EMOTION AFFECTED DECISION MAKING IN VIRTUAL HUMAN SIMULATION

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ABSTRACT

Human modelling is an interdisciplinary research field. The topic, emotion affected decision making, was originally a cognitive psychology issue, but now has been recognized as an important research direction for computer science, biomedical modelling, etc. To fill the gap between psychology and bioengineering on emotion affected decision making is the main focus of this paper. This paper is based on well accepted Ortony's theory of emotions and latest bounded rationality theory, trying to connect the emotion process and decision making. A computational emotion model is proposed. The initial framework of this model in virtual human simulation within the platform of Virtools^{TM} is also presented.

Keywords: decision making, emotion structure, emotion calculation, virtual human

INTRODUCTION

To build vivid, lifelike, 3D computer models of the human being is exciting, and it has many applications, for example, for training, design ergonomics, simulation in hazardous environments, in computer games and in the film industry. Generally speaking, human modelling and simulation consists of three aspects: external modelling, perception modelling and internal modelling. The external modelling is to generate vivid 3D computer models of virtual human. It includes appearance modelling and motion modelling. Appearance modelling consists of human body modelling, face modelling (facial expression and hair), and cloth modelling. Motion modelling is to generate realistic, desired motion. Perception modelling is to establish synthetic perceptions for virtual human. It includes synthetic vision, synthetic audition and synthetic tactile. Internal modelling includes the modelling of virtual human's personality, emotion and decision making process. There are quite a few research groups in this area which are very active, for example, the MIRALab [1] and Virtual Reality Lab [2] in Switzerland, The Centre for Human Modelling & Simulation in University of Pennsylvania, USA [3]. Prof. Norman Bolder, who started human modelling and simulation in the late 70s and invented the world first virtual human (Jack^{TM}), predicted that within decades, virtual humans will be indistinguishable from real humans, "Ours may be the last generation that sees and readily knows the difference between real and virtual things". He even worried "What distinguishes a virtual human clone from one patterned after no specific flesh-and-blood person?" "Who will determine their ethic and morals?"[4]. While the prediction is very attractive and promising, there are still some technical issues to be resolved. It will not be realised purely depending upon the advancement of computational power.

The gap between psychology and computer sciences is the main research area of this paper. What presented here is how to fully utilize current computer science and animation technology for virtual human modelling, and then combine them with latest cognitive psychology achievement. The intention of this paper is to introduce a human model with humanoid behaviours. The model can 'understand' and reproduce what emotional people would like to do under some certain situation, but not a model that leads to generate an emotional machine. Virtools^{TM}, a 3D simulation development toolkit, is used as the test platform [5].

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METHODS

The research into human's behaviour under dangerous environment is of special importance for many practical applications. In this paper, fire escape is chosen as an example to illustrate the emotion affected decision making and the structures of emotion functions used in this research.

1. Environment Understanding

In this research, the environment detection process is treated as a process including synthetic perception and domain knowledge. The environment information for the virtual character is not only obtained though synthetic perception, but also though some background knowledge, which is called domain knowledge. The domain knowledge includes experience, basic knowledge or prospect of environment, etc.. For example, when human detected there is a fire nearby, he/she will naturally have a sense about the fire which is a kind of danger and should be kept away. This kind of sense is because he/she might have been told so before, or he/she had been scalded or naturally afraid of the flash. All these are domain knowledge. It is also interesting to mention that different domain knowledge could lead to different level of emotion reaction. In this model, this is considered as the domain knowledge factors affecting the related emotions, which is actually a part of personality. For fire escape scenario, a virtual character should first detect the dangerous event, fire, based on limited domain knowledge; then choose a reasonable path to escape. The main domain knowledge is about where is the available path. In order to reduce the calculation quantity, the available paths of virtual characters should not be the whole plane, but the lines that link virtual effective nodes (nodal path). The method is based on a group of function blocks: 'Nodal Path' in Virtools^{TM}. This is to simplify path searching and virtual character can make the main effort to decide which path to go and how to get the goal.

