Using Virtual Synergy for Artificial Intelligence and Robotics Education

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Abstract

Virtual Synergy is a three-dimensional environment for collaboration between humans, software agents and robots. We have created several tools to enable the use of Virtual Synergy as a viable tool for classroom instruction as well as research work. We have created software to enable robots to work inside of a three-dimensional environment of Virtual Synergy as well as libraries for agent creation in several languages and agents necessary for making Virtual Synergy a practical tool for artificial intelligence and robotics education inside and outside of the classroom.

I. INTRODUCTION

Virtual Synergy[1] combines a 3D graphical interface with physical robots to allow for collaboration among human participants, simulated software agents and physical teams of multi-terrain robots. A research prototype of this interface, is being developed and applied to the tasks of urban search and rescue (USAR) [1,4,7] robot teams. Using the interface to communicate and monitor the robots gives the human operators the ability to function as team members, where the robots can fluidly shift from being completely independent to teleoperated.

Because incorporating hands-on robotics exercises into the classroom excites students, the AI and robotics communities will benefit by having a standard accessible fast-paced interactive 3D graphical interface for interacting with robots. Virtual Synergy is a three-dimensional environment for collaboration between humans, software agents, and robots. The Virtual Synergy system has implementations of agents that run on robotics platforms, including the Sony Aibo and the ActivMedia Pioneer[3]. Virtual Synergy is an extension to Gamebots[2], a modification of the commercial three-dimensional game Unreal Tournament by Epic Games. Figures 1 shows a Pioneer robot controlling its virtual character in the 3D graphical virtual world in which students and software agents may also have characters.

Since Virtual Synergy's creation in January of 2003, the platform has been used in several applications in education and research work. Virtual Synergy provides an innovative and intuitive interface for humans, robots, and software agents to interact in virtual environment. The Virtual Synergy platform opens the doors to learning through real-time experimentation and real-time simulation. Several aspects of robotics systems like localization, planning, and collaboration can be developed and fine-tuned through Virtual Synergy. In the past year, applications such as Urban Search and Rescue, Planning Agents, and two player games like tic-tac-toe have been successfully via Virtual Synergy. Virtual Synergy is an intuitive game-like interface. Virtual Synergy allows agent implementations to be written in any language and have become the cornerstone of the University of New Orleans' Artificial Intelligence and Robotics curriculum.

Figure 1: Pioneer Robot and Virtual Synergy Interface

II. VIRTUAL SYNERGY

The Virtual Synergy platform consists of several components. One such component is the Virtual Synergy text-based protocol, which allows agents to be implemented in any language with TCP/IP sockets. This allows us to learn about robotics and automation without the burden of using a language they have no development experience with. Current agents have been implemented in languages such as: Java, C++, and Common Lisp. Future agents are planned in Python and other languages with a network socket implementation.

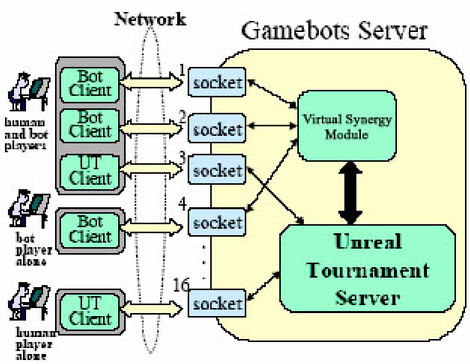

Figure 3: Clients connect to Gamebots server via a network.

Virtual Synergy also adds support for agents running on robotics platforms such as the Sony Aibo and the ActivMedia Pioneer. Because Virtual Synergy is based on a simple text protocol, any robotics platform that supports TCP/IP can host an agent.

III. VIRTUAL SYNERGY IN THE CLASSROOM

A. Urban Search and Rescue

Urban Search and Rescue is the search and rescue of people trapped in collapsed man-made structures [3]. Robots are expendable and therefore a suitable alternative to humans entering a collapsed structure then searching for and rescuing victims inside.

