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Medical applications in case-based reasoning

ALEC HOLT[1], ISABELLE BICHINDARITZ[2], RAINER SCHMIDT[3] and PETRA PERNER[4]

[1]*Health Informatics, Department of Information Science, University of Otago, PO Box 56, Dunedin, New Zealand;*
e-mail: aholt@nfoscience.otago.ac.nz
[2]*Informatics & Artificial Intelligence Laboratory, Institute of Technology/Computing and Software Systems, Box 358426, University of Washington, Tacoma, WA 98402, USA;*
e-mail: ibichind@u.washington.edu
[3]*Institut für Medizinische Informatik und Biometrie, Rembrandtstrasse 16/17, 18057 Rostock, Germany;*
e-mail: rainer.schmidt@medizin.uni-rostock.de
[4]*Institute of Computer Vision and Applied Computer Sciences, Körnerstraße 10, 04107 Leipzig, Germany;*
e-mail: ibaiperner@aol.com

Abstract

This commentary summarizes case-based reasoning research applied in the medical domain. In this commentary the term 'medical' is used in an all-encompassing manner. It comprises all aspects of health, for example, from diagnosis to nutrition planning. This article provides references to researchers in the field, systems, workshops, and landmark publications.

1 Introduction

Case-based reasoning (CBR) in medicine is a vibrant niche area that is undergoing a revival. This area is expected to grow especially as the health sector expands continuously and becomes more accepting of advanced decision support systems in clinical practice. There have been over 250 papers published in this area with more than a third published in the last four years. Many of these articles are not published in traditional CBR journals and conference proceedings; some are found in medical informatics publications. Publishing in a wide range of journals and the idiosyncrasies of the medical discipline have made researchers who study CBR in medicine a disparate group.

Physicians have to process a mass of information, which can be contradictory, and they have to understand the various levels of probabilities of harm associated with a diverse number of patients and the peculiarities of the ailment. In addition, the medical knowledge base is continuously changing, sometimes there is more than one solution, physicians have different approaches, and medicine is a complex domain to model. Therefore, there is a niche area for CBR in medicine. There have been many investigations of CBR in the medical community. Berger organized an on-line CBR-MED site, and Bichindaritz has revived this by creating an on-line CBR-biomed site (`http://www.cbr-biomed.org`). Macura organized a tutorial on CBR at the 1995 American Medical Informatics Association (AMIA) conference and in 1997 produced a special issue of *Artificial Intelligence in Medicine* on CBR. More recently, Bichindaritz & Marling have organized workshops on CBR in the Health Sciences at the 2003 and 2005 International Conferences on Case-Based Reasoning, and the 2004 European Conference on Case-Based Reasoning. These workshops were attended by most of the contemporary medical researchers in CBR, and motivated the creation of a special issue of *Artificial Intelligence in Medicine* on *CBR in the Health Sciences* in 2005. Furthermore, both the 2003 Conference on Artificial Intelligence in Medicine Europe and the 2003 Medical Informatics Europe Congress devoted special sessions to CBR.

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Table 1 CBR medical systems

Task type	Citation	System name	Application domain
Diagnosis and decision support systems	Kolodner & Kolodner, 1987	SHRINK	Psychiatry
	Koton, 1988	CASEY	Heart failure
	Turner, 1988	MEDIC	Dyspnoea
	Lopez & Plaza, 1993	BOLERO	Pneumonia
	Bradburn & Zeleznikow, 1993	FLORENCE	Health care planning
	Bichindaritz, 1995	MNAOMIA	Psychiatry
	Haddad *et al*., 1997	SCINA	Detection of coronary heart diseases
	Bichindaritz *et al*., 1998	CARE-PARTNER	Stem cell transplantation
	Marling & Whitehouse, 2001	AUGUSTE	Alzheimer's disease
Classification systems	Bareiss & Porter, 1987	PROTOS	Audiological disorders
	Macura *et al*., 1994	MACRAD	Image analysis
	Grimnes & Aamodt, 1996	IMAGECREEK	Image analysis
	Bichindaritz & Potter, 1994, 2004	PHYLSYST	Phylogenetic classification
	Perner, 1999	CTS	Image analysis
Planning systems	Bichindaritz & Seroussi, 1992	ALEXIA	Hypertension
	Berger, 1994	ROENTGEN	Radiation therapy
	Petot *et al*., 1999	CAMP	Daily menu planning
	Montani *et al*., 2000	T-IDDM	Diabetes treatment
Tutoring systems	Gierl, 1993	ICONS	Antibiotics therapy for intensive care
	Fenstermacher, 1996	CADI	Cardiac auscultation diagnosis and instruction

In 2001 comprehensive reviews on CBR in medicine were published (Schmidt & Gierl, 2001; Schmidt *et al*., 2001). In Section 2 we summarize the major CBR in medicine application areas.

