THE CITY UNIVERSITY OF NEW YORK

APPLICATION FOR **PSC-CUNY 35** RESEARCH AWARD PROGRAM

Control Number: (For Office use only)	Name: Kopec (first) Danny Co-PI: (Attach copy of this page with CO-PI info)		Review Panel: Computer Science
Rank: ❑ Distinguished Professor ❑ Professor X Associate Professor ❑ Assistant Professor ❑ Lecturer ❑ Instructor ❑ Other_____	Tenure: X Yes ❑ No ❑ CCE	Type of Award: (**choose one**) X One year ❑ Two year ❑ Renewal (one consecutive year only) ❑ Out- of-Cycle (date of hire:_____) ❑ Emergency (justification attached)	
Department: Computer and Information Science	College: Brooklyn	Subjects (where college Approval is required) ❑ Human ❑ Animal	Progress Report: ❑ Attached ❑ Will Follow By December 15th
Supplementary Materials attached : X Yes ❑ No (Do not check off if only appendices are attached)	Home Address: 34 East Webster St. Merrick, NY 11566 Telephone: (H) 516 – 867- 2628 (W) 718 – 951 - 5578	Email Address: kopec@sci.brooklyn.cuny.edu Fax: (718) – 951 - 4842 Amount requested: $ _8,000__ yr. 1 $_____ yr. 2	

Title of Proposed Project**: Software Technology: Application of Artificial Intelligence-Based Methodologies For Reduction of Medical Errors**

Brief Abstract:

The medical sector is one which employs and depends on "multidisciplinary" service sectors. Hence errors can occur across a number of disciplines which contribute to the medical sector. In earlier work funded by CUNY 32-34 we classified all of the medical errors discovered in our literature study into categories according to the type of error which was deemed to have been involved (Kopec, Kabir, Reinharth, et. al, 2003). Some of those categories, in addition to being classified by cause, involve classification by whether or not "a human role" was responsible for that error. A subsidiary result of our earlier work is that we have developed a database of over 100 papers in the area of medical errors and this can now serve as a repository for other researchers interested in the field.

In our analysis we have observed that administrative errors, diagnostic errors, errors in treatment procedures, and all categories of medication error are mainly due to "the human role". Experimental studies in several different hospitals indicate that the application of physician's order entry systems, computer-based clinical decision support systems, computerized alert systems, smart cards for patient information, for example, can reduce medical errors by a considerable amount. Studies have shown diverse ranges of error reduction, but the minimum expected level is at least a 50% reduction in errors.

One system under development is an Expert System to distinguish "Headaches" from "Migraines" developed in conjunction with a practiing neurologist. A web-based application using the Expert System Shell CLIPS has been developed and we are in the process of gathering experimental data. Another proposed system is a SmartBook in JavaScript to provide all the necessary information about Diabetes.

Another way to approach the study of medical errors is to consider where most errors are prone to occur. There is significant evidence (Lynn and Goldstein, 2003) to suggest that medical errors will most frequently occur in patients with chronic and terminal illnesses – for this is the environment where most people will come into contact with health care systems. Case-Based reasoning is an AI technique which tries to exploit the similarities of two situations and match decision-making to the best-known precedent cases. We will attempt to develop a Case-Based Reasoning system which will employ this technique to improve palliative care (Kolodner, 1998) .

Principal Investigator: I understand that: (1) The award may be revoked in whole or in part should my relationship with the City University cease to exist provided that such revocation shall not include any amounts obligated previous to the effective date of revocation. (2) The general terms and conditions of this proposal as stated in the application form, program guidelines and elsewhere have been read and accepted. (3) Any funds granted as a result of this application are to be expended for the purpose outlined herein in accordance with University and Foundation policies, and any funds not expended for this purpose shall revert to the PSC-CUNY Research Award Program upon completion or termination of award, whichever is earlier. (4) Equipment purchases are covered under Section 4.3 of *Project Director's Guide*.

Signature:_____ Date: _____

Campus Endorsement: This is to certify that the applicant is authorized to conduct the study described by the accompanying proposal of this campus, and that the undersigned is satisfied that the scope of the applicant's project will not interfere with his/her professional duties. *Release time, where requested, has our approval.* Other support will be provided on campus to assist this study.

