Agent Based Monitoring of Gestational Diabetes Mellitus (Demonstration)

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ABSTRACT

Gestational diabetes is a type of diabetes affecting temporarily some otherwise healthy pregnant women. Current medical practices do not allow the doctors to monitor such patients as closely as needed. Pervasive Health is a discipline requiring distributed ICT infrastructures to help bridging the gap between the patients and the doctors. In this demo paper we present a complete information system for patient monitoring, including mobile devices for acquiring data from patients and a Web interface for doctors to check the status of their patients. At the core of this information system a multi-agent system monitors the patient health state and triggers alerts to the doctor to raise attention on the specific conditions of a patient. This allows the doctor to react faster to changes of condition of the woman, benefiting the baby's and the mother's health.

Categories and Subject Descriptors

J.3 [**Computer Applications**]: Life and Medical Science; I.2.11 [**Artificial Intelligence**]: Distributed Artificial Intelligence

General Terms

Management, Measurement,Experimentation

Keywords

Intelligent Agents, Pervasive Health, Gestational Diabetes

1. INTRODUCTION

Gestational diabetes mellitus (GDM) [5] affects 2%-5% of all pregnancies and manifests itself with high blood sugar levels. A GDM patient has a higher risk to develop preeclampsia, which can lead to eclampsia, a condition causing the woman to have epileptic seizures and coma, or her baby may develop macrosomia, a condition for which the baby grows too much due to the extra glucose absorbed. Current treatment consists in diet adjustment and introduction of anti-diabetic drugs such as insulin and metformin. The treatment starts by requesting the patient to self-monitor and note down their blood glucose 4 times per day and their blood pressure twice per day. The notebook with the physiological values is then handed to the medical doctors and nurses once or twice per week. The caretakers then propose treatment adjustments according to the patient's status. The problem is that in the two or three days in-between routine checks the patient may develop preeclampsia, eclampsia, or her baby may develop macrosomia [1]. Consequently, a closer monitoring would allow the caretaker to react quickly, preventing damage to the baby's and the mother's health.

For this purpose, Pervasive Health [6] is an approach that aims at bringing healthcare to everyone everywhere, by breaking the boundaries of hospital care, allowing the patients to be monitored during their day-to-day activities. Current Pervasive Health Systems (PHS) have the problem to deal with large amount of data produced by the patients, consequently medical doctors are often loaded with a lot of information on which it is difficult to react promptly, limiting the PHS effectiveness. We have developed the Gestational Diabetes Mellitus Management System (GDMMS), a PHS to handle patient monitoring and react fast on the development of dangerous conditions. We have integrated a multi-agent system (MAS) where we engineered the medical knowledge to reason about the patients' conditions. Each patient has a monitoring agent. If an agent detects a possible harmful condition it creates an alert to notify the doctor in charge. In [2] we described parts of the MAS to handle the monitoring of GDM affected patients by using Event Calculus [4] based agents with abductive logic capabilities. Currently, we are preparing a field test of the entire system at the Lausanne university hospital where patients enter their values using a mobile application, and doctors have a Web interface to interact with the system. We present the usage of the entire system, including smart phones and server infrastructure to monitor GDM patients, by showing how the interaction between its components happens. In particular we will show how our agents produce alerts for medical doctors and nurses, given an anomalous temporal pattern in the patients' physiological data.

2. THE GESTATIONAL DIABETES MELLITUS MANAGEMENT SYSTEM

The GDMMS is at a first glance a conventional information system. Data is entered by users, here most typically via a specific application that runs on Android smart phones, a server back end to store the data, and a web interface to display this information in different ways to the responsible caretakers. The overall architecture is shown in Figure 1.

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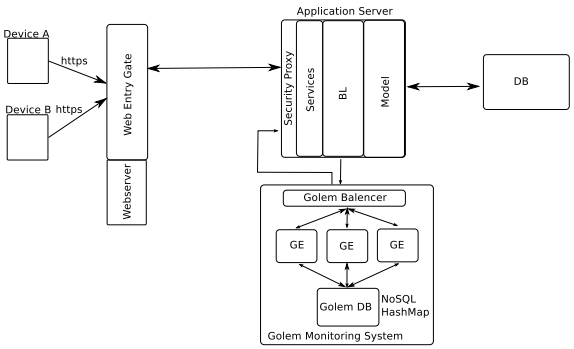

Figure 1: Overall architecture of the GDMMS

The Mobile Infrastructure.

Even though measuring devices for blood-pressure or blood-sugar exist that can transmit data by themselves, we developed an independent Android application. We did so because these newer types of sensors are not accredited for usage in the hospital we collaborate with. Therefore the woman enters her physiological values into a specific applications we have developed. Note that our server-side system offers a REST interface, and therefore is not limited to the usage with this specific application.

The Web Interface.

Our server side system is based on REST interfaces and *Java Persistence API* to handle the data produced within the interaction with the patients and the doctors. Our Web interface is built around *Google Web Toolkit* technology. By means of such interfaces, the doctors have access to the patients' health status, the patients' alerts, and the data associated to the patients. Patients' alerts are also associated to her physiological values and, by clicking on the alert, the doctor can get a summary of the patient's physiological values as associated to the alert of interest. Finally, the Web interface shows to the caretakers the patient's historical values (ethnicity, previous illnesses, age, allergies) and the medicines taken and the contact data of the patient, in the case an alert requires the prompt intervention of the caretaker, such as in the case of preeclampsia.

The Persistent Personal Agent System.

As mentioned before we have added a MAS to the server side that can analyze the patients data and monitor their condition. This MAS is based on the GOLEM platform [3]. The agents are executed within distributed containers that deal with the agents' life-cycles. Our MAS is regulated by a load balancer which splits the traffic generated by the patients in distributed GOLEM containers. The agents are treated as persistent resources associated to a patient, every time a patient logs into the system the agent state is resumed from an agent database. Similarly, when the patient logs off or it's session expires, the GOLEM container serializes and saves the agents in the agent database for future use. This allows us to handle a large number of patients, since the number of active agents is reduced. In particular our agent mind is based on deductive rules using the Event Calculus, to produce treatment adjustment alerts, and on abductive logic rules, to produce macrosomia and preeclampsia alerts.

3. THE DEMONSTRATION

We present the complete system in live operation. We show the components, their interaction, and a live demo. Therefore we present three concrete scenarios, with synthetic patient data. In the first scenario we consider a patient that is experiencing a poor glycemic control, requiring a set of actions to be implemented by the medical doctors to adjust her treatment by introducing further glucose checks or more insulin during the day. In the second scenario we demonstrate the abductive logic capabilities of our agents by showing how preeclampsia alerts are produced when the patient presents a set of symptoms related to preeclampsia or when the patient presents a high blood pressure related to a protenuria confirmed by the medical doctors. In the third scenario, we consider a patient that is towards the end of the pregnancy, has poor glycemic control and is gaining too much weight. Under this condition, our agents produce an alert of macrosomia as the weight gain may be an indicator of the fact that the baby is growing too much.

4. CONCLUSIONS

The GDMMS system will go live in a field test that is performed with the university hospital Lausanne. In a first phase we will collect feedback form patients and doctors to adopt the systems to their needs. Afterwards, we will enter a second field-test with a larger number of patients to measure the effects of the usage of PHSs from the medical perspective. So we see that the GDMMS system will have a strong foundation and will hopefully improve the care for pregnant women and their babies. Furthermore ideas and components, among them the MAS, will be applied to other illnesses in a EU project that has just started.

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