In the spring of 2003, a scaled down version of this application was a class project. The objective was to traverse a maze with obstacles (i.e. a collapsed structure), search for target objects (i.e. victims), and map the victims' location in the virtual world. We used the Sony Aibo robot and ActivMedia Pioneer to traverse an unknown maze. Using a left wall-following algorithm, the Aibo would send environmental information to Virtual Synergy. Environmental information includes obstacle and wall locations. Agents using Virtual Synergy can build a three-dimensional representation of the environment. When the Aibo locates a victim it send location information of the target object to Virtual Synergy. Just as walls and obstacles were represented in the virtual world so are the victims that are found. Once the Aibo has completely traversed the maze it will have created a detailed map in Virtual Synergy.

Figure 4: Pioneer robot traversing maze search for targets

B. Tic-Tac-Toe

In fall of 2003, the graduate artificial intelligence class was given the assignment to make a robot play tic-tac-toe with a human. The game is set up as follows: 9 squares were taped off on the floor with four different colored tapes, where no two adjacent squares were the same color. The robot used in this project was a Sony Aibo. The robot and opponent will alternate turns placing markers in the Virtual Synergy interface. Changes in the game board are communicated to the robot and used to formulate the robots subsequent moves. When the robot chooses a move to make it communicates that move to the Virtual Synergy Interface where it is represented for the human. At the same time the robot is physically moving to the corresponding square on the floor to place a marker. Once the robot knows its location it can move to its new location. Then the robot places a marker on its new square and waits for the opponent to complete its turn. Through this project students investigated artificial intelligence methods by implementing two player search and constraint satisfaction techniques.

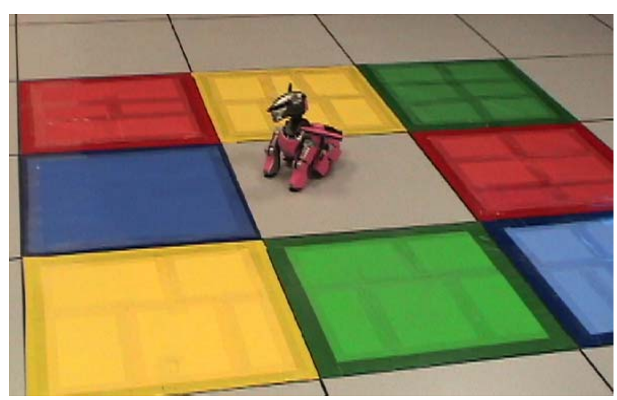

Figure 5: Sony Aibo robot in tic-tac-toe board.

C. Data Recording Agent

Virtual Synergy can represent information about robots and humans. Virtual Synergy not only represents information about software agents; it also acts as a sensor for these software agents. Virtual Synergy allows software agents implemented in an array of languages to exist in the virtual world, and use the output of humans, robots, and other software agents to complete its specified task. The Data Recording Agent is such an agent with the task of logging events that occur in the virtual world of Virtual Synergy.

The Data Recording Agent displays a real-time two-dimensional map of everything within the Virtual Synergy world, while logging this information to file. The Data Recording Agent can replay previous sessions, allowing past incarnations of the virtual world to be recreated for research and performance assessment. In addition the Data Recording Agents can append new events to an existing log file.

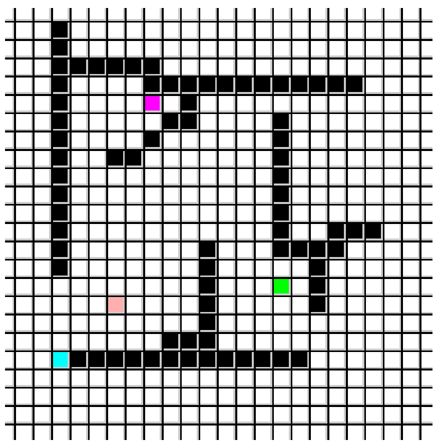

Figure 6: Two-dimensional map of Virtual Synergy created by the Data Recording Agent.

