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A PROPOSAL TO HI-TECH POLLUTION BASED ON THE CRITERION OF "RELATIONISM-FIRST" - A PRINCIPLE EXPERIMENT FOR THE RELATION BETWEEN ACOUSTIC AND EM FIELDS AROUND VDT -

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Abstract

It seems that Hi-tech pollution and many other difficult modern problems come up from even slighting many kinds of complicated relationship among various environmental factors including even ethical or cultural faces and giving priority to only utility over any other everything. In this paper, to solve these problems, we first pay attention to the criterion of "Relationism-First" that once after employing at the first stage of study as many environmental factors as possible at the same time and investigating the mutual correlation among them (for trueness), then our specified interesting cases for engineering application should be considered (for effectiveness). In previous paper, as a trial method for mutual intersubjective analysis, by taking care of light and a shade, that is, two factors of utility and risk, an extended correlation analysis for only two environmental factors has been applied. In this paper, another extended correlation analysis applicable to the fluctuation limited within the finite interval is newly introduced. Furthermore, as a principle experiment for the proposed method, by applying it to the contrasted two environmental factors: magnetic field (related to risk) and sound (related to utility) in EM environment around VDT before and after attachment of Tecno AO (active bio-controller as some magnetic oscillator), the proposed method is experimentally confirmed, too.

1. INTRODUCTION

Nowadays, even in the wave-motion type environmental problem, we can see many actual phenomena composed of extensive environmental factors in different fields with mutual relationship among them. For instance, these examples are given as follows. The nervous system of mankind is so much affected by any field of sound, light and electromagnetic waves in the neighborhood of the specific frequency band from 15 Hz to 20 Hz (because calcium ions are occasionally lost out). This is particularly induced even by the signal modulated into high frequency band with the slow change of its amplitude. Furthermore, the generated order,

generated time interval and each of their proper durations between sound and flash of lightning cannot be recognized as it is. There are the biological priority effect between the sense of sight and the sense of hearing that the sense of hearing is reflected by the sense of sight with more strong ability of evoking attention, the promotion effect between different senses, the synergistic effect between sense and stress, participation in VDT syndrome such as general malaise, relevance to circadian rhythm due to the reflection to the pineal body by the exposure of light and electromagnetic fields, the change of brain waves in the case when we have received sound and light at the same time, chromesthesia, the cooperation effect of music and picture and so on. Since now these modern problems and high technology are double-faced sides of the same coin, we can give many concrete examples.

In fact, owing to the popularization of IT instruments such as cellular phone, cordless phone, personal computer and so on, both in the inside of the room and in the inside of the car, we are surrounded more and more by electronic instruments and live always under the exposure of artificial electromagnetic radiation as if smog. So, the environmental problems (such as VDT syndrome, electromagnetic wave erethism and so on) in which the reflection of compound effect and accumulation effect induced by mixture of sound, light, electromagnetic wave, heat and so on, must be taken into consideration are arising even if we choose the problems in the only limited field of the wavy physical science as an example [1]. However, as the present situation that every knowledge branches, it seems that each problem is decomposed owing to our human professional interest first to some parts in fragments belonging to different fields and each part is separately studied. Furthermore, not only in the acoustic environment but also in the electromagnetic environment, it can be said that almost all are mainly the studies in the frequency domain and few are studies in the time domain. Even in basic studies to solve the problems, it seems that any of quantitative studies related to compound effect and accumulation effect between different environmental factors such as sound, electromagnetic wave and so on in electrified indoor environment cannot be almost found even as a motive and a trial. If we remember in principle the genesis of our existence, it can be said that there are in principle no any phenomena not related to other different environmental factors including the one in the humanities.

