

A Model and Prototype for Using Intelligent Software Agents to Monitor Patient Adherence to a Medication Regimen

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Background: Reported percentages of patient non-adherence to prescribed medication regimens vary between 35% and 90%. Electronic medical records that contain the treatment plan and systems that allow Internet communication between patient and provider can be coupled to capture input about adherence to prescribed treatments and to monitor and evaluate compliance continuously. These systems can even inform the provider when the prescribed regimen is not being followed, or when indicators of a poor outcome appear, thus allowing the provider to intervene. However, this level of sophistication requires intelligent software agents that can "reason" about the data and respond appropriately. These agents can be configured to perform many such tasks in the interface where the patient and clinician interact. We previously developed a software infrastructure that uses the Internet to provide a lifelong, individual health record and that supports secure electronic messaging among caregivers, patients, and physicians. This is implemented in HealthCompass, currently in field tests at Celebration Health in Orlando, Florida. To enhance this system, we analyzed the tasks intelligent software agents might perform on behalf of the physician, the patient, and the caregiver.

Methods: As a model for analysis we selected Type 2 Diabetes Mellitus because it is a common, difficult-to-manage chronic illness for which detailed clinical practice guidelines are available from the American Diabetes Association. We analyzed the different monitoring scenarios in the guidelines with object-oriented techniques. The result guided the architectural design for a system of intelligent agents, which continuously monitor the patient's adherence to a medication regimen. An additional set of agents acts on data input into a patient's health record and sends e-mail notifications to the physician and patient caregiver. Using the HealthCompass software to supply the database, record storage, and Internet communications, a prototype system was built that uses the treatment plan contained in the database to control the activities of the agents. To determine whether the agents performed according to the model, we then subjected the prototype to a functional evaluation by creating exemplar patients and post-treatment scenarios with different levels of compliance.

Results: Our initial analysis identified five categories of agents useful in monitoring patient compliance with a medication regimen. Our analysis provided detailed analytical models for two medication compliance scenarios: (1) Was the prescription filled? (2) Was the dosage taken appropriately? In the resulting prototype, agents monitor three different compliance activities: prescription compliance, dosage compliance, and change of medication. Additional agents monitor the patient's progress according to the treatment plan specified. If the patient deviates from the plan, the agents follow specified criteria and send email messages either to the patient, the caregiver, or the physician.

Conclusions: We modeled one aspect of the interactions required to manage a chronic illness and built a software prototype that uses intelligent agents to monitor patient adherence to a medication regimen and notify the primary caregiver and attending clinician of compliance problems. Our model analysis and prototype demonstrate that (1) agents can be configured to perform monitoring activities specified in clinical guidelines, (2) agents could effectively perform the tasks defined in our analysis, and (3) A lifelong health record can be used as a repository to support personalized continuous compliance monitoring with agents. The next steps are to extend the agents' capabilities and to model other disease settings. Ultimately, the clinical impact of monitoring by agents on patient outcomes will need to be measured.