*International Journal of Innovative Computing, Information and Control*
Volume **9**, Number **8**, August **2013**

ICIC International ©2013 ISSN 1349-4198
pp. 3271–3284

# ENRICHING MENTAL ENGINEERING

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Received July 2012; revised November 2012

Abstract. *The new growing research field of Affective Computing (AC) provides a new horizon for quantitative analysis of human emotional states using IT techniques. In this paper, a new academic system called "Enriching Mental Engineering (EME)" is proposed for the problem of mental health from the view of engineering. EME is being established as an academic discipline, by being keenly aware of the poverty of the mind from which people living in modern society suffer. In EME, quantitative measurement of richness of the mind is regarded as a central technique. This is measured from the information like subject physiological data, textual information, behavior, and tone of voice. Meanwhile, EME also systemizes external stimuli by an emotional energy function. The emotion energy function is proposed to calculate a person's emotional stimuli at a certain point from factors like choice of words, voice, facial expressions, physiological information, and behavior. Furthermore, an application of EME is illustrated through an analysis of the depressive tendencies in blogs.*

**Keywords:** Enriching mental engineering, Measure of mental richness, Mental state transition network, Emotion energy function

1. **Introduction.** Modern science and technology have improved our living environment greatly, but have people become happier than before in accordance with technological progress? Why does the total number of suicides in Japan exceed 30,000 every year? The truth is that our spiritual life is not benefit from the rich material life. Mental health problems have become very common and an urgent social problem recently. Although there are a lot of controversies about the way mental health problems are diagnosed, what causes them, and which treatments are most effective, it is time to pay attention to the development of practical techniques that deal with the global annual increase in patients suffering from psychiatric and psychological disorders.

From the view of medicine, the two most common forms of treatment offered are talking treatments and medication. Treatments aim to relieve and help to cope with distressing symptoms. There are often clinical guidelines issued by specialized agencies which medical professionals are encouraged to follow. However, specialized agencies are hard to handle the increasing number of people with various mental health problems, such as depression, anxiety, personality disorders. With the rapid development of Information Technologies (IT), the application of IT techniques on medicine is becoming more and more popular. The new growing research field of Affective Computing (AC) [1] provides a new horizon

for quantitative analysis of human emotional states using IT techniques [2], and many AC methods have been proposed for human emotion recognition in multimodes, such as speech [3,4], languages [5,6], face [7-9], and gesture [10]. However, one of the biggest questions is: "What are the couplings between these techniques and mental health"? So it is necessary to establish a disciple of engineering that combines the AC techniques to deal with the enrichment of the mind [11].

This paper proposes a new academic system called "Enriching Mental Engineering" (EME) for the problem of mental health from the view of engineering. EME is being established as an academic discipline, by being keenly aware of the poverty of the mind from which people living in modern society suffer. This study clarifies the definition, content, and methods of EME as an academic discipline. In EME, on the one hand, quantitative measurement of richness of the mind is regarded as a central technique. This is measured from information such as a subject's physiological data, as well as textual information written by the subject, the subject's expressions, behavior, and tone of voice. On the other hand, measurement of external stimuli is conducted by an emotional energy function in EME. The emotion energy function is a function that calculates a person's emotional stimuli at a certain point from factors such as a person's choice of words, voice, facial expressions, physiological information, and behavior. EME covers several fields, such as computer science, artificial intelligence, computational linguistics, clinical psychology, psychiatry, and religion. EME can be considered a new academic field that integrates the aforementioned disciplines.

The remainder of this paper is organized as follows. The background and motivation behind the proposal to develop EME as an academic discipline is described in Section 2. Section 3 describes an outline for EME, and at the same time, it will define mental richness in engineering terms and state the research contents and major tasks of EME. When dealing with people's minds from the perspective of engineering, it will be necessary to define scales of mental richness. Section 4 discusses the mental state transition network as a subject that deals with this issue. This network is obtained by measuring actual emotional changes in different situations, using questionnaires and other methods, and then modeling such information statistically. Section 5 proposes an emotional energy function. After that, the method of estimating external stimuli using this function is described. In Section 6, an analysis of the depressive tendencies in blogs is explained in order to extract depressive tendencies from blogs using EME. Lastly, Section 7 provides a summary and describes several planned tasks that should be studied in the future.

## 2. **Motivation.**

2.1. **Problem of depression in Japan.** The total number of suicides in Japan has exceeded 30,000 every year since 1998. According to the Suicide Prevention Central Protection Center website, the suicide rates for middle-aged and senior citizens are declining, whereas those for youths are on the rise. Poverty of the mind is believed to be the main reason for suicide rather than lack of money or material objects. Depression manifests itself as various symptoms of mental and physical states. Although there are individual differences in these symptoms, the symptoms generally include those listed items in Table 1.