In this paper, based on the primary criteria of “Relationism-First”[2], as a special case of high-tech pollution, the intermediation between only each two factors chosen from environmental multiple factors of wave motion type (which are different phenomena each other at least even in physical sides) in environment around VDT is taken into consideration as a trial (this artificial restriction sometimes may neglect any type of the third and forth environmental factors and so on). More concretely, first, the extended correlation analysis applicable to the environmental factors fluctuating within a finite range is newly introduced. Next, the effectiveness of the proposed methodological trial is confirmed in principle through some basic experiment by paying a special attention to mutual intermediation itself, especially as to its hierarchization not only in mutual relationship of only average and lower order type but also in every higher order type statistical moments of the fluctuation (even if the concrete meaning of which has not still been clarified).

2. EXTENDED CORREALATION ANALYSIS BETWEEN TWO FACTORS FLUCTUATING WITHIN FINITE REGION

In this paper, by paying our attention to factors in only natural scientific field which are mainly in a passive state, and are easy to be proved, the proposed method is limited to the relationship between only two factors x and y as a trial at an early stage of our study. In the previous papers, we have introduced the extend correlation analysis for the environmental factors with the fluctuating range $(-\infty,\infty)$. In this paper, we newly introduce the extended

correlation analysis for the environmental factors x and y fluctuating within finite level ranges [a, b] and [c, d], respectively. The summary of this correlation analysis [3] is shown in the following.

The joint probability density function (abbr., pdf) of x and y fluctuating randomly in complicated distribution forms can be generally expressed in the following orthonormal series expansion form:

$$P(x,y) = P_0(x)P_0(y)\sum_{m=0}^{\infty}\sum_{n=0}^{\infty}A_{mn}\varphi_m^{(1)}(x)\varphi_n^{(2)}(y) \tag{1}$$

with

$$A_{mn} = \left\langle \varphi_m^{(1)}(x)\varphi_n^{(2)}(y) \right\rangle , \tag{2}$$

where $P_0(x)$ and $P_0(y)$ are dominant distributions of x and y, respectively. In the case when the fluctuation ranges of x and y are limited to finite intervals [a,b] and [c,d] , as $P_0(x)$ and $P_0(y)$, we can take beta distributions defined as

$$P_0(x) = \frac{(x-a)^{\gamma_1-1}(b-x)^{\alpha_1-\gamma_1}}{(b-a)^{\alpha_1}\,\mathrm{B}(\gamma_1,\alpha_1-\gamma_1+1)} \tag{3}$$

and

$$P_0(y) = \frac{(y-c)^{\gamma_2-1}(d-y)^{\alpha_2-\gamma_2}}{(d-c)^{\alpha_2}\,\mathrm{B}(\gamma_2,\alpha_2-\gamma_2+1)} \quad . \tag{4}$$

Then, orthonormal functions $\varphi_m^{(1)}(x)$, $\varphi_n^{(2)}(y)$ are obtained such that

$$\varphi_m^{(1)}(x) = \sqrt{\frac{\Gamma(\alpha_1-\gamma_1+1)(\alpha_1+2m)\Gamma(\alpha_1+m)\Gamma(\gamma_1+m)}{\Gamma(\alpha_1+1)m!(m+\alpha_1-\gamma_1+1)\Gamma(\gamma_1)}}\; G_m\left(\alpha_1,\gamma_1;\frac{x-a}{b-a}\right) \tag{5}$$

and

$$\varphi_n^{(2)}(y) = \sqrt{\frac{\Gamma(\alpha_2-\gamma_2+1)(\alpha_2+2n)\Gamma(\alpha_2+n)\Gamma(\gamma_2+n)}{\Gamma(\alpha_2+1)n!(n+\alpha_2-\gamma_2+1)\Gamma(\gamma_2)}}G_n\left(\alpha_2,\gamma_2;\frac{y-c}{d-c}\right), \tag{6}$$

where $G_n(\alpha,\gamma{:}z)$ denotes Jacobi's polynomial [4] defined as

$$\begin{aligned} G_n(\alpha,\gamma;z) &= \frac{\Gamma(\gamma)z^{1-\gamma}(1-z)^{\gamma-\alpha}}{\Gamma(\gamma+n)}\frac{d^n}{dz^n}\left[z^{\gamma+n-1}(1-z)^{\alpha+n-\gamma}\right] \\ &= 1+\sum_{i=1}^{n}(-1)^i\binom{n}{i}\frac{\Gamma(\alpha+n+i)\Gamma(\gamma)}{\Gamma(\alpha+n)\Gamma(\gamma+i)}z^i \end{aligned} \tag{7}$$