According to Ortony's theory, there are three basic classes of emotions: reaction to events, reactions to agents, reactions to objects [6]. The environment detection process is actually an event, object, or agent translating process. As an event, object or agent been detected, some factors which could affect emotions would be changed as partial result of event, object or agent understanding. For example, in the case of fire escape, when the character understands there is a fire nearby, the factor 'desirability of the event' will be decreased and 'likelihood of the event' will be increased. Both of the factors are determined independently by time-associated functions. Then the intensity of fear will be changed according to its related emotion functions and factor-weight settings.

2. Emotion Function

Herbert Simon claimed that an explanatory account of human rationality must identify the significance of emotions for choice behaviour [7]. The significance of his opinion has been recognized and appreciated more recently. Gratch et al applied a computational framework of appraisal and coping to model emotion as a core aspect of virtual human's behaviours [8]. With the development of bioengineering and psychology, emotion is now being considered as playing an important role in guiding and regulating choice behaviour. It is necessary to design some practical structures for emotion as building blocks, which could be easily integrated into a practical bounded rationality system. The notion of emotion is a macroscopic concept. The emotion function proposed in this paper is based on the classification of 22 basic emotions in Ortony's emotion theory [6].

2.1Dimension of emotions

One dimensional emotion: Joy

Joy is a kind of well-being emotion, which is considered as one of the most basic emotion. The intensity of joy and distress are affected by the simplest control factor desirability among all the emotions. Fig.1 can be treated as programming flow chart of the emotion joy. The intensity of joy is set as a value in (0~1) and could be expressed as follow:

$$Intensity\ of\ Joy = Potential\ of\ Joy - Threshold\ of\ Joy \quad \text{(eq.1)}$$

The intensity of joy is only affected by one input factor: the degree of desirability, so it is called one dimension emotions. Inside the emotion block, there are some parameters need to be considered which affect the intensity of joy. First parameter is the time (t). It is believed that, as time goes on, the intensity of majority emotions will be decreased (i. e., joy), but some of them will be increased (i. e., fear). The other parameter is the personality (p), which is a group of factor-weight settings to different emotions, and also the threshold of the emotion.

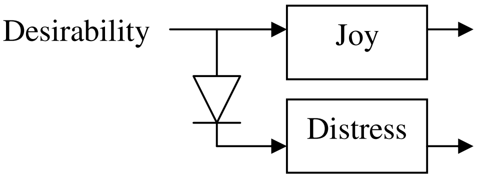

Fig.1 Programming Flow Chart of Joy

Multi-dimensional emotion:

Majority emotions are affected by more than one input factors. It is more complex to define and calculate the values of them than one-dimensional emotions. Hope is a kind of prospect-based emotion, which is also a kind of emotion reaction to events. The intensity of hope is affected by two input factors as shown in Fig.2. There are two factors affecting the intensity of the emotion, so hope is called a 2-dimensional emotion.

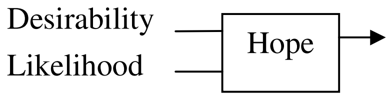

Fig.2 Programming Flow Chart of Hope

Table 1 is the summary of dimensions and input factors on Ortony's 22 basic emotions. In Tab.1, Desirable(1) means the degree of desire about desirable event for the others; Desirable(2) means the desire about undesirable event for the others; Desirable(3) means the desire about event for oneself. In Table 1, each emotion has a unique subscript to designate that emotion, and each input factors has a few subscripts to show that it is the input for those emotions with the same subscript.

2.2 Calculation of Emotion

Intensity

It is mentioned above that majority emotions are affected by multi-factors. The degree of each factor is defined by a value between 0 and 1. The presentation of a 4-dimensional emotion in its emotional space is: $E_1(a_1, b_1, c_1, d_1)$.

