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Research Article

A Mathematical Fuzzy Transform for Evaluating the Effect of Recombi Nant on Growth Hormone

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Abstract: The fuzzy transform (FT) is a novel, extensively utilized soft computing method with solid mathematical underpinnings. This article presents the technique using data on plasma levels of Interleukin-6, which is indicative of low-grade inflammation or severe activity. We first show how useful it is for describing and identifying attribute dependencies. Moreover, we use it to connection mining of a functional kind. Moreover, the fuzzy membership values that have been found are specified linguistically, which means that fuzzy transforms make up their antecedent, and only evaluative linguistic terms characterize their consequent.

***Keywords*:** fuzzy transform (FT), fuzzy membership function, plasma level

MSC: 03E72, 15B15

1. Introduction

Zadeh [1] made the first use of fuzzy set theory in applications."The idea of a fuzzy set offers a convenient starting point for the development of a conceptual framework that resembles the framework utilized in the case of ordinary sets in many respects," Zadeh continues. There are many uses for fuzzy sets generally, especially in the domain of pattern recognition.

Perfilieva [2–4] was developed FT method and their application uses in many real fields like differential equation solving, filtering, data compression and the creation of approximate models. As its name suggests, a correspondence between two universes, one consisting of fuzzy objects and the other of real numbers, is the main component of the F-transform. The fuzzy objects in the first universe can be viewed as an interpretation of certain verbal phrases, with the universe reflecting the particular context in which they are spoken. By using a fuzzy transform, real numbers that correspond to the typical values of the respective monitoring attribute are associated with the fuzzy objects [5].

The related research has examined the approach's many good features, which include determining how to assign the corresponding value [6, 7]. One of these is whether the pertinent value is optimal in terms of weighted square root deviation. The aim of this work is to demonstrate the wide range of applications and potential use of the F-transform in data analysis. Initially, we address the task of identifying and describing relationships among given attributes. In this case, one attributes which we'll refer to as monitoring, is fixed and is thought to depend (or function) on other distinct attributes.

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According to Štepnicka [8], Applications in Economics of Decision Support Methods in Uncertain Environments, fuzzy transformations for two-variable functions were covered.

At first, it is unclear how many and what kind of independent traits there are. We show that a functional dependence exists, and propose a formal expression for it by constructing inverse F-transforms of all possible hypothetical functions. Secondly, we demonstrate that the F-transform can be employed as a specific data-mining instrument, particularly for the purpose of mining associations within numerical data.

Every scientific subject goes through a phase in its development where attempts are made to develop mathematical theories to account for and explain the findings that the discipline is studying [9, 10]. The mathematical techniques employed in the study are highly beautiful, even though many of these models have little application in everyday situations. In an attempt to make the theory more applicable in real-world scenarios, a number of models based on various hypothetical scenarios have been devised.

Perfilieva have demonstrated a few results utilizing the fuzzy transform for real-time data. He recently found the answers to the issues surrounding reef growth. Hypopituitarism with Growth Hormone Deficiency, Weibull-G Exponential distribution model for secretion of GH, RH in beef cows were discussed in [11, 12]. This experiment will be closely examined to determine whether interleukin-6 dose-dependently increases growth hormone release. In order to produce circulation levels of Interleukin-6 similar to those observed during intense, sustained exercise, recombinant human Interleukin-6 was administered intravenously to healthy individuals for three hours. During intense activity, the pituitary releases large levels of growth hormone, the prototypical anabolic hormone, as well as growth hormone antagonist interleukin-6. An essential mechanical function of interleukin-6 is seen in growth hormone. Growth hormone increased significantly as a result of interleukin-6 infusion, peaking one hour after the infusion began $(p < 0.001)$.

2. Fuzzy set

If X is a universe discourse and any element $x \in X$, then fuzzy set A defined on X is a collection of ordered pair, $A = \{(x,\ \mu_A(x)) : x \in A\}$, Where $\mu_A(x) : X \to [0,\ 1]$, $\mu_A(x)$ is called a Membership (basic) Function(MF) [5, 13].

