DYNAMICALLY PROGRAMMABLE M-PSYCHIATRY SYSTEM FOR SELF-MANAGEMENT OF BIPOLAR DISORDER

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Abstract – A rule-oriented approach to programming mobile psychiatric monitoring systems was designed. Initial simulations of rule processing have tested system personalisation issues and reviewed characteristics of the rule-oriented approach including the degree of task expressiveness and ease of expressing domain knowledge. A technical trial is being prepared to analyse the approach in a non-simulated environment.

I. INTRODUCTION

The Personalised Ambient Monitoring (PAM) project is investigating the feasibility of reducing the incidence of debilitating episodes of Bipolar Disorder (BD) by monitoring activity signatures using mobile and environmental sensors. Monitoring activity signatures may detect changes in patient mental health and alert sufferers and their care providers early enough to maintain eurythmia.

System personalisation is a core issue for PAM since activity signatures differ amongst patients and can change over the course of patient lifetime. The types of sensors used, and their patterns of usage, must be personalised in order to match patient states and be accepted by users. System personalisation requires a dynamic and flexible programming method but it must also be easy to program, represent domain information and above all result in correct system behaviour.

This paper discusses the developement and initial assessment of a rule-oriented approach to personalise PAM technology called PAM-A. The research extends other work on rules-based sensor network programming by using rules to turn a mobile phone into a mobile sensor network gateway. We used a simulated scenario to test whether this approach could simplify programming, make proving program correctness easier, and remain highly expressive, as is asserted for other forms of rules-oriented sensor networks in [2]-[3].

II. METHODS

A mobile phone-based healthcare platform was designed and tested against a scenario to review domain knowledge expressiveness, programming simplification and program correctness.

A. Platform Description

The Personalised Ambient Monitoring Infrastructure (PAM-I) is a wireless network comprising wearable sensors, mobile phones and in-home sensors. Data is enhanced with patient-recorded answers to mood and activity questionnaires.

Custom Java-based middleware called the Personalised Ambient Monitoring Architecture (PAM-A) was developed to program PAM-I devices by handling inter-device network connections, controlling data streaming frequencies, recording streamed data to persistent storage and transferring data offsite for long term storage and analysis. PAM-A stores connection and frequency settings, along with questionnaire results in a knowledgebase. It uses a Java-based implementation of Prolog for mobile devices as a rule engine to control monitoring [1]. Settings are processed by the rule engine and used to personalise the system. Figure 1 depicts PAM-I and PAM-A.

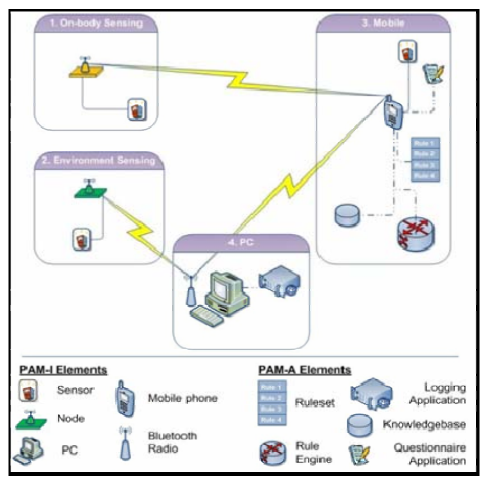

Figure 1. Graphical view of PAM-I and PAM-A

B. Scenario Test

The degree to which the rule-oriented programming model of PAM-A could easily and correctly express a common BD case was examined by simulating characteristics of the system using a scenario we called "Manic Phoning". The scenario identified increased talkativeness by monitoring the mobile phone call log and dynamically reacting to changes with appropriate notifications. It was chosen to illustrate a series of interactions between identified actors and exclusively concentrated on the phone software, thereby testing the programming model without regard to hardware concerns. The scenario was motivated by research into changes in BD patient talkativeness [4].

The PAM-A software and rules were tested with Symbian s60 (3rd ed.) mobile phone emulator. To test the scenario, its description was encoded as Prolog facts and rules, and actions were coded as first-class objects in Java. The rules and objects were dynamically loaded into the device mediator at runtime.

III. RESULTS

The test environment successfully simulated making phone calls and sending appropriate warning notifications. The program simulated accessing the mobile phone call log a number of times and tried to detect the prodrome "talkativeness". The ruleset described actions to check call frequency and duration after each call was made. The maximum call per day threshold and maximum call length threshold were easily personalised to match the scenario description. The prodrome "talkativeness" was registered when the thresholds were exceeded and personalised warning text messages were sent at the expected times. When messages were sent, the knowledgebase was dynamically updated with the time the message was sent to prevent multiple notifications per day.

IV. DISCUSSION

The system simulator met its goal of monitoring aspects of patient behaviour using a mobile rule engine to respond correctly to changes in user behaviour. However, the programming approach was not as simple to use as originally envisioned due to complex interrelationships between the ruleset and the action objects. Writing valid Prolog rulesets to declare the domain knowledge was relatively easy as was programming the Java action objects, yet, the success of the program was founded on a working knowledge of both languages and views into how the rules and actions interacted. Future work is required to simplify the process to allow domain experts to describe expected usage patterns resulting in valid and complete rulesets.

Work is now underway to test PAM-A in a live environment using real sensors and mobile phones during a technical trial. The trial will be used: to evaluate component integration and system acceptability, to assess reliability issues, to determine the feasibility of capturing behaviour unobtrusively and to investigate whether the recorded data can be used to inform an operational research model.

PAM-A is being used to personalise wearable and environmental sensor data for the trial. Rules on phones are used to access built-in sensors such as GPS receivers and questionnaire applications, and control data collection rates of wearable sensors to balance power issues with the need for complete sets of data. They are also being used to personalise mobile phones and wearable/environmental sensors to make sure that the devices selected for monitoring, and their monitoring patterns are acceptable to subjects. We hope to show that rules can be used to auto-configure the monitoring to match patient preferences. For instance if sleep monitoring was desired but a patient objected to placing a sensor in bed, rules could be used to configure other environmental sensors such as PIR sensors to attempt to monitor for nightly activity.

V. CONCLUSION

The PAM m-psychiatry healthcare information system was designed to monitor activity signatures of the mentally ill, with the hope of reducing manic and depressive episodes. To deal with inherent system personalisation issues, the PAM team have developed a novel dynamic sensor network middleware integrating logic rules and first-class action objects. Initial simulations of the system have shown promising results. A technical trial is being prepared to analyse system acceptability and reliability.

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