Visualization of Atmosphere Information for Distance Education System Based on Fuzzy Inference Using Customized Knowledge

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Abstract:
A distance education system is designed based on fuzzy inference, where visualized atmosphere information is shared by all learners in a virtual classroom. It provides high aspirations, low isolated feeling, low stress, and high affinity to learners, and offers learner's psychological information, individual difference information, and hints of system improvement to the system manager. The effect of visualized atmosphere information in the learner's psychological states is confirmed by T score of POMS test for 15 graduate students using CAI contents, and comparison experiment with traditional distance education. The proposal of atmosphere information presentation of virtual classroom provides a first step in establishing Education Academy beyond Space Time (EAST).

Keywords: *distance education, visualization, fuzzy inference, atmosphere, POMS*

1. Introduction

Several approaches such as an adaptive system based on the learner's user model have been proposed for effective distance education [1] [2], where not only system's adaptation to the learner but also learner's adaptation is necessary. The best effective learning is not easy to realize under using only the unilateral system's adaptation because the learning process depends on learner's emotion. On the other hand, unilateral learner's adaptation to the system is also not simple to make enough efficiency for each learner because it requests high motivation of the learner. The motivation of learners becomes an important issue for learners' performance [3]. The learner's isolation and stress feelings in distance education are still open research topics. The classroom lecture which has learners' sufficiency has many interactions among learners and lecturer, where the atmosphere of the lecture is shared by the learners and the lecturer. Therefore, educational environment which has interaction among learners and system such as virtual classroom lecture is necessary to realize effective distance education.

A distance education system is proposed to realize indirect interaction among learners and education system, to decrease the learner's stress and isolated feelings, and to inspire learners, where visualized atmosphere information in a virtual classroom is shared among all learners based on fuzzy inference. The expression of human feeling about atmosphere sometimes has fuzzy words; therefore the fuzzy inference is accepted to extract atmosphere information. A multimodal interface, such as Kinect® sensor is allocated to each learner's learning environment in order to capture the learner's state information, i.e., facial expression, gesture/posture, and sound, for the distance

