

Possible PhD Topics

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The following list is based on a few elaborated ideas and is certainly not complete. See the research pages cited above for other ideas, including:

- policy-based management of home care, emerging from the Match project (<http://www.match-project.org.uk>)
- a service-oriented toolkit for environmental monitoring, emerging from the Sassa project
- workflows in social science, emerging from the Dames (<http://www.dames.org.uk>) and Geode projects (<http://www.geode.stir.ac.uk>).

Topic 1: Rigorous Decision Support

Motivation

The aim of this research topic is to design a generic and rigorous methodology for creating a **clinical DSS** (Decision Support System). This would be evaluated in the field of chronic heart disease. The focus would be on developing new techniques for designing technical aspects of decision support, and would be complementary to existing guidelines, models, methods, formats and tools. There is a substantial evidence showing that clinical DSS has the potential to improve practitioner performance, to reduce medical errors, and to improve patient care. The plan is to concentrate on two key aspects of clinical DSS design that need improvement: **abstractness** and **analysis**.

Context

This proposal builds on two pieces of work at Stirling. The CGT project (Clinical Guidance Tree, CSO March 2000–June 2003) involved Computing Science and Mathematics at Stirling (Richard Bland, Claire Beechey), Nursing & Midwifery at Stirling, and NHS Forth Valley. The outcome was a prototype system for helping patients to evaluate the consequences of treatments and lifestyle changes for specific medical conditions. However, the approach exhibited a lack of abstractness, analysis, practicality and flexibility. I have been working towards addressing these. I now have an initial notation for describing decision trees, and have prototype tool support for translating this into CGT representation (for exploration) and into Lotos (for analysis). See the ADIT web page for more details: <http://www.cs.stir.ac.uk/~kjt/research/adit.html>.

Requirements

There are many existing approaches to DSS, all with their own individual styles and formats. DSS developments tend to be locked into one particular approach and cannot be readily migrated to others. What are needed are abstract designs (i.e. tool-independent and format-independent) that can be automatically mapped onto particular software packages. Furthermore, when making critical decisions, as is common in healthcare, it is essential to have the highest confidence in the decision support algorithms encoded in the system. This requires three aspects to be addressed: formalisation, validation and verification.

Benefits

There are obvious potential benefits for medical practitioners (GPs, practice nurses) and for patients. The studentship would also advance knowledge in formal methods for functional

correctness of DSS (which has received very little attention, apart from some work on Markov models of decision trees).

Objectives

The research would define and evaluate a clinical DSS methodology with the following characteristics:

- **generic**: independent of particular decision support tools, and of particular diseases/conditions
- **high-level**: hiding low-level design and implementation details, but being neither too abstract nor too specific
- **usable**: by a variety of non-computing users, such as healthcare professionals and patients themselves
- **reliable**: supporting validation and verification, during DSS development and its subsequent evolution
- **safe**: capable of meeting key criteria for correctness and safety
- **proven**: shown to be useful for diseases/conditions where a reliable DSS would be valuable in general practice.

Outcomes

The concrete outcomes of this research would be:

- **methodology**: a defined way of creating clinical decision support that takes into account all stakeholder views
- **techniques**: abstract and rigorous techniques for creating, validating, verifying and implementing a clinical DSS
- **software support**: realising novel aspects of the methodology, and integrating it with major DSS approaches
- **exemplar**: a DSS for use in general practice to help in assessing those with chronic heart failure
- **strategy**: identification of key barriers and facilitators for further development and uptake of the methodology.

External Collaborators

I have good working relationships with a number of healthcare academics who would hopefully participate in this project. These contacts would allow the views of medical practitioners to be taken into account, and would provide access to patients for evaluation of the system (subject to NRES/Health Board approval).

Topic 2: Prompting for Cognitive Impairment (with Dr. Alex Gillespie, Department of Psychology)

Background

Providing care for people with cognitive impairment (e.g. dementia, brain injury and learning difficulties) is a major social and economic problem. It has been estimated that the cost of formal and informal care provision in the UK is currently £66 billion per year, and is expected to increase rapidly (Counsel + Care, 2008).

This project is a direct response to this need. It combines two complementary strengths at Stirling in a project that is appropriate for a PhD student to be jointly supervised by Computing Science and Psychology. The project will produce a technology that will empower people with cognitive impairments to live more independently, by reducing the load on their informal carers, and by reducing the need for professional care.

Dr. Gillespie has developed the GUIDE system to provide interactive verbal guidance for people with cognitive impairment. GUIDE talks users through activities of daily living (e.g. dressing, food preparation and personal hygiene) in much the same way as carers do. Although several prompting systems exist, GUIDE is unique in being the only voice-based system. This is preferable because (a) interaction with GUIDE is entirely naturalistic (there is no learning curve), and (b) other prompting systems require the user to divert their limited attention to instructions on a screen. Research funded by the CSO has provided proof of concept for GUIDE. A prototype has demonstrably increased the independence of people with dementia when preparing food and donning a prosthetic limb. GUIDE has generated considerable interest; clinicians across the UK are keen to trial the system, including the Brain Rehabilitation Trust that manages a dozen rehabilitation units. The current prototype lacks a robust and accessible front end for creating prompting protocols, and lacks an integrated means of delivering these protocols.

Prof. Turner has developed CRESS (Communication Representation Employing Systematic Specification, www.cs.stir.ac.uk/~kjt/research/cress.html) for visual design of dialogues (and other kinds of services). CRESS supports automatic translation of dialogues to scripts that use voice synthesis and recognition. CRESS is unique in this capability, and in automated validation of correct dialogue design. So far, CRESS has been used only in small telephony applications such as booking a hotel room. Application to voice-based guidance for cognitive impairment will capitalise on the foundational work of CRESS. CRESS is an ideal basis for re-designing the GUIDE software from the ground up to create a robust software platform that can be widely used.

Objectives and Deliverables

CRESS and GUIDE are naturally complementary and mutually supportive. It is proposed to synthesise the two hitherto separate projects in new research that achieves the following outcomes:

- a voice-based prompting system that can materially assist those with dementia to perform daily tasks
- a visual design tool for creating prompting dialogues in a rigorous manner
- a validation tool for checking the integrity of prompting dialogues
- evaluation of the software by people with brain injury.

Methodology

CRESS is designed for any kind of dialogue. However, this is too general for use with cognitive impairment. Instead, CRESS needs to reflect the kinds of dialogues that have been

found appropriate by GUIDE. This implies certain conversational patterns and design rules for dialogues. Although a visual dialogue editor exists for CRESS, this is not so suitable for non-technical users (such as medical specialists or carers). A new dialogue editor is therefore needed to conform to GUIDE principles. Cress is able to validate dialogues through translation to the Lotos formal language. Again, this is not appropriate for the general user. It will be necessary to devise a way of performing automatic validation using predefined dialogue design rules. CRESS currently makes use of Nuance tools for speech synthesis and recognition. However, these tools are proprietary and obsolescent. It will therefore be necessary to acquire and adapt open-source solutions that will allow the new approach to be freely used in its intended application.

Work on GUIDE is needed to determine the best way to deliver prompts. A key issue is the extent to which commands, explanations and questions should be used when prompting. Experimental research with students will develop an evidence base for how best to construct and realise prompting protocols. Once developed, the system will be trialled in the new Brain Injury Rehabilitation Trust unit (Springburn, Glasgow). A prompting protocol for using a washing machine will be developed and installed in the washing room. Clients will then receive GUIDE support via the new software platform when using the washing machine. Gathering data from the installed system in a real-world setting will allow software and design issues to be resolved and the efficacy of to be evaluated.