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A new method for simulating human emotions

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Abstract: How to make machines express emotions would be instrumental in establishing a completely new paradigm for man machine interaction. A new method for simulating and assessing artificial psychology has been developed for the research of the emotion robot. The human psychology activity is regarded as a Markov process. An emotion space and psychology model is constructed based on Markov process. The conception of emotion entropy is presented to assess the artificial emotion complexity. The simulating results play up to human psychology activity. This model can also be applied to consumer-friendly human-computer interfaces, and interactive video *etc*.

Key words: emotion robot; psychology entropy; Markov model; artificial psychology

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1 Introduction

The artificial psychology (AP) theory that we presented is to imitate human psychology activities with artificial machines (computers, objective function algorithm) by means of information science [1]. Characters that display affection are challenging project facing to modern scientists, especially when those characters interact with real people possessing real affection. In this paper, the artificial psychology model is presented for our project on affection interaction between emotion robot and real human. The emotion robot can perceive real human affection by recognition of facial expression and gesture. The emotion robot can generate his emotion behavior (especially by facial expression and gesture) autonomously through techniques based upon our artificial psychology model. We are able to communicate naturally with the emotion robot that possesses his unique personalities and moods [1-5].

As human beings, we have an innate understanding of what affection is. The affection is an integral part of our decision-making systems. It always tunes our decisions according to our personalities, moods, and momentary affection to give us unique responses to situations presented by our environment. Our unique personalities determine that we all think and hence solve problems in unique and different ways. In an evolutionary sense, this diverse method of solving problems is highly effective. The affection responses are used to make the characters that we encounter believable and engaging. For example, if we were to walk into a virtual bar and all of the characters in the bar had distinct personalities, the scene would be a very impressive and believable social situation. If the characters show no affection, our suspension of disbelief would be immediately broken and we would be reminded that we were in a computer-generated simulation rather than in our own fantasy world. An important point to reiterate here is that we're specifically dealing with affective interactive characters. These characters have responses and behaviors that cannot be prescript or predefined to any great degree and must instead employ systems that are able to produce behavior in response to changes in the environment and interactions with the user.

The emotion robot (ER) can produce three fundamental components as output: gestures, facial expressions, and voice. Facial expressions are a general category and are dependent upon the context of the situation in which the character exists. When expressing a gesture and facial expressions, the ER selects what gesture and facial expressions are appropriate to his personality and current mood. So a gentle agent is unlikely to do anything aggressive, for example. When perceiving some anger emotion information, ER can determine what gesture and facial expressions are carried out. An outgoing, extroverted character might perform an action enthusiastically, although this probably wouldn't be the case for an extreme introvert. Now, facial expressions are the way in which we communicate with our emotion agent. With the AP,

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many personal robots would be seen served as a companion—rather like a server [6-9].

2 Method

The first question that should be cleared is whether more than one feeling can coexist before the emotion space is constructed. This question is disputed in psychology area for many years, but it is not clear yet. In this paper the mix feeling is considered. Now a three-dimension emotion space (anger, fear, happiness) is constructed (see **figure 1**). Each dimension in the space is divided as three levels (0, 0.5, 1). For example, the fear is described in three levels (no fear (0), any fear (0.5), fear (1)). There are 27 states in this feeling space.

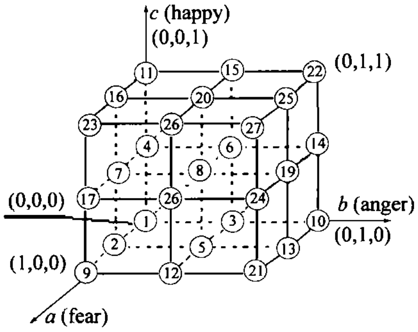

Figure 1 Emotion space.

The point of intersection of coordinate axes (origin) is regarded as neutral feeling status. The activity of the human psychology is believed as a Markov stochastic model. The change of the human feeling is regarded as state-transition process in the emotion space. Let us classify human feeling into m classes, and each class is divided into n levels, there are n^m feeling states in the emotion space. Here define l: $l = n^m$, l dimensions state-transition probability matrix is expressed as follows:

$$P_{\text{affect}} = \begin{pmatrix} p_{1,1} & p_{1,2} & \cdots & p_{1,j} \\ p_{2,1} & p_{2,2} & \cdots & p_{2,j} \\ \cdots & \cdots & \cdots & \cdots \\ p_{i,1} & p_{i,2} & \cdots & p_{i,j} \end{pmatrix} \qquad (1)$$

where p_{ij} is the transition probability from i state to j state, and satisfies as follow formula:

$$\sum_{j=1}^{l} p_{i,j} = 1, \quad i \in [1,2,3,\cdots,l] \qquad (2)$$

How can we estimate the affection space and transition probability matrix? Here the concept of emotion entropy is defined as follows.

$$A_i = -C\sum_{i=1}^{l} p_i \log p_i \qquad (3)$$

Where A_i represents the psychology entropy at i feeling state;

$$p_i = (p_{i,1}, p_{i,2},\cdots, p_{i,i},\cdots, p_{i,l}), l = n^m, \sum_{j=1}^{l} p_{i,j} = 1, \quad i \in (1,2,\cdots,l) \qquad (3)$$

where $p_{i,j}$ is the transition probability from i feeling state to j feeling state; C is a constant.

Emotion entropy represents the constructed agent's personality. If the psychology entropy value is big, the agent constructed is passionate. Otherwise the agent is indifferent.

In this paper, given the fact as follows:

(1) At next time, the transition probability of feeling state coming to itself is the biggest among other states. Other transition probability is decreased with distance increased between the two states.

