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A New Curve Smoothing Method for Trend Curves

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1. Introduction

As CRT-based display and advanced information technology were applied to advanced reactors such as APR-1400 (Advanced Power Reactor – 1400), human operators' tasks became more cognitive works. As a result, Human Factors Engineering (HFE) became more important in designing the MCR of an advanced reactor.

In HFE, measuring anthropometric/physiological values is very important, but exact measurement is very difficult. For example, measuring EEG, ECG, and eye movement is affected by many unwanted noise or artifacts and they include much incompleteness inevitably. So pure anthropometric/physiological signal cannot give much information to the evaluator, there should be some algorithm that enables the evaluator to understand the trend more easily.

2. Methodology

Original incoming signal is smoothed in two ways : (1) by the ordinary Gaussian smoothing method (2) by the proposed method. Ordinary Gaussian smoothing method smooths all parts of the signal equally. This causes the important part(much fluctuating part) to be smoothed too much, and the unimportant part(small fluctuating part) to be smoothed excessively.

From the incoming signal, the number of inflection is calculated. The signal is analyzed by a finite and constant window, and in this paper the window size is 10. As the number of inflection grows, the possibility of occurring unwanted accident gets higher, so the signal should be analyzed more accurately. For the accurate analysis, much smoothing is not appropriate. So we should use small standard deviation of the Gaussian smoothing. But the incoming signal is anthropometrical or physiological, there can be incompleteness in the signal. In this reason, fuzzy mathematics is used in the calculation of the standard deviation of the Gaussian smoothing. Let the number of inflection of the $i-th$ window be z_i. Define $m_i = (z_1 + z_2 + \cdots + z_i)/i$. m_i is used in defining fuzzy sigmoidal membership function(Fig 1).

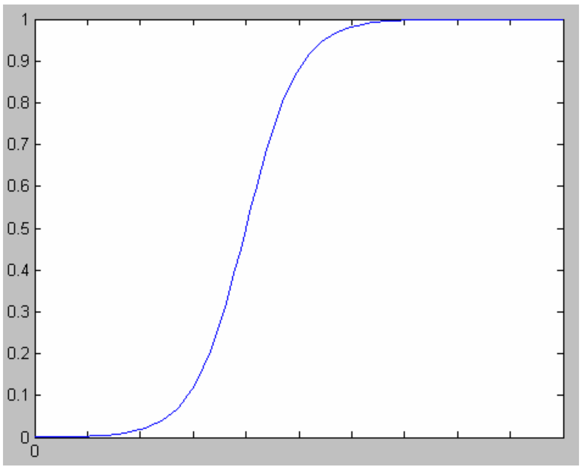

Figure 1 Fuzzy Sigmoidal Membership Function

For each window, sigmoidal membership function is evaluated respectively, and the center of the membership function is m_i.The equation of the fuzzy sigmoidal membership function is as follows :

$$\mu = \frac{1}{1+\exp[-k(x-m)]} \qquad (2.1)$$

Where k is a constant and m is the center of the membership function.

From fuzzy sigmoidal membership function μ, the standard deviation σ of the Gaussian smoothing is

$$\sigma = (b-a)\mu + a \qquad (2.2)$$

From (2.2), a is minimum of σ and b is maximum of σ. In this paper, the value of a and b are 0.1 and 100 respectively. Obtaining σ, the Gaussian smoothing of the input signal is evaluated as follows :

$$\begin{aligned} F(t) &= s(t) * g(t,\sigma) \\ &= \int_{-\infty}^{\infty} s(x) g(t-x,\sigma) dx \qquad (2.3) \\ &= \int_{-\infty}^{\infty} s(x) \frac{1}{\sqrt{2\pi}\sigma} \exp[\frac{-(x-t)^2}{2\sigma^2}] dt \end{aligned}$$

3. Results

The original signal is stock price of Samsung Electornics Co., Ltd., and 300 sample prices were selected. The smoothed results of the original signal are Fig 3 and Fig 4. From Fig 3 we can see that original part having much fluctuation is smoothed too much, so it looks similar to the part of small fluctuation. This disables good analysis about the accidental case. However, Fig 4 shows that the part of much fluctuation is not smoothed much, so the evaluator can get more information from that part.