The distribution parameters, $\{\alpha_1, \gamma_1\}$ and $\{\alpha_2, \gamma_2\}$, of $P_0(x)$ and $P_0(y)$ are respectively determined to satisfy the following relation:

$$A_{10} = 0,\ A_{20} = 0 \tag{8}$$

and

$$A_{01} = 0,\ A_{02} = 0\,. \tag{9}$$

By using two pairs of mean and variance of x and y, $\{\mu_x, \sigma_x^2\}$ and $\{\mu_y, \sigma_y^2\}$, we easily have

$$\alpha_1 = \frac{(\mu_x-a)(b-\mu_x)}{\sigma_x^2} - 2\,, \tag{10}$$

$$\gamma_1 = \frac{\mu_x-a}{b-a}\left\{\frac{(\mu_x-a)(b-\mu_x)}{\sigma_x^2}-1\right\}, \tag{11}$$

$$\alpha_2 = \frac{(\mu_y - c)(d - \mu_y)}{\sigma_y^2} - 2\,, \tag{12}$$

and

$$\gamma_2 = \frac{\mu_y - c}{d - c}\left\{\frac{(\mu_y - c)(d - \mu_y)}{\sigma_y^2} - 1\right\}\,. \tag{13}$$

The conditional pdf $P(y|x)$ of y conditioned by x can be generally expressed as follows:

$$P(y|x) = \frac{P_0(y)\sum_{m=0}^{\infty} A_{mn}\varphi_m^{(1)}(x)\varphi_n^{(2)}(y)}{\sum_{m=0}^{\infty} A_{m0}\varphi_m^{(1)}(x)}\,. \tag{14}$$

From Eq. (14), by expressing y in the orthonormal series expansion:

$$y = c_0\varphi_0^{(2)}(y) + c_1\varphi_1^{(2)}(y)\,, \tag{15}$$

the regression function of y is given as

$$\langle y|x\rangle = c_0 + c_1\frac{\sum_{m=0}^{\infty} A_{m1}\varphi_m^{(1)}(x)}{\sum_{m=0}^{\infty} A_{m0}\varphi_m^{(2)}(x)} \tag{16}$$

Substituting Eq. (6) into $\varphi_0^{(2)}(y)$, $\varphi_1^{(2)}(y)$ in Eq.(15) leads to

$$y = c_0 + c_1\sqrt{\frac{(\alpha_2+2)\Gamma(\alpha_2-\gamma_2+1)\Gamma(\gamma_2+1)}{\Gamma(\alpha_2-\gamma_2+2)\Gamma(\gamma_2)}}\left(1 - \frac{\alpha_2+1}{\gamma_2}\frac{y-c}{d-c}\right). \tag{17}$$

In Eq. (17), upon comparing the coefficients of y in the left hand with the ones of right hand sides, the following simultaneous equations are obtained:

$$c_0 + c_1\sqrt{\frac{(\alpha_2+2)\Gamma(\alpha_2-\gamma_2+1)\Gamma(\gamma_2+1)}{\Gamma(\alpha_2-\gamma_2+2)\Gamma(\gamma_2)}}\left(1 + \frac{\alpha_2+1}{\gamma_2}\frac{y-c}{d-c}\right) = 0\,, \tag{18}$$

$$-c_1\sqrt{\frac{(\alpha_2+2)\Gamma(\alpha_2-\gamma_2+1)\Gamma(\gamma_2+1)}{\Gamma(\alpha_2-\gamma_2+2)\Gamma(\gamma_2)}}\,\frac{\alpha_2+1}{\gamma_2}\frac{1}{d-c} = 1\,. \tag{19}$$