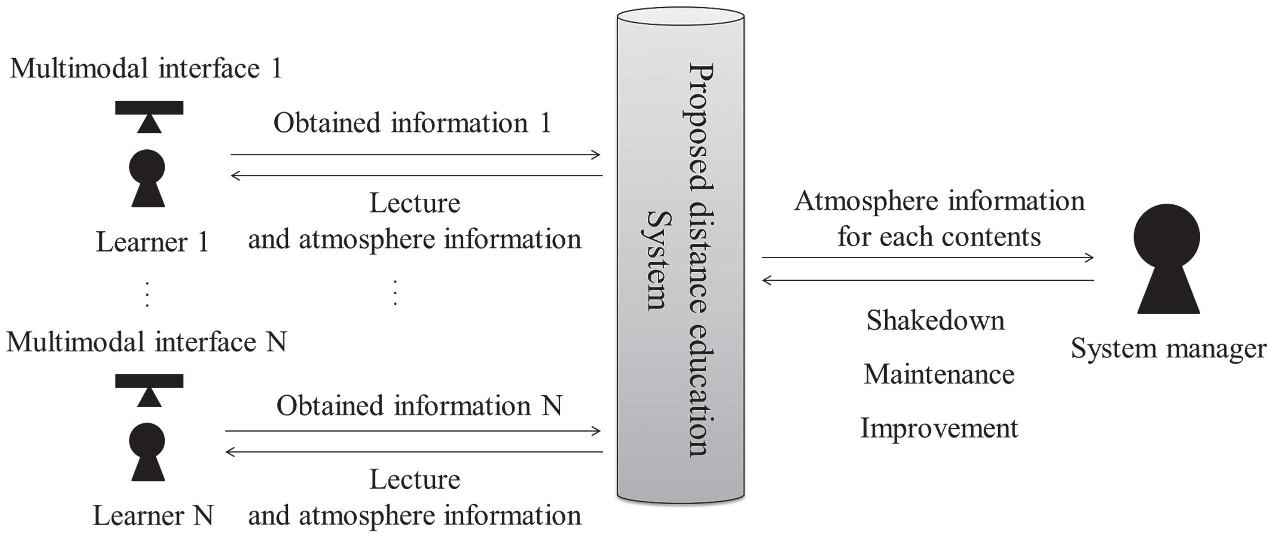

Fig. 1. Interactions among learners, system, and system manager in proposal

education system. The learner's state is mapped into a learner's emotion in affinity arousal-pleasure space [4]. Atmosphere information in the virtual classroom is obtained as an emotional vector on fuzzy atmosfield $[-1, 1]^3$ [5] [6] by applying rule based fuzzy inference to learner's emotion information. A visualization program provides the atmosphere information of the virtual classroom to each learner.

Each learner studies by communicating with the system and is able to recognize the atmosphere of all other leaners that are supposed to stay in the same virtual classroom at the same time. Each learner gets much more motivation, decreases isolated feelings, reduces stress, and increases the feeling of acceptance of the system via the visualized virtual classroom atmosphere. System manager gets each learner's mood state, obtains an individual difference of atmosphere recognition by learners, and makes use of educational contents improvement or business strategy.

The availability of the atmosphere information is confirmed through a comparison experiment of the proposed distance education with a traditional distance education using CAI contents of computational intelligence [7] by 15 leaners. The evaluation is based on learners' mood obtained via the Profile of Mood State (POMS) test [8].

A distance education system with atmosphere information is proposed in 2. The definition of customized knowledge, visualization of atmosphere information, and their application to distance education are introduced in 3. The efficiency of the atmosphere information is confirmed by using POMS test and CAI contents in 4.

2. Distance Education System with Atmosphere Information

A distance education system is designed, where a concept of atmosphere in Education Academy beyond Space Time (EAST) is described. A multimodal interface is settled to each learner's learning environment, visualized atmosphere information in a virtual classroom of the EAST is indicated on the screen of traditional distance education, and records of atmosphere information about learner are provided to the system manager.

The mutual interaction among learners, system, and system manager in the virtual classroom is illustrated in Fig. 1. The EAST consists of several virtual classrooms, which are formed by learners, system, and system manager. EAST provides a new distance education which has both advantages of distance education, such as distance education (as an education beyond space) and e-learning (as an education beyond time), where the learner shares the time and their experience of learning even if they learn the lecture contents whenever and wherever they want. The virtual classroom of EAST has interactions among them, where the locations and learning instances of learners are different one after another generally. A concept of virtual classroom of EAST actualizes new learning environment in such a way that each learner feels as if he/she is learning in a real classroom by sharing the same atmosphere. The atmosphere of virtual classroom is formed mainly by emotions of all learners and a virtual lecturer in the system, and reminds each learner the existence of other learners and a virtual lecturer. A multimodal interface, such as Kinect® is employed to capture each learner's state from facial expression, gesture/posture, and sound information. Feelings about atmosphere information by each learner are obtained from each learner's emotions by using rule based fuzzy inference. They are unified into final atmosphere information in the virtual classroom by using average and standard deviation operations. Finally the atmosphere information in the virtual classroom is visualized/displayed on the screen of each learner's learning environment as two figures, where one figure indicates average atmosphere with shape-color-length model and another shows standard deviations of three atmosphere components by 1/8 ellipsoidal body model.

Each learner is easy to forget other learners' existence even if he/she basically recognize that the other learners are also learning the same contents, because there is no information about the other learners' existence in the traditional distance education system. The traditional distance education system provides mainly educational contents only, and accordingly the learner may feel isolation and frustration. The learner may know the existence of other learners if the system proffers real classroom like environment. In the proposed distance education system, it is supposed to exist a classroom in the education environment, called a virtual classroom, and to be located by all learners, system, and system manager. The atmosphere information which is estimated from each learner's emotional data is visualized on the screen of the learner's terminal. The visualized atmosphere information indicates other learners' feelings about the lecture; therefore the isolated feelings of learners may be decreased. The learner's mood is also reflected immediately to the atmosphere information of the virtual classroom from instance to instance; consequently the learner may relieve the frustration by watching the change of atmosphere information in response to his/her mood. In such a way like this, the proposed system improves affinity of learners gradually to the lecture in the virtual classroom.

