PENNSTATE ARL

Autonomous Mission Management for Simulated UUVs

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Outline

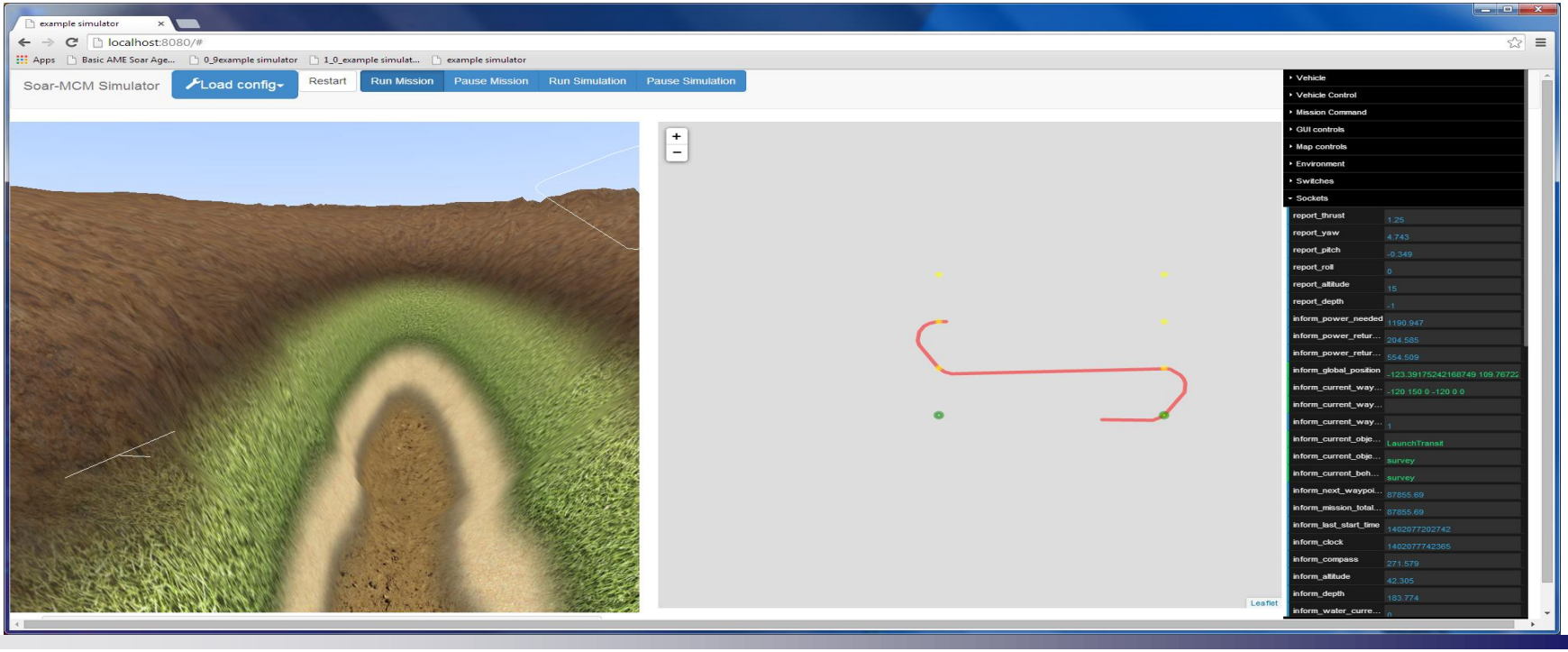
- Mine Counter Measures (MCM)
- Simulation
- Soar agent description
- Example scenario
- Future areas
- Conclusion

UUVs for MCM applications

- MCM: find and remove mines from water
- UUVs are used to automate parts of mission
  - usually follow series of waypoints to record sonar data
- Interest in autonomously altering missions based on gathered sensor data
  - when does mission need to be altered
  - how to recover from errors
  - conflicting information
- Goal of our project: to explore use of cognitive architecture for management of established autonomy capabilities

JavaScript-based simulator

- Physics-based motion models (vehicle controllers, currents)
- Ability to specify sea-floor topography
- Power usage models for sensors, motors
- Interactions via ZeroMQ messages