Signature:_____ Title: _____ Date: _____

PSC-CUNY 35 RESEARCH AWARD PROGRAM PROPOSED BUDGET			
Name: Danny Kopec	**1st year ____X____ 2nd Year _____**		
Principal Investigator Academic Year Salary $_____ *(only for those requesting summer salary)*		Requested Amount	
Principal Investigator	*(summer salary-maximum $3,000)*		(5400)
	Fringe Benefits 22%		(5955)
Release Time	*($3,000)*		(5800)
	Fringe Benefits 28%		(5950)
Research Staff		$7000	(5410)
	Fringe Benefits Part Time 8%	$560	(5940)
Equipment	(*item $1,000+)*	$350	(7900)
Expendable Supplies/Small Equipment		$90	(6200)
Travel	*(mode, destination, & estimated per diem)*		
Domestic			(6910)
Foreign			(6920)
Local			(6930)
Payment to Subjects			(7020)
Manuscript Prep/ Publication			(8040)
Other			
	Total Amount Requested	$8,000	

BUDGET JUSTIFICATION: Please justify all major items, but limit to space provided. Also, supply a job description for all Research Assistants.

(1) The proposed project is a continuation (at a more advanced level) of earlier research in medical errors under CUNY-32 through CUNY-34. Mr. Gene Shagas has come to Brooklyn College in pursuit of an MS degree in Information Systems with a very strong technical background coupled with experience in health care quality management.

He has developed the Migraines vs. Headaches Expert System using the CLIPS expert system shell. Some of the technologies used here include a GUI and Presentation Layer in HTML and Javascript, Application and Data Manipulations layers in PERL Script and C. Further data collection in XML format. Multilingual aspects of the system are addressed through the use of XSLT (Sun Microsystems 2003c).

Mr. Shagas will work 175 hours (at $20/hour) in the completion of these systems. He is in dire need of raw data to complete this research, which is also part of his MS Thesis.

(2) Suzanne Tamang is pursuing an MS Degree in Computer Science and Health Science. She has experience working in field of palliative care which couples nicely with her thesis topic "Improving Quality of Care at the End of Life: an information systems approach to reducing medical errors. Ms Tamang will be developing the Case-Based Reasoning component of our proposed research. She will be working 200 hours at $17. 50 per hour on this project.

BIOGRAPHICAL SUMMARY: **NAME:** Danny Kopec

EDUCATION

INSTITUTION	DEGREE	YEAR	FIELD of STUDY
University of Edinburgh	PhD	1983	Machine Intelligence
Dartmouth College	BA	1975	Psychology Modified with Mathematics

RESEARCH & PROFESSIONAL EXPERIENCE: Summarize research and professional experience which is pertinent to this proposal. List in chronological order the titles and complete references to publications in the past three years and to representative earlier publications important to this application (Use an asterisk to identify publications which resulted from PSC-CUNY grant supported work). DO NOT EXCEED THIS PAGE.

My research interests have focused in three areas: **intelligent tutoring systems, experimental computer science/cognitive science via computer chess, and technological mishaps**. These domains are related to more specific problems in a number of artificial intelligence-related domains including problem solving, knowledge-based systems, human-computer interaction, expert systems, natural language processing and the management of interdisciplinary teams.

Computers are pervading nearly every aspect of human life. Their use in **complex systems** and the real possibility of catastrophic accidents (especially where human error may be involved) must be addressed. In 1982, I co-authored a report with Professor Donald Michie, (my then Ph.D. thesis supervisor at the University of Edinburgh in Scotland and renowned leader in the domain of knowledge engineering and machine learning) to the Commission of the European Communities entitled: ***Mismatch Between Machine Representations and Human Concepts: dangers and remedies***. The various forms of computer malfunction and accidents involving computers and complex systems were subsequently addressed in in two papers: **(1) *Technology Transfer Crises in the 1980s: mishaps at the human interface;* (2) *Societal and Technological Problems of Computers (with Q. Jiang).* Below are presented the full references for publications and works I have participated in that are relevant to this domain of research.**

Kopec, D, Michie, (1982) *Mismatch between machine representations and human concepts: dangers and remedies*. Report to the EEC under subprogram FAST (Forecasting and Assessment in Science and Technology), Brussels, Belgium.

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Kopec, D., Wood, C. and Brody, M. *An Educational Theory for Transferring Domain ExpertKnowledge Towards the Development of an Intelligent Tutoring Systems for STDs*. Journal of Artificial Intelligence in Education, Vol. 2 (2), Winter, 1991, pp. 67-82.

Kopec, D. Brody, M., Shi,C., and Wood, C. *Towards an Intelligent Tutoring System with Application to Sexually Transmitted Diseases* in Artificial Intelligence and Intelligent Tutoring Systems: Knowledge-based systems for learning and teaching, (eds. D. Kopec and B.C. Thompson), Ellis Horwood Publishers, Chichester, England, May,1992, pp. 129-51.

