Assessing the POSTURE Prototype: A Late-Breaking Report on Patient Views

Paper 123

ABSTRACT

This paper describes a study which assesses a software prototype designed as part of the POSTURE project. *POSTURE (Pressure Offloading Support Technologies for Ulcer REduction)* comprises the design and development of a prototype system to help patients suffering from *Diabetic Foot Ulcer (DFU)* self-manage their treatment. The system is designed to take input from commercial wellness sensors and other sensors specially crafted for tracking aspects of foot ulcer progress. The sensor data is fed into a data-backed decision support tool which interacts with users via an intelligent agent, using a chatbot style interface, underpinned by *computational argumentation-based dialogue.* A recent *Patient and Public Involvement (PPI)* study was conducted in which DFU patients were presented with the prototype system design and offered opinions about the utility of the system from their unique perspectives. The preliminary results of this study are presented here.

KEYWORDS

Computational Argumentation, Human-Agent Interaction, Health

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1 INTRODUCTION

Ensuring patients' concordance with treatment plans (including drug regimes, physiotherapy and orthotics) is recognised worldwide as a public health challenge. Non-concordance leads to reduced efficacy of treatment and wasted healthcare resources. A 2003 WHO report claims that "in developed countries only 50% of patients who suffer from chronic diseases adhere to treatment recommendations" [10] and that increasing adherence could potentially impact population health far more than improving specific medical treatment. Reasons differ from patient to patient, and an individual patient's reasons may evolve, making it hard to develop a "one-size-fits-all" approach to improving concordance. Interventions for health-related behaviour change include: cognitive-behavioural techniques, education, integrated care, self-management interventions (e.g., reminders and diaries) and risk-communication decision aids [4]. The most common uses of technology in such interventions support and encourage self-monitoring of behaviour and goal setting, by providing feedback, information and prompts [8].

Building on advances in *artificial intelligence (AI)*, specifically in the field of *computational argumentation* [9], and on advances in data science techniques and in the amount and types of data it is possible to collect, we are developing a data-driven persuasion technology approach to improving patient concordance. Computational argumentation, a subfield of AI, offers significant potential to act as a bridge between human and machine reasoning. Argumentation allows conflicts among alternative beliefs and decision options to be explored and resolved through application of rational principles of dialectical reasoning that are familiar in human reasoning and debate. *Argumentation-based dialogue* [7] applies these intuitive principles to formalise distributed reasoning between both computational and human agents. This methodology can allow people to engage effectively with technology to perform shared reasoning and decision-making through structured interaction, where the participants construct, share, challenge and evaluate arguments. Computational argumentation-based dialogue can implement strategies for encouraging concordance: *persuasion dialogue* [2] can convince patients they should comply; *information-seeking dialogue* [11] can help patients understand data behind tracking their progress; and *inquiry dialogue* [3] can explore reasons for non-concordance. While there is a wide body of work that considers formal argumentation-based models of reasoning and of dialogue, there is limited research that considers how such models can be practically deployed to support interactions between technology and human users. In particular, models do not currently account for non-rational reasoning or decision-making (e.g., that driven by emotions) and there is little work that empirically evaluates such models with human users.

The POSTURE project examines *Diabetic Foot Ulcer (DFU)* as a case study for investigating the role of technology-centric approaches to help patients self-manage chronic conditions. Diabetic foot disease is a complication of diabetes and, if untreated, could lead to amputation. A removable brace (or "boot") is routinely prescribed to patients with DFU to reduce wound pressure and stabilise the foot so it can heal. They are advised to wear the boot all the time; however, studies have shown that only 28-66% of patients' daily steps are taken whilst wearing the boot [1, 6]. There is evidence that many patients take their boots off when at home and that they routinely underestimate the number of steps they take at home [5]. This low rate of compliance with recommended treatment provides strong incentive for this case study.

