An Affective Model for Inter-generational Social Games

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***Abstract*—Inter-generational social or family game provides a lot of benefits for elderly life. During playing those games, emotions of player in the communication process are very important for perception, decision-making and interaction, which are also very difficult to be detected and observed. In order to detect player's emotions and to compute their intensities, we propose a novel method, based on OCC emotional theory and Fuzzy Cognitive Maps model, to compute affect according to internal goal desirability of player and external event consequence of the game world. Two case studies are provided to illustrate the modeling and simulating process in this paper. The result shows that emotions can be predicted and computed by this method during playing game.**

***Index Terms*—Fuzzy Cognitive Maps, Affective Model, OCC, Elderly Entertainment, Inter-generational Game**

I. INTRODUCTION

The gap between the youth and the elderly has been enlarging in the modern age, especially with respect to the use of computer and internet technology. Children nowadays enjoy playing computer games while the elderly have much less participation in this entertainment area. In fact participation in game playing activities is a good way to improve elderly' adaptability and provide them with more social interaction and family communication. In virtual game world, elderly look for friends, build up their social network, communicate with their families, share information, and spend a lot of time. Suitable inter-generational game activities are especially important for caregivers to help them adapt to living in the homes.

- The sensory stimulations involved in those games can promote elders' physical health and enhance their cognitive function, social skills and emotional control.
- Those games offer opportunities for the elderly to interact with the outside world and families which helps to reduce their sense of loneliness and avoid social disengagement.
- Active participation in social or family games enhances elderly' skills and so helps them to understand their abilities better. The achievement and recognition received from games enhance their self-worthiness.
- Playing those games with families enriches elderly' lives, allays their anxiety and emotional distress, and helps to reduce wandering behavior amongst demented residents.

In the field of serious game, many researchers have been working on designing games for elderly. In 1990, Whitcomb found that many games have been judged unsuitable for elders for a number of reasons, such as the small size of the objects on the screen, rapid movements or reactions required, or the sound being inappropriate. However, his research suggested a wide array of positive benefits for elders who take part in well-selected games over an extended period. For example, social interaction is stimulated when these activities are introduced into the game, and participation may increase as the activities continue. [1]

In 1995, Weisman analyzed the benefits of computer use by the elderly. Their research shows that computer use is not only valuable as a learning tool, but a diagnostic one as well. They discussed the possibilities of using computer games in their work with the elderly in the future. [2]

In 2005, Cheok et al. developed "Age Invaders", a novel game which allows the elderly to play harmoniously together with children in physical space. Their system also allows natural social-physical interactions amongst generations, both physically and through the Internet. [3]

In 2006, Gamberini et al. proposed "Eldergames", a platform to develop games using advanced visualisation and interaction interfaces to improve the cognitive, functional and social skills of older users. [4]

In 2007, Wijnand et al. reviewed and discussed digital game design for elderly users. They looked beyond the traditional perspective of usability requirements imposed by age-related functional limitations, towards the design opportunities that exist to create digital games that will offer engaging content combined with an interface that seniors can easily and pleasurably use. [5]

To the best of our knowledge, seldom elderly games or inter-generational games infuse affective or emotional analysis technologies. We believe that the social/family inter-generational or elderly game should have the capability to understand the player's emotions in certain degree, since they are performed as a "silent language" that are crucial for the entire communication process and the interactions between children and their grandparents.

In this paper, we will focus on the perspective of understanding emotional factors of players and propose a computational approach to predict player's emotions. Based on the context awareness emotion elicitation, we are trying to assist parents or grandparents to notice and understand the feelings and emotional status of their children. The rest of this paper is organized as follows. In Section 2, we first review existing work in the related fields, bringing the background of affective computing, emotional models and our computational model. In Section 3 we specifically describe the emotion elicitation approach in our system. In Section 4, we introduce some case studies based on our project Virtual Singapura II [6]. The final section concludes this paper and discusses some future work.

II. Related Works

Our work is based on newer affective computing, classical OCC emotional model and FCMs computational model. In this section we will survey the state of art for them.