(2) Without any outer inputs, origin position is the feeling neutral point. The human feeling always tends to stay at this position.

To constract real emotion, a mathematic proposition is abstracted.

On the positive number axis, there is a close interval L: $[1, m]$, the even probability in close interval is 1, and its probability at positive integer i is p_i, $i \in (1,2,\cdots,m)$, and $\sum_{i=1}^{m} p_i = 1$, $\prod_{i=1}^{m'} p_i > 0$. Now this interval is divided into n not-empty subintervals, $n \in (1,2,\cdots,m)$, l_k presents k subintervals, $k \in (1,2,\cdots, n)$, therefore $\forall (l_1, l_2,\cdots,l_n) \neq \phi$, $L = \bigcup_{i=1}^{n} l_i$. Let a_i represents a figure of integral number included in the subinterval number i, and $a_i \in (1,2,\cdots,m)$. Here $p_{i,j}$ ($i \in (1,2,\cdots,n)$, $j \in (1,2,\cdots,a_i)$) is the probability of an event in l_i subspaces at the jth non-negative integral number. There are two arrays with $n-1$ terms which are smaller than 1: r_i, k_i, $0 < r_i < 1$, $0 < k_i < 1$, $i = 1,2,\cdots,n-1$.

Given some references as m, n, a_i, r_i and as follow conditions:

$$k_i(\forall(p_{i,1}, p_{i,2},\cdots, p_{i,a_i})) \geq \forall(p_{i+1,1}, p_{i+1,2},\cdots, p_{i+1,a_{i+1}}), \quad i = 1,2,\cdots,n-1 \qquad (5)$$

$$r_i \sum_{k=1}^{a_i} p_{i,k} \geq \sum_{k=1}^{a_{i+1}} p_{i+1,k}, \quad i = 1,2,\cdots,n-1 \qquad (6)$$

Calculating the probability of the sequence of number $p_1, p_2,\cdots, p_n$, satisfies the conditions as follows:

$$-\sum_{i=1}^{m} p_i \ln p_i = \max \qquad (7)$$

It is difficult to solve this problem directly. Its approximate solution can be reached by numerical method. After the state transition probability matrix is presented, a dynamic process of feeling change can be simulated. The first question is how to decide the initial state probability vector. A stochastic number is decided according to an even probability distribution between 0 and 1. If the figure is in an interval, the point in this interval will be selected at the next time. In other words, the feeling at this nod is selected as emotion state at the next time.

3 Computer simulation

Firstly it is required to show the intentions of computer simulation. The objective of computer simulation is trying to find a way to realize a humanlike psychology activity by computer. The emotion state of human tends to almost equanimity without any outer interference. Once it gets any stimulation, the state of human emotion will change. Though this change is uncertain, but for a specified agent it has statistic properties. It can be predicted by our experience. Based on these views, human emotion activity is simulated according to our artificial psychology model.

In order to show the results with typical examples, the initial state is farther to the origin. The parameter is set as follows: number of dimensions, 3; number of graduation, 5; sensitive factor, 0.6; initial position is at the No.125 nod; total simulation steps are 200 steps. The computer simulation results are shown in **figure 2.**

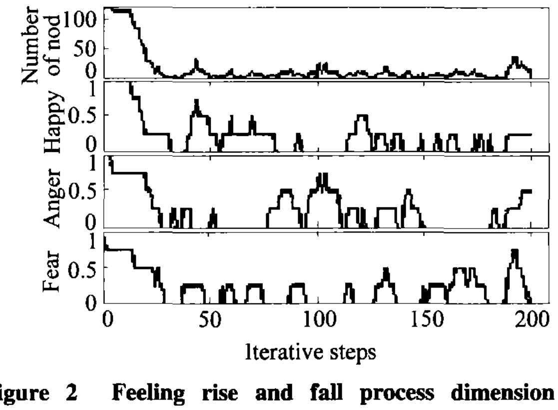

Figure 2 Feeling rise and fall process dimension 3, graduation 5, sensitive factor 0.6

We set the number of dimensions 3, number of graduation 5, sensitive factor 0.3, initial position is at the No.125 nod, total simulation steps are 200 steps. The simulation results are shown in **figure 3.**

Presently, we build the Artificial Psychology model according to the preliminary conditions and maximum psychology entropy. Setting the related references can simulate various personality of human.

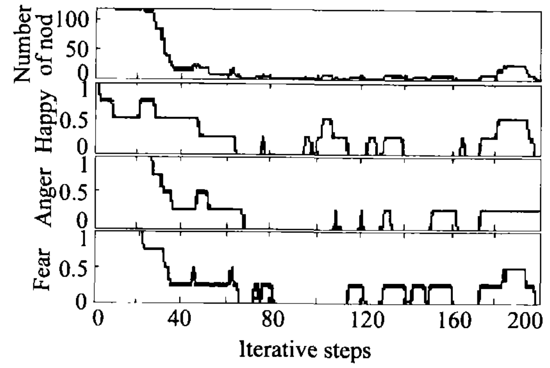

Figure 3 Feeling rise and fall process dimension 3, graduation 5, sensitive factor 0.3.

4 Conclusions

An artificial psychology model used in our emotion robot is first proposed in this paper, on which we present the emotion agent's emotion changes with Markov stochastic process. The experimental results show that the proposed method is applicable to simulate human psychology by intelligent agent. To further explore the artificial psychology model, some further improvements are currently being investigated, *i.e.* using hide Mmarkov model (HMM). The results of our work are of importance in numerous domains: research and assessment of human emotion (psychiatry, neurology, experimental psychology), consumer-friendly human-computer interfaces, and interactive video.

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