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Medical applications in case-based reasoning

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Abstract

This commentary summarizes case-based reasoning research applied in the medical domain. In this commentary 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 are 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 organised 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.

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 1980's (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, 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.

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; Bichindaritz & Potter, 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 ausculation diagnosis and instruction

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, 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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