

Emergency Psychiatric State Prediction for Ambient Assisted Living

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Abstract—Mental healthcare can be the smart home service for ambient assisted living. In this paper, a web of objects embedded smart home architecture is presented for mental healthcare. Patients’ psychiatric symptoms are collected through lightweight bio-sensors and web based psychiatric screening scales and then analyzed using machine learning algorithms.

I. INTRODUCTION

Incorporating smartness in home environment to ensure security, comfort and healthcare [1] of dwellers are the primary goals of a Smart Home. A plenty of activity recognition methods are proposed for monitoring physical health in smart home environment, but mental and cognitive health [2] status are not explored yet in such an extent for assisted living.

In this paper, we propose a smart home web of objects based architecture especially in mental health care scenario. We monitor dwellers’ or patients’ major psychiatric symptoms using home based lightweight bio-sensors and web based psychiatric rating scales e.g. Beck Depression Inventory (BDI) to measure patients depression level [3]. The bio-sensor observations and psychiatric rating scores are used to assess dweller’s mental health status and to predict emergency psychiatric mental state. The emergency psychiatric states of patients’ are modeled as the discrete set of states of hidden Markov model (HMM), where objectified sensor observations and patients’ history are considered as the observations of HMM. Then the Viterbi, a machine learning algorithm, is used to generate the most probable psychiatric mental state sequence based on those observations. Finally, the prognosis of emergency psychiatric state is determined from the most likely psychiatric mental state sequence.

II. MENTAL WEB OF OBJECTS EMBEDDED SMART HOME ARCHITECTURE

The smart-home web of objects architecture (SWOA) is presented in Fig. 1 for personalized mental healthcare of dwellers. The biosensors network with psychiatric disorder screening scales is embedded with home appliances network to collect psychophysiological and psychometric data of any inhabitant. The collected observations are dispatching as web of objects through residential gateway where signal

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quantification, user authentication, device identification and communication units play significant role for smart home orchestration. The objectified device observations are virtualized in SWOA virtualization layer for service collaboration among smart-home services. In this paper, we discuss only the emergency mental healthcare services provisioning model in following sections.

III. PSYCHIATRIC MENTAL STATE MODELING

Psychiatric mental state monitoring is the vital part of

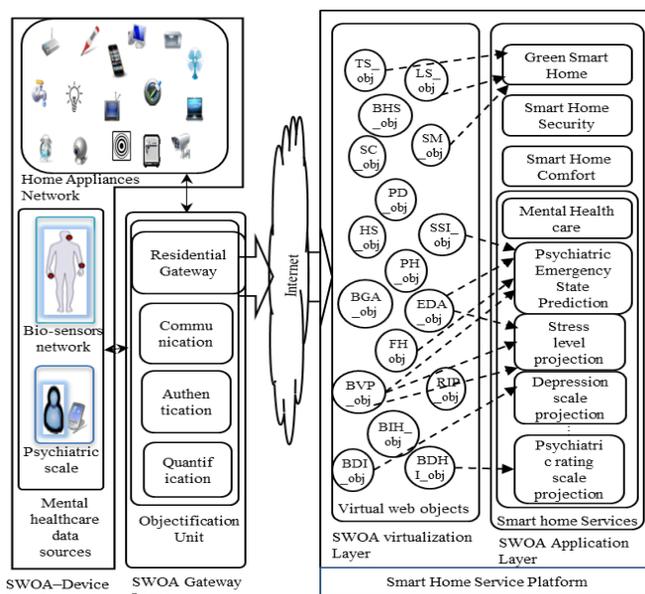


Fig. 1. Mental web of objects embedded smart home architecture where different home appliances and sensor observations are virtualized in virtualization layer of smart-home web of object architecture. The virtualized web objects are defined as TS: Temperature Sensor, LS: Light Sensor, FH: Family History, PH: Patients’ History, SM: Smart Meter, BHS: Beck Hopelessness Scale, SC: Smart Camera, BGA: Brown-Goodwin Aggression, BIH: Barratt Impulsivity Hyper-scale and BDHI: Buss-Durkee Hostility Inventory, SSI: Scale of Suicidal Ideation.

emergency psychiatric mental healthcare service in smart home architecture. The success of emergency psychiatry persistently depends upon accurate and just-in-time determination of life-threatening mental states. As far as we know there is no such pathological diagnosis which can pinpoint the atypical and emergency mental states. Therefore, statistical and probabilistic measurements based on the observations are the alternative to model emergency psychiatric mental states. We used the objectified three low-cost bio-sensors i.e. electro-dermal activity sensor (EDA), respiratory inductance plethysmography sensor (RIP), and blood volume and pulse sensor (BVP). The collected

observations are then archived from online psychiatric screening reports to enable home based emergency psychiatric service.

A. Emergency psychiatric mental state modeling

To model the emergency psychiatry system, we consider the psychiatric mental states as hidden states because these states are not fully or partially observable. We can predict those hidden states through some biosensor observations, psychiatric screening scores, individuals' traits and family histories. The future psychiatric mental state of a patient is depended on current state exclusively. Thus, hidden Markov model (HMM) is barely apposite to model psychiatric mental states of individuals.