Description of Soar agent

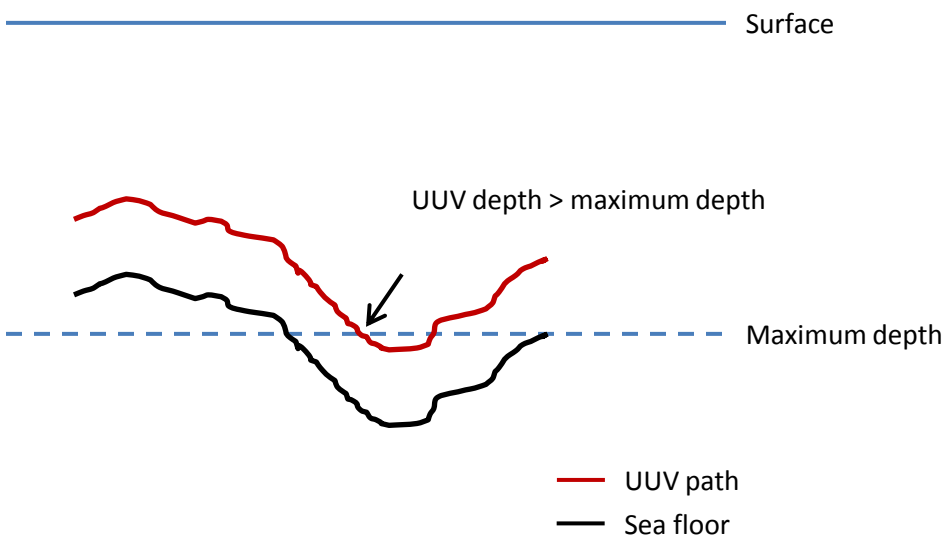
- Monitors execution of simulated MCM missions
  - missions consist of profiles (transit, survey, spiral, etc.)
  - profiles performed by behaviors that use low-level controllers to complete profile by reaching waypoints
- Manages safety constraints UUV behaviors may not consider
  - minimum altitude, minimum depth, maximum depth
  - uses available actions to attempt to resolve fault and then return to desired behavior
    - set depth/altitude control, surface, scuttle, abandon waypoint(s)
    - monitors effectiveness of actions in resolving fault
- Manages lack of progress to waypoint
  - detects circling, repeated attempts, distance not decreasing

Agent implementation details

- Complex operators used to detect and manage undesired events
  - starting to deal with simultaneous events
- Accessing old sensor data
  - use operators to maintain recent sensor data in WM to monitor trends and help recognize faults
  - query episodic memory when unexpected conditions necessitate that older information be considered

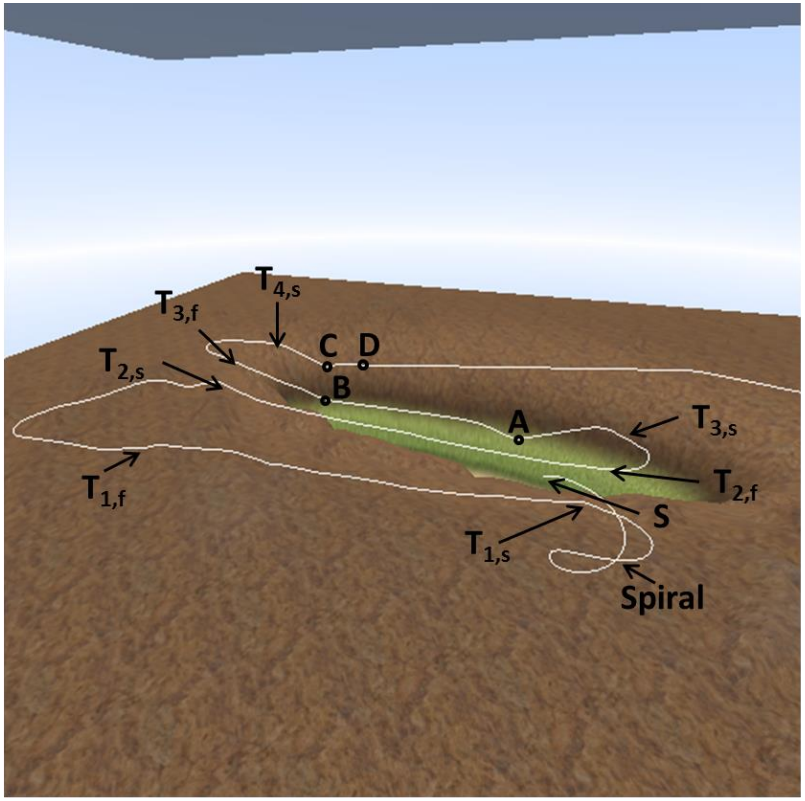
UUV reaches maximum depth

- Possible causes:
  - behavior or mission planner does not take limit into account
  - loss of control authority
- The Soar agent
  - attempts to prevent UUV from violating depth constraint
  - returns behavior to desired state when possible without violating depth constraint



UUV reaching maximum depth

- UUV performing survey profile over a trench
  - A: While altitude following, UUV reaches its max depth limit
  - B: Water column permits altitude following while observing max depth limit
  - C: While altitude following, UUV reaches its max depth limit
  - D: altitude becomes so high that track is abandoned



S: the location the UUV started the mission
Spiral: mission profile used to reach specified altitude
$T_{i,s}$ and $T_{i,f}$: the start (s) and finish (f) locations of Track i

Potential next steps

- Detecting impeded progress
  - currents
  - conditions that can't be observed directly from inputs (nets)
- Energy monitoring
- Simulation of more representative sensors (lose bottom lock, need GPS fix)
- Mission specific depth/altitude limits in addition to safety limits
- Profile priorities (time, relative importance) to inform mission replanning

Summary

- Nuggets
  - Soar capabilities seem good fit for MCM autonomy needs
    - many areas to consider
  - Collaboration with SMEs at NSWC-PCD
- Coal
  - Idealized sensors

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