By solving Eqs. (18) and (19), we obtain

$$c_0 = \frac{\gamma_2(d-c)}{\alpha_2+1} + c\,, \tag{20}$$

$$c_1 = -\frac{\gamma_2(d-c)}{\alpha_2+1}\sqrt{\frac{\Gamma(\alpha_2-\gamma_2+2)\Gamma(\gamma_2)}{(\alpha_2+2)\Gamma(\alpha_2-\gamma_2+1)\Gamma(\gamma_2+1)}}\,. \tag{21}$$

By taking the expectation of Eq. (14) with respect to x, the estimated pdf $P_s(y)$ of y from the sampled data of x is given as

$$P_s(y) = P_0(y)\sum_{n=0}^{\infty} E_n\varphi_n^{(2)}(y) \tag{22}$$

with

$$E_n = \left\langle \frac{\sum_{m=0}^{\infty} A_{mn}\varphi_m^{(1)}(x)}{\sum_{m=0}^{\infty} A_{m0}\varphi_m^{(1)}(x)} \right\rangle_x\,. \tag{23}$$

As a special case, statistical Hermite series expansion and statistical Laguerre series expansion are included in the series expansion form stated in this paper.

3. MUTUAL CORRELATION ANALYSIS FOR EXPERIMENTAL ENVIRONMENT AROUND VDT

When a shooting game (DOOM LEGACY) was playing on a personal computer, the sound level and the magnetic field strength were measured each 5 seconds and 101 sets of sampled values were obtained. The setup of this experiment is shown in Figure 1. In this experiment, the sound level meter was set at the location of 30 cm distant from the personal computer and the EM strength meter was set at the location of d (15cm, 30cm and 45cm) distant from VDT.

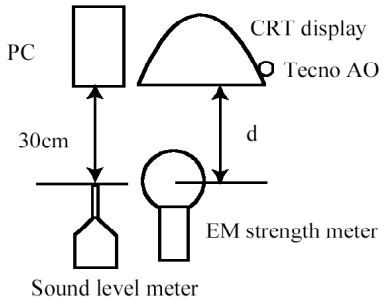

Figure 1. Experimental setup.

First, when the active bio-controller as some magnetic oscillator (Tecno AO) was not attached to VDT, the sound level and the magnetic field strength were measured. The proposed method has been applied to this data and the result for the case when the EM strength meter was set at the location of 30cm distant from VDT is shown in Figures 2 to 4. Then, we calculated as a=34mA/m,b=36mA/m,c=50dBA,d=70dBA.

