Temporal Logic Imitation: Learning Plan-Satisficing Motion Policies from Demonstrations

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Interactive ROBOTICS

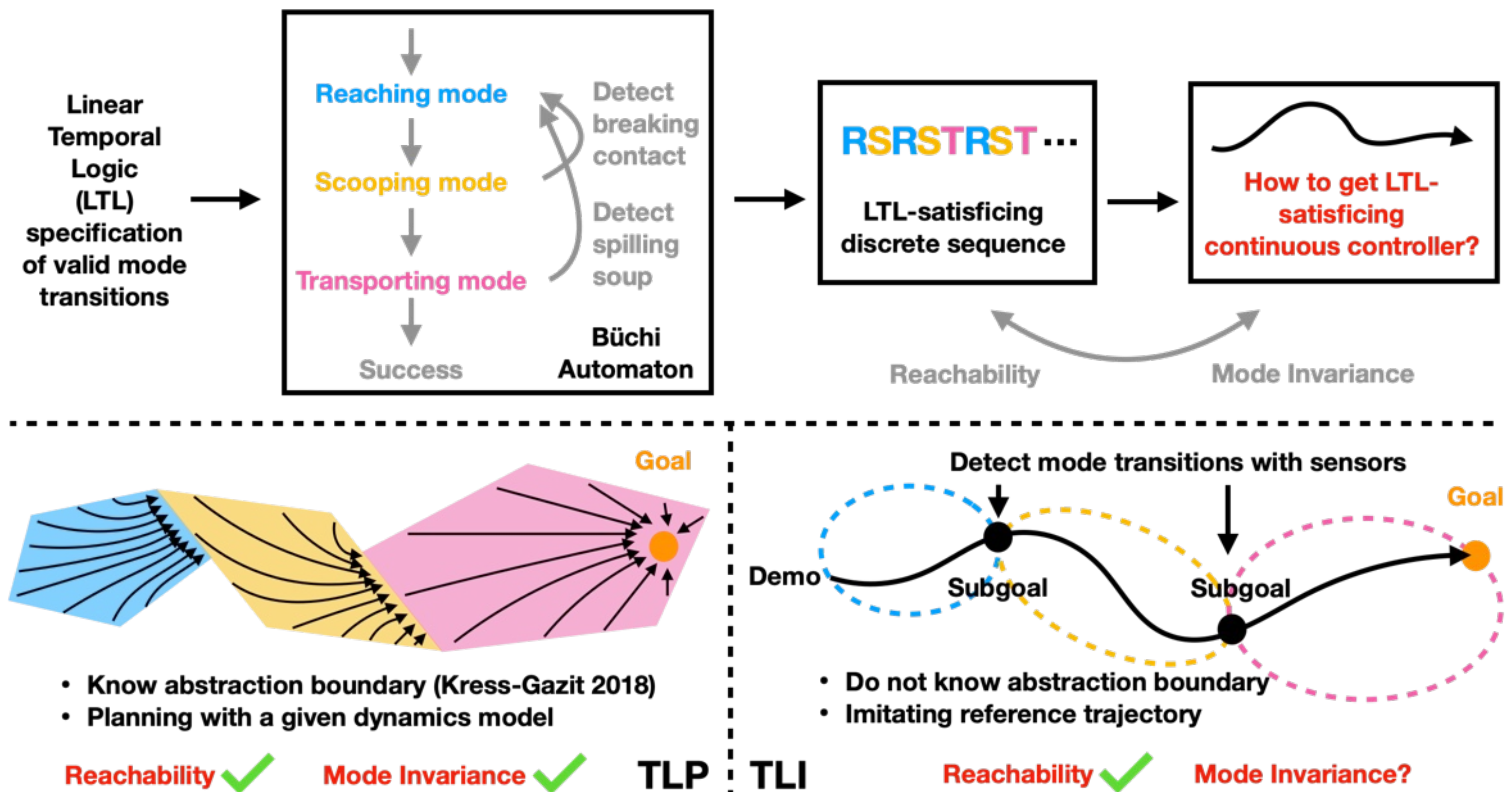## What makes imitation learning hard?   - Human-in-the-loop perturbations!