A. Affective Computing for Education

Affective computing is one of new areas of artificial intelligence today, which is an interdisciplinary field spanning computer sciences, psychology, and cognitive science. The concept of "affective" was originally a topic of study in the psychology and cognitive sciences. The modern branch of computer science originated with Rosalind Picard's paper in 1995 on affective computing. [7]

Emotions in human communication process are very important for perception, decision-making, interaction, and intelligence. Therefore, applying affective computing to games is essential to maximize the player's immersive experience in the playing process.

In 1999, Carnegie Mellon University developed an affective mobile robot named Sage with a full-time job in the Carnegie Museum of Natural History. Its goal is to provide content to museum visitors in order to augment their museum experience. Nourbakhsh et al. discussed all aspects of the related research and development in their paper [8]. Saga can provide some emotions liking happy/busy, lonely, tired, frustrated and confused. They used a fuzzy state machine model, whereby external events would gradually trigger transitions from one state, or mood, to another. The particular implementation referred to some computational modeling of emotion. [9-11]

In 2002, Conati presented a probabilistic model to monitor a user's emotions and engagement during the interaction in games [12, 13]. In 2005, Boff et al. presented a virtual character placed in an educational environment with the main purpose of stimulating cooperative learning among students. [14].

In 2010, Ailiya et al. proposed a practical approach which uses FCM to represent OCC-based emotional rules to bridge the gap between psychological theory and the real operation of agent system. They integrated an emotional agent into a pedagogical project which uses OCC-based rules to do cognitive appraisal and involves Fuzzy Cognitive Map to do the numerical computation [15]. They also proposed a teachable agent design in 2011 that is a type of pedagogical agent which instantiates Learning-by-Teaching theory through simulating a "naive" learner in order to motivate students to teach it. [16]

Affective computing also applied in several existing pedagogical systems [8, 12-17]. The typical way of using affective computing in virtual game environment consists of two categories. One is related to eliciting the Non Player Character's (NPC's) emotions due to its own perceptions over environment changes, and the other is related to the understanding and the sympathy to player's emotional states. The two categories functionally serve different purposes – the prior concerning the capability of NPC to express proper emotions to make it believable and the latter one considering students' emotions and trying to assist player according to their current internal status.

B. OCC Emotional Model

Ortony, A., Clore, G., Collins, A. proposed the OCC emotional model in 1988. They think that emotions are the results of the following three types of subjective appraisals [18]:

- The appraisal of the pleasantness of the consequences of events with respect to the agent's goals. Those emotions that we call goal-based or event-driven emotions will be stimulated by valenced reaction to consequences of events and appraised by agent's internal goals, including happy-for, resentment, gloating pity, hope fear, satisfaction, fears-confirmed, relief, disappointment, joy and distress;
- The appraisal of the approval of the actions of the agent self or another agent with respect to a set of behavior standards. Those emotions that we call standard-based or agent-driven emotions will be stimulated by valenced reaction to actions of agents and appraised by agent's internal standards, including pride, shame, admiration and reproach;
- The appraisal of the liking of objects with respect to the attitudes of the agent. Those emotions that we call attitude-based or object-driven emotions will be stimulated by valenced reaction to aspects of objects and appraised by agent's internal attitudes, including love and hate.

Generally speaking, in our understanding of OCC model, emotions are reacted by both internal factors and external factors. Internal factors include agent's goals, preferences and attitudes, whereas external factors include events, agents and objects in environment. OCC model also considers another four compound emotions which result from both consequences of events and actions of agents, they are: gratification, remorse, gratitude and anger.

The original OCC model, with its 22 different types of emotions, looks probably too much fine grained. In practice, some researchers think the OCC model should be simplified to match the abilities of the character [19]. A simplified version of this theory was presented in 2003 by Ortony, where he considered only two different categories of emotional reactions: positive and negative. [20]

Based on OCC theory, Conati et al. presented a probabilistic model that assesses student emotional reaction during a game in 2002. Their model can predict a player's emotional state by assessing the player's appraisal of interaction with the game, in light of the player's goals and personality [13]. In 2009, Zhang et al. developed an emotional agent for serious game DINO, which is designed based on Goal Net model. Their agent's emotions are modeled by the OCC model and incorporated into FCM inference. [21]

C. Fuzzy Cognitive Maps

Fuzzy Cognitive Maps (FCMs) is a computable modeling tool, which can be used for simulation of complex systems [22]. It allows simulating state transition process of black box systems through use of cause and effect relationships. A FCM consist of a collection of nodes linked by edges, which are used to describe a given complex system. The nodes represent concepts, relevant to a given domain, whereas the causal links between nodes are represented by edges. The edges are directed to indicate the direction of causal relationships. Additionally, each edge includes weight information representing strength of the relationship. Those weights information are fuzzified, which can be positive (a promoting effect) or negative (an inhibitory effect). This feature enriches description of connection and allows using varying degrees of causal influence.

