An Interface for Communicating Branching Plans for Human-Agent Decision Making

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Abstract

Recent advances in visualisation technologies have opened up new possibilities for human-agent communication. In particular, visualisation of agent planned actions can play an important role in allowing human users to understand agent intentions and to help decide when control can be delegated or when human decision making is required. This is especially true for application domains where branched plans are required due to the typical uncertainty experienced. We have developed an interface which uses 3D visualisation to communicate key details of such plans to practitioners. The system has been used in experiments to evaluate the impact of presentation mode on practitioner understanding. Link to system video: https://youtu.be/xhkqNbAa4Bs. Link to Unity WebGL: https://tinyurl.com/icaps21demo

Introduction

The focus of this work is agent-human communication and the use of visualisation to support clear communication of agent intentions and reasoning to human practitioners. In systems requiring joint human and AI agent decision making there is a need for human users to understand the intentions of agents, along with the agent rationale for different decisions. This requires the AI agent to be able to explain its reasoning to the human, something which remains a significant challenge (Fox, Long, and Magazzeni 2017; Miller 2019). nnkThis is reflected in initiatives like DARPA's Explainable AI Program (Gunning and Aha 2019) and events such as (EXTRAAMAS 2020) and (XAIP 2020).

For those application domains where AI agents use automated planning to control behaviour, the challenge is how to clearly communicate to the human the intentions of the agent which are encapsulated in its generated plans. It has been shown that 3D visualisation and plan simulation can help human user understanding of agent intent (Chakraborti et al. 2018; Zolotas and Demiris 2019). However, generating understandable visualisations is challenging because a plan sequence already implicitly encapsulates the balance made between dependency, constraint and choice, as well as the implied implementation of the plan steps themselves.

The focus of our work is exploration of the use of visualisation technologies in application domains where branched plans are required due to the typical uncertainty experienced. In such settings a visual interface allows practitioners to explore different possible branches prior to execution in order to understand potential variation and implications. We have developed a system that: generates complete branched plans; automatically identifies a diverse subset of the branches that characterise the space of alternatives; and provide a visual interface to assist practitioner exploration of alternatives (Porteous, Lindsay, and Charles 2021).

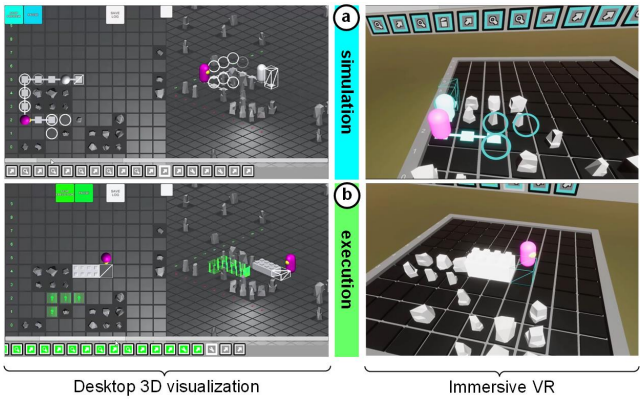

Figure 1: Graphical User Interface for communicating agent plans in a virtual construction world: Desktop version (LHS); Immersive VR version (RHS); simulation (a) and execution (b) modes are differentiated visually (see text).

The prototype system is set in a virtual construction domain which captures some of the typical uncertainty which is a feature of such domains. The environment captures various typical aspects of construction, including preparation, movement of robots and materials and the actual construction. Scenarios feature uncertainty in both the required preparation of the ground to permit construction and movement, and in the integrity of building materials. The model includes actions for movement, block-placing and sensing actions for identifying debris, such as rubble and rocks, in the environment.

Interface System Overview

For our virtual construction domain, we have developed a graphical user interface for presenting 3D visualisations of

