The Research of Psychology Modeling Applied to Virtual Human

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Abstract

Using computers to simulate human affective activities is a challenging work. After the analysis of human affective characters, this paper puts forward some artificial psychology models and mainly discusses a model based on HMM, and the concept of affective entropy which is used as the parameter index of constructing and evaluating individual characters of virtual human. This model considers human affective procedure as a two layers stochastic process. The psychology models symbolized by individual affective characters can be constructed by adjusting the initial parameters in the model. As the affective engine, it also can be used to predict the final result of affective procedure in the form of probability. So it can be applied to the fields of virtual human、game、affective robots、humanized computing, etc.

Key words: artificial psychology、HMM、affective modeling、affective computing

1．Summarize

Artificial psychology is the machine realization of human psychology activities (especially affective、wills、characters、creativity),using the methods of information science. Scholars in and broad have done many works in the aspect of applying HMM in affective modeling. This paper puts forward some artificial psychology models to simulate affective communication function of human brain. Using affective engine and conscious incentives as its input, we simulate the affective action then produce the affective output. This paper considers emotion as a type of information which symbolizes the life states and is a sequence produced by affective procedure and proposes that this affective procedure is a Markov process. First, HMM signal model provides theoretic ground for us to describe the process procedure of affective signals so it can get the expected output. Second, the modeling for affective signals can make us research signal source－affective procedure better and can simulate the signal source to produce signal. As a result, this paper chooses HMM as the modeling method for affective information.

2. Some artificial psychology models

1) Artificial modeling based on geometry space

On the work of self-closed effective computing model based on geometry space (showed in pic1), we introduce the outside incentives and the concept of individual characters and use the combination method of HMM and BP neural network to describe the main and subordinate psychology characters of human and to make it simulate the transferring of human emotion by ignoring the cross points.

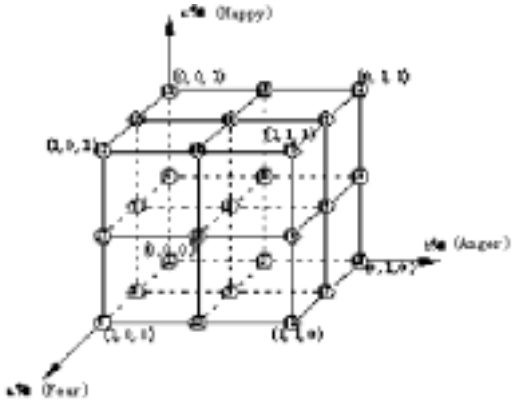

Fig.1 Geometry affective space of three axes

2) HMM method based on probability space

First, we define two states of emotion — frame of mind and enthusiasm and accorded two basic transfer procedure and put forward the probability space of emotion states. Then we bring forward two models— One is based on Markov chain, another is based on HMM and emotion transfer model to simulate the two basic transfer procedure of emotion. We both define the emotion energy and emotion intension and emotion entropy to describe the emotion characters and emotion states. It is proved by computer simulation that these models can correctly describe the self-transfer procedure of emotions and the dynamic procedure of transferring and changing when outside incentives exist. They also can describe the emotion intension's changing rule under the influence of the outside incentives, present emotion state and personal character. They provide a new method for the theory research of effective computing and automatic creating. It is showed in Fig.2:

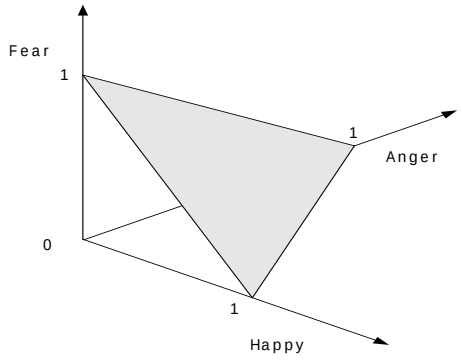

Fig.2 The identical triangle in the probability space of emotional state

3) Nonlinear dynamic model based on emotion dimensions

According to basic emotion theory in emotion psychology and emotion dimension theory suggested by Wundt.W, we consider emotion procedure as a stochastic dynamic process which controlled by a nonlinear dynamic equation. The general style of equation is as follow:

$$X= f(x, t) + g(x, t) u \qquad (1)$$

The x represents the expectation value of emotion state and u represents the outside incentive. It is showed in Fig.3:

Fig.3 Machinery emotion procedure

We consider the machinery emotion procedure as a composed procedure of mood and enthusiasm.