The atmosphere information in the virtual classroom is recorded for each learning instance. The atmosphere for each screen of learning contents will be changed successively according to the accession by learners. Such history of atmosphere information is stored in the system, including 1) the atmosphere of the virtual classroom at the scene and the accessed learner, and 2) the accessed learner's feeling of the atmosphere of the scene. The history of atmosphere information in the virtual classroom includes the information, i.e., which contents inspire learners and whether the learning is completed in appropriate atmosphere or not. These can help to improve learning effect of the distance education system and generate business chance for the system manager.

3. Evaluation of Visualized Atmosphere Information based on Leaner's Mood with POMS

Fuzzy atmosfield [5, 6] shown in Fig. 2 has been proposed to represent an atmosphere in multi-agent society which consists of many humans and robots, where the atmosphere is changing one after another. Fuzzy atmosfield is accepted to represent atmosphere in a virtual classroom, where the virtual classroom is recognized as the multi-agent society consisting of learners, system, and system manager as agents.

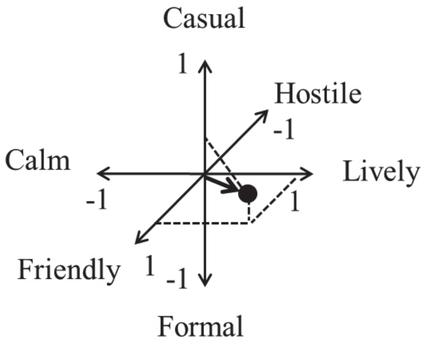

Fig. 2. An example of atmosphere represented in fuzzy atmosfield [6]

3.1. Input Information of Fuzzy Inference for Atmosphere Estimation

A concept of virtual classroom is introduced in the proposed distance education system, and its atmosphere is supposed to be changed successively. The Atmosphere in the virtual classroom for each learning instance is estimated by using rule based fuzzy inference. The input of fuzzy inference is 3D emotional vectors in affinity arousal-pleasure space [4], and is captured by learners' multimodal interface device with neural network and fuzzy set [9]. It should be noticed that the affinity axis is suited to represent the relationship between a learner and learning contents because affinity arousal-pleasure space represents emotion and learner's impression of the learning contents in a space.

3.2. Fuzzy Inference Rule Based on Customized Knowledge

Each learner's feelings of the atmosphere in the virtual classroom are estimated by max-min center of gravity method of the fuzzy inference using a 3D emotional vector of each learner as input information. Because there is an individual difference in feelings of atmosphere [10], some kinds of customized knowledge of each learner is necessary for estimating each learner's feelings of atmosphere correctly. The relations between learner's emotion and feeling of atmosphere, which are obtained by questionnaire in virtual classroom lecture for each learner, are used as customized knowledge. The customized knowledge in a database is used to create if-then fuzzy inference rules.

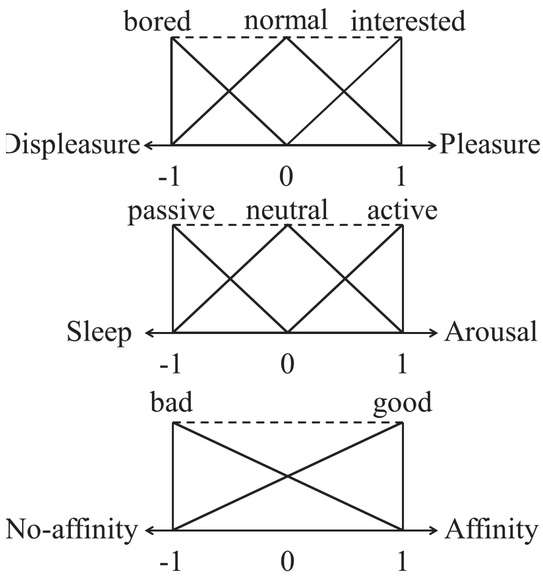

Fig. 3. Membership functions in affinity arousal-pleasure space [8]