FCMs can evolve with time, and can involve feedback mechanisms. Specifically, the effect of change in a concept node may affect other concept nodes, which eventually can affect back the node that initiated the change. The weight of relationship between two nodes usually takes any value in the [-1, 1] range. -1 represents fully negative causal effect, whereas +1 means fully positive causal effect, and zero denotes no causal effect. Other values correspond to different fuzzy levels of causal effect. Definition of system relationships can be described by a matrix, called the complete edge connection matrix.

Considering the system with N concept nodes, we have a $N \times N$ matrix representing the FCM, in which the elements in the matrix are the causal link strengths. State of the system is determined by a state vector, which specifies current values of all system variables. The FCM iteratively updates the state of the system. During each iteration the value of each node is calculated based on the current values of every node by exerting influence on it through its causal link. After multiplying these values by edge weight between the two nodes, which represents the strength of the relationship between the nodes, the sum of these products is taken as the input to a transformation function that is used to reduce unbounded inputs to a certain range.

The value of each node in any iteration is computed from values of nodes in preceding state, using approach shown in Figure 1 and the following equation:

$$N_j(k+1) = f(\sum_{i=1}^{n} e_{ij} \times N_i(k))$$

Where $N_i(k)$ is the value of i^{th} node in the k^{th} iteration (system state), e_{ij} is edge weight (relationship strength) between nodes N_i and N_j, k is the corresponding iteration, n is the number of concepts, and f is the transformation (threshold) function.

Three types of transformation function which are commonly used are Binary, Trivalent and Sigmoid function [23]. In our simulation process, for computing emotion from value -1 to 1, we choose the Sigmoid function $f(x) = \tanh(x)$ as a threshold function, which is a continuous-output transformation function and can provide true fuzzy conceptual node states from the interval [-1,1].

FCMs have been applied in many different areas, including educational game area. [24-25]

III. METHOD

Based on OCC emotional model, we choose four goal-based emotions to design the affective computing method for social/family game Virtual Singapura II [6], which are *happy-for*, *resentment*, *gloating* and *pity*. They all belong to Fortunes of others branch in OCC cognitive structure of emotions. According to OCC, these four emotions are in two groups. Their values can be quantized as follows:

- Emotion for other's desirable consequences, the total value ranges -1 to 1.
  - *Happy-for* emotion's value ranges 0 to 1, 0 means no *happy-for* and 1 means most intensive *happy-for*.
  - *Resentment* emotion's value ranges 0 to -1, 0 means no *resentment* and -1 means most intensive *resentment*.
- Emotion for other's undesirable consequences, the total value ranges -1 to 1.
  - *Gloating* emotion's value ranges 0 to 1, 0 means no *gloating* and 1 means most intensive *gloating*.
  - *Pity* emotion's value ranges 0 to -1, 0 means no *pity* and -1 means most intensive *pity*.

OCC's authors also mentioned that the intensity of goal-based emotions is depended on goal's desirability. For gathering those data, we designed a set of questionnaires related to student's desirability in the game before the gameplay. Below is one example of those questionnaires:

TABLE I. EXAMPLE OF QUESTIONNAIRE

Hi, my friend, please choose your desirability in this game before playing. ● How do you like to get golden coins in this game? - If you get 100 golden coins, you happiness will be: (-10 to 10) - If you get 50 golden coins, you happiness will be: (-10 to 10) - If you get 10 golden coins, you happiness will be: (-10 to 10) - If you get 0 golden coin, you happiness will be: (-10 to 10) ● How do you like your grandma getting golden coins in this game? - If she get 100 golden coins, you happiness will be: (-10 to 10) - If she get 50 golden coins, you happiness will be: (-10 to 10) - If she get 10 golden coins, you happiness will be: (-10 to 10) - If she get 0 golden coin, you happiness will be: (-10 to 10)