3. The method of fuzzy transform

A known function on a finite domain (also known as a discrete function) or a continuous function on a bounded domain can be transformed using the fuzzy transform technique. The domain is predictable to be partitioned by fuzzy sets. Given a function, the FT gives a set-to-point correspondence between the fuzzy sets of the partition and certain average values of the function. In this part, functions involving a single variable will be examined because to their inherent simplicity. On the other hand, the F-transform of a function with two or more variables is just a straightforward expansion of the definitions given [9, 11].

Definition 3.1 [11] Let A be any bounded closed interval $[x,\ y]$ of real numbers R and within A, the fixed notes be $p_1 < p_2 < \cdots < p_n$ such that $p_1 = a,\ p_n = b$ for $n \geq 2$. $M_1(p),\ M_2(p),\ \ldots,\ M_n(p)$ are membership functions of $M_1,\ M_2,\ \ldots,\ M_n$ respectively and defined on any closed bounded interval in R, form a fuzzy partition of A.

If they satisfies the following condition for $i = 1,\ 2,\ \ldots,\ n$.

i) $M_i : A \to [0,\ 1]$, $M_i(p_i) = 1$.

ii) if $p \notin (p_{i-1},\ p_{i+1})$ then $M_i(x) = 0$, here for the uniformity, we put $p_0 = a$ and $p_{n+1} = b$.

iii) Each $M_i(p)$ is continuous.

iv) $M_i(p)$ is monotonically increases on $[p_i,\ p_{i-1}]$ for $i = 2,\ \ldots,\ n$ and $M_i(p)$ is monotonically decreases on $[p_{i-1},\ p_{i+1}]$ for $k = 1,\ \ldots,\ n-1$.

v) $\sum_{i=1}^{n} M_i(p) = 1,\ \forall p \notin A$, where $M_1(p),\ M_2(p),\ \ldots,\ M_n(p)$ are membership functions and also called as basic functions.

If the points $p_1,\ p,\ \ldots p_n$ of $[x,\ y]$ are equidistant $p_k = x + h(i-1),\ i = 1,\ 2,\ \ldots,\ n$ where $h = \dfrac{y-x}{n-1}$, then a partition $M_1(p),\ M_2(p),\ \ldots,\ M_n(p),\ n > 2$ is called as uniform and two more properties are fulfilled for $i = 2,\ \ldots,\ n-1$.

vi) $M_i(p_i - p) = M_i(p_i + x)$, $\forall p \in [0,\ h]$.

vii) $M_i(p) = p_{i-1}(p - h)$, $\forall p \in [p_i,\ p_{i+1}]$ and $M_{i+1}(p) = M_i(p - h)$, $\forall p \in [p_i,\ p_{i+1}]$.

Let $C[x,\ y]$ be the set of continuous functions on closed interval $[x,\ y]$, the following definition introduces the fuzzy transform of a function $f \in C[x,\ y]$.

Definition 3.2 Let f be any function from $C[x,\ y]$ and $M_1,\ M_2,\ \ldots,\ M_n$ be membership (basic) functions which form a fuzzy partition of $[x,\ y]$ and. We say that n-tupe of real numbers $[F_1,\ F_2,\ \ldots,\ F_n]$ given by

$$F_k = \frac{\int_x^y f(p)M_i(p)dp}{\int_x^y M_i(p)dp} \tag{1}$$

$i = 1,\ 2,\ \ldots,\ n$ is the (integral) Fuzzy Transform (FT) of f with respect to $M_1,\ M_2,\ \ldots,\ M_n$. The above function (1) satisfies following properties:

(i) $z = F_i$, Minimizes $\int_x^y (f(p) - z)^2 M_i(p)dp$

(ii) For a class 2 function f, $F_i = f(p_i) + O\left(h_i{}^2\right)$, where $h_i = |\text{Supp}(M_i)|$, the length of the support of M_i.

Once we know the FT components F_i, we can (approximately) reconstruct the original function f as

$$\bar{f}(x) = \sum_{i=1}^{n} F_i M_i(p) \tag{2}$$

The formula (2) is called the FT inversion formula. The formula (2) represents a continuous function that approximates f.