Kopec, D. and Wood, C. Introduction to SmartBooks. Booklet to accompany interactive educational software *AIDS SmartBook*, Jones and Bartlett Publishers, Boston, MA (1994). * Also published as United States Coast Guard Academy, *Center for Advanced Studies Report No. 23-93*, New London, CT., December, 1993.

Kopec, D. (2001*) SmartBooks: A generic methodology to facilitate delivery of postsecondary education .in* Proceedings AMCIS 20001 (Americas Conference on information Systems. Boston, August 2-5, 2001, Curriculum and LearningTrack; (CDROM).

Kopec, D., Kabir, M., Reinharth, D. et al. *Human Errors in Medical Practice: Systematic Classification and Reduction With Automated Information Systems*. Journal of Medical Systems, Vol. 27, No. 4, August 2003, pp. 297-313. **(appended)**

Kopec, D., Whitlock, P., and Kogen, M. *Enhancing Post-Secondary Instruction With Peer Tutors, SmartBooks™ and SmartTutors.* (just released) A Chapter for the Book: *International Network for Engineering Education and Research - 2002: A Chronicle of Worldwide Innovations*. (October, 2003) **(appended).**

Relevant Texts

1. Leveson, N. (1995) SAFEWARE, Addison Wesley Publishing Company, Reading, MA, 680 pages.
2. Neumann, P. (1995) COMPUTER-RELATED RISKS, ACM Press New York, 367 pages.
3. Perrow, C. (1999) NORMAL ACCIDENTS, 2nd ed., Princeton University Press, Princeton, NJ, 451 pages.

OTHER FUNDING: **NAME**__Danny Kopec:

TOTAL NUMBER OF PRIOR PSC-CUNY AWARDS____3_

PSC-CUNY AWARDS (over past five years)

DATE:	TITLE	NEW or RENEWAL	AMOUNT
9/00-6/01	Diagnosis and Design of Complex Systems Software	New	$4400.00
9/01-6/02	Diagnosis and Design of Complex Systems Software	Renewal	$4400.00
9/03-6/04	Software Technology: From SmartBooks to Artificial Intelligence Towards the Reduction of Medical Errors	Renewal	$3200.00

EXTERNAL RESEARCH GRANT/AWARD PROPOSALS
(over past five years; indicate funded/not funded)

Place an asterisk next to awards that resulted from PSC-CUNY funding

DATE	TITLE	FUNDING SOURCE	AMOUNT
April 2000	Evaluation and Design of Complex Systems Software	NSF/ITR (Not Funded)	$369K
Dec 2000	Evaluation and Improvement of Medical Systems Software	CISDD/CUNY (Not Funded)	$4K
Jan 2001	DAGPAL: A Declarative Graphics Programming Language and its Application (with Neng-Fa Zhou et. al)	NSF/ITR (Not Funded)	$500K
Jan 2001	SmartBooks: a generic methodology to facilitate delivery of post-secondary education	FIPSE (Preposal)	
July 2002	ScienceTutor: On-line Tutoring to Aid Retention in Gateway Science	NSF 02-043 (Funded, Feb. 2003)	$74,985

References

Bates,D.W., MD, Cohen M. , MS, et. al, *Reducing the Frequency of Erros in Medicine Using Information Technolog,y*, J Am Med Inform Assoc. 2001;8:299-308.

Bates D.W. ., MD; Leape L.L.,MD, Cullen D.J. ,MD.
Effects of Computerized Physician Order Entry and a Team Intervention on Prevention of Serious Medication Errors JAMA October 21, 1998 Vol 280 No 15.

Katz, Alan, "A *Prototype CPR SmartBook"*, Developed in Flash 4.0, CIS-60 Senior Project Course, Brooklyn College, Summer, 2001.

Kohn LT, Corrigan JM, Donaldson MS, editor. *To err is human:building a safer health system*. Washington (DC): National Academy press;2000

Leape L L, Brennan T A, Laird NM, et al. *The nature of adverse events in hospitalized patient: results from the Harvard Medical Practice Study ll*. N Engl J Med.1991;324:377-84.

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Robert, A,MD, MS, Gollihare,B., MS, RN., Thomas, A.
A Computer Alert System to Prevent Injury From Adverse Drug Events
JAMA; October 21, 1998 vol 280 No 15

Vincent C.,Neale G., Woloshynowych M., *Adverse event in British hospitals: preliminary retrospective record review*. BMJ USA volume 1 may 2001.