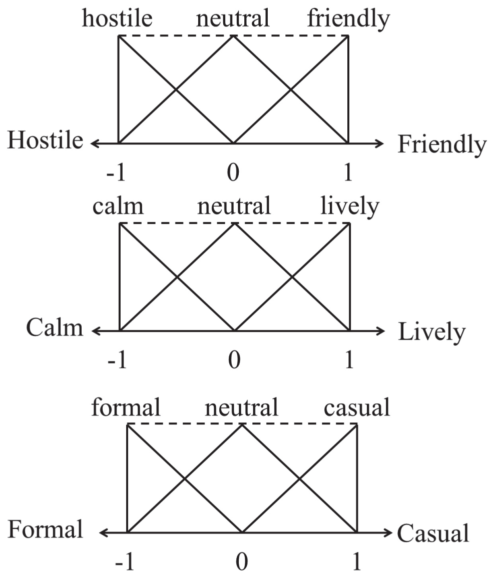

Fig. 4. Membership functions in fuzzy atmosfield [6]

Fuzzy membership functions shown in Fig.3 represent emotions estimated for each learner in affinity arousal-pleasure space $[-1, 1]^3$ (i.e. pleasure-displeasure, arousal-sleep, and affinity-no affinity) [4] and are used in antecedent part of if-then fuzzy inference rules. Each learner's feelings of atmosphere are represented in fuzzy atmosfield $[-1, 1]^3$ (i.e. Friendly-Hostile, Lively-Calm, and Casual-Formal) [6]. The membership functions shown in Fig. 4 are used in consequent part.

3.3. Approximate Representation of Atmosphere Information in EAST

For each learning instance, the atmosphere in the virtual classroom is initially set to zero vector in fuzzy atmosfield. When a new learner accesses the learning instance, the learner's feelings of atmosphere are provided as a vector in fuzzy atmosfield by using fuzzy inference based on customized knowledge. The atmosphere in the virtual classroom of the learning instance is updated at the new learner's access by adding (max operation) the provided vector to the former set of vectors, i.e., the atmosphere is expressed by a set of vectors in the same number of accessing learners. Although the atmosphere information is represented by a set of vectors in fuzzy atmosfield, it is complicated and boring if the information about a set of all vectors is presented directly to learners. Instead, easily understandable approximate information may be welcomed by learners. As such an approximate expression, average vector in fuzzy atmosfield $[-1, 1]^3$ and standard deviation vector in $[-1, 1]^3$ on the set of all atmosphere feeling vectors are accepted. These two vectors are visualized, and presented to the learner by displaying the visualized images on the learner's screen (in the right bottom).

3.4. Visualization of Approximated Atmosphere Information in Virtual Classroom

Atmosphere information of each learning instance is represented by a fuzzy set (a set of vectors in the same number of accessing learners) in fuzzy atmosfield [-1, 1]3, and changes one learner's access after another. It is represented approximately by a pair of vectors, i.e., an average vector in [-1,1]3 and a standard deviation vector in [0,1]3. Visualization of approximated atmosphere information is proposed to inform the atmosphere in a virtual classroom to learners.

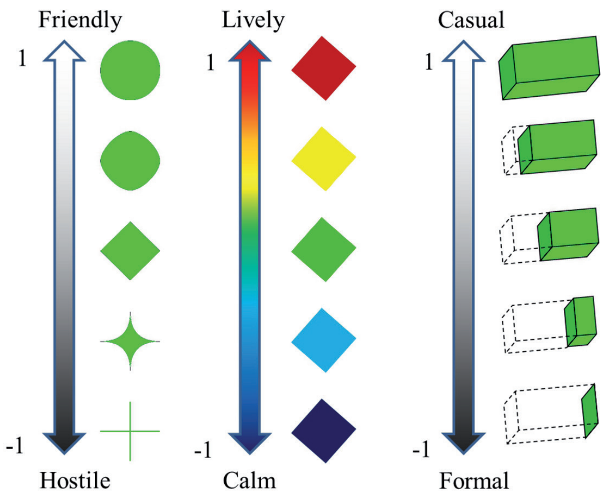

Fig. 5. Visualized representation of atmosphere average vector by shape-color-length model [6]

