An Artificial Emotion Model For Visualizing Emotion of Characters

Junseok Ham, Chansun Jung, Junhyung Park, Jihye Ryeo, and Ilju Ko

Abstract—It is hard to express emotion through only speech when we watch a character in a movie or a play because we cannot estimate the size, kind, and quantity of emotion. So this paper proposes an artificial emotion model for visualizing current emotion with color and location in emotion model. The artificial emotion model is designed considering causality of generated emotion, difference of personality, difference of continual emotional stimulus, and co-relation of various emotions. This paper supposed the Emotion Field for visualizing current emotion with location, and current emotion is expressed by location and color in the Emotion Field. For visualizing changes within current emotion, the artificial emotion model is adjusted to characters in Hamlet.

Keywords—Emotion, Artificial Emotion, Visualizing, Emotion Model.

I. INTRODUCTION

THERE is a word 'indescribable'. We use this word when we cannot express feelings or forms which are not clear. Emotion is hard to measure in size, kind, and quantity. Even though we have some words angry, sorrow, joy, etc to express our emotion, we cannot express our emotion sometimes. For example, in 'Hamlet'[1] by William Shakespeare, the scene Ophelia's funeral, Hamlet has indescribable emotion because of his sorrow due to missing Ophelia, vengeance for his uncle, and hate for his mother. This indescribable emotion is expressed in the form of anger to Laertes.

As in the case of Hamlet, we have a lot of situations that cannot be expressed by text or speech; also sometimes we don't know or cannot explain why we have indescribable feelings or emotions at a given moment. So this paper supposes an artificial emotion model to express current emotion with color and location in an emotion space, and visualize the emotions of the characters in Hamlet with it.

The artificial emotion model needs to express the following four features of emotion to visualize current emotion.

First, there is causality when emotion is generated. Emotion cannot be generated without a cause. When we have some emotions, there must be a cause for the generated emotion. Second, emotions have different time length for generating, maintaining, and decaying according to personality. Hot tempered people get angry easily, and are also easily appeased. On the other hand, timid people hardly get angry, but once they get angry, they fly into a rage, and they are not easily appeased. Third, continued emotional stimulus make large stimulus. Sometimes continual small stimulus can make bigger emotions than big stimulus can. Fourth, each emotion is related with others. We feel more sorrow when we have gloomy feelings.

These features of emotion are usually mentioned in psychology, there are some emotional models to express current emotion. But they are too abstract to make a system for visualizing emotion. So an artificial emotion model will be created which can express the four features of emotion using the emotion model in psychology with a technological approach.

II. DESIGN OF THE ARTIFICIAL EMOTION MODEL

The artificial emotion model analyzes and visualizes emotion in the following four steps. In the first step, the artificial emotion model analyzes events as causality and explains what kind of emotional stimulus has occurred. For the second step, the artificial emotion model visualizes one emotional stimulus at a time. In the third step, the artificial emotion model visualizes the same kind of continued emotional stimulus as a time. In the step, the artificial emotion model visualizes the combined current emotion as a co-interaction of emotion.

A. Analyzing Emotional Stimulus as Causality

The first step is analyzing emotional stimulus as causality between an event and an emotion. The artificial emotion model analyzes the situation according to the causality model based on the OCC (Ortony Clore Collins) model.[2] The OCC Model defines 22 emotions as causality about emotion, and it divides causes into three parts; consequences of events, actions of agents, and aspects of objects. The OCC model cannot express emotion at a time, but it is useful to define the co-relation between causes and emotional stimulus.

It is hard to adjust the original OCC model to the artificial emotion because it has too many emotions 22 emotions to adjust and to realize. So we use only 5 of the 22 emotions which are the commonly expressed emotions in Hamlet. We analyze the causality of the five emotions based on the OCC model.

