EmoSens: Affective Entity Scoring, A Novel Service Recommendation Framework for Mobile Platform

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ABSTRACT

Embedded sensors such as accelerometer, GPS and gyroscope can affect competitiveness of mobile devices. Many mobile device manufacturers have employed various sensors to provide richer and more elaborate service environment for end users. In this paper, we propose a novel recommendation approach using *EmoSens* which works like a sensor of the human emotional state based on the proposed affective entity scoring algorithm. In brief, the algorithm maintains affective scoring vectors for various entities in a mobile device, such as installed applications, multimedia contents and contacts of people, by calculating the difference between prior and posterior emotional states. Once we establish the affective entity scoring, we can provide personalized services based on entities which fit users' current emotional state. Additionally, we can elicit the temporal pattern of emotional changes of the user. As a systematic sensor to provide emotional information, we believe *EmoSens* can benefit users with differentiated emotional experiences through personalized recommendations.

Categories and Subject Descriptors

H.1.2 [**Information System**]: User/Machine System—*Human Factors, Human Information Processing*; I.2.9 [**Artificial Intelligence**]: Robotics—*Sensors*; J.m [**Computer Application**]: Miscellaneous

General Terms

Algorithms

Keywords

Mobile Intelligence, Emotion Aware, Recommendation

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1. INTRODUCTION

As the mobile device market grows and lighter and cheaper sensors are developed, embedded sensors such as accelerometer, GPS and gyroscope are regarded as a crucial component for the competitiveness of mobile devices. Many Leading mobile device manufacturers are trying to provide more elaborate sensory or contextual information to developers for more sophisticated and better-performing applications. Since the mobile device industry has been morphed into media and application ecosystems, the manufacturer no longer needs to take their efforts on discovering their own killer applications. Instead, they have been able to concentrate on how to provide richer and more elaborate data to many third party application developers who can find killer applications from competition.

Compared to physical phenomena such as time, location, and movement, human cognition and internal states are very difficult to measure with simple sensors. Among human cognitive states, emotion and other affective phenomena such as moods can be measured with various modalities. Because human emotion has essential role in human decision-making and memory and psychological satisfaction, sensing and providing users' emotion would help application developers to create useful functionalities for users in areas of communication and multimedia.

In this paper, we propose an emotion recognizable sensor with affective entity scoring algorithm and a novel recommendation approach based on the emotion sensor. With this algorithm, we calculate affective scoring vector by learning the difference between two quantificated emotional state, prior emotional state and posterior emotional state for each entities in a mobile device such as downloaded applications, media contents and contacts of people. Once the affective entity scoring has been made, we can not only recommend services that fit to users' current emotional state but also track the temporal changes of the users' emotional states. As a new type of sensor, *EmoSens* can help users to experience emotional closeness and personalized recommendations. This paper is organized as follows: Section 2 gives a background and related works. Section 3 provides the main idea of the research for developing the *EmoSence* including recognition, quantification details and affective entity scoring algorithm. And we finally conclude with summarizing the research issues and describing future works in section 4 .

2. RELATED WORKS

Over the last decades, many researches have been explor-

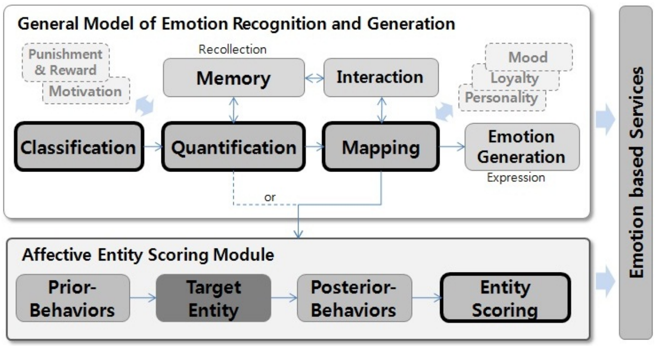

Figure 1: The Conceptual Process of Emotion Recognition, Generation and Affective Entity Scoring

ing human emotions. In the early days, researchers tried to define them in several categories and proposed many models of recognizing and synthesising human emotions. The OCC model has been established to provides a structure of 22 conditions which influence emotions and variables which affect the intensities of the emotions[1]. From the study of facial expression of emotions, Ekman defined six emotions, 'Joy', 'Anger', 'Fear', 'Disgust', 'Surprise' and 'Sadness' as basic emotions which has been widely used in field of psychology and robotics [2]. Wilson [3] developed his conceptual model by categorizing human emotion into momentary emotions, mood and personality. Based on above fundamental studies of human emotion, researchers proposed practical approaches to apply emotions to machines, especially robots, virtual agents, embodied characters and so on. According to recent researches, machine's embedded human-like emotional aspect increases positive reactions from the human [6]. Hence, several studies tried to integrate emotional factors to consumer electronics device [4, 5].