Moreover, depression is known as the "cold of the heart". This refers to the fact that depression is common, that anyone can suffer from it, and that it requires prevention in everyday life. In 2002, the Ministry of Health, Labour and Welfare studied the number of people who had suffered from depression using a random sample of 1664 people. The results showed that approximately 1 in 15 people had experienced depression and that the

TABLE 1. General symptoms of depression

| Psychological symptoms | Physical symptoms |
|---|---|
| Prolonged depressive mood | Decline in appetite and increase or decrease in weight |
| Decreased interest and pleasure in things | Various sleeping disorders |
| Changes in psychomotor activity accompanied by restlessness and retardation | Decline in thinking ability and concentration |
| Thoughts and behaviors related to suicide and death | Various physical aches |

TABLE 2. Recurrence rate of depression as a function of time lapse

| | |
|---|---|
| 10 months | 40% |
| 5 years | 41%–75% |
| 10 years | 58% |
| 15 years | 85% |
| 25 years | 80%–88% |

number of people who had experienced depression in the previous year was approximately 1 in 50. However, depression differs from a cold, despite having such a high morbidity rate, in that it takes approximately half a year for people to be completely cured after beginning treatment. It is said that when depression is prolonged, it may take a year or more for it to be cured. Further, the most fearsome aspect of depression is its recurrence rate. According to the latest handbook on the treatment of depression by John Potokar et al., the recurrence rate for depression increases as depression persists. Table 2 shows the actual recurrence rate.

The chart shows that approximately 90% of people experience a recurrence of depression in their lives. However, it is becoming possible to reduce this recurrence rate as a result of advances in current medical technology. In order to receive such treatment, early detection and self-awareness of depression are required.

DSM-IV-TR [13] and ICM-10 are widely used for classifications of psychiatric disorders, including depression. In this paper, DSM-IV-TR will be discussed. With DSM-IV-TR, one can diagnose depression by answering diagnostic questionnaire items. For this reason, there is no need for a doctor to closely examine the patient by interviewing them. Since these questionnaire items have been derived statistically, even doctors with relatively limited experience can conduct a diagnostic interview in the same way as doctors with rich experience. So practical techniques on detecting various depression and providing reasonable treatments are urgent with the current situation. This is one of the main tasks of EME described in this paper.

2.2. **From a perspective of financial loss.** The Ministry of Health, Labour and Welfare, on September 7, 2010, announced in a research report that the estimated financial loss in 2009 caused by suicide and unemployment resulting from depression amounts to approximately 2.7 trillion yen in Japan. This situation is well exists in many other countries as well.

Of course, financial loss is only one aspect of this problem. This paper would like to emphasize that the saddest aspect is the loss of so many lives and the emotional anguish experienced by many people.

2.3. **How can engineering contribute?** With the spread of the Internet, many people express and publish their inner thoughts in online personal blogs. These blogs contain entries that describe emotional changes leading up to negative emotion tendency such as suicide. For example, a former TBS (a Japanese television broadcasting network) reporter committed suicide on May 26, 2008. The blog entries she wrote shortly before her death contained accounts that implied that she was emotionally unstable, such as "The intervals between jobs are the most painful" and "Because I cannot come up ... with words." In addition, The Communist party director who had lost his son in the 2008 Sichuan earthquake, committed suicide despite having worked hard as one of the persons in charge of disaster restoration. He left messages such as "To my beloved son ... I'll see you in heaven" and "Goodbye, my dear wife" on his blog before committing suicide. It is believed that by analyzing the content of such accounts using engineering methods, one can measure the writer's psychological state and judge the presence of suicidal tendencies or other psychological illnesses. In addition, it is also believed that propositions can be made for treatment plans, such as deciding what kind of external stimulus (such as advice) is to be given to bloggers.

It is also believed that a person's emotional state can be estimated to some degree from their voices, facial expressions, and behaviors by using engineering methods. All of these are the motivations for establishing the EME academic discipline.

## 3. Outline of EME.

3.1. **Richness of the mind.** As a result of living in civilizations that enjoy unlimited technical and material consumption, we currently live in an era where it is difficult to feel happy. In this day and age, what is happiness, and what does life mean to us? Some have pointed out that "Human happiness does not lie only in pleasure or satisfaction; it can be found in pain and sadness as well." As mentioned at the beginning of this paper, the cause of suicide for famous people who are rich is definitely not poverty and is perhaps caused by poverty of the mind rather than from other causes.

According to the happiness rankings announced by the New Economic Foundation, a British think tank, which categorized 178 countries and regions around the world by their average life span and life satisfaction level, the South Pacific country of Vanuatu was ranked in first place, while Columbia came second, followed by Costa Rica, which came third. First world countries struggled in this ranking with Germany coming in the 81st place, Japan 95th, the UK 108th, France 129th, and the US 150th. There were no G8 countries in the top 50. Although these rankings do not represent strict statistical data, they show that the number of suicides and people suffering from psychological illnesses, such as depression, are not small in first world countries.

