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Fuzzy Model for Performance in Cortisol

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ABSTRACT
Elective surgery represents a considerable source of stress for the patient. Many attempts have been made to prepare patients before surgery with the aim of reducing stress and improving outcome. Medical study that their videotape preparation is well suited to decreasing anxiety and stress as measured in terms of intraoperative systolic blood pressure increase, in patients undergoing hip replacement surgery and preserved them to cope better with postoperative pain. In many practical applications, it turns out to be useful to use the notion of fuzzy transform: once we have functions $A_1(x) \geq 0, \ldots\ldots, A_n \geq 0$, with $\sum_{i=1}^{n} A_i(x) = 1$, we can then represent each function f (x) by the coefficients $F_i = (\int f(x).A_i(x)dx) / (\int A_i(x)dx)$. Once we know the coefficients F_i, we can (approximately) reconstruct the original function f(x) as $\sum_{i=1}^{n} F_i.A_i(x)$. The original motivation for this transformation came from fuzzy modeling, but the transformation itself is a purely mathematical transformation. Thus, the empirical successes of this transformation suggest that this transformation can be also interpreted in more traditional (non-fuzzy) mathematics as well. Such an interpretation is presented in this paper.
KEYWORDS: Cortisol, surgery, F-transform
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I. Introduction

Elective surgery represents a considerable source of stress for the patient [**11**], [**12**]. Many attempts have been made to prepare patients before surgery with the aim of reducing stress and improving outcome. In medical study conclude that our videotape preparation is well suited to decreasing anxiety and stress as measured in terms of intra-operative systolic blood pressure increase [**7**], [**11**], [**9**], [**10**] and Cortisol excretion and to reducing the postoperative need for analgesics in patients undergoing hip replacement surgery. Evaluation of preoperative locus of control revealed divergent results [**9**], [**10**] pointed out that in the specific situation of surgical intervention; the ability to surrender control might be more adaptive than a controlling style. The F-transform of function f is a vector with weighted local mean values of f as components. The first step in the definition of the F-transform of
f: X →R is a selection of a fuzzy partition of universal set X by a finite set of basic functions
$A_1(x) \geq 0, \ldots, A_n(x) \geq 0$ ……(1)
which are continuous and satisfy the condition $\sum_{i=1}^{n} A_i(x) = 1$.

II. Fuzzy Transform and the Need for Its probabilistic Interpretation:

Basic functions are called membership functions of respective fuzzy sets, or, alternatively, granules, information pieces, etc. Their choice reflects the type of uncertainty which is related to the knowledge of x. Once the basic functions are selected, we define the F-transform of a continuous function f : X → R as a vector ($F_1, \ldots, F_n$), where

$F_i = (\int f(x).A_i(x)dx) / (\int A_i(x)dx)$. …....….. (2)

F-transform satisfies the following properties:

(i) y = F_i minimizes $\int_a^b (f(x) - y)^2 A_i(x)dx$

(ii) for a twice continuously differentiable function f, $F_i = f(x_i) + O(h_i^2)$, where h_i is the length of the support of A_i.

F-transform is used in applications as a "skeleton model" of f. This model provides a compressed image if f is an image [**3**], values of a trend if f is a time series [**4**], a numeric model if f is used in numeric computations (integration, differentiation) [**5**], etc.

Once we know the F-transform components Fi, we can (approximately) reconstruct the original function f as $\bar{f}(x) = \sum_{i=1}^{n} F_i A_i(x)$ ……………. (3)

In [**2**], the formula (3) is called the F-transform inversion formula. The formula (3) represents a continuous function that approximates f. Under certain reasonable conditions, a sequence of functions represented by (3) uniformly converges to f (see [**1**],[**8**] for more details).