2 Applications of CBR in medicine

Many researchers are working on medical CBR with many diverse applications, ranging from psychiatry and epidemiology to clinical diagnosis. Most of them aim for a successful implementation of CBR methods to enhance the work of health experts, to improve the efficiency and quality of health care. Early CBR in medicine publications appeared in the late 1980s (Kolodner & Kolodner, 1987; Koton, 1988; Turner, 1988; Bareiss & Porter, 1987). The applications of CBR in medicine focus mainly on diagnosis, classification, planning and tutoring (Table 1). Many systems have been applied; we discuss some of these next.

Two landmark papers exemplify CBR coupled with evidence-based decision making and CBR in a clinical setting. In the first paper, Bichindaritz *et al*. (1998) applied CBR to provide evidence-based medical decision support over the Internet. They integrated automatic processing of medical practice guidelines and clinical pathways with CBR. It was called CARE-PARTNER and it used cases and prototypical cases to represent the variety and complexity of knowledge. This knowledge system was interactive and allowed physicians to select and organize diagnoses, treatment, and follow-up actions, and make recommendations according to the latest validated medical expertise. In the second paper, Schmidt & Gierl (2001) successfully implemented CBR in the complex domain of intensive care medicine for antibiotics therapy decision support, where physicians are accountable for their decisions.

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Researchers who have contributed substantially to CBR in medicine include Gierl, Schmidt and their colleagues, who focused on a range of applications including children dysmorphic syndromes, antibiotics therapy advising for intensive care and monitoring emerging diseases (Gierl, 1993; Schmidt & Gierl, 2001). Notable is their ICONS system (Gierl, 1993), first applied to the determination of antibiotic therapy treatment for intensive care, then to the prognosis of kidney function defects. For this latter application, ICONS learned prototypes associated with graded levels of severity through temporal abstraction (Gierl, 1993), and matched new cases with these prototypes to predict the severity of a renal disease.

Bichindaritz, Sullivan, Seroussi, Kansu, Potter and their colleagues focused on hypertension diagnosis and therapy, psychiatry diagnosis, treatment and follow-up, stem cell transplantation long-term follow-up decision support, as well as phylogenetic classification (Bichindaritz & Seroussi, 1992; Bichindaritz & Potter, 1994; Bichindaritz, 1995; Bichindaritz *et al*., 1998; Bichindaritz & Potter, 2004). In ALEXIA (Bichindaritz & Seroussi, 1992), CBR used a deep pathophysiological model of hypertension to assess the similarity between cases favoring the important attributes in the model. MNAOMIA (Bichindaritz, 1995) is a CBR system that can adapt to the medical task at hand, namely diagnosis, treatment planning and clinical research assistance. Later refined in CARE-PARTNER (Bichindaritz *et al*., 1998), this CBR system proposed a cooperation framework between cases and clinical practice guidelines in the domain of stem cell post-transplant care.

Portinale, Bellazzi, Montani, Stefanelli and their colleagues focused on diabetic patients' management, therapy and haemodialysis treatment (Montani *et al*., 2000; Schmidt *et al*., 2001). Their system highlighted the importance of temporal abstraction to facilitate similarity assessment between cases, and thus retrieval (Montani *et al*., 2000).

Marling, Petot, Sterling, Whitehouse and their colleagues (Petot *et al*., 1999; Marling & Whitehouse, 2001) focused on designing individualized therapy plans (i.e. for nutrition menus, patient care for Alzheimer's disease and cardiac and pulmonary disease). In particular, AUGUSTE (Marling & Whitehouse, 2001) demonstrated the utility of CBR for supporting treatment planning in a medical domain lacking a strong domain theory.

Perner (1999) focused on biomedical image interpretation, segmentation and similarity analysis for computed tomographies and microscopic images.

3 Future research directions

Adaptation remains a problem in CBR in medicine and only a few systems are used in a clinical setting. As in other domains, case mining is becoming an important area of research. There are some exciting future areas such as Web-based electronic medical records, the concept of well patient care records (having access to and monitoring your health even if you are well), personalization, handheld computing for clinical decision support in hospitals and the nexus of CBR and evidence-based practice, which all argue well for using CBR in medicine.

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