An average vector is illustrated by shape-color-length model [6] as shown in Fig. 5. A standard deviation vector is illustrated by using 1/8 ellipsoidal body model in [0, 1]3 as shown in Fig. 6, where the surface is colored by the correspondence from [0, 1] to [red, purple].

As an example, visualized approximated atmosphere information in the case of average vector (0.4, 0.7, -0.4) and standard deviation vector (0.1, 0.5, 0.2)

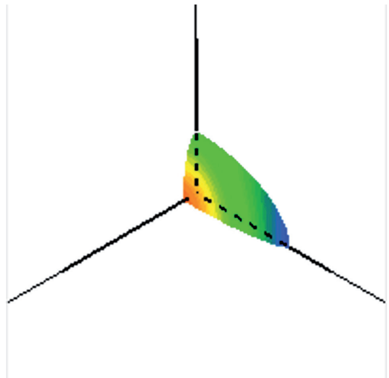

Fig. 6. Visualized standard deviation vector of atmosphere by 1/8 ellipsoidal body model

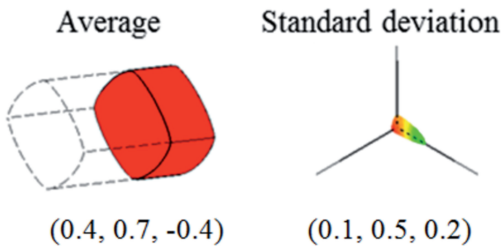

Fig. 7. An example of visualized atmosphere

is shown in Fig. 7, where the atmosphere is assessed as friendly in uniform, lively with split whether strongly live or not so strong, and a little casual in uniform.

4. Evaluation of Visualized Atmosphere Information based on Leaner's Mood with POMS

4.1. Visualization of Atmosphere Information

A part of '2-3 Fuzzy Logic and Reasoning' in CAI contents of computational intelligence [7] is accepted for the experiment to 15 learners (graduate students) to confirm the availability of visualized atmosphere information in the virtual classroom. An example of the screen of CAI contents with the visualized atmosphere information (in the right bottom area) is shown in Fig. 8. It should be noticed that the atmo-

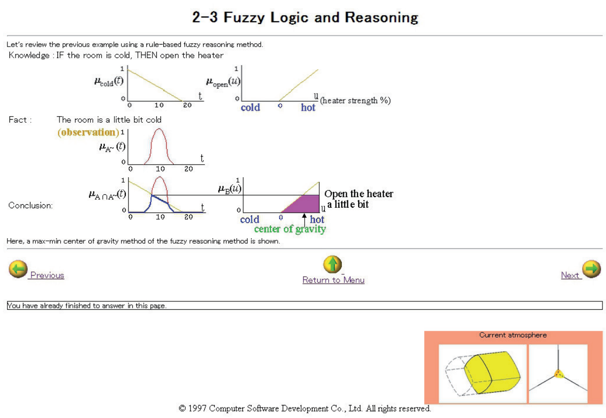

Fig. 8. A scene of CAI contents with visualized atmosphere information

Tab. 1. Results of POMS Test in Traditional Distance Education

Learner	T-A	D	A-H	V	F	C
1	55	42	42	45	41	49
2	53	60	49	37	66	57
3	56	54	58	58	50	51
4	54	46	49	50	44	57
5	45	49	40	69	40	49
6	56	51	50	48	40	45
7	45	45	44	63	41	47
8	50	43	42	55	50	51
9	37	49	40	51	43	64
10	34	42	43	63	40	40
11	55	62	64	41	66	61
12	53	43	47	50	38	49
13	53	58	58	58	56	51
14	48	56	59	66	50	47
15	37	48	40	58	41	44