It is understood that enrichment of the mind is important. However, how to enrich one's mind has not been studied previously on an academic level, especially as an academic engineering discipline.

3.2. **What is EME?** EME is an academic framework that studies richness of the mind from an engineering perspective by using various modern technologies. In EME, quantitative measurement of richness of the mind is regarded as a central technique. This is measured from information such as a subject's physiological data, as well as textual information written by the subject, the subject's expressions, behavior, and tone of voice.

Simultaneously, it also systemizes the external stimuli necessary for improving the measured mental state by further enriching the subject's mind.

EME covers several fields, such as computer science, artificial intelligence, computational linguistics, clinical psychology, psychiatry, and religion. EME can be considered a new academic field that integrates the aforementioned disciplines.

3.3. **Definition of richness of the mind as an engineering term.** So far, we have spent the majority of our daily lives in a physical space. In order to enrich this physical space, we have developed various academic disciplines and technologies and enjoyed their benefits. However, with the advent of the network society, information environments and spaces surrounding us have greatly changed, both in quality and in quantity. The amount of time that we spend in information spaces is increasing rapidly. In information spaces, unlike physical spaces, both good and bad information are transmitted widely and rapidly. Thus, people's psychological weakness and poverty of the mind are manifested in a more prominent manner. In EME research, we research and develop new academic engineering disciplines and technologies in order to enrich one's mind, even in relation to the increasing time spent in information spaces.

Regarding the enrichment of one's mind, several theories were proposed in ancient times using religion, while in modern times, theories are derived from clinical psychology and other disciplines. Traditionally, problems of the mind have been considered as problems of consciousness and physical functions. However, EME adopts a different approach, which will be discussed in this paper.

**Definition 3.1.** *Richness of the mind is a scale that measures one's sense of the value of people's lives and existence, as well as the skills required for receiving various stimuli coming in externally.*

$$m(p) = f(h, em, ev, r) \tag{1}$$

*The external expression of mental richness is depicted by the following emotional state* $e$*.*

$$e(p) = g(L, S, F, A) \tag{2}$$

*Here* $L$ *is an emotion in a verbal expression,* $S$ *is an emotion detected in a voice,* $F$ *is an emotion detected in a facial expression, and* $A$ *is an emotion detected in a behavior. That is, an emotional state is a function of people's choice of words, voice, facial expression, and behavior.*

**Definition 3.2.** *The scale for richness of the mind is a time series function of emotional states during a certain period.*

*Here the richness of the mind scale is expressed by a number between* 1 *and* $-1$*. That is, the richness of the mind scale* $v$ *is a function of an emotional state* $e$ *and a time period* $T$*.*

$$v(p) = k(e, T) \tag{3}$$

$v(p)$ *is an indicator that represents the scale of the mind, the higher the number, the richer the mind. However, when this value becomes negative, the mind becomes impoverished.*

3.4. **Tasks for EME.** Several issues can be raised when establishing the academic framework of EME. However, these issues can be broadly categorized into the following two tasks.

Task 1: Research on technology for measuring the scale of mental richness

Task 2: Development of engineering methods for improving the mental richness scale

