Ambient Intelligence for Monitoring Depression

Philip A. Coler
University of Minnesota, Morris
600 E. 4th St.
Morris, MN 56267
coler013@umn.edu

ABSTRACT

This paper discusses how ambient intelligence can be used to treat depression and monitor for relapses. All over the world people are suffering from depression. There are many ways to take care of and treat depression. Keeping track of all the symptoms is not an easy task for one person to do over a long period of time. This is where an ambient intelligent agent comes into play. This paper covers some information on stress as a common precursor to depression, and depression and how ambient intelligence can be used to help manage both of these conditions. This ambient intelligent agent can be the tool that monitors the patient and notifies the necessary people if there are signs that a relapse may occur.

Categories and Subject Descriptors

H.5.2 [**Information Interfaces and Presentation**]: User Interfaces; I.2.1 [**Artificial Intelligence**]: Applications and Expert Systems—*Medicine and Science*; J.3 [**Life and Medical Sciences**]: [Health]

General Terms

Theory, Human Factors

Keywords

Ambient intelligence, multi-agent model, ambient agent model, stress, depression, monitoring, agent

1. INTRODUCTION

In many medical fields monitoring is an important aspect of everyday work. When it comes to monitoring medical conditions, doing so over a long period of time can be very difficult. Some cases can be monitored continuously because the patient is stationed in a hospital where doctors and nurses are constantly there. In the case of depression it is not so easy because many people suffering from depression are not

required to stay in a hospital. Patients that have learned to control their depression are able to live at home and go on with their everyday lives. These people may control their depression by use of antidepressants and a network of helpers. A concern however is that a patient could potentially relapse. Relapses can be avoided more often with constant monitoring of the patient's everyday actions, however not many patients suffering from depression have the resources to have someone monitoring them everyday. That kind of monitoring also takes quite a bit of time that providers cannot give. This is where an ambient intelligent agent comes into play.

Another condition that can be monitored by an ambient intelligent agent is stress. Stress can lead to many negative outcomes and may even lead to depression. Stress is a large enough contributor to depression that it may need to be monitored as much as depression is. Section 1.2 states the background information on stress. Following that, Section 2 describes an ambient agent designed to monitor stress.

Following this introduction, background information on ambient intelligence will be covered in Section 1.1 The definition and symptoms of depression will be covered in Section 1.3. The relationship between ambient intelligence and depression is covered in Section 3.

1.1 Ambient Intelligence

Ambient intelligence can be defined as one of a few research fields focusing on how to support humans in everyday activities [4]. Ambient intelligent environments are places that interact with humans and monitor them in their everyday lives to support them. An ambient intelligent agent monitors what is required for a person to go about their daily tasks. Using the observations from monitoring the person the ambient agent can set itself up to help with their everyday tasks. As an example assume a person has a house with everything attached to a computer and everything in this house can be automated.