III. Example

One hundred patients were enrolled in the study after giving written informed consent. Inclusion criteria were as follows: age of 18 years or above, diagnosis of osteoarthritis of the hip joint, no previous hip replacement surgery, anxiety and pain were evaluated daily for 5 days, beginning with the preoperative day, as well as postoperative intake of analgesics and sedatives, were recorded. Urinary levels of Cortisol were determined in 12-hour samples collected at night for 5 nights, beginning with the preoperative night. Forty-six patients were randomly assigned to the preparation group, and 54 were assigned to the control group. After the operation, mean levels of state anxiety decreased in both groups, but levels in the preparation group stayed lower during the 4 postoperative days. Pain rating on the visual analog scales increased between the preoperative day and the morning before surgery and decreased form day to day postoperatively.

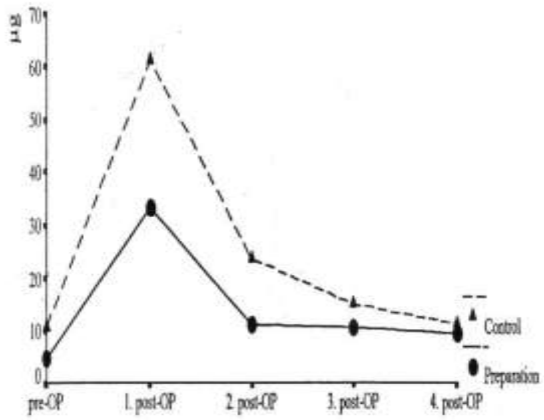

Figure 1

Let us give an example of the F-transform of

$$f_1(x) = \begin{cases} 0.83x + 0.17, x \in [0,1] \\ -0.58x + 1.58, x \in [1,2] \\ -0.17x + 0.75, x \in [2,3] \\ -0.08x + 0.3, x \in [3,4] \end{cases}$$

$$f_2(x) = \begin{cases} 0.42x + 0.08, x \in [0,1] \\ -0.33x + 0.83, x \in [1,2] \\ -0.03x + 0.23, x \in [2,3] \\ -0.05x + 0.28, x \in [3,4] \end{cases}$$

with respect $A_1, \ldots, A_4$. For simplicity, we assume that basic functions $A_1, \ldots, A_4$ are of triangular shape and constitute a uniform partition of [0,4]. Their analytical representation is as follows:

$$A_1(x) = \begin{cases} 0, otherwise \\ 1 - x, x \in [0,1] \end{cases}$$

$$A_2(x) = \begin{cases} x, x \in [0,1] \\ 2 - x, x \in [1,2] \\ 0, otherwise \end{cases} \quad \ldots\ldots\ldots (4)$$

$$A_3(x) = \begin{cases} x - 1, x \in [1,2] \\ 3 - x, x \in [2,3] \\ 0, otherwise \end{cases}$$

$$A_4(x) = \begin{cases} x - 2, x \in [2,3] \\ 4 - x, x \in [3,4] \\ 0, otherwise \end{cases}$$

By (2) the values of the components $F_1, \ldots F_4$ of the F-transform are $F_1=0.42$, $F_2=0.76$, $F_3=0.19$, $F_4=0.14$.