Tab. 2. Results of POMS Test in Proposed Distance Education

Learner	T-A	D	A-H	V	F	C
1	42	43	39	43	37	42
2	56	67	48	30	70	66
3	56	53	54	56	43	51
4	53	45	50	46	44	53
5	39	44	38	69	38	40
6	48	51	48	51	46	55
7	45	43	44	74	41	47
8	45	42	40	53	48	49
9	36	41	38	43	43	49
10	37	44	37	61	37	38
11	60	71	66	53	58	61
12	55	46	48	51	48	46
13	48	55	47	60	51	44
14	45	56	56	66	45	49
15	39	44	40	45	41	49

sphere information in the right bottom area in Fig. 8 changes as a new learner accesses to this screen, i.e., from average (0, 0, 0) with standard deviation (0, 0, 0) in the case of no average (0.3, 0.2, 0.2) with standard deviation (0.2, 0.3, 0.2) as shown in Fig. 8 right bottom area when the 15^{th} and the last learner finished studying this screen.

4.2. System Evaluation by Learners' Mood Using POMS

A traditional style distance education, i.e., without no atmosphere information, is practiced as a preliminary experiment for 15 learners (4 master and 11 PhD students) on two sections '2-1 What is Fuzzy Logic?' and '2-2 Fuzzy Set Operations' in the 2nd chapter of CAI contents [7]. The contents which are used for the experiment are only theoretical scripts to avoid the influence of an upsurge of emotion. Profile of Mood States (POMS) test [8] is done to obtain learners' mood for 15 learners after finishing two sections. Then main experiment by proposed distance education with atmosphere information is accomplished using a section '2-3 Fuzzy Logic and Reasoning' in the 2^{nd} chapter of CAI contents [7] for the same 15 learners. The POMS test is also carried out to the 15 learners after finishing the study.

In both experiments, each learner is expected to input the 5 grade answers to 65 questions in POMS. Table 1 shows T scores for 15 learners in the POMS test for traditional style distance education, where T-A, D, A-H, V, F, and C are Tension-Anxiety, Depression-Dejection, Anger-Hostility, Vigor, Fatigue, and Confusion, respectively. And T scores for 15 leaners on the POMS test for proposed distance education are listed in Table 2. The difference that T scores in Table 2 minus the scores in Table 1 is summarized in Table 3.

Table 3 indicates that the effect of visualized atmosphere information is different one learner after another. The best efficiency is found in Tension-Anxiety of leaner 1 and vigor of learner 15, so it is concluded that learner 1 decreases frustration and learner 11 becomes lively. In the interview after experiments, learner 1 says that he relaxes to see the visualized atmosphere information rather than the case of traditional style distance education with no atmosphere information, and learner 11 mentions that he takes an interest in watching the transition of visualized atmosphere information on proposed distance education, which coincides with lower stress of learner 1 and high affinity of learner 11. Anger-Hostility of learner 13 is comparatively lower than that of others, which means that his angry emotion is reducing. Learner 13 answers in the interview that he learns comfortable by feeling that other learners learn in the same virtual classroom through atmosphere information. It indicates that lower isolate feelings of learner 13. Confusion of learner 9 attains the lowest score in the experiments, which is concluded that learner 9 decreases confusion. In the interview learner 9 says that he read the contents carefully when he feels the difficulty of contents because visualized atmosphere information becomes hostile at that time. It means that high aspiration of learner 9.