The mood procedure is used to simulate human mood and describe the steady state of machinery emotion. It is expressed by balance state in systematic dynamic equation when incentive equal zero. This balance state may express as isolated balance point or limit cycle。

The enthusiasm procedure is used to simulate human enthusiasm and to discern the communicator's emotion through machine. The incentive is decided by environment. The enthusiasm procedure of machine is the respondent procedure of system to the environmental incentives as showed in Fig.4:

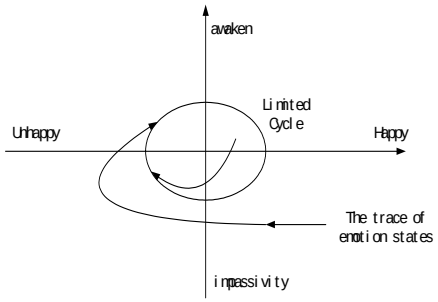

Fig.4 The transfer of the machinery emotion state

The same scene and incentives may produce different emotion changing procedure because human's emotion is fluctuant so using stochastic parameters to describe the changing procedure of emotion is appropriate. We consider the enthusiasm procedure as a stochastic process using human mood as the initial state. The expectation value of the stochastic process moves along the track of systematic dynamic equation. The rules of the machinery emotion procedure are that when no outside incentives exist, it express as the balance state of mood — systematic dynamic equation and when outside incentives exist and the balance state used as the initial state, it express as the stochastic process which use the systematic response as the expectance curve.

3. Artificial psychology model based on HMM

3.1 Affective entropy

Affective information is rich and its amount is huge. We research emotion and can consider it as a near Hidden Markov Process in the procedure. In the all, we can use the entropy method in information theory to study the emotion. We think that if we divide affective space into n^m emotion states, and propose that it is in state i at one time, so the probability of it to other states makes up a affective probability vector.

$$\vec{e}_i=(p_{i1},p_{i2},\cdots,p_{ii},\cdots p_{il}),l=n^m,\sum_{j=1}^{l}p_{ij}=1,i\in(1,2,\cdots l) \quad (2)$$

We define affective entropy as follow:

$$e_i=-C\sum_{j=1}^{l}p_{ij}\log p_{ij} \qquad (3)$$

Variables: e_i — affective entropy at state i

p_{ij} — probability from state i to state j

C — constant about logarithm and unit choose.

Thus, we see affective entropy as measurement of stability of human emotion. By using the affective entropy, we can construct and evaluate individual characters of virtual human.

3.2 Affective modeling based on HMM

A HMM can be described by parameters as follow: λ= (π, A, B). The usual arithmetic of HMM applied in practice are as follow: forward—backward arithmetic、Viterbi arithmetic and Baum—Welch arithmetic.

We choose classical discrete HMM to construct affective model. First, we need to confirm the affective class number on each layer. In another word, we want to know how many states it has—corresponding to observe number N in HMM model. At each mood state, each expression rises in a fixed probability. HMM are consist of two parts: one is Markov chain which described by π、A. It is obvious that different π、A decide different form of Markov chain. In human affective modeling, because of different conscious incentives, starting from any time, it can reach any states in the next time. The classification of states routing of Markov chain, (give an example in three states), can be described by Fig.5 as follow:

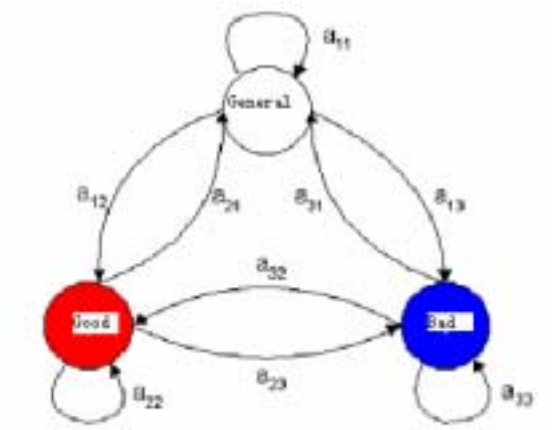

Fig.5 Markov chain about three states of emotion changing

Human's expressions are rich. We consider expression as discrete variables for simple and divide it into three expressions showed in Fig.6.