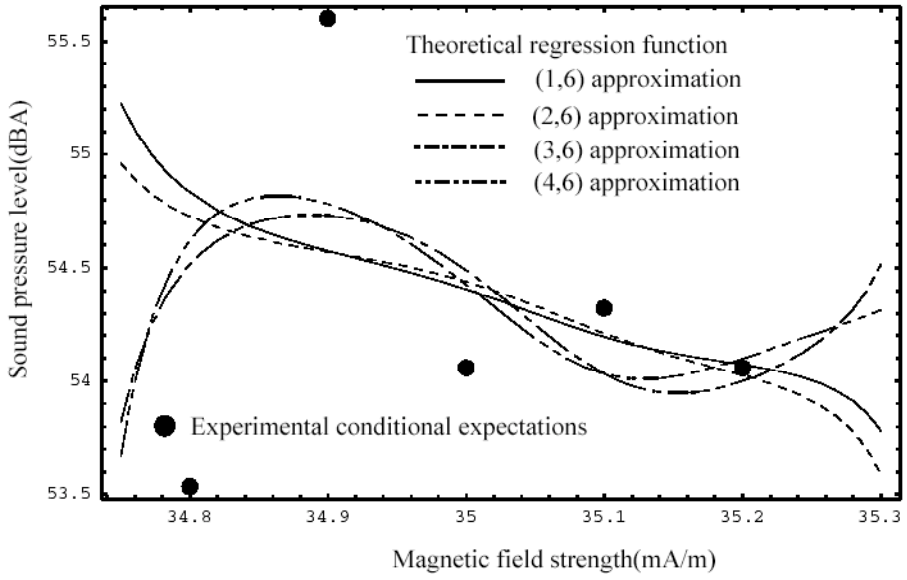

Figure 2. A comparison between experimental conditional expectations and theoretical regression functions of the sound pressure level to the magnetic field strength without attachment of Tecno AO.

To get the theoretical regression functions of Figure 2, in Eq. (16), as the denominator, initial term and the terms from the 1st to 6th order were used, and as the numerator, initial term and term of the 1st order, initial term and terms from 1st to 2nd order, initial term and terms from 1st to 3rd order and initial term and terms from 1st to 4th order were used. We call them (1,6) approximation, (2,6) approximation, (3,6) approximation and (4,6) approximation curves, respectively.

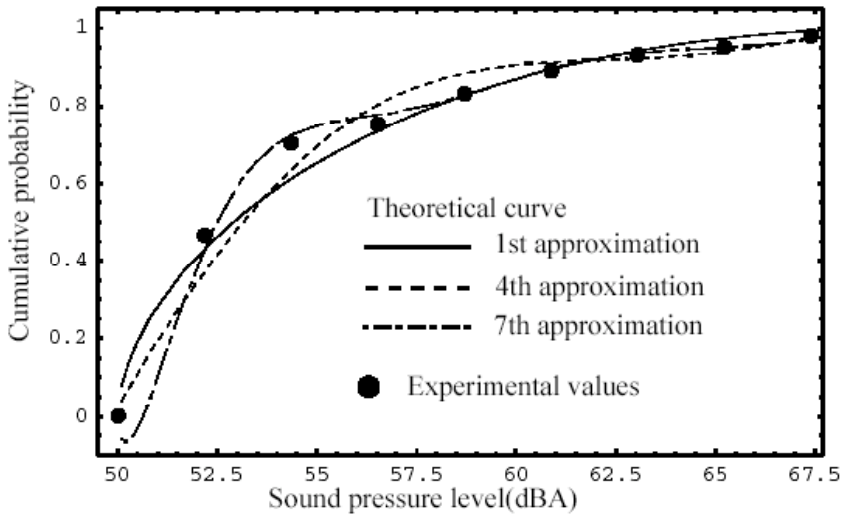

Figure 3. A comparison between the theoretically estimated cumulative probability distributions of the sound pressure level based on the magnetic field strength fluctuation and experimentally sampled values without attachment of Tecno AO.

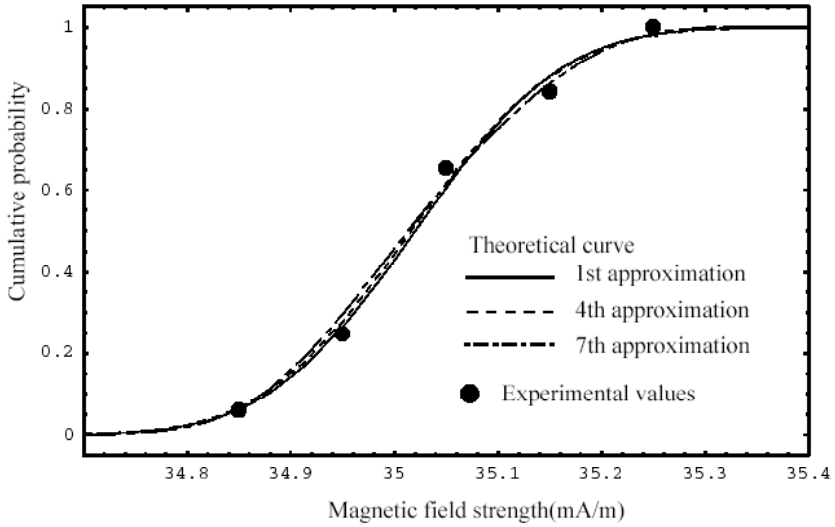

Figure 4. A comparison between the theoretically estimated cumulative probability distributions of the magnetic field strength based on the sound pressure level fluctuation and experimentally sampled values without attachment of Tecno AO.