J. Ham is with the Department of Media, Soongsil University, Seoul, Korea (e-mail : gjboy@ssu.ac.kr)

C. Jung is with the Department of Media, Soongsil University, Seoul, Korea (e-mail :eruda73@ssu.ac.kr)

J. Park is with the Department of Media, Soongsil University, Seoul, Korea (e-mail : KAGA@ssu.ac.kr)

J. Ryeo is with the Department of Media, Soongsil University, Seoul, Korea (e-mail : hoya350@ssu.ac.kr)

I. Ko is with the Department of Media, Soongsil University, Seoul, Korea (e-mail : andy@ssu.ac.kr)
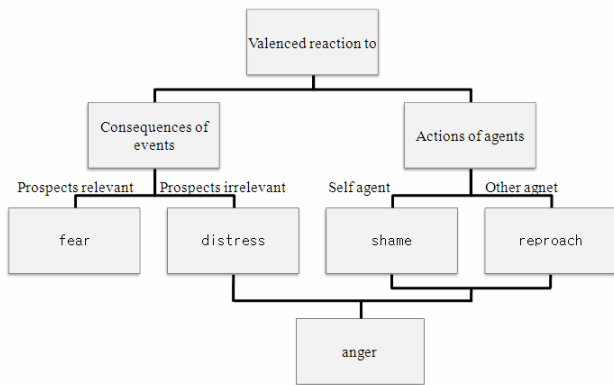
Fig. 1 The causality based on the OCC model

Fig. 2 A sound wave form of one musical instrument

Fig. 1 shows five (fear, distress, shame, angry, and reproach) emotions are mainly used in Hamlet. The original OCC model divides causes of emotion generation into 'consequences of events', 'actions of agents', and 'aspects of objects', but there are fewer 'aspects of objects' , and there are mostly 'consequences of events' and 'actions of agents' in Hamlet. So we divide causes into two groups; 'consequences of events' and 'actions of agents'.

In the OCC model, fear or hope is generated when consequences of events have been prospected, but there are no emotions related with hope; there is only fear in Hamlet. Distress is generated when consequences of events are not related to prospection. When the action of another person is approving, and disapproving to oneself, shame is generated. Also reproach is generated when actions of another person are disapproving. Anger is generated when the consequences of events are not concerned with respect, and the actions of others are disapproving.

For example, in the scene on the way to a ship-port to England, Hamlet is against himself when he cannot take action although he is watching Fortinbras. In the OCC model, this is disapproving to oneself about 'action of agents', so the emotion of shame is generated. The shame that we think usually is sometimes an emotion which we feel when we hurt our pride, but it is an emotion, feeling when we are disapproving to ourselves in the OCC model.

B. Expressing Emotion According to Times

The second step of visualizing emotion through the artificial emotion model expresses analyzed emotion in first step as times. The artificial emotion model visualizes one emotional expression of a person as the sound wave form of one musical instrument.
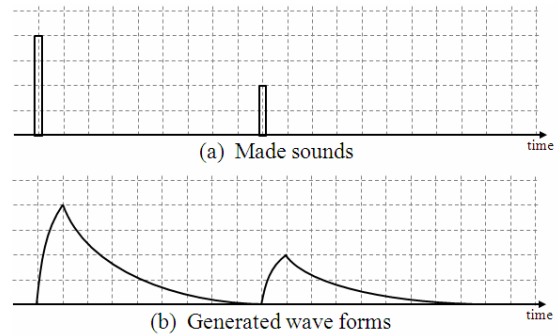
It is regular that the sound wave form of one musical instrument makes a sound. Fig. 2 (a) shows a situation when one musical instrument makes two sounds a big one and a small one. Then, two sounds wave forms are generated like (b); the form is regular although the amount is changed. Like the sound wave form of one musical instrument, a person has regular times of generating, maintaining, and decaying of emotion. They can be changed by amounts of emotional stimulus, but the forms of generating, maintaining, and decaying emotion are not changed.
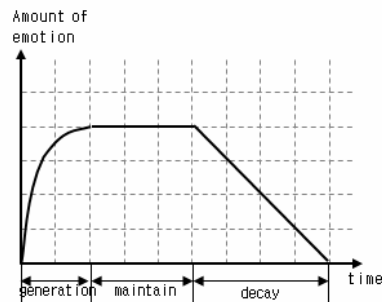