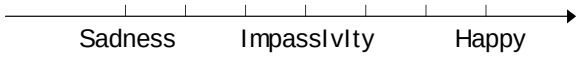

Fig.6 Emotion axes

Initial probability vectors correspond to probability of each emotion states before the training of HMM. According to different history situation of outside incentives and the particular characters of given roles, we can give the corresponding initial probability vector. In the Markov chain of affective model, the value of each element in states transferring probability matrix A are decided by many factors. First, they are in related with characters of this individual. In the character space constructed by Ian Wilson, the position of character points will affect the states transferring tendency. If considered from information view, the value of affective entropy will affect the distribution of elements' value in each row of state transferring matrix. The more large the value of affective entropy, the more average of the elements' distribution in each row, otherwise, the distance between the elements' values will be enlarged. Second, to one individual, the value of state transferring matrix in his affective model is related with the type of conscious incentives. The value of state transferring matrix is decided according to different

conscious incentive. In addition, it is also in related with the history states of accepted incentives and the effect of inside mechanism of its self. The observed sequence applied to model's training should be given according to the characters of the constructed role. It is the performance of the most surface layer—expression sequence.

So, we can train the affective model on the base of the initial datum mentioned above. Our task is to decide the parameters in the affective model of given role then produce observed sequence of affective behave according to these parameters. In another word, it is how to adjust parameters — λ= (π, A, B) to make P(O/λ) largest. So, we adopt Baum—Welch arithmetic to estimate the parameters in affective model. In view of the problem of underflow, we get the formula of parameter revaluing as follow:

$$\bar{\pi}_i = \sum_{l=1}^{L} \alpha_1^{*(l)}(i)\beta_1^{*(l)}(i) \qquad (4)$$

$$\bar{a}_{ij} = \frac{\sum_{l=1}^{L}\sum_{t=1}^{T_l-1} \alpha_t^{*(l)}(i)a_{ij}b_j(O_{t+1}^{(l)})\beta_{t+1}^{*(l)}(j)/\Phi_{t+1}}{\sum_{l=1}^{L}\sum_{t=1}^{T_l-1} \alpha_t^{*(l)}(i)\beta_t^{*(l)}(i)} \qquad (5)$$

$$\bar{b}_{jk} = \frac{\sum_{l=1}^{L}\sum_{t=1}^{T_l} \alpha_t^{*(l)}(j)\beta_t^{*(l)}(j)}{\sum_{l=1}^{L}\sum_{t=1}^{T_l} \alpha_t^{*(l)}(j)\beta_t^{*(l)}(j)} \qquad (6)$$

且$O_t = V_k$

Φ is the ratio item used to process the forward variable α and backward variable β. l is the corresponding sequence number.

3.3 Affective—mutual virtual human system driven by affective model

Considering incentive signal produced by emotion, we concentrate on conscious incentive. Though styles of human consciousness are various, human accept two signals of encouragement and punishment most as other animals. Encouragement signal is the signal which can activate happy nerve center in brain. Punishment signal is the signal which can activate the unhappy nerve center in brain. So our affective system mainly responds to these two signals. The function of this incentive signal which comes from emotion recognition module is to translate the unprocessed signals into one of these two signals.