Successful Task Replay

Original plan — Perturbation — Recovery (a)

Invariance failure (c)

No invariance failure after modulation (d)

DS
Demo
BC

Reaching the goal by DS' global stability (Khansari-Zadeh 2011)

Goal

Not reaching the goal due to covariate shift (Ross 2011)

Imitate a motion

DS
Demo
Subgoal DS

Invalid mode transition

Subgoal

Subgoal

Goal

Reaching mode   Scooping mode   Transporting mode
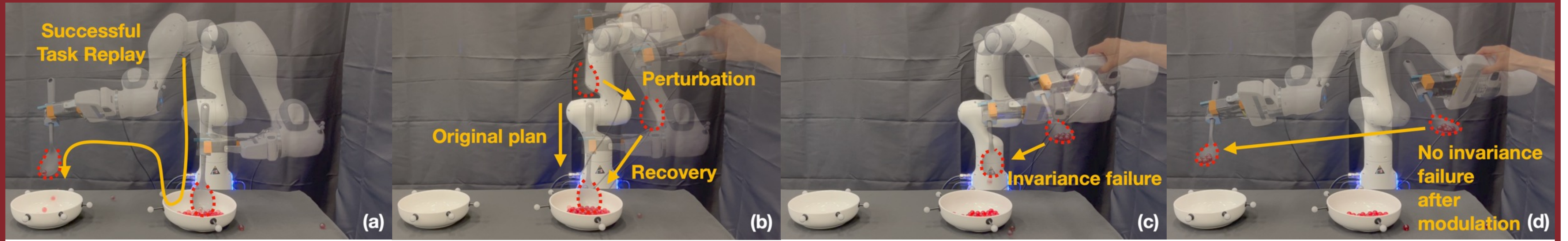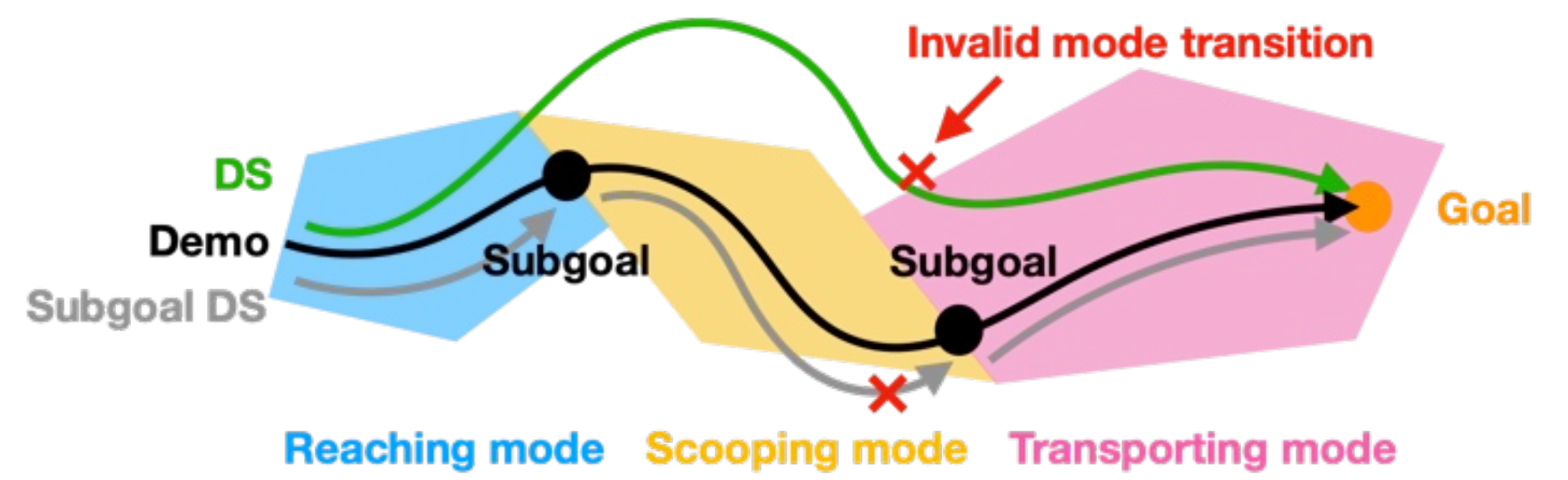
Imitate a mode sequence

Temporal logic planning vs Temporal logic imitation

Linear Temporal Logic (LTL) specification of valid mode transitions

Reaching mode
Scooping mode
Transporting mode
Success

Detect breaking contact
Detect spilling soup

Büchi Automaton

RSRSTRST ...

LTL-satisficing discrete sequence

How to get LTL-satisficing continuous controller?

Reachability   Mode Invariance

Goal

- Know abstraction boundary (Kress-Gazit 2018)
- Planning with a given dynamics model

Reachability ✓   Mode Invariance ✓   **TLP**

TLI

Detect mode transitions with sensors

Goal

Demo
Subgoal   Subgoal

- Do not know abstraction boundary
- Imitating reference trajectory

Reachability ✓   Mode Invariance?

How to ensure reachability and mode invariance of mode-based motion policies?

BC

DS

Original Policy   0 Noise   Small Noise   Large Noise   1-Cut Modulation   2-Cut Modulation

These mode exits are unforced, and are due to a lack of invariance