The Data Recording Agent, like all other Virtual Synergy agents, acts on some sensory input available from Virtual Synergy. The Data Recording Agent's inputs are the synchronous sensory messages provided by the Virtual Synergy umod. Once the agent receives a message, it records the message to file and updates its two-dimensional map with the new information. The two-dimensional map can track the actions of all entities in the virtual world.

The Data Recording Agent allows us to study how well robot and software agent resources are utilized between incarnations of the virtual world. The play back feature of the Data Recording Agent allows a previous incarnation to be recreated in the two and three-dimensional maps. Using the play back feature of the Data Recording Agent will improve the design of software agents, efficiency of robot behavior systems, and the effectiveness of autonomy in the system[5,6,8].

Figure 7: 3D Map in Virtual Synergy of Figure 6

D. Mission Planning Agent

Another application of Virtual Synergy is the Mission Planning Agent. This agent's purpose is to allow other agents the use of a planner via a documented text protocol. Any agent wishing to do planning submits a problem request to the planning agent, and the planning agent responds with a solution, or in the event there is no solution, an error message. The agent is implemented in Lisp, and was the prototype application for the lisp Virtual Synergy library. The agent uses Sensory Graphplan (www.cs.washington.edu/ai/sgp.html), developed at the University of Washington as an extension of Graphplan. Sensory Graphplan extended Graphplan by allowing for uncertainty and sensing actions in planning [4].

In the spring of 2004, the University of New Orleans' introductory artificial intelligence class will use the planning agent as part of their final project, which is creating social agents. The University of New Orleans robotics team will also use the planning agent in our Urban Search and Rescue application. The Lisp library developed for the agent will also be made available to those who wish to use Lisp in the artificial intelligence class.

IV. VIRTUAL SYNERGY OUTSIDE THE CLASSROOM

The UNO Robotics Team attended the IJCAI-03 in Acapulco, Mexico. While attending the conference the team competed in the AAAI Robot Rescue Competition. This year was the first year our team competed in the USAR competition. The team finished with the third highest score and earned a technical award for an innovative three dimensional map created by the Virtual Synergy user interface. The competition consisted of three preliminary runs for all teams, and two final runs for the top four teams. The UNO Robotics Team was the only team to roughly double its score in each run. The UNO Robotics Team's platform has shown itself to be flexible and dynamic.

In the first two runs, the team used four Aibo robots, one blimp, and three human operators. The Aibos were individually tele-operated by two of the human operators and the third operator remotely controlled the blimp. The blimp operator also assumed the role of mapmaker. As the human controllers gathered data from the environment, they verbally communicated with the mapmaker to build a global map in the three dimensional environment. The Aibos' integration with Virtual Synergy allowed for more consistent mapping of the environment. The team is currently developing an autonomous multi-agent system.

Figure 10: Robots finding victim in orange test arena

V. CONCLUSION

Virtual Synergy is the cornerstone of University of New Orleans' artificial intelligence and robotics curriculum. Virtual Synergy has been used as a visualization and map-making tool for Urban Search and Rescue research. It has also been used for multi-agent collaboration work. Students at University of New Orleans have built software agents in many languages to work with Virtual Synergy, including agents running on robotics platforms. Students in a graduate artificial intelligence class wrote tic-tac-toe software for Virtual Synergy, allowing humans and agents to play tic-tac-toe in a virtual world, while having the robot play the same game on a physical board. Other students used Virtual Synergy for implementing a solution to a subset of the Urban Search and Rescue domain. Virtual Synergy allows students to use a familiar language in order to concentrate on artificial intelligence concepts instead of on language syntax and semantics. In addition, Virtual Synergy uses a familiar intuitive three-dimensional user interface [10]. In conclusion, Virtual Synergy can as serve as a basis for a number of class projects on artificial intelligence and robots, well as for research on human-robot interfaces and human-robot-agent collaboration [9,11,12].

Figure 11: Human-Robot-Agent collaboration in Virtual Synergy.

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