Tab. 3. Difference of T Scores between Traditional and Proposal

Learner	T-A	D	A-H	V	F	C
1	-13	1	-3	-2	-4	-7
2	3	7	-1	-7	4	9
3	0	-1	-4	-2	-7	0
4	-1	-1	1	-4	0	-4
5	-6	-5	-2	0	-2	-9
6	-8	0	-2	3	6	10
7	0	-2	0	11	0	0
8	-5	-1	-2	-2	-2	-2
9	-1	-8	-2	-8	0	-15
10	3	2	-6	-2	-3	-2
11	5	9	2	12	-8	0
12	2	3	1	1	10	-3
13	-5	-3	-11	2	-5	-7
14	-3	0	-3	0	-5	2
15	2	-4	0	-13	0	5

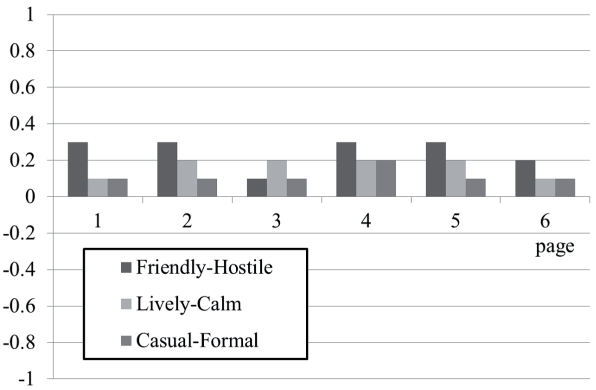

Fig. 9. History of average atmosphere information in the proposed distance education system

The history of atmosphere information with proposed distance education is shown in Fig. 9 (average) and Fig. 10 (standard deviation). Average of Friendly-Hostile in 1st, 2nd, 4th, and 5th page are higher than that of other pages, which indicates that 15 learners study smoothly. The 4th page has higher average of Casual-Formal, which means that 15 leaners are inspired by the contents. It also shows that the 4th page is an appropriate instance to realize effective discussion. Studying by 15 learners is done under appropriate atmosphere in the virtual classroom because whole contents have no prominent atmosphere. The system manager says in the interview that the history of atmosphere information includes the characteristics of the CAI contents and leads to make a strategy for business.

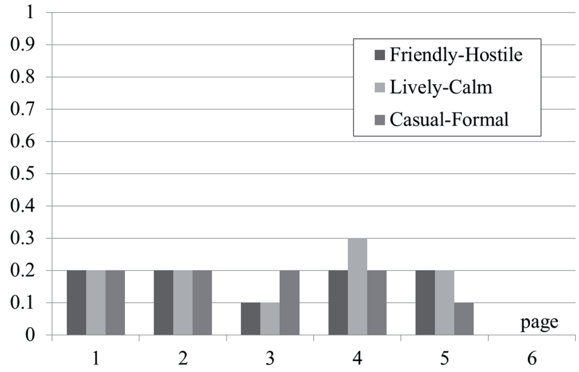

Fig. 10. Standard deviation records of atmosphere information in the proposed distance education system

5. Conclusion

The availability of atmosphere information visualization for each learner is confirmed by simulation using CAI contents on computational intelligence [7]. The effect of the proposed distance education system is validated by 15 graduate students using implemented distance education with CAI contents [7]. The effects of the proposal are shown as high aspiration of learner, decreasing of isolate feelings, and lower confusion by the POMS test.

The record of atmosphere information during the learning process of each learner shows that the visualization of atmosphere information improves the atmosphere assessed by the learner, and figures out which contents make the learner interesting. The improvement of the atmosphere during the learning process leads to increase the learner's performance, such as providing the learner's high affinity feeling and decreasing the learner's isolated feelings. The availability of atmosphere information for the system manager is also confirmed by analyzing records of atmosphere information during learning processes of all learners, e.g., the analysis of records of atmosphere information may help the system manager to detect which contents are effective for the learner.

The proposal of displaying atmosphere information in a virtual classroom aims to establish an innovative distance education system which exceeds face-to-face traditional education system, in the sense of affinity of classroom atmosphere, e.g., the system detects what the atmosphere is the best for each learner and realizes the effective distance education via controlling atmosphere during their learning processes. No learners dislike studying and feel any stress, such as isolation, confusing, and disgust, because all educational contents customized to each learner inspire all learners and make them interesting. The proposal can also help the system manager to work out his/her strategy of the business by analyzing the records of atmosphere information.

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