Let us say that every day a person gets up, makes a pot of coffee, and takes a shower. An ambient intelligent house would take in these observations and start up the coffee maker right before the owner wakes up and turn on the shower when the owner enters the bathroom. Other things an ambient agent can take in are the experiences of the user. The experiential factors can be represented by the internal states of the user [5]. The experiential factors are one way that ambient intelligence relates to stress and depression. Other general uses for ambient intelligence are RFID, Biometrics, and Nanotechnology.
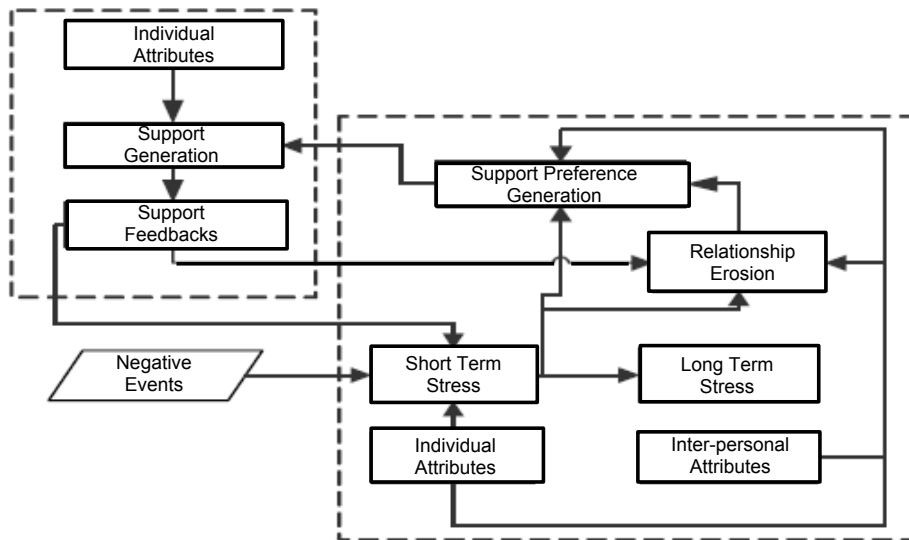
Figure 1: Mult-Agent Model [1]. This model explains the relationship between a patient's support groups and the patient.

1.2 Background on Stress

Stress can be defined as *"a state resulting from a stress; especially: one of bodily or mental tension resulting from factors that tend to alter an existent equilibrium"* [7]. Stress can be caused by personal problems, social issues, and job issues [9]. People with certain kinds of personalities can have different kinds of support systems. People with neurotic personalities have been found to have a negative correlation between social support and social engagement which means that people who have little social engagement tend to have less social support. People with a more assertive personalities tend to receive more support [1].

1.3 Background on Depression

Depression, can be defined as *"a psychoneurotic or psychotic disorder marked especially by sadness, inactivity, difficulty in thinking and concentration, a significant increase or decrease in appetite and time spent sleeping, feelings of dejection and hopelessness, and sometimes suicidal tendencies"* [6]. Some common causes of depression are genetics, abuse, death or loss of a loved one, and substance abuse [8].

A constant worry when it comes to the treatment of depression is the occurrence of a relapse, where a person suffering from depression has been treated, but later falls back to either their original state of depression or a worse state. When it comes to depression a patient does not just get rid of it after a bit of treatment. It is an ongoing battle to fight off the symptoms and possible relapses. A relapse is bad because reverting back to the original depressed state can cause the patient to have to start over with treatment. Starting over can mean more financial burden or even a higher level of depression.

2. AMBIENT INTELLIGENCE AND STRESS

One of the biggest factors in monitoring depression is monitoring stress. Stress can lead to depression and in cases of patients suffering from depression, stress can lead to relapse.

There are some signs to be aware of but first a person suffering from stress needs to know exactly what they are dealing with.

2.1 The Multi-Agent Model

The multi-agent model, pictured in Figure 1, is split up into two sides, the support provision and the support receipt. An agent is the system that is doing any of the monitoring and notifying of conditions. The support provision side is where the support supplied to a person suffering from stress is determined. The support provision side takes in the individual attributes of the person dealing with stress, it generates the support, and has support feedbacks. On the support receipt side the person suffering from stress helps determine how much and what kind of support they need. The support receipt side is where the individual attributes of the person dealing with the stress and the inter-personal attributes are. The inter-personal attributes are those between the person suffering from stress and their social provision or social group [1].

Walking through the Multi-Agent Model, a person who could potentially suffer from stress has a negative event happen which leads to short term stress. Either the stress can get to them and become longer term stress or relationship erosion. Alternatively, the person may take steps to prevent negative outcomes by generating support preferences. Let us say that the person suffering from stress starts to have issues with their relationships. They notice this and generate a preference for support. After that point in the model the support generation occurs.