Wilson RM, Runciman, WB, Gibberd RW, Harrison BT, Newby L, Hamilton JD.
The Quality in Australian health care study. Med J Aust 1995; 163:458-71.

Wood, C. L., *"Use of Concept Maps in Micro-computer Based Program Design for an AIDS Knowledge Base"*, EDD Thesis, University of Maine, Orono, 1992.

Yetman R. , MD, *Preventing Misuse Errors in Health Care Organizations.*

Vol. 8, No 8 August 2001 JCOM.

Applications of Artificial Intelligence-based Methodologies for Reduction of Medical Errors

Introduction

The Migraines and Headaches Application

Headaches in a variety of forms are one of the most common complaints presenting to the clinician. The International Headache Society has proposed a classification of headache; but these rules to diagnose Migraine seem to be oversimplified (Olesen 1998, Troost 2002). We decided to create an application to distinguish between Migraine and Headache this using more sophisticated rules and future implementation of the Expert System (CLIPS). CLIPS is a productive development and delivery Expert System tool which provides a complete environment for the construction of rule and/or object based expert systems (GHG Internet Services 2003).

The problem we're working on is to create an application to distinguish between Migraines and Headaches. We started from a simple rules implementation. The strategic goal, however, is to create a self-learning program, based on an Expert System, which can collect and analyze all patient data.
The application is intended primarily for physicians, but patients could also use a simple version.
This could be both an online and stand-alone application. Once the point of a "self-learning program" is achieved, the online approach is better for new data collection and rules updating.
Paper forms are not required, but it could be an option for people with no computer and/or Internet. The program itself can dynamically generate the Forms.
GUI and Presentation Layer are written on Hypertext Markup Language (HTML) and JavaScript, while the Application and Data Manipulation layers are written on Common Gateway Interface (CGI) Perl script. As of today, Data collected in Extensible Markup Language (XML) format in a file for the future analysis. The Java API for XML Processing (JAXP) supports processing of XML documents using Document Object Model

(DOM), Simple API for XML (SAX), and Extensible Stylesheet Language Transformations (XSLT) (Sun Microsystems 2003).

We can use Java and XML with Apache open source products to build Simple Object Access Protocol (SOAP) client and server components on the Internet. SOAP is a request/response remote procedure call (RPC) protocol based on HTTP and XML. SOAP, a simple alternative to the request/response protocols DCOM and CORBA/IIOP, has the advantage of being based on HTTP, thus providing a better chance that packets will get through firewalls and proxy servers separating client and server. Java and XML can be used with Apache open source products to build SOAP client and server components on the Internet (Sun Microsystems 2003). Using such Data Exchange also important to address the "serious issue of cyber-security". The nature of the Microsoft platform that dominates every desktop everywhere is such that its dominance, coupled with its insecurity, cannot be ignored and is a matter of corporate and national policy. The best solution is to adopt a combination of different computer systems that will reduce the risk of a single security incident crippling a company or a government agency, or, “having more than one operating system running inside your enterprise would be a substantial improvement” (Stevenson, 2003).

The Expert System Shell CLIPS Installation and Implementation

CLIPS is a productive development and delivery Expert System tool which provides a complete environment for the construction of rule and/or object based expert systems (GHG Internet Services, 2003). The data can be inserted into this Expert System in several ways.

Direct data entry using existing interface (GHG Internet Services, 2003).

Web-based interaction with CLIPS.

CGI program handles the output from the HTML Migraine form page. The program will be sent the form data when the user clicks on the "Submit" button in the forms page. CGI programs can be written in almost any language that can process text data from standard input and send text data to standard output. Since CLIPS is written on C programming language, we recommend CGI program to be written in C as well.

This is the URL to the latest Form 1.1.3. revision:

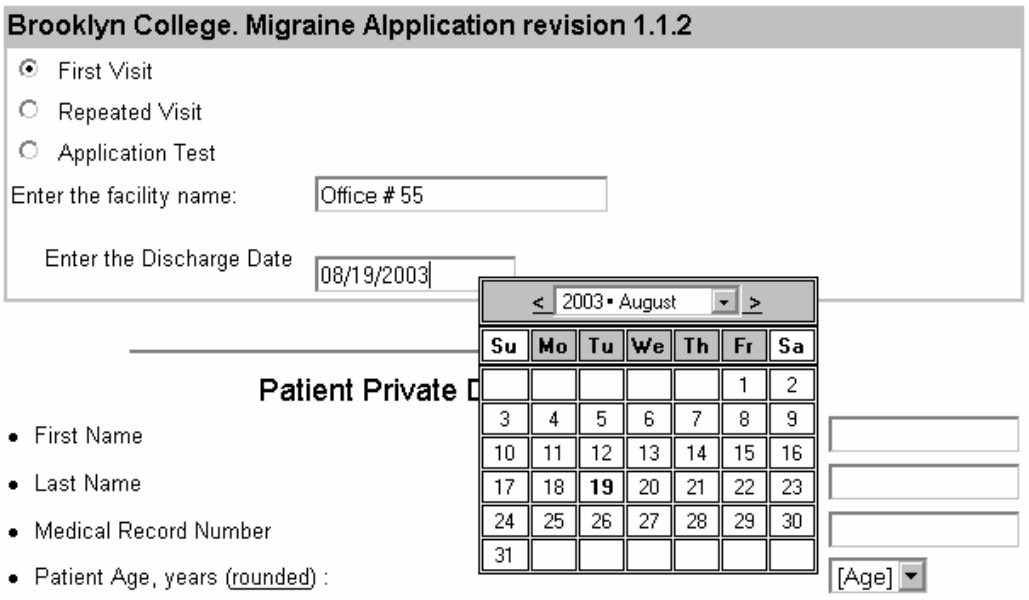
http://acc4.its.brooklyn.cuny.edu/~gshagas/migraine_rev113.html

The Migraine Data can be analyzed using Expert system tools. The enclosed proof of concept link shows the connection CLIPS-to-HTML is possible.

http://acc4.its.brooklyn.cuny.edu/~gshagas/clips.html

Java Server Pages and Applets have some advantages over CGI.

Figure 1. Migraine Application HTML Form (with Drop-down Calendar)



A Case-based Reasoner for Palliative Care

Case-based reasoning (CBR), is a proven artificial intelligence (AI) technique that has been used effectively in the medical field. Successful systems that employ CBR techniques include: CASEY (Koton, 1988), for heart failure diagnosis, FLORENCE (Bradburn and Zeleznikow, 1993), a care planner for nurses, and MEDIC (Turner, 1998) a diagnostic reasoner on the domain of pulmonology.

CBR uses an explicit database of problem solutions to address new problem-solving situations. The general rules are created by selecting expert cases. This approach can reflect the results of previous successes, while

avoiding past errors. The underlying idea is the assumption that similar cases have similar solutions. Although this may not always be true, this tenant holds true for many aspects of the medical domain.

In the medical domain two knowledge types can be found: explicit or formalized knowledge and implicit or operative knowledge (Montani and Bellazzi, 2002). The formalized knowledge is the medical information that is found in books and clinical guidelines. This type of knowledge is can be represented in taxonomies or rules. The operative knowledge consists in individual expertise, organizational practices and past cases. CBR has proved to be a well suited paradigm for managing knowledge of the operative or implicit type. This project will discuss the implementation of CBR as a problem-solving strategy for the management of patients with chronic and terminal illness.

Chronic and terminally ill patients are disproportionately affected by medical errors. Three key factors suggest that make individuals at the end of life more vulnerable to medical errors and resulting adverse events (Meyers and Lynn, 2003):

1) These patients have more frequent interactions with the health care system, including increased exposure to medication and medical procedures.
2) Errors are more harmful to the patients' health, because of their poor health status.
3) They are exposed to pervasive patterns of care that run counter to well-substantiated evidence-based practices.

A focus on improving shortcomings affecting these vulnerable patients needs to be addressed by the national research agenda . This population is most in need of safe, reliable, coordinated care. Currently, health care and community services are not organized to meet the needs of the growing population of people facing a long period of progressive illness and disability before death.

A growing number of programs have been recognized for success in improving end of life care; these programs support evidence-based practices (Lynn and Adamson, 2003). Important outcome measures of these programs include: new approaches to pain-management, advanced-care planning, palliative-care consultation, and family

support (Meyers and Lynn, 2001). These services reduce medical errors by preventing unwanted and aggressive treatments, providing disease management, improving patient safety and coordinating health care delivery.

Information systems that can support evidence-based practices have the potential to reduce medical error(s) and improve patient outcomes. These applications can also be used to facilitate the classification of medical error data, and understand the complexity of the error process. This project will explore and discuss the advantages and limitations of CBR to achieve these goals.

References

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This page was last updated July 29, 2003

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