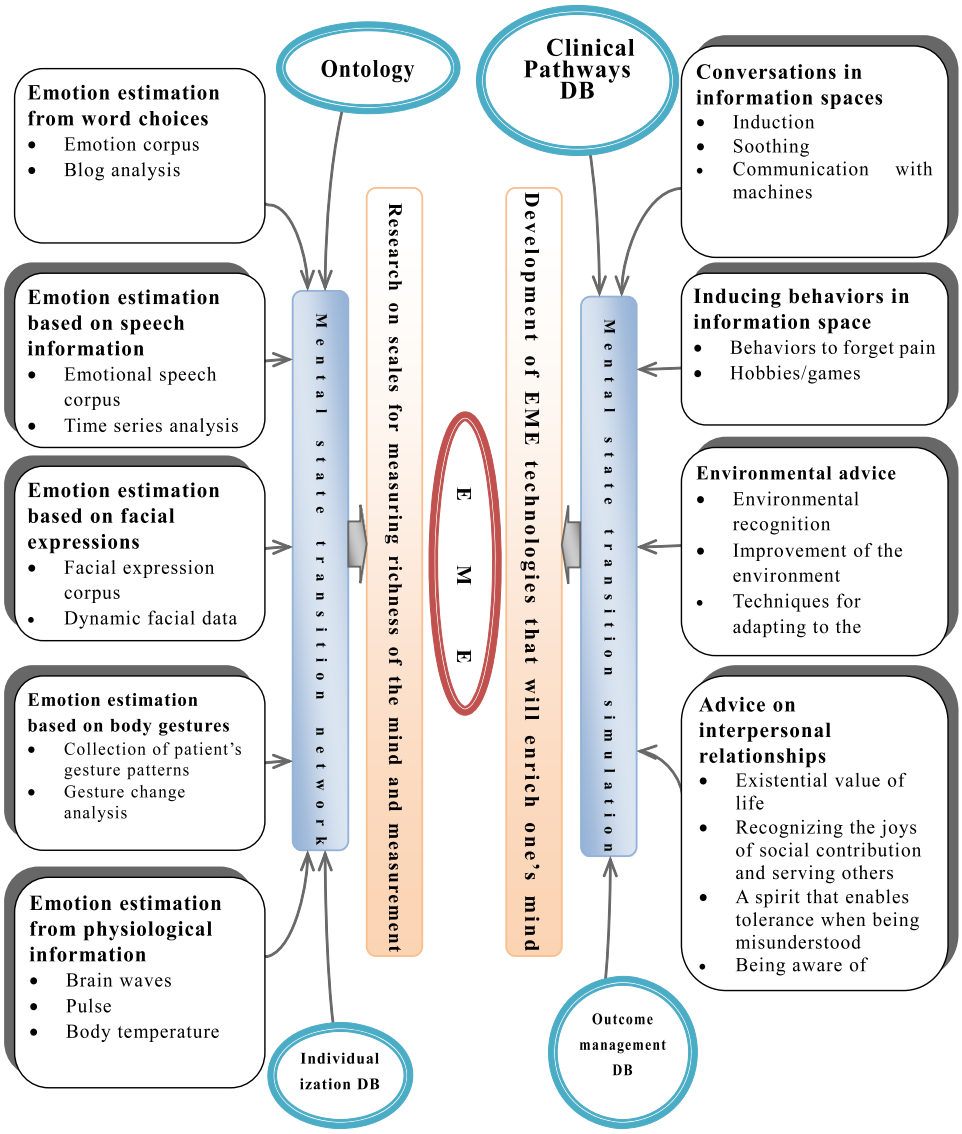


FIGURE 1. Outline of EME

Figure 1 displays the research tasks for EME.

This paper will discuss task 1 and report on the current status of research.

4. **Mental States and the Mental State Transition Network.** Although the scale of richness of the mind is a function of an emotional state and a time period, as expressed in Equation (3), the definition of emotional state and emotional state estimation are major research topics.

This section will focus on a mental state transition network that we have proposed. Although there are various approaches regarding people's minds in various fields, we have examined this from an engineering perspective.

Here we assume that people's emotions exist in several states and make transitions between several discrete states, which correspond to information-processing functions. This is referred to as mental state. When there is no particular need for them to be distinguished, mental state and emotional state will be used interchangeably [12].

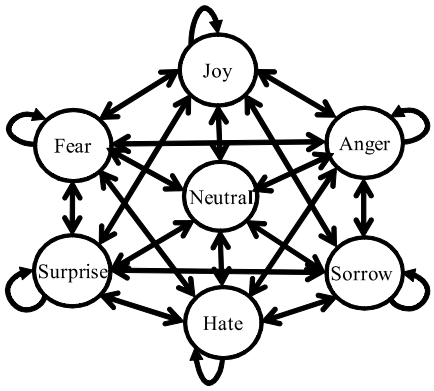


FIGURE 2. Mental state transition network

Here we assume that people's emotions exist in several states and make transitions between several discrete states, which correspond to information-processing functions. This is referred to as mental state. When there is no particular need for them to be distinguished, mental state and emotional state will be used interchangeably.

Under certain conditions, a person's mental state can undergo a transition from one state to another [13]. Although all transitions between states do not have the same probability, there exists a certain expected value if external factors are ignored. A mental state transition network module can be constructed by analyzing a large amount of data, based on a person's individual information.

We have already conducted the following experiment in order to construct a mental state transition network by using a psychological survey method. First, we created, in advance, a transition table S (7,7) representing seven types of emotional state. Under the condition of there being no external stimuli, we asked the participants to write down the possibility of making a transition from state $i$ to state $j$ by using a number between 1 and 10; the larger the number, the higher the possibility of making the transition. Thereafter, the same experiment was conducted under the condition of there being an external stimulus. Based on the data obtained from 200 participants, Table 2 was derived by using a statistical method. The mental state transition network will exist when there are no external stimuli.

Concerning the mental state transition network, the transition possibilities will differ naturally depending on the type of external stimulus. External stimuli will be discussed in the following section.