At first glance the model may seem cyclical, meaning the person would just go back to the short term stress after support feedbacks. The connections here are just interactions that could potentially happen after the negative event. The multi-agent model does not have a route after a person reaches long term stress. The reasoning behind that is because long term stress is what the person wants to prevent
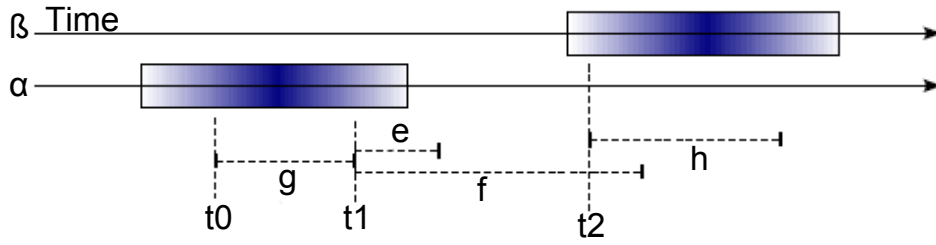
Figure 2: Leadsto Timing Relationships [3]. This graph shows how the different states relate over time.

and there is no need to go beyond that. As stress can be used to describe a smaller portion of depression so can this model be used to describe a portion of the ambient intelligent model.

3. AMBIENT INTELLIGENCE AND DEPRESSION

An ambient agent with several sensors placed throughout the house of a person battling depression can be used to measure different variables. The variables mentioned are assigned different kinds of measurements which are shown in Table 1. Measurements of LEVEL can be assigned to a variable like alcohol intake where the ambient agent needs to know the amount of consumption whether it be low, medium, or high. TYPE can be assigned to a variable such as phone usage where positive usage would be to call a friend and negative usage would be to order large amounts of a product from a television advertisement. FREQ_LEVEL could align with medication intake where a patient is required to take a certain number of pills at a certain frequency. If the pill intake goes below normal FREQ_LEVEL is changed to not_taken and if the patient starts to take too much medication the FREQ_LEVEL is changed to overdose [2].

TASK is one of the items on the table that is not a measurement. TASK is a variable that can be given to either the patient or the people that make up the patient's support system. The element meet_doctor_therapist can be given to the patient so that they know to meet with their doctor because something has gone wrong. This brings us to the ROLE type which is comprised of elements that are assigned to the different people involved in the ambient agent. The roles are assigned accordingly. The patient is assigned the ROLE of patient, friends and family are assigned friends_family, and the doctor and/or therapist is assigned doctor_therapist. The fact that friends are grouped with family and doctor is grouped with therapist is because when it comes to depression and many other medical conditions all of the parties involved need to be notified. COND covers the status of the patient. The patient can either be healthy, suffering from anxiety, or at risk of relapse [2].

3.1 Ambient Agent Model

Following the model in Figure 3, those measurements and observations are read and monitored by the ambient agent. The ambient agent splits these observations into its separate parts. The belief base monitors conditions that have to do with everyday actions like frequency of pill intake, alco-

hol level reading, social activities, phone usage, and blood volume pressure reading [2]. The analysis model, using the measurement types in Table 1, monitors things like coping skill level, social interaction level, and positive or negative types. The analysis model will then make a prediction and that is when the support model comes into play. The support model keeps track of tasks, conditions, and roles. Sections 3.3 and 3.4 give detailed examples of uses of the ambient agent model. First, however, we must define LEADSTO, the fundamental reasoning tool used by the ambient agent.

3.2 LEADSTO

Using Figure 2 to better explain, state α holds true during all or part of time duration g. A transition period then begins somewhere in duration e and ends in duration f. At that ending point state β begins and holds true during duration h. These durations are part of trace γ. A trace is a time-indexed sequence of states. This is just a portion of the LEADSTO language. Paper [3] provides more on LEADSTO. A more formal mathematical definition is as follows where $\twoheadrightarrow$ represents LEADSTO and the time interval.