Fig. 3 An example of an Emotion Graph Unit

The artificial emotion model expresses a form of one emotion using an Emotion Graph Unit. The Emotion Graph Unit is the minimum unit of emotional expression in the artificial emotion model that shows how much time is needed for generating, maintaining, and decaying emotion. Hot tempered people like Hamlet get angry easily but also they are appeased easily. On the other hand, timid people like Gertrude, do not get angry easily, but once they get angry, they are angry for a long time, and need a long time to be appeased. Fig 3 is an example of the Emotion Graph Unit; It shows the Emotion Graph Unit is constructed of three parts; a generation part, a maintain part, and a decay part.
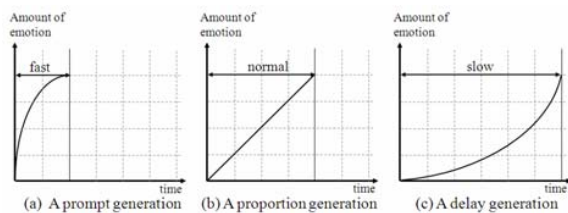
Fig. 4 Forms of emotion generation

The generation part of the Emotion Graph Unit takes one form of (a), (b), and (c) in Fig. 4 according to the form of a generating emotion. People who have the form of (a), a prompt generation, express an emotion promptly when they have gotten emotional stimulus. People who have the form of (c), a delay generation, express emotion scantly and slowly at the beginning, but they express an emotion explosively after a few moments. People who have the form of (b), a proportion generation, have an emotion in proportion to time. [3]

A generation form of the Emotion Graph Unit about Hamlet can be inferred by his actions. Hamlet promptly killed Polonius behind the curtain although he agonized over killing the King or not. Also he got angry promptly when he saw Laertes sob in front of a tomb of Ophelia. Therefore a generation form of the Emotion Graph Unit for Hamlet is the form of (a); a prompt generation.
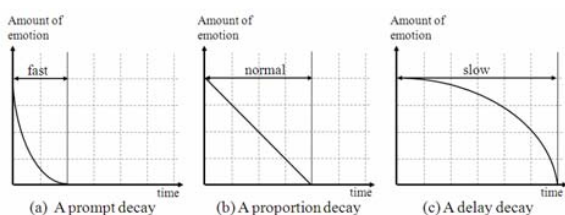

Fig. 5 Forms of emotion decay

The decay part of the Emotion Graph Unit takes one form of (a), (b), and (c) in Fig. 5 according to a form of a decaying emotion. People who have the form of (a), a prompt decay, lose their emotion promptly in a short time. People who have the form of (c), a delay decay, need a long time to start losing their emotion actively. People who have the form of (b), proportion decay, lose their emotion in proportion to time. [3]

The decay form of Emotion Graph Unit according to the personality of Hamlet is inferred to (a), a prompt decay. Hamlet got angry when he saw Laertes sobbing in front of a tomb, but he was appeased soon in the next scene, and apologized to Laertes. Therefore the decay form of the Emotion Graph Unit for Hamlet is (a) a prompt decay which loses emotion in a short time.

Lastly, the Emotion Graph Unit is a sum of the generation part, the maintain part, and the decay part. The generation part takes one form in Fig. 4, and the decay part takes one in Fig. 5. Also a maintain part is a line between the generation part and the decay part according to the maintaining time of emotion.
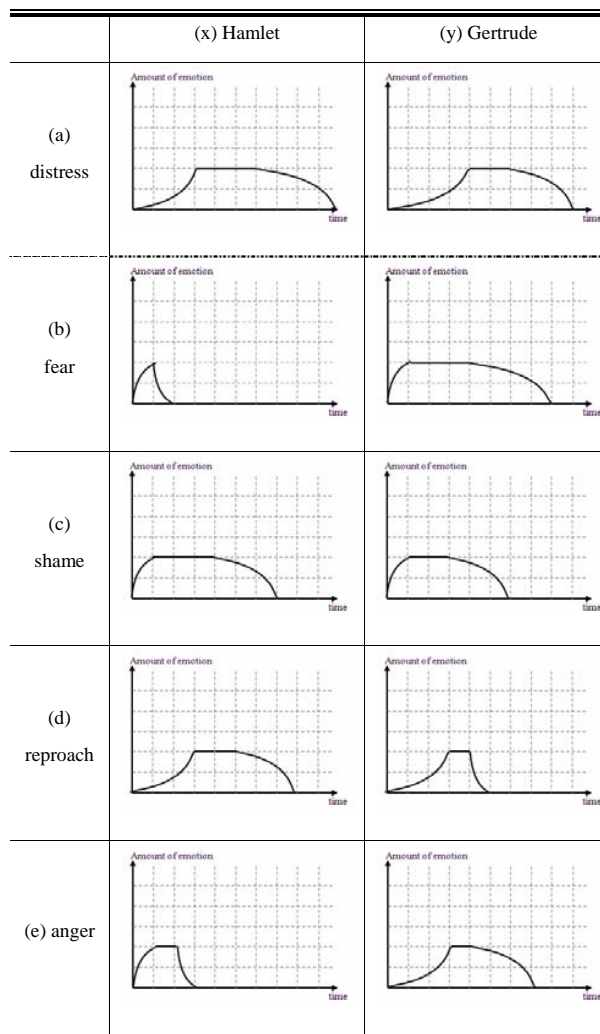