4. Background of the problem

Twelve young (26 years old), healthy, active, but not particularly trained men participated in the study. The participants $(n = 6)$ were divided into two groups and given an infusion of either recombinant human Interleukin-6 or albumin. A lower dose of the recombinant human interleukin-6 was used than has been previously demonstrated to be safe in prior investigations. The doses of Interleukin-6 were determined during pilot experiments. Achieving plasma Interleukin-6 levels similar to those observed after intense exercise or low-grade inflammation is the aim [2]. The rate of infusion for the recombinant human Interleukin-6 was 5 g/h, and albumin was used as a carrier. The control group received just albumin during the experiment.

At baseline, 1, 2, 3, 4, and 5 hours following the start of the 3-hour recombinant human Interleukin-6 infusion, blood samples were collected. The Enzyme-Linked Immune Sorbent Assay and Diagnostic System Laboratories Active kit were used to assess the amounts of growth hormone in serum. The sensitivity was 0.03 mg/ml, the intra-assay co-efficient of variability was 3.3 to 4.3, and the inter-assay co-efficient of variability was 6.3 to 6.5. The impact of recombinant human interleukin-6 infusion on growth hormone levels is shown in Figure 1.

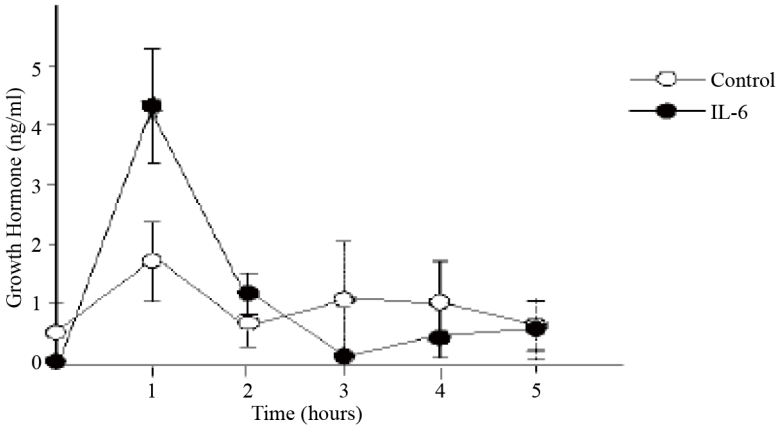

Figure 1. The graph of effect of recombinant on Growth Hormone (GH)

5. Applications of f-transform (FT) to data analysis

Let us give an example of the FT; we construct the class 2 function of figure 1 as follows:

$$f_1(p) = \begin{cases} p,\ p \in [0,\ 1] \\ -0.73p + 1.73,\ p \in [1,\ 2] \\ -0.23p - 0.73,\ p \in [2,\ 3] \\ 0.07p - 0.16,\ p \in [3,\ 4] \\ -0.05p + 0.3,\ p \in [4,\ 5] \end{cases}$$

$$f_2(p) = \begin{cases} 0.27p + 0.11,\ p \in [0,\ 1] \\ -0.23p + 0.61,\ p \in [1,\ 2] \\ 0.11p - 0.07,\ p \in [2,\ 3] \\ -0.045p + 0.41,\ p \in [3,\ 4] \\ -0.14p + 0.77,\ p \in [4,\ 5] \end{cases}$$

Assume that the membership (basic) functions of $f_1(p)$ and $f_2(p)$ are triangular functions and form a symmetric partition of $[0,\ 5]$ are $M_1,\ \cdots,\ M_5$. Their analytical representation is as follows:

$$M_1(p) = \begin{cases} 0,\ \text{otherwise} \\ 1 - p,\ p \in [0,\ 1] \end{cases}$$

$$M_2(p) = \begin{cases} p,\ p \in [0,\ 1] \\ 2 - p,\ p \in [1,\ 2] \\ 0,\ \text{otherwise} \end{cases}$$

$$M_3(p) = \begin{cases} p-1,\ p \in [1,\ 2] \\ 3-p,\ p \in [2,\ 3] \\ 0,\ \text{otherwise} \end{cases}$$

$$M_4(p) = \begin{cases} p-2,\ p \in [2,\ 3] \\ 4-p,\ p \in [3,\ 4] \\ 0,\ \text{otherwise} \end{cases}$$

$$M_5(p) = \begin{cases} p-3,\ p \in [3,\ 4] \\ 5-p,\ p \in [4,\ 5] \\ 0,\ \text{otherwise} \end{cases}$$