To get the theoretical cumulative probability distribution of Figure 3, both in the numerator and in the denominator of Eq. (23), terms from initial to 3rd order were used and in Eq. (22), initial term, initial term and terms from the 1st term to the 3rd order, and initial term and terms from the 1st to the 6th order were used. We call them the 1st approximation, the 4th approximation and the 7th approximation, respectively. To get the theoretical cumulative probability distribution of Figure 4, both in the numerator and in the denominator of Eq. (23), terms from initial to 4th order were used.

The result for the case with attachment of Tecno AO and d=30cm is shown in Figures 5

to 7. Then, the calculation was executed as a=32.2mA/m, b=35.4mA/m, c=48dBA, d=73dBA.

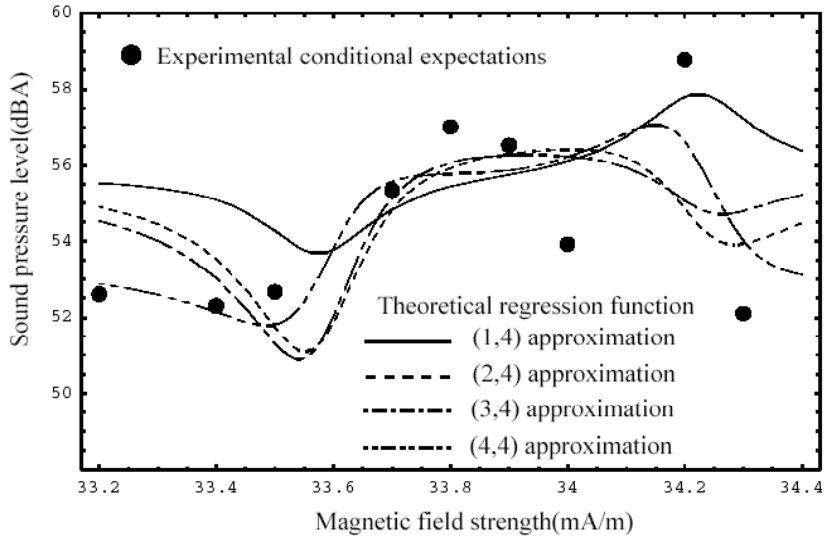

Figure 5. A comparison between experimental conditional expectations and theoretical regression functions of the sound pressure level to the magnetic field strength with attachment of Tecno AO.

To get the theoretical regression functions of Figure 5, in Eq. (16), as the denominator, initial term and the terms from the 1st to 4th order were used, and as the numerator, initial term and term of the 1st order, initial term and terms from 1st to 2nd order, initial term and terms from 1st to 3rd order and initial term and terms from 1st to 4th order were used.