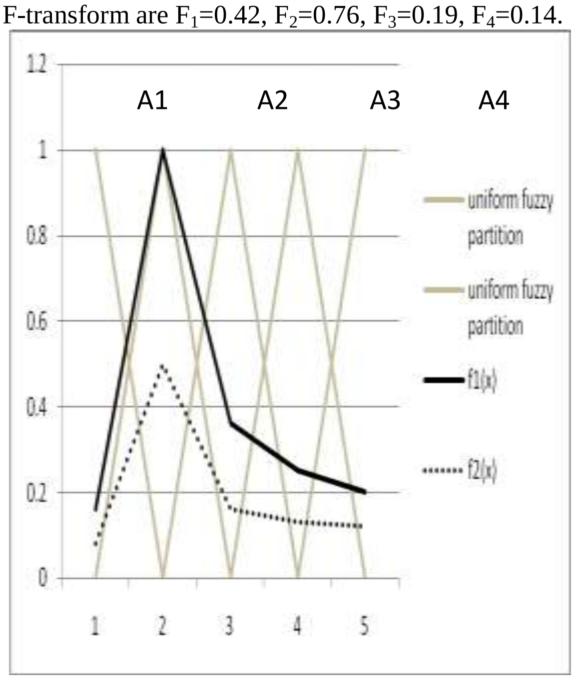

Figure 2

Figure2 provides a graphical representation of the basic functions $A_1, \ldots, A_4$, of the function f_1 (x) and f_2(x) of its F-transform components $F_1, \ldots, F_4$, and of the inverse Ftransform

$\bar{f}_1$(x) and $\bar{f}_2$(x) (see fig 3 to fig 5)

IV. F-Transform: Original Motivation.

The original motivation for F-transform came from fuzzy modeling [**2**][**3**]. For example, in the

situation corresponding to the inverse F-transform, we have n rules
If x is A_1 then y = F_1,
If x is A_n then y = F_n …………….. (6)

These rules are Takagi-Sugeno (TSK) rules with singleton (constant) right-hand sides. For TSK rules, the value corresponding to a given input x is $\bar{f}$ (x) $=\sum_{i=1}^{n} F_i A_i(x) / \sum_{i=1}^{n} A_i(x)$. Since $\sum_{i=1}^{n} A_i(x)$=1, we get formula (3).

The purpose was to show that this type of modeling can be as useful in applications as more traditional techniques such as Fourier transform and wavelet transform. Moreover, F-transform has a potential advantage over Fourier and wavelet transforms: in contrast to the purely mathematical basic functions used in Fourier and wavelet transforms, the basic functions Ai in a fuzzy partition usually come from natural language terms like "low" or "high" (for a detailed description of fuzzy modeling, see, e.g., [**6**]).

Just like any other tool of applied mathematics, F-transform is not a panacea. It is more successful in some problems, and in other problems, it is less successful. It is therefore desirable to combine F-transform with other mathematical tools, so as to combine relative advantages of different techniques. For combining F-transform with other mathematical tools, it is desirable to come up with a purely mathematical (non-fuzzy) interpretation for this transform.

In particular, since most mathematical data processing tools are based on probability and statistics, it is desirable to come up with a probabilistic interpretation for F-transform.

4.1 The Known Probabilistic Interpretation of Fuzzy Modeling Leads to a Probabilistic Interpretation of F-Transform.

We have mentioned that F-transform was originally designed as a particular case of fuzzy modeling. A seminal paper [**5**] provided a reasonable probabilistic model for a particular case of fuzzy modeling.

In this paper, we show that a modification of the probabilistic interpretation from [**5**] enables us to justify formulas of F-transform without making any additional assumptions about the probability distributions. In mathematical terms, this modification consists of using Bayes formulas—and making assumptions about prior distributions (a natural way to describe prior knowledge in statistics) instead of making assumptions about the actual distributions. Thus, we get an even more natural probabilistic interpretation of F-transform. Specifically

(i) the paper [**5**] shows, in effect, that there exists a reasonable probabilistic interpretation of the Ftransform formulas;
(ii) however, in principle, this interpretation leaves the possibility that there exist other equally reasonable assumptions about the probability distributions can lead to different formulas;
(iii) in our modified interpretation, we show that the basic probabilistic setting uniquely determines the F-transform formulas, without the need to make any assumptions about the probability distributions.

We also show that a similar modification can be applied to the probabilistic interpretation of general fuzzy modeling formulas. From the mathematical viewpoint, the resulting formulas are very similar to the formulas from [**5**] (with the exception of the Bayes formula step). However, in our opinion, this mathematically minor modification leads to a major change in interpretation: now, to probabilistic researchers, F-transform is
(i) not just a possible model, corresponding to one of the possible reasonable choices of probability distributions,
(ii) but the model uniquely emerging from the natural probabilistic setting.
Similar conclusion can be made about the probabilistic interpretation of more general fuzzy models.