By this way, we can build a knowledge base of player's desirability for the game. In our case, the knowledge base of goals includes the following six items:

- Desirability-of-My-Awards (DMA), which denotes the desirability of player for his/her own awards. According to game setting rules, we defined 4 situations of DMA: gaining 100 golden coins, gaining 50 golden coins, gaining 10 golden coins, and gaining no golden coin;
- Desirability-of-Other's-Awards (DOA to whom), which denotes the desirability for another player's awards with the same situations of DMA;
- Desirability-of-My-Farm-Health (DMFH), which denotes the desirability of player for the health of his/her own farm. According to game setting rules, we defined 3 situations of DMFH: farm having water, farm having a little water, farm having no water;
- Desirability-of-Other's-Farm-Health (DOFH to whom) , which denotes the desirability of player for the health of another player's farm with the same situations of DMFH;
- Desirability-of-My-Flower (DMF), which denotes the desirability of player for his/her own flower. According to game setting rules, we defined 4 situations of DMF: flower blooming, flower growing, flower fading, and flower dying;
- Desirability-of-Other's-Flower (DOF to whom), which denotes the desirability of player for his/her own awards with the same situations of DMF.

For different players, their knowledge base will be different, which shows the personality.

In summary, to apply our method on a specific scenario in the game world, the algorithm includes four steps:

- **Step 1:** *Gathering data to build knowledge base of user desirability*
- **Step 2:** *Generating the FCM model and it's computational matrix*
- **Step 3:** *Executing the FCM computation*
- **Step 4:** *Displaying/expressing the result*

In order to get better understandings of how two groups of Fortunes of others emotion are produced during playing in the game, we will introduce two case studies base on our game scenario.

IV. Case Studies

Our proposed approach has been implemented in the prototype of social game Virtual Singapura II (VS II). VS I project aims to build a 3D virtual learning environment which provides primary school and secondary school students in Singapore a culturally familiar environment to learn science [17]. The new version is planning to infuse FarmVille similar SNS feature into the game. One game scenario is that in the game, players are asked to plant trees or flowers in their fields. Each player need to complete several prompt quiz games to improve their farming capability. They can help each other with their families (Fig. 1). In this section we will illustrate how to use our proposed approach to analyze players' emotional tendency and detect their emotions.

Fig. 1. Screenshots of 3D family inter-generational game VS II.

A. Case Study I

Scenario 1 in VS II: in the virtual world of VS II, one boy helps his grandma to solve a hard quiz, and then he was awarded 100 golden coins, grandma's dry farm got water as his help, finally the flower bloomed in her farm.

Affective computing in scenario 1:

(1) *Gathering user's desirability*

After users answer the survey of desirability, we gathered the data shown in the right of Table II and Table III.

TABLE II. Positive Boy's Desirability Look-up Table

	Situation 1	Situation 2	Situation 3	Situation 4
DMA	1	0.5	0.1	-0.5
DOA to grandma	0.8	0.4	0	0
DMFH	1	0.2	-1	n/a
DOFH to grandma	0.8	0	-0.5	n/a
DMF	1	0.5	-0.5	-1
DOF to grandma	0.8	0.4	-0.4	-0.8

TABLE III. GRANDMA'S DESIRABILITY LOOK-UP TABLE

	Situation 1	Situation 2	Situation 3	Situation 4
DMA	1	0.5	0.1	-0.5
DOA to boy	1	0.5	0.1	-0.2
DMFH	1	0.2	-1	n/a
DOFH to boy	1	0.2	-0.8	n/a
DMF	1	0.5	-0.5	-1
DOF to boy	1	0.4	-0.4	1

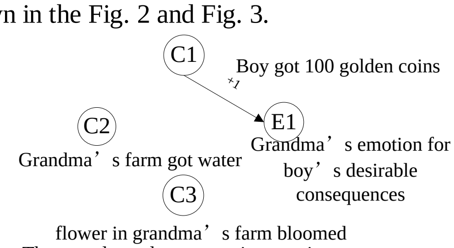
(2) *Modeling scenario using FCM*

According to the above scenario, the following consequences of event relate to desirability of user:

- Boy got 100 golden coins (C1, relates to his goal for award)
- Grandma's farm got water (C2, relates to her goal for health of farm)
- Flower in grandma's farm bloomed (C3, relates to her goal for flower status in her farm)

What we want to calculate is the emotion to other's desirable consequences (E1).

