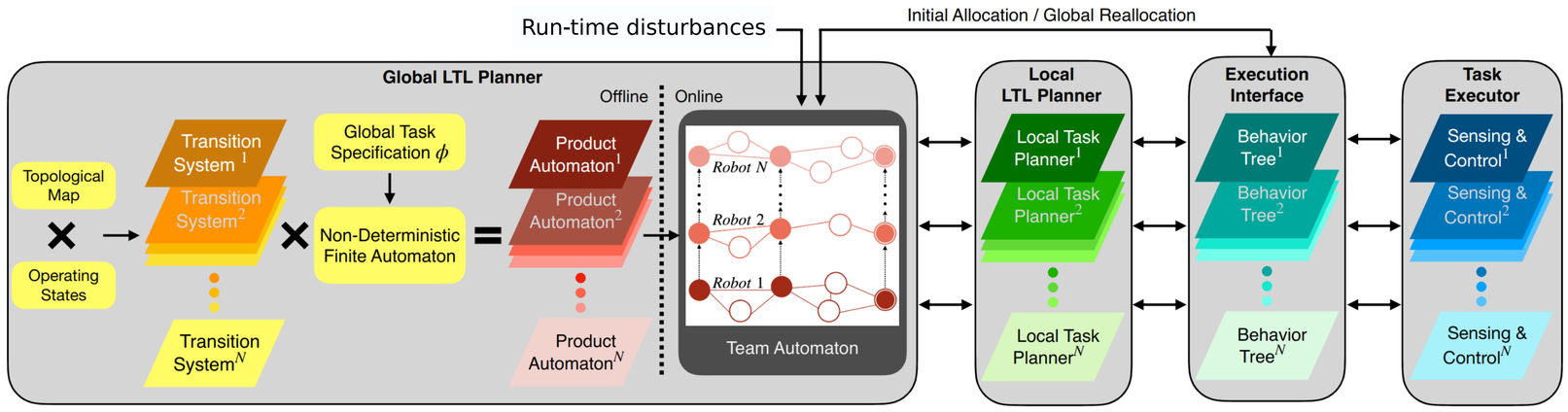
Example 2: local reallocation due to state change



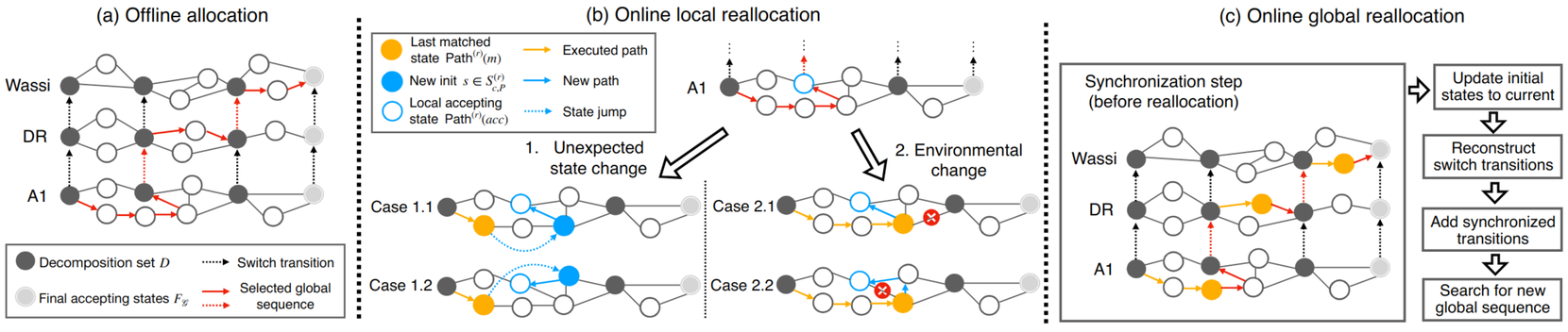
object fallen — go fetch a new one

Method

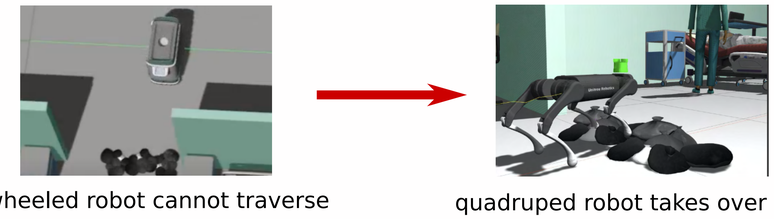
The overall framework is shown as below. It consists of global LTL planner, local LTL planner, execution interface, and lower-level sensing and control. We generate a topological map beforehand and combine it with the operating states for each robot to get the transition system.



The online reallocation is divided into local reallocation (b) and global reallocation (c), where the global one only gets triggered when the local one fails. We consider two fundamental types of disturbances -- unexpected state change, and transition system change.

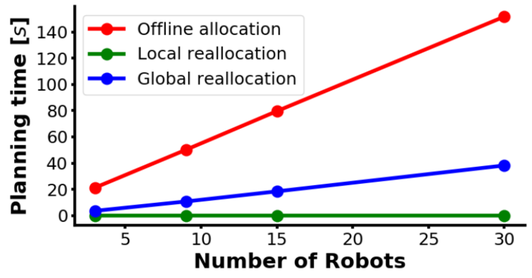


Example 3: global reallocation due to environment change



wheeled robot cannot traverse — quadruped robot takes over

Scalability analysis



Conclusion and Future Works

In this work, we present a heterogeneous, multi-robot task allocation and planningframework equipped with a hierarchically reactive mechanism from extensive disturbances.

Future works include more complicated scenarios such as unstructured terrain to further leverage the capabilities of legged robot. A another layer of LTL planner will be devised to make decisions on the motion primitives selection such as jumping or waliking.