$$\gamma \models \alpha \twoheadrightarrow_{efgh} \beta$$

$$\forall t_1 : [\forall t[t_1 - g \leq t < t_1 \implies \gamma(t) \models \alpha]]$$
$$\implies \exists d[e \leq d \leq f \ \& \ \forall t'[t_1 + d \leq t' < t_1 + d + h$$
$$\implies \gamma(t') \models \beta]$$

An example *before* state would be:
- observed(agent, pill_intake(overdose))

An example *after* state would be:
- belief(agent, pill_intake(overdose))

If state 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 [3]. For example if belief of substance abuse is recorded by the ambient agent at a beginning state and at a certain time, this implies that there exists a later time that the same state can perform an action of giving advice to avoid substance abuse. To clarify, this delay is after the time interval where e and f are the minimal and maximal durations of the delay, respectively. This logic applies to all relationships between two different states.

3.3 Example: Pill Intake

Using medication intake as an example, a patient being monitored by the ambient agent takes their daily medication
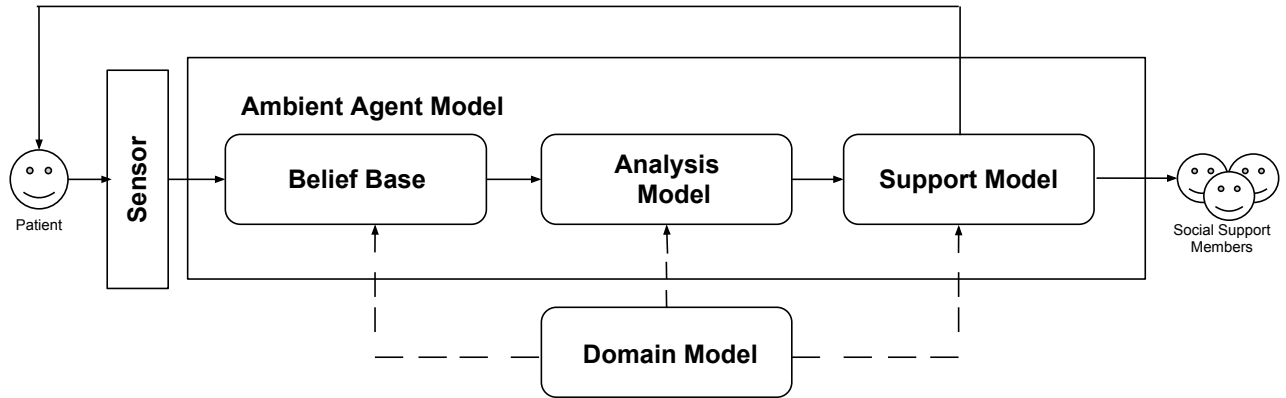
Figure 3: Ambient Agent model [2]. This figure is used to model the transitions between the different sub-models of the ambient agent.

Table 1: Type Used

Type	Values
LEVEL	{low, medium, high}
TYPE	{positive, negative}
FREQ_LEVEL	{normal, not_taken, overdose}
TASK	{avoid_substance_abuse, social_activities, relaxation_activities, coping_skills, meet_doctor_therapist}
ROLE	{patient, friends_family, doctor_therapist}
AGENT	{low, medium, high}
COND	{risk_relapse, anxiety, healthy}

as they are supposed to and then one day starts taking less and less, and then none of their pills altogether. The ambient agent takes this data in and first establishes a "belief". At the point were the patient has stopped taking their pills all together the ambient agent assigns a negative frequency level for the medication intake belief. After that the ambient agent analyzes the new data. It records this as a high level of substance abuse.

Some people may think that substance abuse is taking too much of something, but in this case the ambient agent needs to monitor both the high intake and the low intake. The high intake could mean the patient may overdose while the low intake means the potential for relapse is higher. At this point the agent recognizes that the patient has a high potential for relapse and begins the support model by notifying family members, close friends, and doctors of this development. They are anyone who can intervene in the situation and also

people the patient trusts. With this sort of monitoring the ambient agent is able to make reasonable decisions regarding the patient's health and well being. The following are the possible values for how the ambient agent may monitor pill intake in the case of an overdose:

The ambient agent notices the patient taking too many pills. Notice that the measurement values are taken from Table 1.