## 5. Measurement of External Stimuli Using an Emotional Energy Function.

Transition possibilities, within the mental state transition network, will differ naturally depending on the type of external stimuli. Usually, external stimuli are understood in a broad sense to be external information other than the mind. However, this paper will define external stimuli as an energy that operates on the mental state transition network. For example, when a person receives happy information, those items of information that cause the display of an emotional appearance of happiness in the person's speech, gestures, and expressions will be defined as an external stimulus called "happiness". In other words, when a person is in a certain emotional state, he/she will undergo transition to another emotional state when his/her emotional energy exceeds a certain threshold [15].

### 5.1. Emotional energy function.

For obtaining emotional energy, the following emotion energy function is defined.

TABLE 3. Mental state transition network when there are no external stimuli

| Next \ Current | Joy | Neutral | Sorrow | Surprise | Anger | Fear | Hate |
|---|---|---|---|---|---|---|---|
| Joy | 0.421 | 0.213 | 0.084 | 0.190 | 0.056 | 0.050 | 0.047 |
| Neutral | 0.362 | 0.509 | 0.296 | 0.264 | 0.262 | 0.244 | 0.252 |
| Sorrow | 0.061 | 0.090 | 0.320 | 0.091 | 0.123 | 0.137 | 0.092 |
| Surprise | 0.060 | 0.055 | 0.058 | 0.243 | 0.075 | 0.101 | 0.056 |
| Anger | 0.027 | 0.039 | 0.108 | 0.086 | 0.293 | 0.096 | 0.164 |
| Fear | 0.034 | 0.051 | 0.064 | 0.076 | 0.069 | 0.279 | 0.075 |
| Hate | 0.032 | 0.042 | 0.068 | 0.048 | 0.121 | 0.092 | 0.313 |

**Definition 5.1.** *The emotion energy function is a function that calculates a person's emotional stimuli at a certain point from factors such as a person's choice of words, voice, facial expressions, physiological information, and behavior.*

*Here emotional stimuli are defined as external stimuli that operate on the mental state transition network. The emotional energy function is expressed in Equation (4).*

$$E = E_e(L_e, S_e, F_e, P_e, A_e) \tag{4}$$

*$E$ is the external stimulus – in other words, emotional energy – and $E_e$ is an emotional energy function. $L_e$, $S_e$, $F_e$, $P_e$, $A_e$ are estimated emotions, based on word choice, voice, facial expressions, physiological information, and behaviors such as gestures, respectively. These are all expressed in vectors and can have several emotional values.*

*Supposing that the five structural factors of the $E_e$ function are independent of one another, $E_e$ could be simplified in the following manner.*

$$E_e = \alpha_1 L_e + \alpha_2 S_e + \alpha_3 F_e + \alpha_4 P_e + \alpha_5 A_e \tag{5}$$

*$\alpha_i$ $(i = 1 \sim 5)$ is the weight of external stimuli on each structural factor.*

5.2. **Measuring external stimuli.** Theoretically, external stimuli can be measured using Equation (5) if emotional vectors for each factor can be found.

For example, let us suppose that emotional vectors for each of the following factors were obtained within a certain period of time.

$$L_e(L_{e1}, L_{e2}, L_{e3}, ..., L_{en})$$
$$S_e(S_{e1}, S_{e2}, S_{e3}, ..., S_{en})$$
$$F_e(F_{e1}, F_{e2}, F_{e3}, ..., F_{en})$$
$$P_e(P_{e1}, P_{e2}, P_{e3}, ..., P_{en})$$
$$A_e(A_{e1}, A_{e2}, A_{e3}, ..., A_{en})$$

The following external stimulus $E_e$ can be obtained from Equation (5).

$$E_e(E_{e1}, E_{e2}, E_{e3}, ..., E_{en})$$

Moreover,

$$E_{ei} = \alpha_1 L_{ei} + \alpha_2 S_{ei} + \alpha_3 F_{ei} + \alpha_5 A_{ei} \tag{6}$$

$(i = 1 \sim n$; $n$ is the number of emotion types).

However, there is no guarantee that the emotional vectors of the above five factors will always be obtained. For example, when estimating the emotion of a writer from his/her blog, values other than that of $L_e$ cannot be estimated. When estimating the emotion of a patient, perhaps only $F_e$ can be obtained. Therefore, when using Equation (5), one or several factors may need to be selected that correspond to the actual situation.

Further, regarding the weight, $\alpha_i$ ($i = 1 \sim 5$), it is believed that this needs to be determined by analyzing large-scale observational data statistically and using the experiences and knowledge of specialists as references.

6. **Detecting Depression from Blogs.** We have made several achievements in terms of emotion estimation based on word choice, voice, and facial expressions. The details will be omitted here, and are explained instead in the reference literature [16, 17, 18, 19, 20, 21]. Here the method of detecting depression from blogs is described.