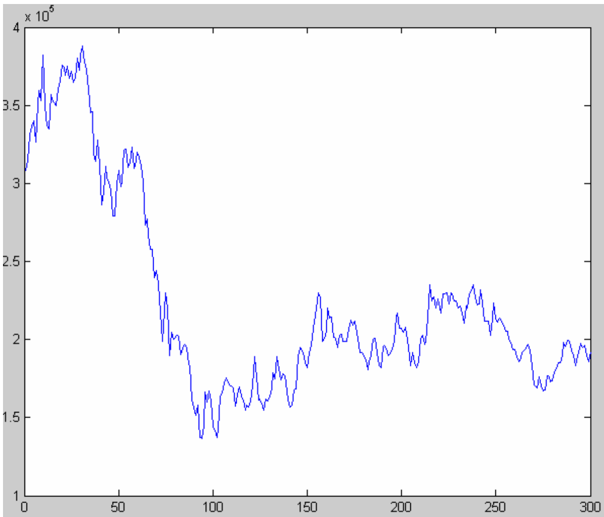

Figure 2 Original Input Signal

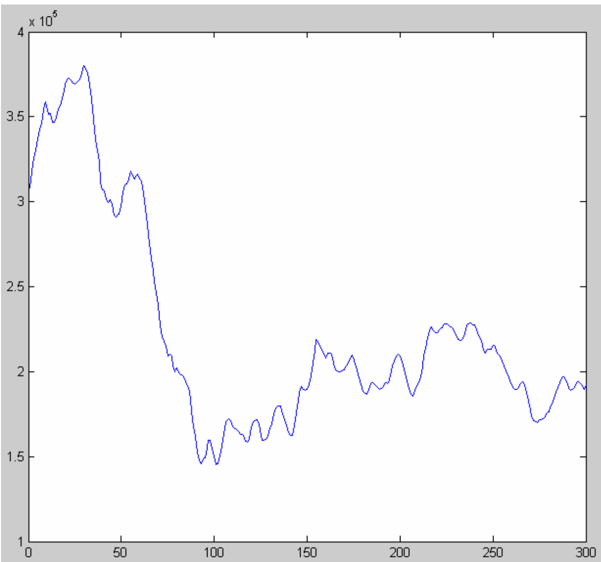

Figure 3 Gaussian Smoothed Signal

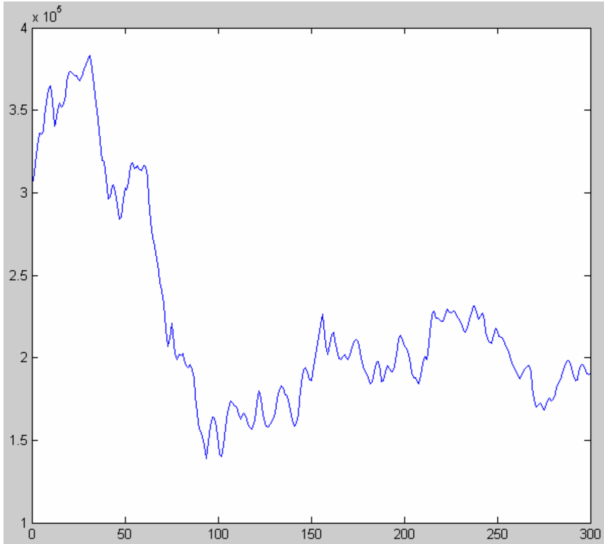

Figure 4 Smoothed Signal by the New Method

4. Discussions

In Fig 2, there are several much fluctuating periods. Fig 3 is the ordinary Gaussian smoothed curve, and much fluctuating characteristic cannot be analyzed effectively with respect to the original curve, because ordinary situation(small fluctuation) and accidental situation(much fluctuation) are smoothed equally. But in Fig 4, accidental period(much fluctuation) can be analyzed more accurately than in Fig 3 because the accidental period is in more detail and ordinary period is relatively simplified than the accidental period. This new smoothing process is expected to give the evaluator better performance.

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