6. Mathematical results

Figure 2 depicts the basic (membership) functions $M_1, \cdots, M_5$, of the functions $f_1(p)$ and $f_2(p)$ and their components of F-Transform are $F_1,\ \ldots,\ F_5$ for the corresponding real time data [5].

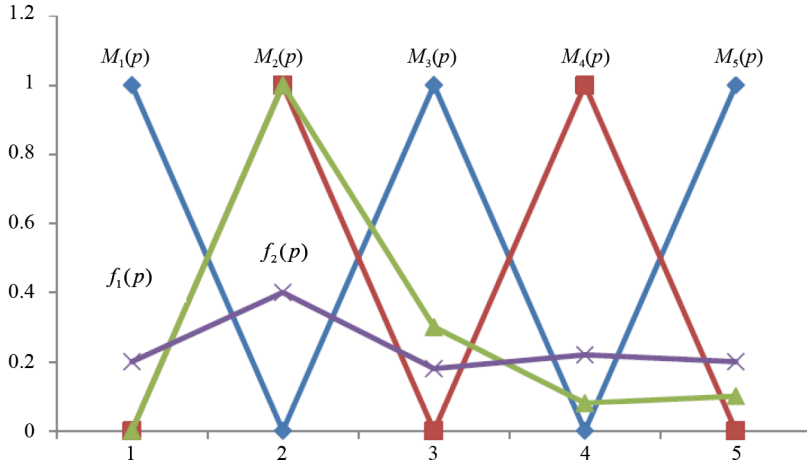

Figure 2. The Mathematical Functions $f_1(p)$ and $f_2(p)$ of effect of recombinant on Growth Hormone (GH) with Membership (Basic) Function

Next finding the value of F-transform inversion function $(\bar{f}_1(p))$ for the corresponding $f_1(p)$ of its components $F_1, \cdots, F_5$ using formula (2), F-transform component values are given below.

$$F_1 = 0.2,\ F_2 = 0.297,\ F_3 = 0.203,\ F_4 = 0.24,\ F_5 = 0.2$$

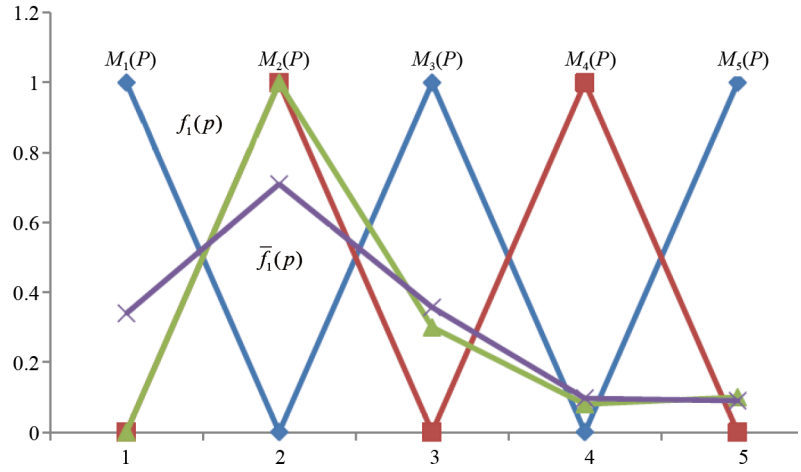

Figure 3. Comparison results between $f_1(p)$ & $\bar{f}_1(p)$ of effect of recombinant on Growth Hormone (GH) with Membership (Basic) Function