Fig. 6 Differences between Hamlet and Gertrude according to their personality

Hamlet is seen to be an irresolute man because he is thought to have killed his uncle but he just thought and agonized. On the other hand, he is seen to be a man of decision; killing Polonius without hesitation because he thought the form behind the curtain might be his uncle. He may be seen to have a double personality, but it can be explained by (a) and (e) of Fig. 6. The anger (e) in Fig 6 has (a) the prompt generation in Fig. 4, while the distress (a) in Fig 6 has the decay generation in Fig. 4. So when anger and distress are generated simultaneously, anger is generated faster than distress. So, Hamlet killed Polonius immediately. On the other hand, the Emotion Graph Unit of anger has a short maintain part, and the decay part has the form of (a) a prompt decay in Fig. 5. The Emotion Graph Unit of distress has a long maintain part, and the decay part has the form of (c) delay decay in Fig. 5. Therefore, distress maintains longer and higher than anger, so he was seen to be irresolute man after a regular time interval had past.

C. *Expressing Emotion According to Continual Stimulus*

The third step of visualizing emotion through the artificial emotion model, is expressing the continual stimulus to the Emotion Graph using the Emotion Graph Unit of 2.2. Continual small stimulus can make bigger emotions than big stimulus can. The Emotion Graph uses this feature with the sum of the Emotion Graph Unit. The Emotion Graph expresses amplification and an offsetting when the same emotional stimulus is inputted continuously.

(a) times to generate emotional stimulus

(b) Generated Emotion Graph
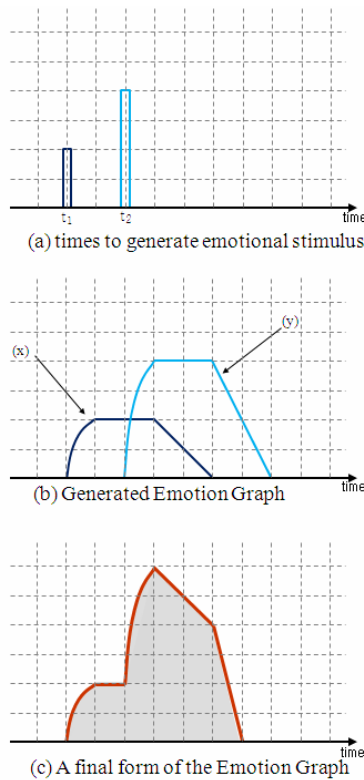
(c) A final form of the Emotion Graph

Fig. 7 An example of a sum of a continual emotional stimulus in the Emotion Graph

The Emotion Graph is expressed by sums of the Emotion Graph Unit. Fig. 7 shows how the Emotion Graph is changed by inputting two emotional stimuli. When emotional stimulus are input at t_1 and t_2 of (a), two Emotion Graphs are generated. (x) and (y) of (b) show these within the Emotion Graph Unit. But the time of t_2, (x) and (y) of (b) is summed because there is already (x) of (b) when (y) of (b) is generated. Finally, the graph (c) is generated.