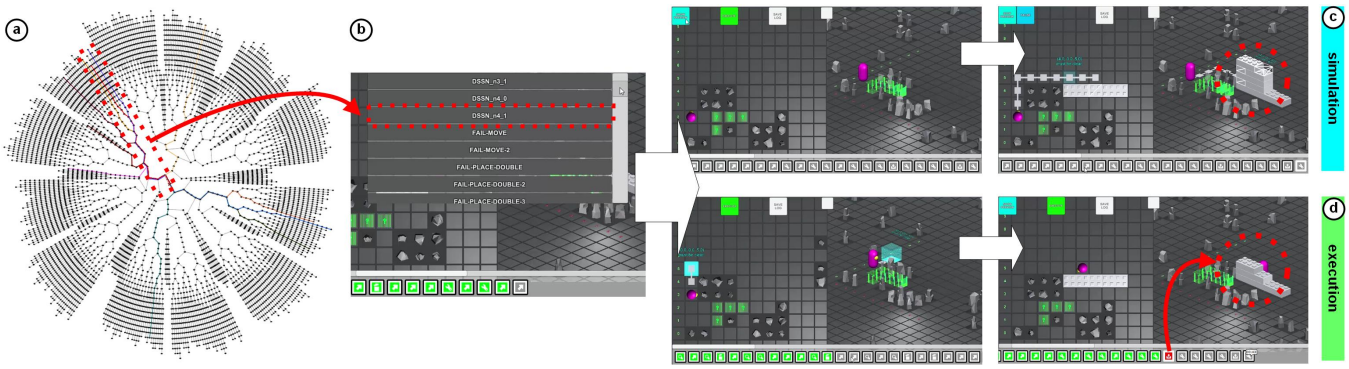

Figure 2: Example User Interaction. Complete branched plan is generated, characterising branches identified and visualised using a radial graph layout (a); user selects which branch to explore (b); user selects visualisation either in Simulation mode (c) or Execution mode (d). The figure shows Simulation mode, where user observes simulation of one branched plan trace (c) and Execution mode, where user observes agent navigate around rocks into a position to start construction (d).

agent plans to practitioners and for use as an experimental testbed. An example is shown in Figure1. The interface provides for visualisation of planned agent behaviours, in *simulation*, i.e. prior to execution, and actual *execution* (parts (a) and (b) of Figure1 respectively). The interface is implemented using the Unity3D game engine[1] and includes desktop and immersive VR versions (shown on the left and right hand sides of Figure1 respectively).

The desktop interface provides a side-by-side synchronous view of the current action being visualised: a top-down view of the agent acting in the world (left-hand side), and a 3D isometric view (right-hand side). The interface has an icon-based representation of the sequence of actions in the execution trace (along the bottom in the desktop version and at the top of the line of sight in the VR version).

User Interaction

For the demonstration the desktop version of the system will be made available. Users will be able to explore various branched plan scenarios within our construction domain, which are visualized on a 3D stage using the Unity3D game engine. Examples of user interaction are shown in Figure 2. Each of these scenarios has a real state of the world and a contingent plan, and the interface supports the user to explore and understand the plan. Demo participants will be able to interact as follows:

- Users can view the radial graph layout of generated branched plans and zoom and pan to explore the difference between alternative branches.
- Users can select to run different scenarios and explore system functionality such as: selecting to observe the simulation of a plan and different possible branches; selecting to observe the actual execution of a plan; using the timeline interface to move forward or rewind backwards through a plan to a different start point; and pausing simulation or execution.
- The interface allows alternative possible executions to be simulated in advance (top of Figure 2), where the agent's intended actions are superimposed over the current state of the world. The system includes visualisations for actions, sensing actions (e.g., sensing for obstructions) and inference rules.
- The user can then step through an actual execution of the plan (bottom of Figure 2), where branches of the plan are selected based on sensing in the environment. In the example, the agent navigates around rocks into a position to start building and then starts construction.

[1]Unity 3D https://unity3d.com/.

References

Chakraborti, T.; Sreedharan, S.; Kulkarni, A.; and Kambhampati, S. 2018. Projection-Aware Task Planning and Execution for Human-in-the-Loop Operation of Robots in a Mixed-Reality Workspace. In *IEEE International Conference on Intelligent Robots and SystemsIROS*.

EXTRAAMAS. 2020. 2nd Int. Workshop on EXplainable, TRansparent Autonomous Agents and Multi-Agent Systems. https://extraamas.ehealth.hevs.ch/topics.html.

Fox, M.; Long, D.; and Magazzeni, D. 2017. Explainable planning. *arXiv preprint arXiv:1709.10256* .

Gunning, D.; and Aha, D. 2019. DARPA's Explainable Artificial Intelligence (XAI) Program. *AI Magazine* 40(2).

Miller, T. 2019. Explanation in artificial intelligence: Insights from the social sciences. *Artificial Intelligence* 267: 1–38.

Porteous, J.; Lindsay, A.; and Charles, F. 2021. Communicating Branching Plans for Human-Agent Decision Making. In *4th Int. Workshop on Explainable AI Planning (XAIP)*.

XAIP. 2020. 3rd International Workshop on Explainable AI Planning (XAIP). http://xaip.mybluemix.net/\#.

Zolotas, M.; and Demiris, Y. 2019. Towards explainable shared control using augmented reality. In *IEEE International Conference on Intelligent Robots and Systems, IROS*.