In other words, our minor modification uncovers an even deeper fundamental earning of the probabilistic interpretation
originally proposed [5]

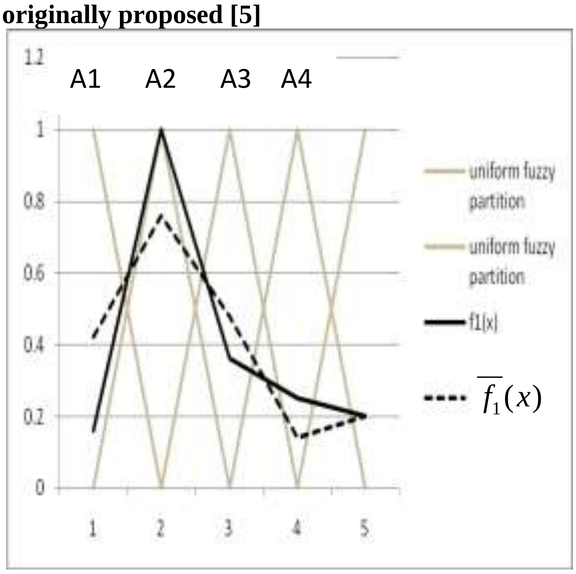

Figure 3

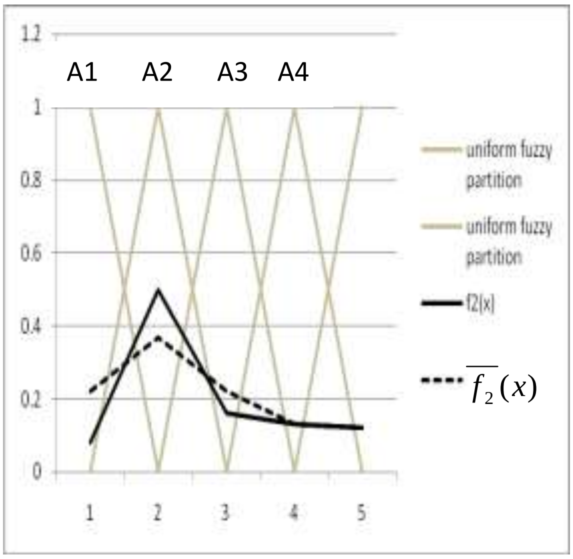

Figure 4

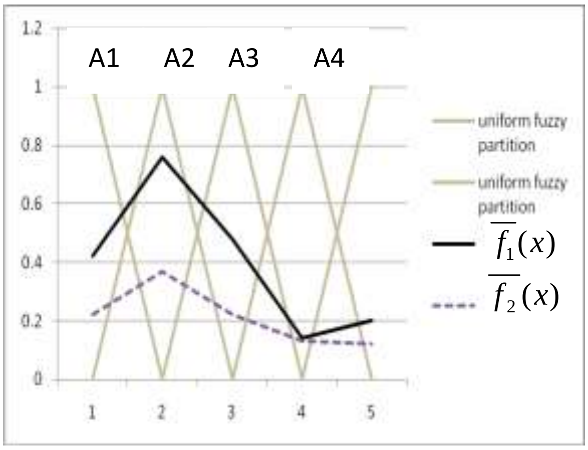

Figure 5

V. Conclusion

We describe a modification of a probabilistic interpretation described in [**5**]. In this modification, the corresponding probabilistic model uniquely leads to the formulas of the F-transform. A similar modification is described in a more general situation of fuzzy modeling. The results of these analyses that use of the videotape decreased anxiety and stress, measured in terms of urinary Cortisol excretion and intraoperative systolic blood pressure increase, which are beautifully fitted with the expressions for Fuzzy Transform and Fuzzy modeling.

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