2 THE POSTURE PROTOTYPE

Figure 1 illustrates the architecture of the prototype POSTURE system. On the left side of the diagram, a range of sensors can

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provide information about a patient, including specialised sensors—to detect if the boot is being worn or not; to measure the difference in temperature between a patient's two feet (a key indicator of ulcer progress); and to determine where a patient's foot is in contact with the boot—and more generic sensors to monitor a patient's location (e.g., GPS) and track activity at home, at work and other places. The data is transmitted (yellow blocks) to a centralised database (blue block) and cleaned (green blocks) for processing by a computational argumentation-based reasoning and dialogue system (pink blocks).

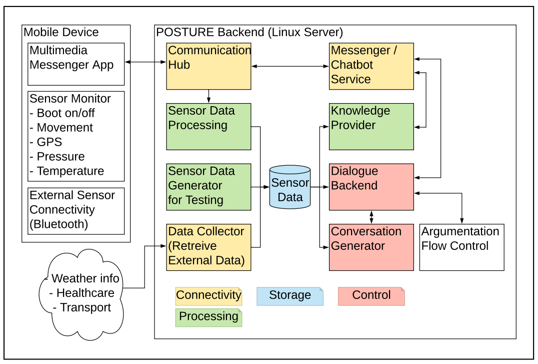

Figure 1: Architecture of the POSTURE system

The data can be shared with patients and *Health Care Professionals (HCPs)* via a tablet interface. An example is shown in Figure 2, which contains a screenshot of the POSTURE prototype that has been implemented on an Android tablet and was presented to users as part of the PPI study conducted in September 2018 (described below). The left side of the screen contains a dashboard where users can examine data graphically. The coloured bar chart indicates the numbers of steps the example patient took in different locations, while wearing the boot (and not wearing it). The line chart above it indicates the difference in temperature between the patient's two feet; the decrease over time is a good sign. This patient is fairly compliant and wears their boot more than not, and the data easily confirms that progress with healing is positive.

Figure 2: Example screenshot of POSTURE prototype

3 THE PPI STUDY

In September 2018, we conducted a small *Patient and Public Involvement (PPI)* study with DFU patients and HCPs. Participants were presented with the prototype system (Figure 2) and offered opinions about the utility of the system from their unique perspectives. Ten subjects participated in the study (6 patients and 4 HCPs), in conjunction with a regular DFU clinic held weekly in a local hospital. Conversations were held opportunistically in the waiting area of the clinic, and patients volunteered to participate. Participants were shown the tablet containing synthetic data for a fictitious patient named "Peter". They were allowed to interact with the interface and were asked a number of questions to gauge their reactions to the idea of such a system, as well as this particular prototype.

Overall, responses were extremely favourable. The HCPs were very excited by the prospect of being able to know more about what happens to patients outside of the hospital and in between visits. They pointed out that they would very much like to be able to see the data collected, even if their patients are less interested in looking at the details of their data. Getting notifications about important changes in condition would be useful, since some aspects of diabetic foot disease can progress quickly. The HCPs commented that many diabetic patients have eye trouble, so having a voice-operated system could be beneficial.

Patients reported that they liked the "chat" aspect of the design and preferred having the chatbot over just looking at graphs. Several patients commented that the size and colours of the text should be adjustable (e.g., to make it larger or higher contrast), due to vision or other problems (e.g., dyslexia). Some indicated that a speech-enabled interface would be helpful. One patient indicated that he did not need reminders to wear the boot, whereas others thought reminders would be helpful. Multiple patients stated that it is very difficult to fit the boot properly. This was confirmed by the HCPs. So the concept of a boot that contained sensors to indicate the accuracy of fit was welcomed. One patient commented on the "peace of mind" that the system would give him, not only to ensure that he was wearing the boot enough, but also to catch important changes in his condition. All the patients were happy with the notion of collecting the data regularly and sharing it with their healthcare team.

4 SUMMARY

The results of this study are extremely positive. The purpose of the study was to gather preliminary feedback from prospective users of the prototype system in order to confirm that the concept has potential for practical application and would be well-received by patients and health care professionals. Current work involves completing the prototype system by connecting it to physical sensors (in place of synthetic data). Future steps include plans for a controlled study with patients over an extended period of time.

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