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RIA: Selecting Information to Include in Cooperative Task — Oriented Dialogues

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Final Report for Period: 09/1995 - 12/1999   **Submitted on:** 06/14/2000

Principal Investigator: Turner, Elise H.   **Award ID:** 9696055

Organization: University of Maine

RIA: Selecting Information to Include in Cooperative Task- Oriented Dialogues

Project Participants

Senior Personnel

> **Name:** Turner, Elise
> **Worked for more than 160 Hours:** Yes
> **Contribution to Project:**

Post-doc

Graduate Student

> **Name:** Donia, Laura
> **Worked for more than 160 Hours:** Yes
> **Contribution to Project:**

Research assistant provided as part of institutional support from the
University of New Hampshire. This MS student worked on the project for a year as a programmer.

> **Name:** Matthias, Collette
> **Worked for more than 160 Hours:** Yes
> **Contribution to Project:**

Research Assistant provided as part of the institutional support from
the University of New Hampshire. Collette worked some as a programmer for some preliminary experiments on informativeness. She also worked
on the natural language interface that we expected to use with the project. That work led to her MS thesis and a publication.

Undergraduate Student

> **Name:** Phelps, John
> **Worked for more than 160 Hours:** Yes
> **Contribution to Project:**

Supported by REU supplement to grant. Worked on multiagent testbed. Also continued work as graduate student helping to design experiments to test heuristics.

> **Name:** Cram, Dwight
> **Worked for more than 160 Hours:** Yes
> **Contribution to Project:**

Supported from REU supplement from this grant. Worked on the multiagent testbed.

> **Name:** Roper, Thomas
> **Worked for more than 160 Hours:** Yes
> **Contribution to Project:**

Supported from REU supplement for this grant. Tom worked on the
multiagent testbed.

Organizational Partners

Other Collaborators or Contacts

The testbed for our project is a simulator for autonomous underwater vehicles working together to assign vehicles to tasks. We have collaborated with Prof. Roy Turner and his students at the University of Maine to build the simulator. The Autonomous Undersea Systems Institute (AUSI) in Lee, NH has provided domain expertise. We are working with Prof. R. Turner's group and AUSI on a project, funded by the Office of Naval Research, to organize and reorganize vehicles in an autonomous underwater oceanographic network. The problem of assigning vehicles to tasks is important to that work.

Activities and Findings

Project Activities and Findings:

The goal of this project was to delevop a technique for selecting information to volunteer in problem solving dialogues. The technique was to create usefulness ratings for information based on the problem solving of the agent that may communicate the information. Heuristics translate specific problem solving activities into contributions to the overall usefulness rating for the information. To this end, our objectives included determining the type of information that should be included in dialogues and implementing heuristics.

We began work on this grant by reading the distributed artificial intelligence and natural language processing literature to find out what others consider to be important information to communicate. At the same time, we implemented an initial system using problem solvers available over the Internet. Results from this work were reported at the 1994 Conference of the Cognitive Science Society, at a 1994 AAAI Workshop on Planning for Inter-agent Communication and in a technical report.

Early in the project, we anticipated testing usefulness ratings for human-computer interactions. To prepare the natural language system, it was extended to handle pronominal references to quantified expressions. This work was reported in the Journal of Natural Language Engineering.

We had difficulty with the initial system because the problem solvers that we were able to access were not designed for multi-agent systems. Our work was moved to a simulator that was being developed by our artificial intelligence research group. The change in testbeds coincided with the Principal Investigator's move from the University of New Hampshire to the University of Maine. An REU supplement allowed undergraduates to be hired to make the extensive modifications necessary for the simulator to be used for our project. In addition to modifications needed to support problem solving and communication, we designed and implemented code that was specifically needed for creating and evaluating usefulness ratings. This included modifying agents so heuristics and usefulness ratings coud be used, implementing a heuristic, and creating an experimental test harness. This work helped us to identify additional heuristics and to better understand the details of support for usefulness ratings that would need to be added to agents. The experimental test harness was used to study the effectiveness of usefulness ratings by studying the changes in problem solving times relative to changes in the threshold used to determine if information should be communicated. Our studies suggested that usefulness ratings can reflect the usefulness of information in problem solving. This result was reported at Agents 2000.

Project Training and Development:

We have concluded that:

Usefulness ratings can reflect the usefulness of information during problem solving.

Heuristics can be developed that rely on widely-used, specific, easily accessed problem solving. Different combinations of heuristics should be used in different problem solving contexts.

Agent problem solving and communication must be altered to implement heuristics and take advantage of usefulness ratings. Communication can be altered in a general way. Currently heuristics are implemented by making time-consuming modifications to the problem solver based on details of existing code. A more general way to implement these heuristics should be found in the future.