3. EMOTION-BASED RECOMMENDATION

Most of emotion based systems and applications have basic processes of recognition and generation. Typically, they have several stages for the recognition - classification, quantification and mapping stages. After the stages, a machine infers the human's emotional state, and optionally, the machine generates its own emotional state or make recommendations for users. The upper figure of Fig.1 shows a general process of recognizing human emotions. When necessary the process can have additional modules such as memory, interaction and mood to enhance its accuracy and performance. As in the bottom of Fig.1, the affective entity scoring module is responsible for building entities' affective scoring matrix by learning the difference of quantificated emotional state between prior and posterior behaviours(Eq.1). We will discuss details in the following paragraphs.

3.1 Emotion Recognition in Mobile Platform

People usually carry mobile devices such as smart phone throughout daily life, so we can derive contextual information of the user by collecting sensory data and analyzing contextual information such as email and text messages. Mobile devices have various entities and we can calculate corresponding affective score by calculating recognized emotional factors. Following is the formalism to introduce the affective entity scoring.

Table 1: Examples of Application and Object

Relation	$\hat{A}$	$\hat{O}$
$\mathcal{R}_1$	Game(Single Mode)	N/A
	Utility	N/A
$\mathcal{R}_2$	Communication/SNS	People
	News/Book	Text,Image
	Multimedia	Music,Movie,Image

Definition 1. (**Entity**) If there is a set of k users $\hat{U} = \{u_1, u_2, \ldots, u_k\}$, a set of n applications $\hat{A} = \{a_1, a_2, \ldots, a_n\}$ and a set of r objects $\hat{O} = \{o_1, o_2, \ldots, o_r\}$, an entity is a tuple $\widetilde{E} = \langle \hat{U}, \hat{A}, \hat{O}, \mathcal{R}_1, \mathcal{R}_2 \rangle$, where $\mathcal{R}_1 \subseteq \hat{U} \times \hat{A} \times \hat{O}$ and $\mathcal{R}_2 \subseteq \hat{U} \times \hat{A}$ which represents ternary and binary relationship, respectively.

Unlike the binary relationship $\mathcal{R}_1$, in case of the ternary relationship $\mathcal{R}_2$, application a_n contains the objects o_r that include text,music,movie,image or people. For example, a user can communicate with other people through social network applications such as Facebook or Twitter as shown in Table 1.

Definition 2. (**Quantification**) When a quantification module receives a classified sensory data x, the data is normalized by the function $q(x_t \mid t \in T)$, where T is the types of sensors, and the function returns $y(0 \leq y \leq 1)$.

Definition 3. (**Mapping**) If there is a set of l quantificated sensory data $\hat{Y} = \{y_1, y_2, \ldots, y_l\}$, emotion factors can be calculated by the mapping function $m(\bigcup_{i=1}^{|l|} y_i) = \{(f, \Phi) \mid f \in Fand\ 0 < \Phi \leq 1\}$, where F is the set of emotion factors and Φ is the strength of the factors.

To quantificate emotions, any emotional factor such as big five personal traits[7] or circumplex model[8] can be adopted. Furthermore, we can use additional functions for the higher level mapping of the emotional state. For example, we can interpret emotional factor f into familiar words such as Ekman's 6 emotions by using the following function, $m'(\bigcup_{j=1}^{|f|}(f_j, \Phi_j)) = \{e \mid e \in Eand 0 < |e| \leq |E|\}$, where E is a set of emotions. However, sufficient training phase should be preceded by the mapping process for converting from quantificated sensory data to higher level emotions. For the training phase, we collected a sensory data with periodic feedback of emotional state from a user.

3.2 Affective Entity Scoring

Definition 4. (**Affective Scoring**) An objects' emotional score can be represented as a tuple $S = \langle \widetilde{E}, F, \Phi, \mathcal{R}_3, \mathcal{R}_4 \rangle$ where $\mathcal{R}_3 \subseteq \widetilde{E}_{(\mathcal{R}_1)} \times F \times \Phi$ and $\mathcal{R}_4 \subseteq \widetilde{E}_{(\mathcal{R}_2)} \times F \times \Phi$.