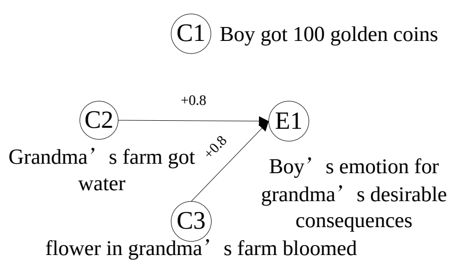
Now we model the scenario 1 as two FCM diagrams, which are shown in the Fig. 2 and Fig. 3.



The complete edge connection matrix:

$$\begin{bmatrix} 0 & 0 & 0 & 1 \\ 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 \end{bmatrix}$$

Fig. 2. Fuzzy cognitive map for scenario 1. (for computing grandma's emotion to boy's desirable consequences)



The complete edge connection matrix:

$$\begin{bmatrix} 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0.8 \\ 0 & 0 & 0 & 0.8 \\ 0 & 0 & 0 & 0 \end{bmatrix}$$

Fig. 3. Fuzzy cognitive map for scenario 1 (for computing boy's emotion to grandma's desirable consequences)

The casual relationships between nodes, which are represented by directed edges, can be looked up from the knowledge base of boy's and grandma's desirability respectively.

(3) *Simulating/executing the FCM computation*

Next, the developed model was simulated. The starting vector is denoted S0. Each state vector consists of four numbers, which correspond to conceptual nodes as follows: C1, C2, C3, and E1. The experiment makes possible to examine the mutual relationships among these elements. The simulation begins with following start state vector S0 = (1, 1, 1, 0), which can be interpreted as the beginning stage of the happening in the game. Three consequences of the event happen and set at value 1. The emotion node is inactive, i.e. the value is set as zero, what indicates that the boy did not get emotion. As the simulation continues successive values of nodes show trends which occur with the progressing time. Rounding to four significant digits, during the simulation the following states are achieved:

For the boy:

S0 = (1, 1, 1, 0)
S1 = (0, 0, 0, 0.92)
S2 = (0, 0, 0, 0)

where Si is the i^{th} state of the system. Next, the model steadily reaches equilibrium, which is state S2= (0, 0, 0, 0).

And for the grandma:

S0 = (1, 1, 1, 0)
S1 = (0, 0, 0, 0.76)
S2 = (0, 0, 0, 0)

(4) *Displaying/expressing the result*

For the boy's simulation, the first state (S0) shows that boy has no emotion. Then after three consequences happened, at state S1 the boy produces *happy-for* emotion to grandma's desirable consequences, and the intensity is 0.92. Because there is no sustaining event to activate, the final state (S2) shows that emotion disappears and the simulation ends in reaching an equilibrium state. The grandma has similar emotion transition process, the difference is that in the state S1, the grandma's *happy-for* emotion intensity is 0.76 (Figure 1. right).

The analysis shows that the boy and the grandma both have positive desirability in their knowledge base, so when other gets the desirable consequences, they will be happy for each other. Now let's move to the next case to see if the boy has negative desirability hided in his knowledge base, what result will be disclosed.

B. Case Study II

Scenario 2 in VS II: in the above event, if the boy does not want to help grandma to answer any quiz for some reasons, and then the grandma's farm are dry out and finally all flowers die.

Affective computing in scenario 2:

(1) *Gathering user's desirability*

After user answering the survey of desirability, we gathered boy's data shown in the Table IV, and grandma's data is same with scenario 1.

