Knowledge Sharing and Case-Based Reasoning in Geriatric Care

Cynthia R. Marling
School of Electrical Engineering
and Computer Science
Ohio University
Athens, Ohio 45701, USA
marling@ohio.edu

Peter J. Whitehouse, MD
Pamela A. Fioritto
Jared E. Bendis
Fairhill Center for Aging
University Hospitals of Cleveland
Case Western Reserve University
Cleveland, Ohio 44106, USA
{pjw3,pxf11,jeb2}@po.cwru.edu

Abstract

This paper presents preliminary research in Knowledge Sharing and Case-Based Reasoning to support the long term care of Alzheimer's Disease patients. Teams of geriatric health care professionals currently develop care plans for patients without computer assistance. Our goals are to facilitate team interaction and to provide decision support for the efficient development of high quality care plans. The difficulties inherent in representing the evolving nature of the disease and in capturing the perspectives of team members from different disciplines make this a rich domain for AI research.

Keywords: Case-Based Reasoning, Knowledge Sharing, Alzheimer's Disease, AI in Medicine, Geriatric Health Care

Introduction

The long term care of Alzheimer's Disease (AD) patients is a large and complex problem, with medical, social, cultural, ethical and financial implications. While computers have not historically played a part in its solution, we are applying computer technology to this problem, and researching the ways in which Case-Based Reasoning (CBR) can assist.

From diagnosis until death, an AD patient requires, on average, from four to eight years of care. AD is a progressive brain disorder, which begins with simple forgetfulness, but progresses until patients lose all ability to care for themselves and eventually become bedridden. The disease is marked by memory loss, personality change, unusual behavior and a decline in thinking abilities. Approximately four million Americans suffer from AD. It has been estimated to affect one in ten Americans over the age of 65 and nearly one in two over the age of 85. The annual economic cost of caring for these patients, in terms of health care costs and lost wages for the family members who must care for them, is estimated at $80 to $100 billion (National Institute on Aging 1998).

Long term geriatric care has traditionally been *multidisciplinary*, involving doctors, nurses and social workers, who work along side each other but function independently. Recently, there has been a drive to create and evaluate the impact of *interdisciplinary* teams, in which health care professionals interact to determine care plans for geriatric patients. This requires that team members share their professional knowledge and their individual perspectives. The goal is for this interaction to improve both clinical results and cost-effectiveness (Klein 1995). The Great Lakes Geriatric Interdisciplinary Team Training (GITT) project is an effort to build interdisciplinary teams and to evaluate their effectiveness. The initial role of the computer is to facilitate knowledge sharing among team members, who are professionally and geographically diverse, and who are not accustomed to using computers in their work.

Because clinical case studies of individual patients are used in the Great Lakes GITT to facilitate team training and interaction, it is only natural to explore how CBR could contribute to the effort. Representing a patient as a multi-dimensional case, with dimensions corresponding to the perspectives of different team members, could elucidate the issues involved and the interactions required for patient care. Past experiences with real patients could be mined to find beneficial care paths for new patients who are similar, along one or more dimensions, to old ones. Our long term goal is to make the computer a full member of the interdisciplinary team. While this work is preliminary and the issues to explore are numerous, the potential to push state-of-the-art in CBR, while making a significant real-world contribution, is great.

The Great Lakes GITT

The Great Lakes GITT is a collaborative project between the Henry Ford Health System and Wayne State University in Detroit, Michigan, and University Hospitals Health System of Case Western Reserve Univer-

sity, Cleveland State University's Department of Social Work, and the Benjamin Rose Institute in Cleveland, Ohio. It is one of eight national GITT projects, which are described in (Siegler *et al.* 1998). The Great Lakes GITT differs from other GITT projects in its inclusion of participants from two different cities, its use of the learning teams model (Senge 1990), and its extensive use of computers. The purpose of GITT is to train current and future health care practitioners to work in interdisciplinary teams to provide care to elders. Most participants are from the disciplines of medicine, nursing and social work, but participants from pharmacy, rehabilitation, nutrition and administration may also be included.