Research Training:

Two graduate students worked on this project. They were funded by the University of New Hampshire as part of the promised institutional support for the project. Both gained experience with experimental design and skill with LISP programming by working on the initial testbed. One of these students continued with the project to write her MS thesis on enhancing tbe natural language interface to handle pronominal references to quantified expressions. By developing a technique based on work in psycholinguistics, she gained experience in bringing work from other disciplines to bear on computer science research.

An REU supplement funded three undergraduates to work on this project at the University of Maine. These students were involved in developing a more robust testbed for the project. This allowed them to gain experience in programming large systems, including a reasoner and an inter-agent communication module. These students also participated in project meetings to help them gain an understanding of how

research is conducted. Two of these undergraduates have gone on to graduate school - one at the University of Delaware and one at the University of Maine. The third plans to return to graduate school in a few years.

Students working on this project participated in the Cooperative Distributed Problem Solving (CDPS) group that the Principal Investigator co-leads with Prof. Roy Turner. This group was founded at the University of New Hampshire and later moved to the University of Maine. It usually has 5-10 students, including both male and female and both graduates and undergraduates. Work on this project, including reading of related current literature, was discussed in the group, giving all members exposure to research on natural language processing and inter-agent communication.

Outreach Activities:
In addition to conference presentations described elsewhere, this project has been included as part of seminar talks at Hofstra University and the University of Maine Chemistry Department. It has also been discussed as part of two presentations to high school students in programs designed to interest high school girls in science.

Journal Publications

Turner, E. H. and Matthias, C. M., "Understanding Pronominal References to Quantified Expressions", *Journal of Natural Language Engineering*, p. 345--361, vol. 4, (1998).) Published
Turner, E.H. and Phelps, J., "Determining the
Usefulness of Information from Its Use During Problem Solving", *The Fourth International Conference on Autonomous Agents (Agents 2000)*, p. 207-208, vol. , (2000).) Published
Turner, E. H., "Exploiting Problem
Solving to Select Information to Include in Dialogues between
Cooperating Agents.", *Proceedings of the Sixteenth Annual Conference of the Cognitive Science Society*, p. 882--886, vol. , (1994).) Published

Books or Other One-time Publications

Collette M. Matthias, "Understanding References to Quantified Expressions", (1997). *Thesis*, Published
Bibliography: Master's thesis and technical report

Elise H. Turner and Collette M. Matthias, "Rating the Usefulness of Information to Communicate", (1994). *technical report*, Published
Collection: Computer Science Department, University of New Hampshire, Technical Report
Bibliography: TR No. 94-22

Web/Internet Sites

URL(s):

Description:

Other Specific Products

Contributions

Contributions within Discipline:
Information is an important resource which can be shared by collaborating agents. However, agents often know more than they can say. Therefore, they must select information to communicate which will be the most beneficial to the collaborative task. In many cases, agents do not have a great deal of knowledge or computational resources to bring to bear on this problem. In almost all cases, however, they do have knowledge of their own problem solving.

Our project seeks to exploit this knowledge to select information that should be communicated. Heuristics translate problem solving into usefulness ratings. Each heuristic describes how a specific step in problem solving indicates the usefulness of the information. Simple code fragments implement the heuristics, virtually as a side-effect of problem solving, raising or lowering the usefulness ratings of the information as

appropriate. When a usefulness rating crosses some threshold, that information is communicated.

We have identified several heuristics and implemented one - usefulness ratings should be increased proportionally to the amount of work needed to find the information. Initial studies with this heuristic suggest that usefulness ratings can help to select information so that overall problem solving time is reduced when using appropriate thresholds.

This project has laid the groundwork for continuing to develop and implement heuristics and for creating and using usefulness ratings from problem solving. When fully developed, this method can benefit any multi-agent system in which information is exchanged because it requires no knowledge and little computational effort beyond that needed for problem solving. When more knowledge or computational resources are available, usefulness ratings can give additional input into the decision to communicate a given piece of information.

Contributions to Other Disciplines:

Results from this work may make contributions to fields that are related to natural language processing, such as linguistics, psychology and philosophy, by demonstrating how communication can rely on self-knowledge of the speaker instead of knowledge of the hearer.

Contributions to Human Resource Development:

This project has contributed to human resource development by funding graduate students and undergraduates to participate in the research . It has improved opportunities for underrepresented groups by funding two women graduate students.

Contributions to Science and Technology Infrastructure:

Beyond Science and Engineering:

Categories for which nothing is reported:

Organizational Partners
Any Product
Contributions: To Any Science or Technology Infrastructure
Contributions: Beyond Science or Engineering