- observed(agent, pill_intake(overdose))

It establishes the belief that the patient is going to continue overdosing and the patient's substance abuse level is high.

- belief(agent, pill_intake(overdose))
- belief(agent, sub_abuse(high))

The system makes an assessment that the patient's coping skills are low.

- assessment (agent, coping_skill(low))

The ambient agent then makes a prediction related to the patients risk of relapse. Positive is this case means that there is a risk for relapse.

- prediction(agent, stage(risk_relapse, positive))

After predicting the possible risk the agent determines a plan of action, reduce substance abuse, advise to avoid substance abuse, and it notifies the patient, the patient's family and friends, and the patients doctor and/or therapist.

- belief(agent, seek(avoid_substance_abuse)
- desire(agent, reduced(avoid_substance_abuse)
- intention(agent , advice(avoid_substance_abuse))
- intention(agent, notify(patient, friends_family, doctor_therapist))

3.4 Example: Phone Usage

A more detailed example is when the ambient agent monitors phone usage. If the ambient model sees that the patient is not using their phone, the ambient agent believes that the patient is not using the phone to contact their social groups.

- observed(agent, phone_usage(negative))
  ↠ belief(agent, phone_usage(negative))

Since the ambient agent believes that the patient is not using their phone to contact others it establishes the belief that the patient is not contacting their social support network

- belief(agent, phone_usage(negative))
  ↠ belief(agent, social_support(negative))

If the ambient agent believes that the patient is not interacting with their social support groups, the agent will conclude that the patient is suffering from social withdrawal.

- belief(agent, social_support(negative))
  ↠ assessment(agent, social_interaction(low))

This assessment will help the ambient agent predict if the patient will suffer a relapse.

- assessment(agent, social_interaction(low))
  ↠ prediction(agent, stage(risk_relapse, positive))

If the ambient agent predicts a relapse it will believe the patient is at risk of a relapse.

- prediction(agent, stage(risk_relapse, positive))
  ↠ belief(agent, stage(risk_relapse, positive))

The ambient agent then notifies family, friends, and doctors of the new development.

- belief(agent, stage(risk_relapse, positive))
  ↠ performed(agent, notify(risk_relapse, friends_family, doctor_therapist))

The patient is also notified.

- belief(agent, stage(risk_relapse, positive))
  ↠ performed(agent, notify(risk_relapse, patient))

Having noticed the social withdrawal the ambient agent will want the patient to improve their social interactions.

- assessment(agent, social_interaction(low)) ∧ desire(agent, reduced(risk_relapse))
  ↠ desire(agent, improved(social_activities))

With that data the ambient agent establishes an intention.

- desire(agent, improved(social_activities)) ∧ belief(agent, social_support(negative))
  ↠ intention(agent, advice(social_activities))

The ambient agent then advices the patient.

- intention(agent, advice(social_activities))
  ↠ performed(agent, advice(social_activities))

While the ambient agent monitors phone usage it is also monitoring the many other factors that are present in the patient's life. The monitoring of all the factors is what completes the ambient agent.

4. FUTURE WORK

Future work in the area of ambient intelligent environments could be to make it so that the agent mentioned above does more than just notify others of the current situation the patient is in. The ambient agent could take a more active role in taking care of the patient. The agent could set out pills in the morning right where they patient could see them so that they make sure to take them.

5. CONCLUSION

This paper has shown that an ambient intelligent agent can be used to help monitor stress and depression over a long period of time. I have also shown two models, how they relate, and how different agents can be used as monitors. The example above provides a clear set of steps as to how an ambient intelligent agent would help someone dealing with depression. Though the idea of ambient intelligence got its start from science fiction it is slowly working its way out of the science fiction realm and into the realm of reality.

Acknowledgements

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