An Ambient Intelligent Agent for Relapse and Recurrence Monitoring in Unipolar Depression

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Abstract: Mental healthcare is a prospective area for applying AI techniques. For example, a computerized system could support individuals with a history of depression in maintaining their well-being throughout their lifetime. In this paper, the design of an ambient intelligent agent to support these individuals is presented. It incorporates an analysis and support model for diagnostics based on observed features and for suggested actions. The model used is based on dynamic relations that describe the occurrence of relapse in unipolar depression. By incorporating this model into an ambient agent system, the agent is able to reason about the state of the human and the effect of possible actions. Several simulation experiments have been conducted to illustrate the functioning of the proposed model in different scenarios.

Keywords: Ambient Agent Modeling, Relapse in Unipolar Depression, Temporal Dynamics, Decision Support Systems

1 Introduction

In many cases, depression is a recurring condition; a subsequent depressive episode is called a relapse or recurrence. In principle, the depressive relapse stage can be defined as "episode of major depressive disorder that occurs within six months after either response or remission (no longer meeting the depression criteria)", while, recurrence is a depressive episode occurs after six months have elapsed [3]. Several related works on depression relapse suggested that at least 50 percent of patients who recover from an initial episode of depression would experience at least one subsequent depressive episode throughout their lifetime [4]. Before a relapse happens, there might be changes in the usual symptoms of the illness, or changes in behaviour, thoughts or feelings. Therefore, the earlier those symptoms can be identified, the better chance there is of stopping a relapse / recurrence or reducing the severity of it. To envisage this possibility, there are several conditions to be evaluated, namely; (1) the *neuroticism* of a patient (exaggerating ordinary situations as threatening), (2) the *immunity* against negative feelings (which can be low because of residual symptoms and a history with onset), (3) *lack of social support* (disengagement from social

interactions), (4) the *assertiveness* (if it is low, it results in a lack of self esteem and poor control over anger), and (5) *avoidance coping* (a tendency to solve a problem by avoiding it, which can be signalled by e.g. substance abuse) [3][4]. Essentially, stressful events are one of the most dominant factors that will trigger relapse or recurrence. These events may cause from trauma, grief, pressure, or even from typical daily hassles (such as traffic congestion). Based on the factors described above, a domain model for the occurrence of relapse or recurrence of a depression has been developed [1]. The simulation results have shown the model exhibits important patterns between the events and the course of relapse and recurrence.

In the past, intelligent agent technology has become an important means for increasing decision-making ability and communication. With the advent of wearable devices, and mobile applications, new ways are created for agents to interact, and react about human related information gathered from sensors. Such kind of agents, known as intelligent ambient agents, will be able to contribute to the development of personal care and human wellbeing applications by harnessing vital information from human itself [6]. In this paper, an intelligent ambient agent is presented that could support people that have recovered from a depression to maintain a healthy state, using the domain model for relapse or recurrence of a depression described above.

The remainder of the paper is organized as follows. Section 2 provides the main design of the model. Later, simulation results for selected observable features using the model are illustrated and described in Section 3. Finally, Section 4 concludes the paper.

2 Modelling Approach

The key contribution of this paper is the design of an ambient agent to support people recovered from a depression. In order to achieve this, an approach has been followed in which the domain model for depression functions as starting point for the model that describes the functioning of the ambient agent. Thus, by integrating the domain model, the ambient agent will be able to reason about the processes and its environment. It is obviously important to have such capabilities, since an ambient agent should be aware of human behaviours and states. Through this mechanism, the agent will use this knowledge to provide related actions related to the predicted state of the human and the environment. Figure 1 presents the overview of the integrated model.