Great Lakes GITT participants have access to a password-protected Web site which provides information on geriatric care and interdisciplinary teamwork, as well as a communications forum. Online resources include: a chat room for interactive conversation, bulletin boards for posting discussion topics, calendars for arranging meetings, team directories, a library focusing on the ethical aspects of AD, case studies of geriatric syndromes, pointers on effective teamwork, storyboards for showcasing team efforts, and pointers to selected geriatric sites across the Web.

Knowledge Sharing

Although long term geriatric care requires the integration of a broad range of clinical and social interventions, as well as the ability to reconfigure services quickly as patient needs change, there is a history of *not* sharing knowledge effectively across disciplines (Drinka & Streim 1994). Not sharing knowledge may lead to missed opportunities and/or conflict. For example, a social worker might immediately recognize that a community elder care program would benefit a particular patient, while a doctor or nurse seeing the same patient might not make the same connection. The opportunity to help the patient could be missed or delayed. Interventions might conflict, for example, if the level of medication leaves a patient too sedated or too agitated to fully participate in a community program. Professionals might conflict with each other as well, if they see equally compelling but different aspects of a case and believe only their own perspectives to be valid.

Strategies used to share knowledge in ways that maximize opportunity and minimize conflict are not specific to geriatric care, but are used to promote effective teamwork in any organization. Approaches used in GITT include: recognizing and incorporating the components of highly effective teamwork, as described in (Scholtes 1988); using tools for conflict management, as presented in (Fisher, Kopelman, & Schneider 1994; Fisher & Ury 1981); and using the "fifth discipline" communications protocols for improved advocacy, inquiry and conflict resolution, as in (Senge 1990; Senge *et al.* 1994). The GITT Web site provides participants with synopses of team building strategies, references to books and articles which elaborate on the strategies, and opportunities to practice the strategies in addition to those provided by in-person team meetings.

The Role of Cases

Clinical case studies of geriatric patients are used to facilitate team interaction and knowledge sharing in GITT. A case represents a prototypical patient and is based on one or more actual patients. Each case is a textual description, presented in discrete episodes, interspersed with discussion questions. Although the cases are presented online, they are in a human readable, rather than a machine processable, format. Groups of participants review a case, one episode at a time, and discuss the questions between episodes. Questions may lead to development of a care plan and/or to an elaboration of relevant issues. Not all questions have right answers and not all outcomes are observable, mirroring the situation in real-world geriatric care. Knowledge gained, from the content of the case and from the interaction of discussion, is to be transferred manually by participants to situations they encounter in clinical practice.

Four cases are currently available to GITT participants. Each one took between 30 and 40 hours of effort to develop. Rather than presenting many cases, the emphasis is on developing and presenting exactly the right case to illustrate a geriatric syndrome. This is consistent with case presentation as used in problem-based learning for medical education (Barrows & Tamblyn 1980).

We are currently investigating how we can expand the role of the case. A traditional CBR use would be to automatically use the existing cases to suggest questions to ask and/or treatment plans to follow for similar patients in the future. Though the use is traditional, new issues would need to be resolved, due to the difficulty of representing a patient over time and recognizing similarities at different stages of disease. For one thing, a patient in the early stages of AD is not at all similar to himself in later stages. Furthermore, the disease progresses at different rates and in different ways in different patients. Differences may be due to the individual patient, the patient's environment, and/or the interventions prescribed by health care professionals for the patient's care. Because AD can not be prevented or cured, it is important to recog-

nize and prescribe interventions which are most likely to slow the progression of the disease.

An innovative use of CBR might be to use the cases to illustrate the principles of GITT through cognitive modeling. The first step in using cases, for any CBR application, is to derive a structured representation for a case. AD cases have not only the dimension of time, but also the dimension of perspective. Doctors, nurses and social workers view patients in different ways, which is why it is important for them to work together to begin with. These perspectives must be maintained for accurate case representation, so perhaps they could be leveraged through controlling the amount of weight, or influence, given to each perspective. Then, the doctor who never listens to nurses could be modeled by setting the nurse perspective weights to zero. Perspectives could be added one at a time to see the effect on the care plan. This would not only serve as a training tool for GITT participants, but would also provide a building block for the more traditional application.