The intensity of E_1 can be represented as follows:

$$Intensity(E_1) = magnitude(E_1) = \sqrt{\alpha a_1^2 + \beta b_1^2 + \eta c_1^2 + \tau d_1^2} = rE_1 \quad \text{(eq.2)}$$

The notations α, β, η, λ are the coefficients (weights) for factor a_1, b_1, c_1, d_1,

For an n-dimensional emotion E_n

$$rE_n = \sqrt{\alpha_1 d_1^2 + \cdots + \alpha_i d_i^2 + \cdots + \alpha_j d_j^2 + \cdots + \alpha_n d_n^2} \leq 1 \qquad \text{(eq.3)}$$

Where α_i is the coefficient (weight) for input factor d_i.

$$MAX(rE_n) = 1 \qquad \text{(eq.4)}$$

The structures of different emotions are considered individually in this research. For the fire escape case, the value of 'likelihood of the event' and 'desirability of the event' will determine the intensity of the emotion 'fear' through the emotion function for fear.

Dimension	Emotions	Input factors
1	Joy_1, Distress_2	$\text{Desirable(3)}_{1,2}$
2	Liking_3, Disliking_4, Hope_5, Fear_6, Admiration_7, Reproach_8	$\text{Familiarity}_{3,4}$, $\text{Appealingness}_{3,4}$, $\text{Likelihood}_{5,6}$, $\text{Desirable(3)}_{5,6}$, $\text{Praiseworthiness}_{7,8}$, $\text{Expectation-deviation}_{7,8}$
3	Pride_9, Shame_{10}, Gratitude_{11}, Anger_{12}	$\text{Strength of cognitive unit}_{9,10}$, $\text{Expectation-deviation}_{9,10,11,12}$, $\text{Praiseworthiness}_{9,10,11,12}$, $\text{Desirable(3)}_{11,12}$
4	$\text{Gratification}_{13}$, Remorse_{14}, Satisfaction_{15}, $\text{Disappointment}_{16}$, $\text{Fear-confirmed}_{17}$, Relief_{18}, Happy-for_{19}, Sorry-for_{20}, Resentment_{21}, Gloating_{22}	$\text{Likelihood}_{15,16,17,18}$, $\text{Desirable(3)}_{13,14,15,16,17,18}$, $\text{Effort}_{15,16,17,18}$, $\text{Realization}_{15,16,17,18}$, $\text{Strength of cognitive unit}_{13,14}$, $\text{Expectation-deviation}_{13,14}$, $\text{Praiseworthiness}_{13,14}$, Desirable(1)_{19}, Desirable(2)_{20}, $\text{Presupposition}_{19,20,21,22}$, $\text{Likesome}_{19,20,21,22}$, $\text{Deserving}_{19,20,21,22}$

Table 1 The dimensions and input factors on Ortony's 22 basic emotions

3. Connection to Motion Database

Each motion includes extra information about triggering thresholds for all kinds of considered emotions and the intensity change of those emotions. For this fire escape case, the intensity of emotion 'fear' will be send to motion database. In the motion database, each motion is labelled with a property called activate threshold of fear. The motion will be and only be activated when the intensity of the related emotion is above threshold. Then all those motions which are above threshold will constitute an available motion database.

4. Decision Making Process

The decision making is a planning or navigation algorithm. There are two kind of decision should be made. One is the direction of next motion or venue based on synthetic perception, including where to go and which path is ideal. The other one is the type of next motion, which means what kind of pose/motion will be used in next step. The decision making algorithms are based on the theory of bounded rationality [9] and taking into account of emotions in decision making [10].

5. Behaviour Generation

A serial of behaviour will is generated based on the available motion database as result of decision making. It is easy to understand that there might be more than one possible behaviour available for the virtual character. The choice of those behaviours is determined randomly with some priority in this system. The virtual character will then perform the behaviours and its location in the virtual environment will be changed thereby. After this, steps 1 to 5 will iterate in the new location of environment.

RESULTS

The flow chart for emotion affected decision making process is illustrated in Fig 3, and the blueprint of a graphic script in Virtools™ on emotion affected decision making process is shown in Fig 4. The quantified emotion factors are calculated in the emotion blocks by emotion functions, generated motion sequences from available motion database are performed in Virtools™ directly. A full description about the techniques on virtual human simulation in Virtools™ is presented in an earlier publication [11].