The functioning of the ambient agent can be largely described by three components: an analysis, a belief base, and a support model. For the detailed design,

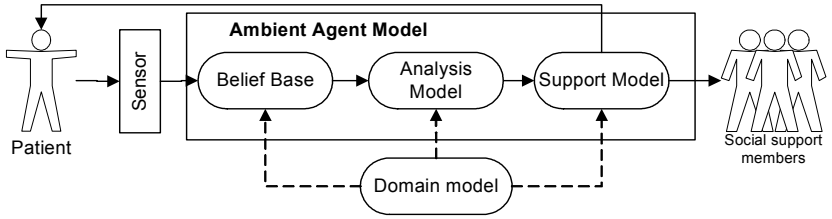


Fig.1 Overview of the Integrated Model

see (http://www.few.vu.nl/~mraaziz/AIME09/AIME2009-model.pdf). In general, the ambient agent interacts with a patient through a set of non-obtrusive ambient devices (i.e.; medicine box that registers medication intake (MEMS), a passive alcohol sensor, a mobile phone/ personal digital assistant (PDA), and a blood volume pressure sensor) [5][7]. This model is developed using a temporal specification language called LEADSTO. Consider the format of $\alpha \rightarrow\!\!\!\!\rightarrow_{e,f,g,h} \beta$, where α and β are state properties in form of a conjunction of atoms (conjunction of literals) or negations of atoms, and *e,f,g,h* represents non-negative real numbers, then it can be interpreted as follows [2];

> If state property α holds for a certain time interval with duration *g,* after some delay (between *e* and *f*), state property β will hold a certain time interval of length *h*.

To specify properties on dynamics relationship, the ontology of the model is designed using predicate calculus. The detailed ontology of the model can be found at (http://www.few.vu.nl/~mraaziz/AIME09/ontology.pdf). Using this pre-determined ontology, the Belief-Desire-Intention (BDI) approach regulates action selection process (internal processing) [6]. The temporal rules of an ambient agent have been specified using the ontology. To utilize the specification, a forward method for belief generation is used. It allows the time sequence and causality, to generated new belief from previous properties. The ambient agent functionality is described by three actions; belief generation in belief base, evaluation of risk, and action selection for the support. Below are several related specifications for social withdrawal case.

BB4: Generating basic belief on phone/PDA usage

When the ambient agent observes there is no phone/PDA usage, then the agent will believe that a patient is not using phone/PDA to communicate with the others.

observed(agent, phone_usage(negative)) → belief(agent, phone_usage(negative))

DB5: Derived belief on social support from the phone usage belief

If the ambient agent believes that there is no phone usage then the agent will believe there is no social interaction between social support network members.

belief(agent, phone_usage(negative)) → belief(agent, social_support(negative))

GE2: Evaluation on social withdrawal condition

If it is believed that patient is not interacting with any social network support members, and having difficulty to control anger and it is believed that patient is vulnerable for the future onset then the agent will conclude that the condition of the patient is having social withdrawal.

belief(agent, social_support(negative)) ∧ belief(agent, assertiveness(low)) ∧ belief(agent, immunity(low)) → assessment(agent, social_interaction(low))

PCB2: Predicting the risk of relapse from social withdrawal condition

If the patient is having social withdrawal then the ambient agent will assess the patient as having potential risk of relapse.

assessment(agent, social_interaction(low)) → prediction(agent, stage(risk_relapse, positive))

BOR: Belief on relapse

When the ambient agent predicts the patient is having a risk in relapse, then the ambient agent will believe the patient is in the risk of relapse.

prediction(agent, stage(risk_relapse, positive)) → belief(agent, stage(risk_relapse, positive))

ANR1: Action to notify social support networks

When the ambient agent believes the patient in the risk of relapse then the ambient agent will notify all friends and family within the social support network.

belief(agent, stage(risk_relapse, positive)) →
performed(agent, notify(risk_relapse, friends_family))

ANR2: Action to notify the patient

When the ambient agent believes the patient in the risk of relapse then the ambient agent will notify the patient.

belief(agent, stage(risk_relapse, positive)) → performed(agent, notify(risk_relapse, patient))