Users of mobile devices, especially smart phones interact with their devices through sequential or non-sequential activities such as touching, dragging, clicking buttons, executing applications, viewing contents and so on. When we assume a_i is a target application that will be scored, affective entity score(γ) of an application a_i is calculated as follows (Eq.1 and Eq.2):

$$\gamma = \varepsilon' - \varepsilon \tag{1}$$

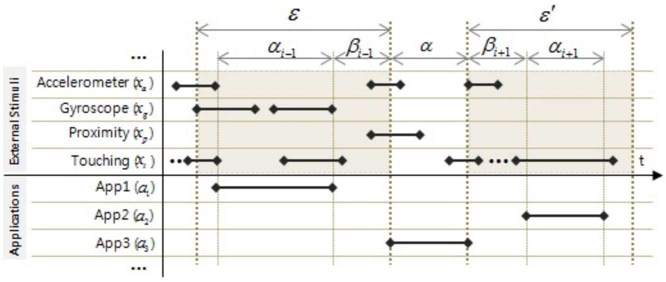

Figure 2: A Usage Pattern of a Mobile Phone

According to Eq.2, we used SMA(simple moving average) filter to smooth out short-term fluctuations and highlight longer-term trends. ε means an averaging affective score of prior behaviours and ε' means an averaging affective score of posterior behaviours, both scores are based on a target activity that executing an application.

$$\varepsilon = \frac{1}{w}\Big(\sum_{j=i-1}^{j-w} m(\alpha_j + \beta_j)\Big),\ \varepsilon' = \frac{1}{w}\Big(\sum_{i=1}^{w} m(\alpha_i + \beta_i)\Big) \quad (2)$$

where, w is the window size ($w \geq \alpha + \beta \geq 1$) and m is a mapping function. From the example of usage pattern in Fig.2, a user can have a finite set of an activity α and an interval β which means the running application and elapsed time between the application, respectively.

$$w = \begin{cases} w - |\bigcup_{i=1}^{|o|} \beta_i|, \text{ if } \beta_i > \theta \\ w, \text{ otherwise} \end{cases} \quad (3)$$

where, θ means the the maximum time interval, for example, when a user turns the phone off for a while, we can assume that the time elapse weaken the users' emotional state.

3.3 Service Recommendation

We plan to apply the proposed affective entity scoring to a variety of recommender systems. Previously, most recommender systems used explicit or implicit forms to collect users' preference by observing the items that users view or visits, analyzing purchase history, asking the users to rate/rank an item and so on. Since the affective entity scoring does not require user's explicit action for data collection, the device can unobtrusively build the users' preference by recognizing the variance of the users' emotional states. We are currently implementing an emotion recognition and service framework on a mobile platform as shown in figure 3, and we plan to conduct experiments to test a number of representative recommender algorithms.

4. FUTURE RESEARCH DIRECTIONS

We proposed a new recommendation approach based on the human emotion by adopting emotion recognition software and affective scoring algorithm. Although the research field of recommender systems has considerably evolved, recommendation based on human emotion including emotion recognition, expression and inducement (especially in consumer electronics) has not been studied in depth. We believe

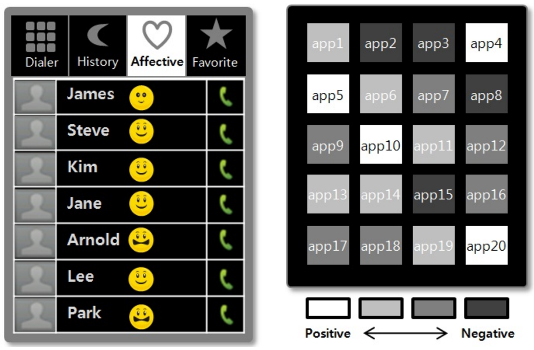

Figure 3: Examples of Affective Entity Scoring based Recommendation Service

it is important to apply emotional aspects to recommender systems because recommendation process is completely relying on the user's preference which is closely related to the user's emotional state. In the future (some of which are currently in progress), we will proceed with the following studies.

1. Emotion Recognition
   Many emotion based systems exist in the field of robotics and agent, but we need to develop quantification and mapping methods appropriate for mobile devices. The quantification function mainly performs normalization process and collecting external stimuli, and mapping function requires elaborative mapping tables that translate quantificated stimuli into human recognizable emotions.

2. Affective Scoring and Updating
   In the paper, we simply used the difference between prior and poster activities. But for the comprehensive analysis, we need to develop and compare many scoring and updating methods based on different machine learning techniques.

3. Emotion-based Recommendation
   We can use existing recommendation algorithms for verifying the affective entity scoring framework. However, we believe the developed framework can be applied to various types of recommendation systems as an additional unit for enhancement of recommendation performance. Therefore, we plan to test various recommendation algorithms with the proposed affective entity scoring and verify the performance improvement.

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