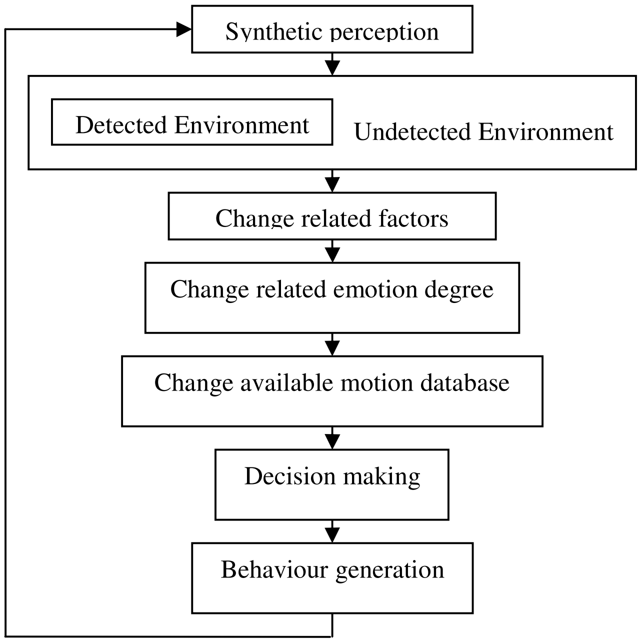

Fig.3 Flow Chart for Emotion Affected Decision Making

DISCUSSION

Human modelling is an interdisciplinary research field. The topic, emotion affected decision making, was originally a cognitive psychology issue, but now it has been realized by more and more researchers as an important research direction for many research fields. This paper tried to do some works which fully utilize current development of psychology, bioengineering and computer science, especially the development of technologies for virtual human modelling, and the latest achievement of cognitive psychology to making contribution to virtual human modelling. The bottleneck problem of the research is how to quantize emotions and how to build an available motion database that flexible and robust.

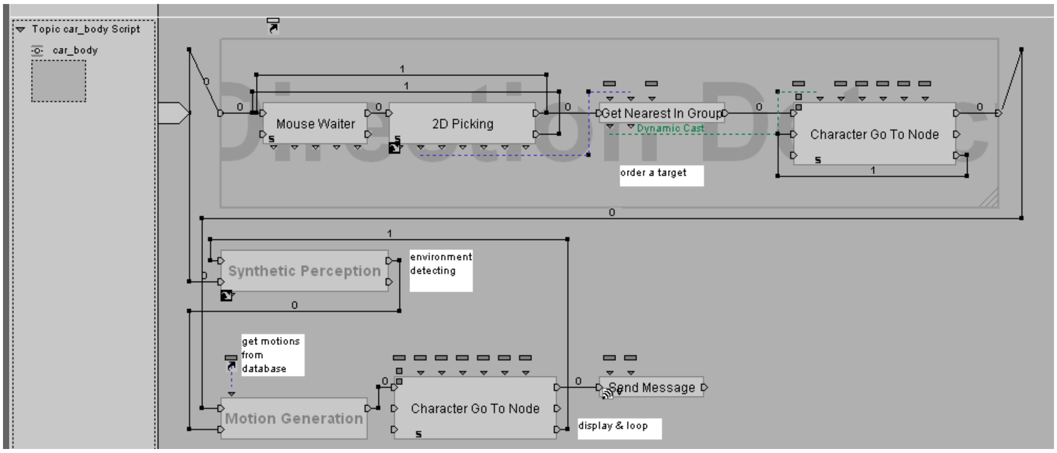

Fig.4 Graphic Scripts for Emotion Affected Decision Making

CONCLUSIONS

The main research area of this paper is the gap between psychology, bioengineering and computer sciences on emotion affected decision making. The main points of this paper are connecting the emotion process and decision making modelling and designing an emotion affected decision making mechanism. This paper presented the initial framework of the emotion affected decision making process and its simulation process in virtual human modelling. Some properties of a practical emotion structures, named dimension of emotion and emotion calculation, are also presented in this paper.

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