Related Research

The medical domain has provided fertile ground for CBR research ever since CASEY (Koton 1988), which diagnosed problems in heart failure patients, and PROTOS (Bareiss 1989), which diagnosed audiological disorders. While early CBR in Medicine systems focused on diagnosis, later systems have addressed a broad range of tasks. ProtoISIS offers decision support to primary care physicians in the selection of diagnostic imaging procedures (Kahn & Anderson 1994). ROENTGEN supports the design of radiation therapy plans (Berger 1994). McRad provides radiological expertise in the form of reference images to support patient evaluation (Macura & Macura 1995). ICONS provides advice on antibiotic therapy in intensive care medicine (Heindl *et al.* 1997).

At least two factors differentiate our work from previous CBR in Medicine research. First, AD cases evolve over a period of years. Each case encompasses a series of problems, interventions and outcomes, any of which could be relevant to future cases. Second, the knowledge needed to plan interventions and predict outcomes for a single patient resides with multiple health care professionals, who have different, possibly conflicting perspectives, which must be reconciled and combined. Any of these professionals may want to use our system to augment their own knowledge with the perspectives of others.

In some respects, the prior work most closely related to our own is that reported by (Bradburn & Zeleznikow 1994). They prototyped an advisory system named FLORENCE in the domain of nursing care. FLORENCE assists nurses with the tasks of nursing diagnosis, prognosis and prescription, by extrapolating results observed in earlier patients to later ones. As in our work, FLORENCE aims to recommend interventions having the greatest likelihood of success. It begins to tackle the issue of temporal cases, in that a patient's progress may be followed for up to ten days. Unlike our work, FLORENCE deals with short term care and assumes that nurses operate independently of other health care professionals.

Because the Great Lakes GITT involves training, educational CBR systems, like those fielded by the Institute for the Learning Sciences, are also relevant to our work (Schank 1998). The ASK systems, like ASK Tom (Ferguson *et al.* 1992), are related in that questions form an integral part of each geriatric case. The Sickle Cell Counsellor (Bell, Bareiss, & Beckwith 1994) resonates for AD practitioners, because genetics and genetic counseling are important in working with AD patients and their families (Post & Whitehouse 1998). In this museum-based system, goal based scenarios engage users as role-playing counselors to virtual carriers of the sickle cell gene. Unlike museum-goers, whose role-playing serves to motivate their learning, GITT participants counsel people professionally within the roles defined by their disciplines.

Future Work

Our immediate goal is to complete the representation of an AD patient as a structured case which encompasses dimensions of time and perspective. Next, we plan to field prototype systems for GITT participants which use these cases for clarifying perspectives and for decision support. We will focus first on the fundamental post-diagnostic decisions which must be made, such as which medications to prescribe. Our aim is to provide mixed-initiative human/computer reasoning, via the cases, to move the computer closer to being a real and productive member of the geriatric interdisciplinary team. We will continue exploring issues of case organization, case similarity over time, and the cognitive processes involved in team dynamics and geriatric care planning. It is our hope, that due to the richness and complexity of our problem domain, many unanticipated AI and geriatric issues will arise to challenge and inspire our research.

Summary and Conclusions

We present preliminary research in knowledge sharing and case-based reasoning in geriatric care. While computers have not been used previously in the long term care of AD patients, we are using them to facilitate

knowledge sharing in geriatric interdisciplinary teams. We are investigating how CBR can more actively support health care practitioners in planning long term care, changing the role of the computer towards that of a virtual team member. This problem provides not only a rich context in which to conduct AI research, but also the potential for real-world impact.

Acknowledgements

The Great Lakes GITT project is funded by the John A. Hartford Foundation, Inc., of New York and the Cleveland Foundation. We would like to thank Joann Castle, Shirley Moore, Julia Rajcan, Marybeth Tupper, Nancy Wadsworth, Nancy Whitelaw, John Wisniewski, and the GITT participants for contributions to this work.

References

Bareiss, R. 1989. *Exemplar-Based Knowledge Acquisition: A Unified Approach to Concept Representation, Classification, and Learning.* San Diego, CA: Academic Press.