An emotional corpus is required for conducting emotion estimation based on word choice. Our research group has already constructed and published the emotion corpus Ren_CECps[1]. The emotion corpus Ren_CECps is a collection of Chinese Weblog articles in which detailed linguistic expressions that represent emotions have been manually annotated [15]. This corpus, which comprises of 1,487 documents, 11,255 paragraphs, 35,096 sentences, and 878,164 words, aims to aid the development of an emotion processing and evaluation system in China. It was constructed, with the co-operation of 11 PhD and MS candidates specializing in Natural Language Processing and Emotion Analysis, over eleven months (July 2008-May 2009).

Currently, we are constructing emotion corpuses in Japanese and English. For the Japanese corpus, we are collecting blogs of users with suicidal and depressive tendencies in particular. Whether a depressive tendency exists is judged by having a person read the blog. The criterion for judging the presence of depressive tendencies is whether the author himself/herself stated that he/she suffers from depression in the blog. Such users are aware of having depressive tendencies and may have undergone the experience of being committed to a mental hospital. On the other hand, there may be users who are not aware of having depressive tendencies. In general, the blogs of such users (who have latent depressive tendencies) are difficult to identify. Therefore, we have collected and categorized blogs of 30 users who had publicly stated that they were prone to depression (depressive-tendencies blogs) and blogs of 30 users who have not made such statements (non-depressive-tendencies blogs).

For approximately 30 days, we collected 1,800 articles from these 60 users. The statistical data obtained from the collected blogs are shown in Table 4.

TABLE 4. Outline of depressive/non-depressive tendencies corpus

| | Depressive | Non-depressive | Total |
|---|---|---|---|
| Number of articles | 900 | 900 | 1,800 |
| Total number of morphemes | 273,479 | 156,082 | 429,561 |
| Morpheme count | 51,996 | 38,034 | 90,030 |
| Number of lines | 16,795 | 13,902 | 30,697 |

Next, we decided to investigate whether there were any differences between the collected depressive-tendencies blogs and the non-depressive-tendencies blogs. In this paper, we focused on the emergence of emotional expressions in each blog and especially on the observation of time series changes in order to conduct a detailed analysis on the differences between users with depressive tendencies and those with non-depressive tendencies.

First, when we collated the statistics of emotional expressions included within depressive-tendencies blogs and non-depressive-tendencies blogs, we obtained the results indicated in Figure 3. This graph shows that negative emotional expressions, such as "hate", "sorrow", "fear", "anger", and "shame", appear more frequently in depressive-tendencies

[1]http://a1-www.is.tokushima-u.ac.jp/member/ren/Ren-CECps1.0/DocumentforRen-CECps1.0.html

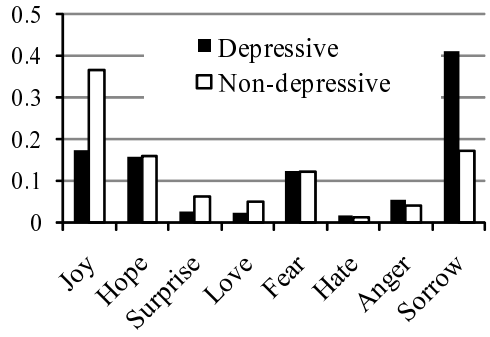


FIGURE 3. Appearance tendencies for emotional expressions

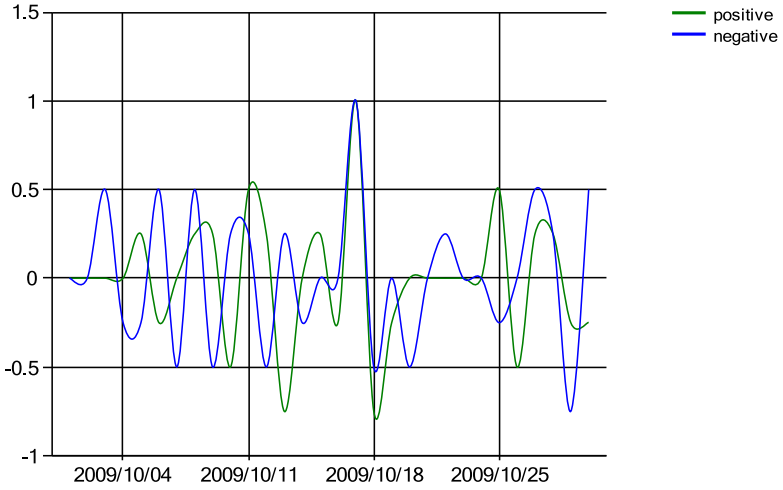


FIGURE 4. P/N variation analysis curve of depressive-tendency users

blogs. At the same time, positive emotional expressions, such as "joy", "like", and "relief", also appear more frequently in depressive-tendencies blogs. The reason for the overwhelming difference concerning the word "hate" could be attributed to the fact that the number of registered words for "hate" is the highest in an emotional expression dictionary. From this, one can see that it is difficult to detect depressive tendencies based on just the appearance of an overall emotional expression.