(a) times to make sounds

(b) Generated sound wave forms

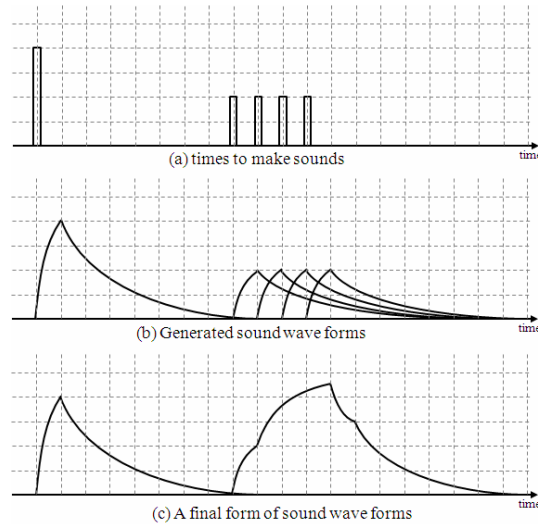(c) A final form of sound wave forms

Fig. 8 An example of a sum of a continual sound wave form

Similar to the Emotion Graph Unit, the Emotion Graph can also be explained in a sound wave form. In Fig 8, (a) shows one big sound source and four small sound sources are generated. Then a big sound wave form and four small wave forms are generated as illustrated in (b). But in the case of the four small wave forms, one wave form is generated before another wave form had decay yet. So, four small wave forms are summed, finally the graph (c) is generated. The four small sound wave forms sound greater than the one big sound wave form [4].

Although Hamlet is not an immoral man, even if he gets very angry once, he kills Polonius without hesitating. Before killing Polonius, Hamlet got a lot of anger stimulus during talks with Gertrude. Therefore, so many Emotion Graph Units are summed, and the Emotion Graph is generated which has an enormous degree. As a result, Hamlet killed Polonius.

D. *Expressing Emotion According to the Co-Relation of Various Different Emotions*

This paper proposes the Emotion Field that visualizes emotion with color and location in emotion space according to the co-relation of various different emotions. To express co-relation of emotions, it applies the emotion model of Plutchik[5]. And to visualize emotion with color, it applies the color model of Mosses Harris [6].

The emotion model of Plutchik represents the co-relation of various emotions based on eight basic emotions in the form of a circle. The emotion model of Plutchik represents the co-relation of emotions using degrees in the circle, it is useful to express co-relation of emotions. But it divides emotions into several areas, so it can only express several simple emotions.

Like the emotion model of Plutchik, the Emotion Field expresses the co-relation of emotions with degrees in the emotion field. We called this, Range Of Degree (ROD). ROD means how often the same emotion is expressed. Contrary to the circle form of the Plutchik model, the Emotion Field has the form of a uneven looped curve because each emotion has a different maximum value. We called this maximum amount of

emotion the Maximum Value (MV). MV means how much of an emotion is expressed.

The Emotion Field visualizes a current emotion with color adapting the Mosses Harris color model. The Mosses Harris color model is a color space model that represents a co-relation of colors based on three basic colors. In the Emotion Field, there is a basic color for each emotion, and intervals along the basic emotions are expressed by interpolation. Also the center of the Emotion Field has zero brightness, and the ends of each emotion have maximum brightness.

The Emotion Field is composed by standard emotion vectors which exist for each emotion. The standard emotion vector is a vector that has a degree of vector to ROD, and a destination of vector to MV. The maximum range of the Emotion Field is made interpolating each end of standard emotion vectors.
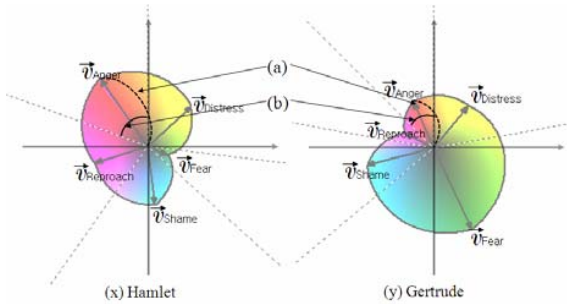