TABLE IV. NEGATIVE BOY'S DESIRABILITY LOOK-UP TABLE

	Situation 1	Situation 2	Situation 3	Situation 4
DMA	1	0.5	0.1	-0.5
DOA to grandma	-0.8	-0.4	-0.1	0.5
DMFH	1	0.2	-1	n/a
DOFH to grandma	-0.5	0	0.5	n/a
DMF	1	0.5	-0.5	-1
DOF to grandma	-0.8	-0.4	0.4	0.8

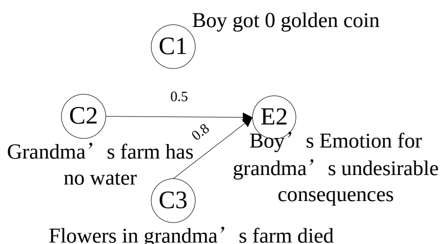
(2) *Modeling scenario using FCM*

According to scenario 2, the following consequences of event relate to desirability of user:

- Boy got 0 golden coins (C1, relates to his goal for award)
- Grandma's farm got no water (C2, relates to her goal for health of farm)
- Flowers in grandma's farm died (C3, relates to her goal for flower status in her farm)

What we want to calculate is the emotion to other's undesirable consequences (E2).

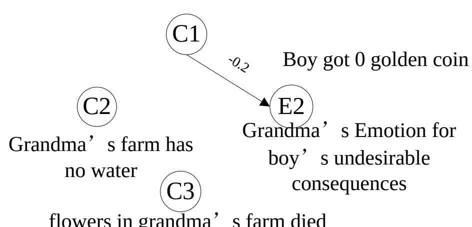
Now we model the scenario 2 as two FCM diagrams, which are shown in the left of Fig. 4 and Fig. 5.



The complete edge connection matrix:

0	0	0	0
0	0	0	0.5
0	0	0	0.8
0	0	0	0

Fig. 4. Fuzzy cognitive map for scenario 2 (for computing boy's emotion to grandma's undesirable consequences)



The complete edge connection matrix:

0	0	0	-0.2
0	0	0	0
0	0	0	0
0	0	0	0

Fig. 5. Fuzzy cognitive map for scenario 2 (for computing grandma's emotion to boy's undesirable consequences)

(3) *Simulating/executing the FCM computation*

In this case, the starting vector is still denoted S0. Each state vector also consists of four numbers. The simulation begins with following start state vector S0 = (1, 1, 1, 0). And during the simulation the following states are achieved:

For the boy:

S0 = (1, 1, 1, 0)
S1 = (0, 0, 0, 0.38)
S2 = (0, 0, 0, 0)

And for the grandma:

S0 = (1, 1, 1, 0)
S1 = (0, 0, 0, -0.2)
S2 = (0, 0, 0, 0)

(4) *Displaying/expressing the result*

For the boy's simulation, the second state (S1) shows that after three consequences happened, the boy has *gloating* emotion to grandma's undesirable consequences, and the intensity is 0.38. And the grandma has *pity* emotion at state S2, the intensity is -0.2.

This result shows that the boy has negative desirability in his knowledge base, so when grandma gets the undesirable consequences, he feels gloating for her. But the grandma still has positive desirability in her knowledge base, when the boy got no coins, she feels pitiful for him. In this situation, the parents should pay more attention to the boy and try to induce him to a more good-will aspect.

C. Analysis and Discussion

According to the analysis of our case study, four types of players' emotions can be predicted when players playing the farm game. If we broadly divide the emotions into two categories, good will and bad will, we find that the good will emotions (happy-for and pity) tend to enhance player's emotional communication and the bad will emotions (resentment and gloating) tend to hinder their emotional communication. Through this type of communication, if a player feels envious when other's doing better or feels gloating when other's doing worse, it does need us to pay more attention and use some hints or guidance to induce the player to concern from a brighter view.

V. CONCLUSIONS AND FUTURE WORKS

Whether living independently or in a family environment, socialization for the elderly is vital. When you provide appealing social/family game experiences for elderly, you help them keep minds sharp and provide emotion detection to defense against loneliness and depression for them.

In this paper, we propose a novel method to compute player's emotions according to internal goals and external events during playing social inter-generational game. Our method is based on OCC emotional theory and FCM computational modeling tool, which can be applied on the design of social inter-generational game for family environment. The simulation process of FCM shows that emotions and their intensities can be computed and predicted by this method.

We are planning to apply this method to more games for elderly and conduct a deep study on the related inducing strategies for our game in future work, as it involves many relevant factors and needs more concrete studies. What we want to do is to detect the possible problems elderly players may face and give a suggestion to more take care of the sensitive and fragile hearts.

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