Next, we will discuss the analysis of time series changes. Generally, blog users write blogs every day. Therefore, this is an optimum tool for discerning daily mental change. When we analyzed the positive/negative emotional expression appearance tendencies derived from 30 days of blog activity collected from each user, we obtained the results shown in Figure 4. In this figure, positive and negative waveforms fluctuate in a complex manner within the short period of 30 days. Although we analyzed all of the collected blogs, we learned that it was extremely difficult to determine whether the user was depressed by observing the movement of the waveform within such a short period of time.

Figure 5 shows the appearance tendencies of positive and negative expressions in the blogs for blog users with depressive tendencies.

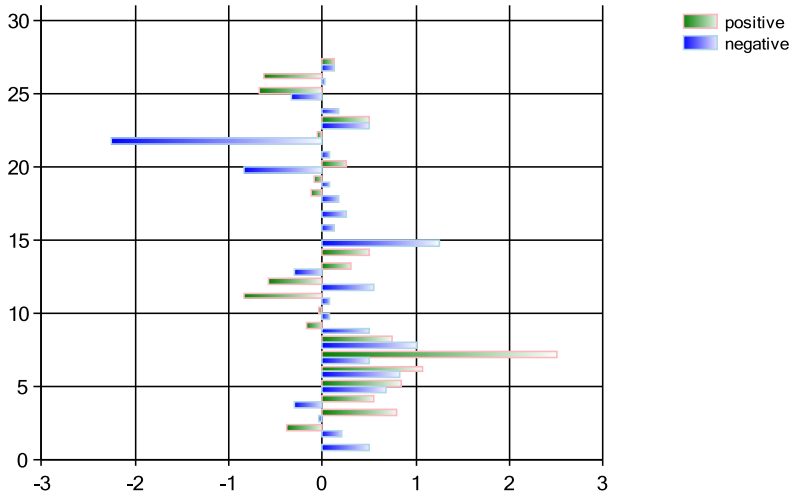


FIGURE 5. Positive/negative expressions tendencies per user

The negative values indicate how much the positive/negative expressions fluctuated since the previous day. As shown by this chart, the increase in negative expressions stands out in the results.

However, depending on the user, there are cases where there is a large decrease in negative expressions, despite having depressive tendencies. Therefore, the degree of decrease in negative expressions does not indicate a decrease in depressive tendencies. From this, we considered identifying patterns from the fluctuations of depressive tendencies.

First, the rate at which a writer with depressive tendencies uses emotional expressions in a blog article is defined as emotional density, which is obtained using Equation (7). $|M|$ represents the total number of morphemes within a blog. $pnw_i$ represents positive and negative expressions within a blog. $PN$ is the aggregation of positive and negative expressions within a blog. $w_i$ is the weight in regard to $pnw_i$. This weight is calculated from expression frequency and other details within the blog corpus.

$$\text{Emotional density} = \frac{1}{|M|} \sum_{pnw_i \in PN} w_i \tag{7}$$

The $PN$ strength for each blog article is determined by examining whether this emotional density includes more positive or negative emotional expressions. Equation (8) indicates this $PN$ strength. This equation takes into account that a negative impression becomes stronger if a negative emotion surpasses a positive emotion even by a small margin and even if there is some positive emotion in the blog because it is greatly impacted by the larger amount of the negative emotion (an emotional drawing-in effect; there are also opposite cases).

$$\begin{aligned} P \text{ strength} &= \begin{cases} ed & \text{if } \ freq(P) \geq freq(N) \\ 0 & \text{else} \end{cases} \\ N \text{ strength} &= \begin{cases} ed & \text{if } \ freq(N) \geq freq(P) \\ 0 & \text{else} \end{cases} \\ & \qquad ed: \text{ emotional density} \end{aligned} \tag{8}$$

We calculated the change in the $PN$ strength on a daily basis to compare its average value between depressive-tendencies and non-depressive-tendencies blogs. Figure 6 shows the result.

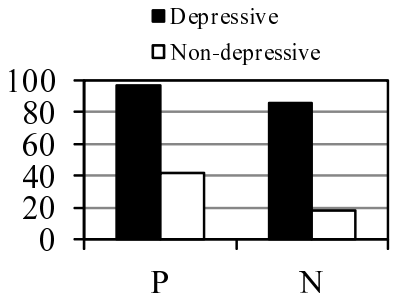


FIGURE 6. Comparison of average values of the $PN$ strength

As shown by these results, both $P$ and $N$ of the $PN$ strength tend to be higher when there are depressive tendencies, compared to when depressive tendencies are absent. Further, $P$ values for both cases-having and not having depressive tendencies-are high. This could be explained by the disproportional placement of words in the emotional expression dictionary used for the analysis. That is, there are many expressions that represent positive emotions in the dictionary.