Fig. 9 Examples of the Emotion Field as personalities

Fig 9 is the Emotion Fields of Hamlet and Gertrude. The standard emotion vectors, ROD, and MV are decided arbitrarily by their personalities. Colors at the standard emotion vectors are decided as follows: distress is yellow, fear is green, shame is blue, reproach is pink, and anger is red. In the case of the vector of anger, (a) is the MV of anger, and (b) is the ROD of anger. Hamlet can feel deeper anger than Gertrude because his MV of anger is bigger than hers. Also Gertrude can feel fear more often than Hamlet because her ROD of fear is bigger than his. [7][8][9]

The Emotion Field express a current emotion with the vector of current emotion ($\overrightarrow{Vc}$). A value of $\overrightarrow{Vc}$ is decided by the sum of each emotion vector. The emotion vector is a vector having ROD of the standard emotion vector to a vector of a degree, and having MV to a vector of a destination. When $\overrightarrow{Vc}$ is closer to the center of the Emotion Field, emotion becomes quiet, and closer to the end of the Emotion Field, emotion grows greater.
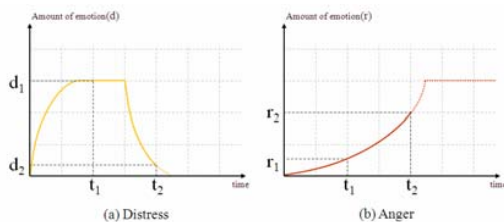

Fig. 10 Distress and anger at time of t_1 and t_2

Fig. 10 is examples of the distress and anger which Hamlet has. He has distress as d_1 and anger as r_1 at the time of t_1. And he has distress as d_2 and anger as r_2 at the time of t_2.
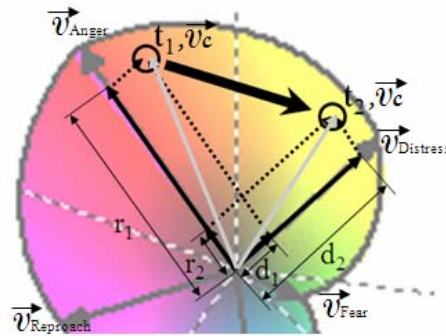

Fig. 11 Changing emotions at the time of t_1 and t_2 in Emotion Field

Fig. 11 shows how to move a current emotion in the Emotion Field. The Emotion Field expresses an emotion of anger mainly at the time of t_1 because $\overrightarrow{Vc}$ directs near the standard emotion vector of anger. At the time of t2, $\overrightarrow{Vc}$ is near the standard emotion vector of distress, so the Emotion Field mainly has an emotion of distress.

Finally, the artificial emotion model visualizes current emotion according to four steps. The first step, it analyzes causes and results of emotional stimulus. In the second step, it visualizes an emotional stimulus by time. The third step, it visualizes continually same emotional stimulus by time. And the last step, it visualizes a current emotion according to the co-relation of emotions.

To visualize emotions with the artificial emotion model, a character that has an extreme range of emotions is needed. So, the artificial emotion model is applied to characters in Shakespeare's 'Hamlet' to create visualization.

III. APPLYING THE ARTIFICIAL EMOTION MODEL TO 'HAMLET'

To visualize current emotion with the artificial emotion model, we chose Hamlet, who shows extreme changing of emotion, and Gertrude who has the opposite personality to Hamlet. To adjust the artificial emotion model, there must be a time table according to a scenario. So, we used 'Hamlet 2000' [10] which was made using a play of 'Hamlet'.

The Emotion Graph Unit at each character had forms as Fig 6, ROD and MV had the values in Fig. 9.

The artificial emotion is applied to a scene which showed Hamlet and Gertrude talking and represented a feeling of confrontation (1:02:37~1:05:14).