Barrows, H. S., and Tamblyn, R. M. 1980. *Problem-Based Learning: An Approach to Medical Education.* New York, NY: Springer.

Bell, B.; Bareiss, R.; and Beckwith, R. 1994. Sickle cell counselor: A prototype goal-based scenario for instruction in a museum environment. Technical Report 56, The Institute for the Learning Sciences, Evanston, IL.

Berger, J. 1994. Roentgen: Radiation therapy and case-based reasoning. In *Proceedings of the Tenth Conference on Artificial Intelligence for Applications.* Los Alamitos, CA: IEEE Computer Society Press.

Bradburn, C., and Zeleznikow, J. 1994. The application of case-based reasoning to the tasks of health care planning. In Wess, S.; Althoff, K. D.; and Richter, M. M., eds., *Topics in Case-Based Reasoning: First European Workshop*, 365–378. Berlin: Springer-Verlag.

Drinka, T. J. K., and Streim, J. E. 1994. Case studies from purgatory: Maladaptive behavior within geriatrics health care teams. *The Gerontologist* 34(4):541–547.

Ferguson, W.; Bareiss, R.; Birnbaum, L.; and Osgood, R. 1992. Ask systems: An approach to the realization of story-based teachers. Technical Report 22, The Institute for the Learning Sciences, Evanston, IL.

Fisher, R., and Ury, W. 1981. *Getting to Yes: Negotiating Agreement without Giving In.* Boston, MA: Houghton Mifflin.

Fisher, R.; Kopelman, E.; and Schneider, A. K. 1994. *Beyond Machiavelli: Tools for Coping with Conflict.* Cambridge, MA: Harvard University Press.

Heindl, B.; Schmidt, R.; Schmidt, G.; Haller, M.; Pfaller, P.; Gierl, L.; and Pollwein, B. 1997. A case-based consilarius for therapy recommendation (ICONS): Computer-based advice for calculated antibiotic therapy in intensive care medicine. *Computer Methods and Programs in Biomedicine* 52:117–127.

Kahn, C. E., and Anderson, G. M. 1994. Case-based reasoning and imaging procedure selection. *Investigative Radiology* 29:643–647.

Klein, S., ed. 1995. *A National Agenda for Geriatric Education: White Papers.* Rockville, MD: US Department of Health and Human Services, Health Resources and Services Administration, Bureau of Health Professions.

Koton, P. 1988. Reasoning about evidence in causal explanations. In *Proceedings AAAI-88*, 256–261. San Mateo, CA: Morgan Kaufmann.

Macura, R. T., and Macura, K. J. 1995. McRad: Radiology image resource with a case-based retrieval system. In Veloso, M., and Aamodt, A., eds., *Case-Based Reasoning Research and Development: First International Conference, Proceedings ICCBR-95*, 43–54. Berlin: Springer-Verlag.

National Institute on Aging. 1998. *Progress Report on Alzheimer's Disease, 1998.* Bethesda, MD: National Institutes of Health. NIH Publication No. 99-3616.

Post, S., and Whitehouse, P. J., eds. 1998. *Genetic Testing for Alzheimer Disease: Ethical and Clinical Issues.* Baltimore, MD: Johns Hopkins University Press.

Schank, R. C., ed. 1998. *Inside Multi-Media Case Based Instruction.* Mahwah, NJ: Erlbaum.

Scholtes, P. R. 1988. *The Team Handbook: How to Use Teams to Improve Quality.* Madison, WI: Joiner.

Senge, P.; Ross, R.; Smith, B.; Roberts, C.; and Kleiner, A. 1994. *The Fifth Discipline Fieldbook: Strategies and Tools for Building a Learning Organization.* New York, NY: Doubleday.

Senge, P. M. 1990. *The Fifth Discipline: The Art and Practice of the Learning Organization.* New York, NY: Doubleday.

Siegler, E.; Hyer, K.; Fulmer, T.; and Mezey, M., eds. 1998. *Geriatric Interdisciplinary Team Training.* New York, NY: Springer.