Figure 6 shows that when detecting the existence of depressive tendencies, the strength of emotional density becomes important.

Further, we decided to represent the change in the $PN$ strength with the following six emotional fluctuation patterns. However, cases where the emotional density remained at 0 were not able to fit into any of the following patterns.

PT1: $\Delta N = 0$
$N$ strength is sustained without change
PT2: $\Delta N > 0$
$N$ strength increases
PT3: $\Delta P < 0$
$P$ strength decreases
PT4: $\Delta P = 0$
$P$ strength is sustained without change
PT5: $\Delta P > 0$
$P$ strength increases
PT6: $\Delta N < 0$
$N$ strength decreases

When we investigated the occurrence of these patterns for each blog user, we obtained the results displayed in Figures 7 and 8. These results show that PT2 tends to appear more frequently among users with depressive tendencies. This is in accordance with the average value comparison of the $PN$ strength. In contrast, PT1 and PT4 are virtually absent from all blogs.

Since analyses for each of the 60 users were restricted to 30 days of data, a short period of time, we would like to conduct a more reliable analysis by increasing the amount of data.

7. **Conclusion.** The importance of spiritual life of people can never be over-emphasized. Affective computing techniques combine computer science with psychology science to deal with human emotions. In this paper, Enriching Mental Engineering (EME), an engineering discipline that deals with richness of people's minds was proposed. In particular, its

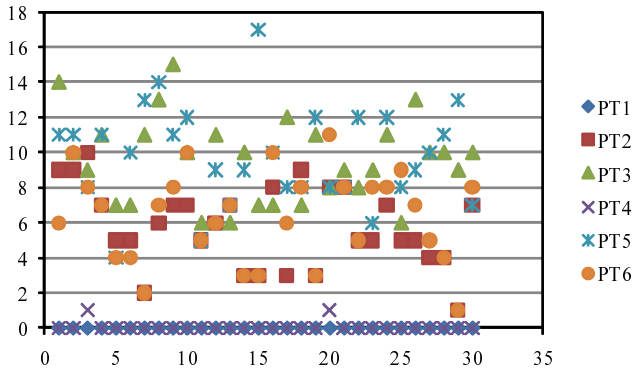


FIGURE 7. Emotional fluctuation pattern distribution in non-depressive-tendencies blogs

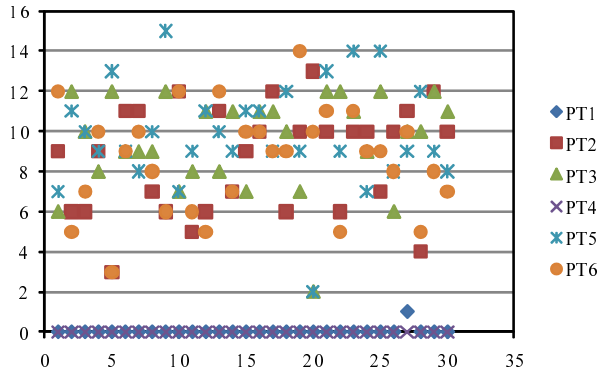


FIGURE 8. Emotional fluctuation pattern distribution in depressive-tendencies blogs

research content, methodologies, and tasks were described with respect to the academic framework of EME.

Based on the results of psychological experiments, a mental state transition network was constructed using statistical methods. We proposed a method for estimating people's mental states and studied the emotional energy function. Further, we constructed a blog emotion corpus and proposed a method of detecting depression from blogs.

With respect to an academic framework, there are still many tasks remaining in EME. In particular, there is a need to research engineering techniques that enrich one's mind. Next, several future tasks will be mentioned.

1. Continue to collect blog corpuses and analyze the interrelation between suicide and depression.
2. Construct a voice database of voice fluctuation and mood changes and conduct a time series analysis of mood changes.
3. Conduct research on mental states and speech expressions of depression, dementia, and other illnesses.
4. Examine richness of the mind in different fields, such as psychology, psychiatry, and religion, in order to clarify the scale of richness of the mind and research measurement methods.
5. Develop estimation methods for external stimuli using the emotional energy function and conduct various experiments.

**Acknowledgment.** This research has been partially supported by the Ministry of Education, Science, Sports and Culture of Japan under Grant-in-Aid for Scientific Research (A) No.22240021, the National High-Tech Research & Development Program of China 863 Program under Grant No.2012AA011103, the National Natural Science Foundation of China under Grant No.61203312, and Key Science and Technology Program of Anhui Province under Grant No.1206c0805039.

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