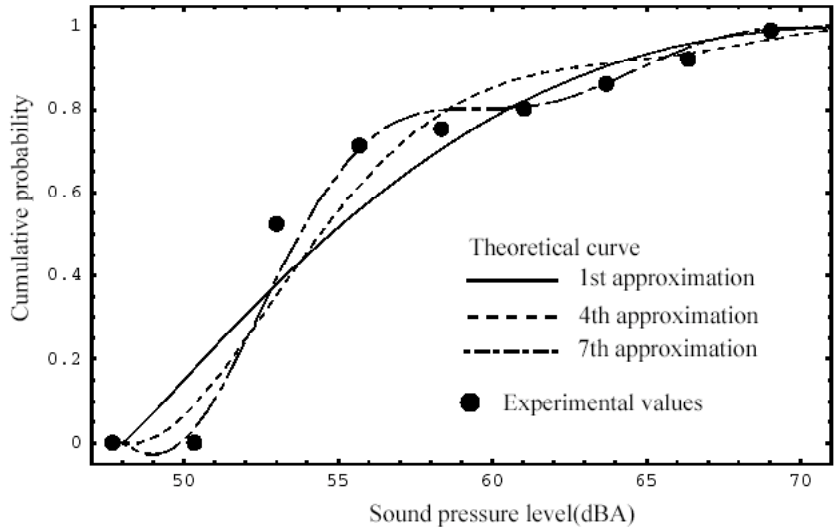

Figure 6. A comparison between the theoretically estimated cumulative probability distributions of the sound pressure level based on the magnetic field strength fluctuation and experimentally sampled values with attachment of Tecno AO.

To get the theoretical cumulative probability distribution of Figure 6, both in the numerator and in the denominator of Eq. (23), terms from initial to 3rd order were used and in Eq. (22). To get the theoretical cumulative probability distribution of Figure 7, both in the numerator and in the denominator of Eq. (23), terms from initial to 4th order were used.

In Figures 3, 4, 6 and 7, it can be clearly seen that the difference between theoretical cumulative probability distribution and experimental values becomes smaller as the degree of approximation increases. This means that it is necessary to make use of not only lower order

correlation but also higher order correlations for the correlation analysis between environmental factors.

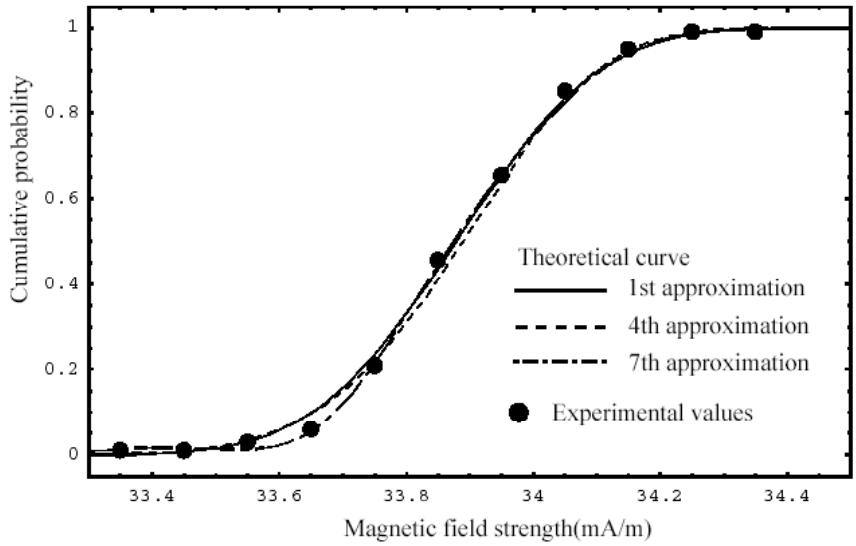

Figure 7. A comparison between the theoretically estimated cumulative probability distributions of the magnetic field strength based on the sound pressure level fluctuation and experimentally sampled values with attachment of Tecno AO.

4. CONCLUSIONS

We have already reported that the criterion of "Relationism-First" is the key to solve every type serious problems that confront us in the modern times. As a trial based on this criterion, in previous paper, we have proposed a methodology introducing an extended correlation analysis for two environmental factors. But it is available for the case when the environmental factors fluctuate within $(-\infty, \infty)$. In this paper, we have proposed the method matched to the case when the environmental factors fluctuate within any finite interval $[a, b]$. Of course, this includes the already proposed method as a special case. Finally, by applying it to a principle experiment on the environment around VDT under playing a game, the proposed method has been experimentally confirmed.

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