TABLE I
EVENTS AS TIMES, AND EMOTIONAL STIMULUS AS EVENT

Time	Characters	Event	Emotional stimulus
1:02:46	Gertrude	Hamlet does a rash act	Reproach(0.5) Anger(0.25)
1:02:47	Hamlet	Gertrude stands with the king	Reproach (0.4) Anger(0.9)
1:02:49	Gertrude	Hamlet reproaches her	Reproach (0.7)

Time	Character	Event	Emotion
			Anger(0.35)
1:02:51	Hamlet	Gertrude reproaches him	Anger(0.8)
1:02:56	Hamlet	Gertrude stands with the king	Reproach (0.5) Anger(0.7)
1:02:56	Gertrude	Hamlet reproaches her	Anger(0.5)
1:03:01	Hamlet	Gertrude hits him	Anger(0.9)
1:03:03	Gertrude	Hamlet reproaches her	Reproach (0.8) Anger(0.55)
1:03:04	Hamlet	Gertrude tries to call for help	Reproach (0.7) Anger(1)
1:03:08	Gertrude	Hamlet pushes her	Fear(0.95)
1:03:15	Hamlet	Hamlet knows someone is hiding	Distress(0.6) Anger(1)
1:03:16	Gertrude	Hamlet shouts	Fear (0.9)
1:03:19	Hamlet	Hamlet thinks the king is hiding	Anger(0.8)
1:03:24	Gertrude	Hamlet kills Polonius	Distress(0.4) Fear (1)
1:03:28	Hamlet	Hamlet knows the person killed is not the king	Distress (0.3) Fear (0.2)
1:03:51	Hamlet	Gertrude reproaches him	Fear (0.3) Reproach (0.5) Anger(0.7)
1:03:56	Gertrude	Gertrude knows the purpose of Hamlet	Fear (0.85) Anger(0.5)
1:04:15	Hamlet	Gertrude tries to call for help	Anger(0.7)
1:04:17	Gertrude	Gertrude tries to call for help	Distress (0.5) Fear (0.6)
1:04:21	Gertrude	Hamlet gets angry	Fear (0.85)
1:04:25	Hamlet	Gertrude offers excuse to him	Reproach(0.9) Anger(0.8)
1:04:39	Hamlet	Gertrude reproaches him	Reproach (1) Anger(0.9)
1:04:40	Hamlet	Gertrude offers excuse to him	Reproach (1) Anger(1)
1:04:45	Gertrude	Hamlet reproaches her	Fear (0.5) Shame(0.65)
1:04:48	Hamlet	Gertrude tries to stop him	Anger(1)
1:04:54	Gertrude	Hamlet gets very angry	Fear (0.6) Shame(0.5)
1:04:57	Gertrude	Hamlet hits her	Fear (1)

Table I shows the events according to the times in the scene; and the emotional stimulus according to events. We applied Table I to two artificial emotion models which are set as Hamlet and Gertrude. When information about time and event is input to the artificial emotion model, it expresses current emotion with the Emotion Graph and the Emotion Field.
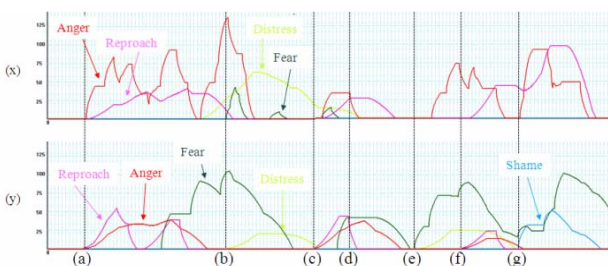