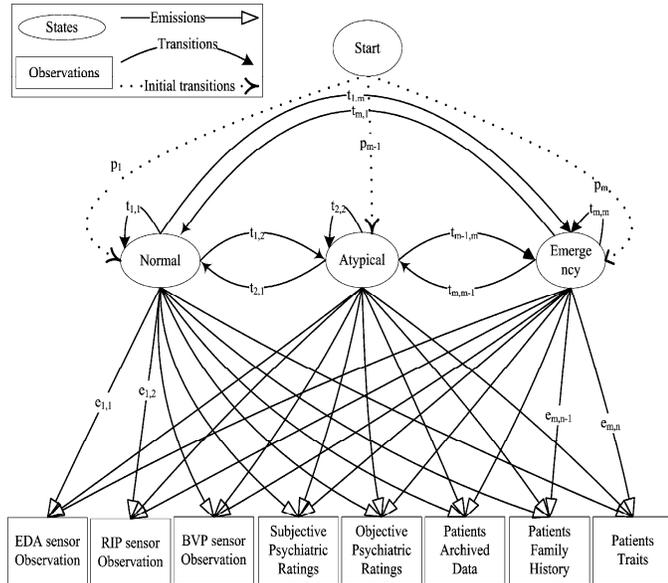


Fig. 2. Hidden Markov model based mental state model for predicting emergency psychiatric mental state.

We consider total M states in the recommended discrete time Markov process and a set of states is defined as $S = \{s_1, s_2, \dots, s_M\}$, where all states are hidden. The objectified observations of 3 biosensors, 10 psychiatric screening scales scores, and 23 historical observations of patients' traits, personal and family histories are considered as the observation set of HMM. The symbolic representation of the observations set as is $O = \{o_1, o_2, \dots, o_N\}$, where N is the number of total observations. Our primary goal is to find out the most probable psychiatric mental state sequence $Q = \{q_1, q_2, \dots, q_p\} \in S$ based on the perceived observations $V = \{v_1, v_2, \dots, v_p\} \in O$ at a given time t .

The defined HMM of mental states has three tuples, i.e. Hidden Markov Model $\lambda = \{\pi, T, E\}$, where π is set of initial states probabilities, T is transition probabilities, and E is emission probabilities. The projected HMM is shown in Fig. 2 with defined parameters of initial, transition and emission probabilities. The Baum-Welch algorithm [4] is used to determine the HMM parameters from gathered dataset. The missing data of the revised dataset is also prophesied by Expectation-Maximization algorithm [4]. Finally, we use Viterbi algorithm to get the most probable psychiatric mental

state sequence Q based on the objectified input observations as shown Fig. 3.

B. Prediction of emergency psychiatric mental state

The emergency psychiatric state is determined from generated state sequence Q . The cardinality of each of the states (i.e. $|s_1|, |s_2|, \dots, |s_M|$) is mined to find out specific

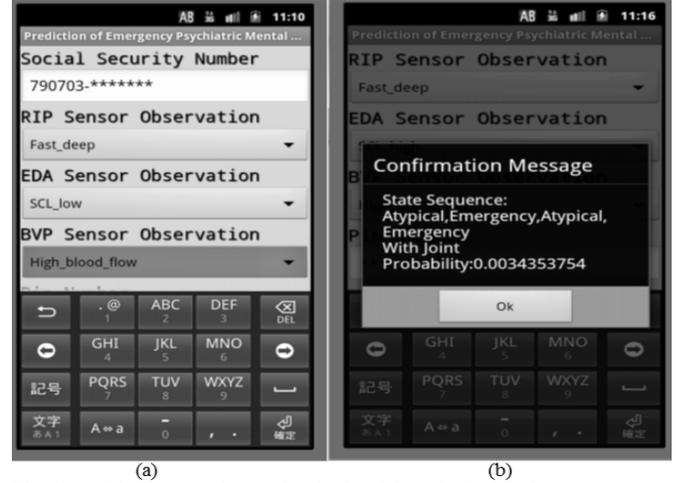


Fig. 3. (a) Bio-sensors observation in the sink node (smart phone) of a smart home networks. (b) The most likely hidden mental state sequence based on the sensor observations, patients traits, personal and family history and psychiatric ratings (i.e. total 36 features).

mental state at this moment. The state having maximum cardinality (i.e. $\tau = \arg \max_i |s_i|$) is extracted to predict the current psychiatric state of the patient. Now, the prognosis of emergency is determined according to the cardinality of τ , that is if $|\tau| \geq T_s$ and $\tau \in \{\text{'emergency'}\}$; then patient is subjected to emergency psychiatry. Here, T_s is the emergency state prognosis threshold. The threshold value T_s is chosen optimally to maximize the area under ROC curve of emergency state reconnaissance.

IV. CONCLUSION

Prediction of dwellers emergency psychiatric states through some objectified psychophysiological and psychometric observations of inhabitants collected through tiny biosensors and psychiatric screening scores is a novel initiative to monitor emergency psychiatric patients in smart-home environment. The novel emergency psychiatric mental state prediction model can be used as the complementary of treatments of psychiatric patients in home environment.

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