From formula (2), we found the value of F-transform inversion function $(\bar{f}_2(p))$ for the corresponding $f_2(p)$ with components $F_1, \cdots, F5$, the value are

$$F_1 = 0.34,\ F_2 = 0.71,\ F_3 = 0.357,\ F_4 = 0.097,\ F_5 = 0.09.$$

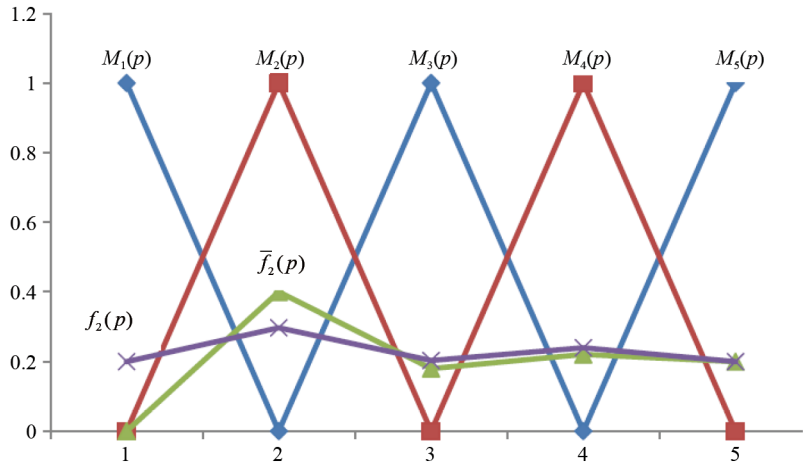

Figure 4. The comparison between $f_2(p)$ and their F-transform inversion function $\bar{f}_2(p)$ of effect of recombinant on Growth Hormone (GH) with Membership (Basic) Function

In Figure 5, we have compared the F-transform functions of $f_1(p)$ and $f_2(p)$ to the real time data (Refer Figure 1) as well as their F-transform inversion functions $(\bar{f}_1(p))$ and $(\bar{f}_2(p))$, respectively.

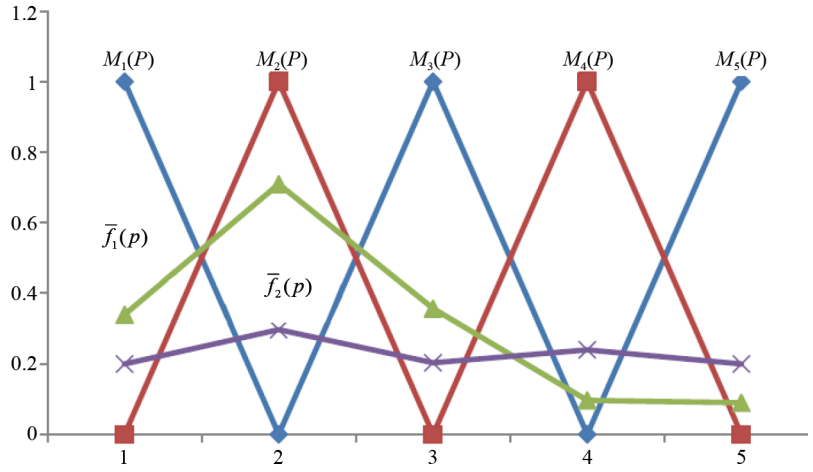

Figure 5. The combined F-transform inversion functions $\bar{f}_1(p)$ and $\bar{f}_2(p)$ of $f_1(p)$ and $f_2(p)$ respectively with Membership (Basic) Function

7. Conclusion

We have shown in this work that the F-transform is a flexible tool for the provided data [14]. Initially, our focus was on identifying and describing attribute dependencies. Secondly, we presented a novel method for association mining that describes relationships between features that are expressed as exact natural language phrases that are directly obtained from numerical data. We present the observed associations in a linguistic form that is easily comprehensible to a wide range of users, and our method is fast. Interleukin-6 infusion is shown to have an impact on growth hormone, which is consistent with the findings of the scientific and medical reports.

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