Fig. 12 Two Emotion Graph of Hamlet and Gertrude

Fig. 12 shows two Emotion Graph according to Table I. In Fig. 12, (a) shows the Emotion Graph of Hamlet, and (b) of Fig. 12 shows the Emotion Graph of Gertrude. At the time of (a), Hamlet and Gertrude reproached each other. Hamlet (x) had big emotions of anger and reproach, so he used violence against Gertrude. Gertrude (y) had emotions of anger and reproach at the beginning, but she had an emotion of fear after Hamlet used violence. At the time of (b), Hamlet (x) killed Polonius while experiencing an extreme emotion of anger. Also he had emotions of fear and distress because he killed a person, but soon calmed down. Gertrude (y) had emotions of fear and distress because Hamlet killed Polonius. But she had emotions of reproach and anger because Hamlet calmed down even though he killed a person. After receiving the emotions of reproach and anger from Gertrude, Hamlet expressed emotions of reproach and anger. As a result, Gertrude (y) had greater emotions of reproach and anger than fear and distress at the time of (d). Gertrude (y) had a strong emotion of fear at the time of (f) and (g), but it seems to be smaller relatively at the time of (f) than (g) because the emotion of reproach and anger has opposite locations to the emotion of fear in the Emotion Field.
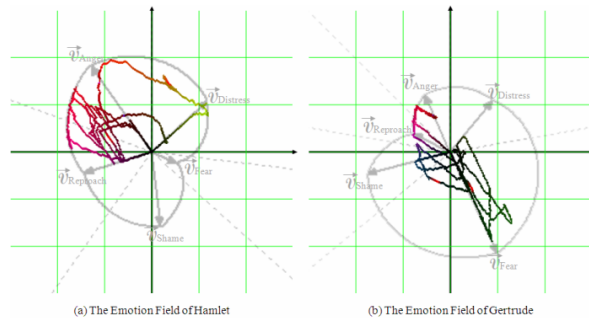

Fig. 13 $\overrightarrow{Vc}$ traces in the Emotion Field of Hamlet and Gertrude

Fig. 13 shows how to move $\overrightarrow{Vc}$ in the Emotion Field of Hamlet and Gertrude according to the Emotion Graph. The Emotion Field of Hamlet (a) shows that Hamlet mainly had emotions of anger and distress. $\overrightarrow{Vc}$ of (a) stayed for a long time near the end of the Emotion Field because of MV. In the case of the emotion of distress of (a), it seems to be small in the Emotion Graph of (x) of Fig. 12, but it stayed in an area of distress because the ROD of distress had a big degree in the Emotion Field.

In the case of the emotion of fear in (a), $\overrightarrow{Vc}$ didn't stay in an area of fear although Hamlet got three times the fear stimulus in the Emotion Graph of Fig. 12. This is due to the emotions of anger and reproach are located opposite to fear in the Emotion Field. So, Hamlet did not express any emotion of fear.

The emotion of reproach and anger seem to be big in (y) of Fig. 12, but $\overrightarrow{Vc}$ stayed for a short time in the Emotion Field of (y) in Fig. 13 because fear is opposite to reproach and anger. In the case of distress of (y) in Fig. 13, distress has a big ROD next to fear; also the stimulus of distress is input two times at the time of (b) and (e) of Fig. 12. But the emotion of distress stayed for short times in the Emotion Graph because of the strong emotion of fear. So, Gertrude seems to lack thoughtfulness.

IV. Conclusion

The Emotion Graph shows each current emotion, and the Emotion Field shows current emotion as a co-relation of emotions. So the artificial emotion model can explain why characters have some emotions in some situations.

But it is decided to make the forms of the Emotion Graph Unit, ROD, and MV arbitrary, so the result of visualizing emotion has less significance. However, the artificial emotion model can visualize the emotion of characters suggesting the possibility the artificial emotion can be applied to other contents or other fields.

Simulating and visualizing current emotion can expand expression at a movie, a play or a drama which emotion plays a big importance. Also, it can be applied to contents where users can participate such as a game or interactive art. So it can expand co-interaction between users and contents.

References

[1] W. Shakespeare, Hamlet
[2] A. Ortony, G. Clore, A. Collins, The Cognitive structure of Emotions, Cambridge University Press, 1998.
[3] D. Kaith, The language of mathmatics : making the invisible visible, New York : W.H. Freeman , 1998.
[4] R. W. Picard, Affective Computing, The MIT Press, 1997.
[5] R. Plutchik, Emotion : A psychoevolutionary synthesis, New York : Harper & Row, 1984.
[6] M. Un-bae, Understanding and applying of colors, Angraphics, 2005.
[7] E. Heller, Wie Farben auf Gefühl und Verstand wirken, Droemersche Verlagsanstalt Th. Knaur Nachf, GmbH & Co, 2000.
[8] J. A. Russell, A circumplex model of affect, Journal of Personality and Social Psychology, 39, 1980, 1161-1178.
[9] P. J. Lang, Cognition in emotion: Concept and action, Cambridge University Press, 1984.
[10] A. Michael, Hamlet 2000, Miramax Films, 2000.