DSI: Desire to improve social interaction

If the ambient agent assesses the patient is having social withdrawal then the ambient agent will desire to improve patient's social interaction by advising the patient about suitable social activities.

assessment(agent, social_interaction(low)) ∧ desire(agent, reduced(risk_relapse))
→ desire(agent, improved(social _activities))

ISIA: Intention to advice on social interaction

When the ambient agent desires to improve patient's social interaction through social activities and ambient agent believes there is no social interaction between a patient and social support network members, then ambient agent will have an intention to advice patient on suitable social activities.

desire(agent, improved(social _activities)) ∧ belief(agent, social_support(negative))
→ intention(agent , advice(social_activities))

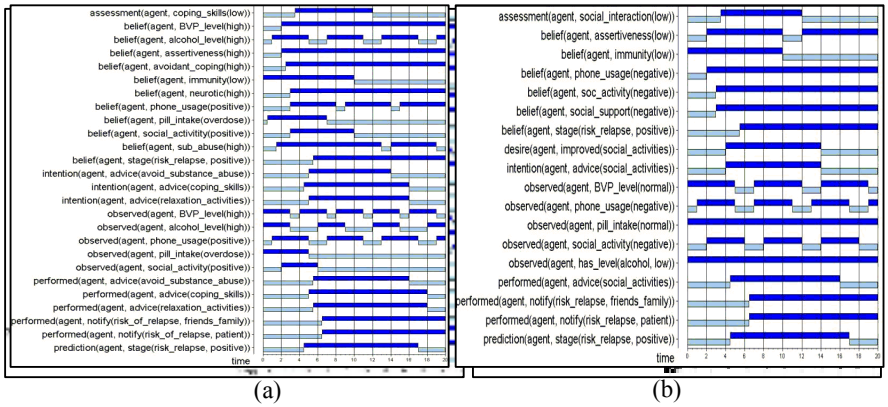
ASIA: Action to advice on social interaction activities

When the ambient agent intends to advice the patient regarding to social activities to the patient, then the ambient agent will advice the patient about those social activities.

intention(agent , advice(social_activities)) → performed(agent , advice(social_ activities))

3 Simulation Results

This section describes the simulation results for two scenarios in which the ambient agent monitors the risk on relapse and provides support by illustrating the functioning of the analysis and support model in the agent. In the figures below, time is shown on the horizontal axis, and the state properties are on the vertical axis; a dark box indicates that a state property is true.



(a) (b)

Fig.2. Simulation traces (a) coping skills deficiencies (b) social withdrawal

Fig.2 (a) depicts a scenario where the ambient agent observes no activities in social interaction, a low assertiveness, and concludes that the patient is highly vulnerable to future onset. The patient is strongly advised to initiate social interaction with others. People within the social support network will be notified by an ambient agent. While in Fig, 2(b), the ambient agent observes a high blood volume pressure, high alcohol

level, and an overdose pill intake. Based on this, the agent assesses that the person is having a risk of relapse, and that this is related to coping skills problem. Therefore, the desires to give advice to improve coping skills, to reduce anxiety and to eliminate substance abuse are translated into intentions to do so, as the beliefs about the conditions are true.

4 Conclusion

In this paper, an ambient agent model was presented for automated relapse and recurrence monitoring, developed using a modelling approach in which the domain model of a process (in our case depression recurrence) forms the basis for the functional model of the agent. By compiling knowledge from the domain model into the agent model, the agent is able to reason about the state of the patient. Thus, it is capable to predict the risk of relapse based on several observable features and beliefs. The proposed model is heavily inspired by scientific findings about the relapse and recurrence. The model has been specified using a formal modelling approach, which enables a qualitative specification. The ambient agent model has been applied to several scenarios in a simulation environment. The presented model provides a basic design on how an ambient model can be used to monitor patient in a risk of relapse and recurrence in unipolar depression. Apart from a more thorough evaluation of the proposed system, future work will focus on generalizing the proposed model to a generic model for risk assessment and support in other domains.

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