Because of different conscious incentives, even in the model of the same people, state transferring probability matrix and visible symbol probability may be different according to different conscious incentives. So to each type of incentive, it has a state transferring probability matrix and a visible symbol probability matrix. The initial value of these two matrixes can be decided according to experience. At the same time, we have to consider the effect of outside incentive to affective entropy to make roles' affective entropy accord to individual characters. In fact, to different people who have different characters, visible symbol matrix and the observed sequence got at the same incentive are different. The state transferring matrix is also different at the same incentive. Optimists have a higher probability from any emotion states to good emotion states than pessimists and a higher probability of happy expression at same emotion with pessimists. So when constructing psychology model, the selection of initial model is very important to construct virtual human with different characters.

The fluctuating of emotion is decreasing as the increasing of time except that there is new incentive. So people are in the impassivity states at most time. When a virtual human communicate with people at the first time, because of no incentives before, she should be in a impassivity state. Along with the communicating with people, her emotion is gradually changing and accumulating accord with characters of human affective activity. Thus, we can suppose the initial probability vector when no any incentives as follow:

$$\pi = (\pi_1, \pi_2, \pi_3) = (1, 0, 0) \qquad (7)$$

However, along with the changing of mutual human—computer reaction, the accepted incentives are also changing, so in some instance, initial probability vector of affective model will have some change. For example, the last incentive is a " punishment" signal, so the affective model trained by datum O_P、A_P and B_P

under this signal can get a affective output including real-time emotion and expression and can get the probability of other emotion sates and expressions which also may happen. If next incentive is an "encouragement" signal, the initial probability vector should be decided by the result probability of each emotion which may happen and we choose the datum O_g and initial model parameters A_g、B_g. But if next incentive is also "Punishment" signal, it needn't to reevaluate model parameters. What we have to do is to produce next result using the model got at last time.

When constructing affective model about roles, our goal is to adjust initial model parameters

$\lambda = (A, B, \pi)$ to make the probability of observed sequence of given model largest. However, under different conscious incentive, we got different observed sequence of virtual human expression so under different conscious incentive, the same role will get different affective model.

4. Experiment result

The interface of the running system is in the Fig.7 and Fig.8as follow:

Fig.7 Affective mutual reaction system1

Fig.8 Affective mutual reaction system2

The interface is made up of three parts:

The part of mode parameters:

The result of model reevaluation is showed in form of chart at the bottom of the interface.

The part of virtual human affective mutual reaction:

It is on the top left of the interface. The top of this part is a multimedia player used to play the affective reaction controlled by computing result of model. The colors showed on the status bar are according to virtual human's emotion. We use the brightness to show the probability of the emotion responding to the color. The memo under the status bar shows the probability of the affective reaction of this expression which both have the emotion and the ability to play multimedia files.

1) The input part of the affective mutual reaction system

This part consists of two command buttons and one dialog frame. The two buttons is used to test affective model directly and doesn't need to judge the class of input signals. Dialog frame is used to accept the contents of dialog between user and virtual human. The contents need to be processed and analyzed by language understanding module and keywords will be abstracted then system can judge the class of input signal. The output of the language understanding module is the "encouragement" or "punishment" signal. It is also the final signal to drive the affective mutual reaction system.

We give virtual human different incentives in different

combination form and get the affective reaction result of the virtual human. Based on the analysis of the reaction result, we think that the result is according with human affective law so the feasibility of the affective modeling method based on HMM is demonstrated.

5. Conclusion

This paper gives some artificial psychology models and points out that the affective entropy is the measurement of stability of human emotion. To apply affective entropy to the construction of affective model and using affective entropy as one of the restriction conditions to construct initial state transferring matrix of affective model provides a computing arithmetic for the formation of the character of virtual human.

The construction of affective model is one of the key techniques to realize virtual human system. This paper gives the concepts of affective entropy and proposes the affective model based on HMM on the ground of analysis of affective layers. The affective transferring probability matrix and the parameter evaluation of different expression output probability vectors under given emotion state are realized using Baum－Welch arithmetic. The affective mutual reaction realized in the paper is based on statistic method not on the method of behave pattern. The testing result of affective model shows that the affective reaction simulated by this model accords with human behave laws. This method is feasible and has the characters of easily modeling and easily constructing different human characters. This research result provides a theoretic method to design virtual human system.

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