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The Fuzzy-Interpolative Concept Applied In Soft Computing

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Abstract: - The paper is discussing about the utility of the fuzzy-interpolative methodology in soft computing. The fuzzy-interpolative controllers are fuzzy controllers that may be equaled with linear interpolative networks. They are alloying the advantages of the linguistic representation of knowledge offered by the fuzzy side with the easiness of the interpolative implementations. A software application focused on psychology is shown: an expert system offering consultancy on the human relation issue.

Keywords: - fuzzy-interpolative, look-up table, action pattern, emotional tension.

1 The Fuzzy-Interpolative Concept

A fuzzy-interpolative controller (FIC) is a fuzzy controller that can be equaled with a corresponding look-up table with linear interpolations. In general, the interpolative networks can approximate any input-output mapping. The fuzzy controllers make no exception: any fuzzy controller can be approximated by interpolative networks. Still comparing to usual fuzzy controllers, a FIC exhibits a more intimate link with the interpolative network: each control rule is associated to its own interpolative node. A typical FIC is the Sugeno controller using triangular fuzzy partitions, prod-sum inference and COG defuzzyfication [5]. Due to their interpolative nature FICs can be immediately implemented in almost any possible software or hardware technology.

The software implementations don't necessarily request specialized environments: C#, Matlab and even ASM applications are already realized in very advantageous conditions. Their developing procedures can be concentrated as a fuzzy-interpolative methodology FIM, introduced in several previous papers [5], [7], [8], [9], [10] .

The basic steps of FIM are the following:

- the identification of the desired control or modeling solution, as a fuzzy-expert system;
- the building of the linguistic control rule base of the corresponding fuzzy-expert system, by McVicar Whelan tables;
- the designing of a corresponding FIC, using strong fuzzy partitions, an appropriate inference and COG defuzzyfication;
- the designing of a corresponding look-up table with linear interpolations;
- the implementation of the look-up table.

2 Fuzzy-Interpolative Soft Computing

Soft computing (SC) is a collection of methods that are trying to cope with the main disadvantage of the conventional (hard) computing: the poor performances when working in uncertain conditions. The fundamental idea of SC is to emulate the human like reasoning. The classic constituents of SC are fuzzy logic, neural network theory and probabilistic reasoning, but new methods are continuously emerging: belief networks, genetic algorithms, anytime algorithms, chaos theory, some parts of learning theory, etc. Due to the large variety and complexity of the domain, the constituting methods of SC are not competing for a comprehensive and ultimate solution. Instead they are complementing each other, for dedicated solutions adapted to each specific problem. Hundreds of concrete applications are already available in control, decision-making, pattern recognition and robotics. The SC systems are tolerant to imprecision, uncertainty, and partial truth. Their main advantages are tractability, robustness, and low cost implementations. In the same time SC is a major developing vector of the Artificial Intelligence.

The FICs are obviously belonging to the fuzzy branch of SC. The easiness of the FICs implementations that is essential for the hardware applications is also an asset for the SC ones.

In any possible software environment the basic architecture cells of FICs, respectively the look-up tables, are either built-in as in the case of MATLAB, or very easy to implement by multi-dimensional arrays type objects [4]. The facility of the aggregation of these objects facilitates the construction of wide extended or highly complicate architectures. In the example that will follow several controllers will be interconnected into a multiple layered structure.

The fuzzy linguistic representation of knowledge allows us to *compute with words* [1], [6] enabling us to cope with the fundamental uncertainties that are the attribute of the great majority of the objects and notions that are surrounding us, that are barely measurable or cannot be measured at all. Such way the computers turn to be able to emulate human reasoning or even human emotions, which are based on perceptions.

3 The Soft Computing in the Human-Related Sciences and Psychology

From the late '70s the fuzzy theory emerged in the field of human-related sciences, in the biomedical aria [3] as well in the very inside of the human mind: behavior, cognition and learning, memory, perceptions, image recognition, language, etc. A productive approach for the treatment of the emotions was exposed in [2]. The theory that stands behind this approach belongs to R. Plutchik and it was developed in the '60s. In few lines, Plutchik identified eight different opposite (positive / negative) emotions. They are paired in four groups: *destruction / protection*, *reproduction / loss*, *union / refusal* and *disorientation / search* resulting four Cartesian axes.

These primary emotions have degrees of intensity, defined according to an expert type procedure. For instance, *disorientation* was defined by three degrees of intensity: *surprise* (0.726), *astonish* (0.83) and *amaze* (0.930).

Other emotions are defined and positioned into the previous vectorial frame, in the same way in which the mixed colors are derived from the primary colors. The procedure can be refined according to the disposable expertise and to the objectives of the application.

4 The Human-Relation Mentor

4.1 The objectives

The idea standing behind the following application was to develop a library of classes for building FICs in a fully object oriented environment and to create a special IDE (Integrated Development Environment) that can be used for a highly effective designing of expert systems. Several such expert systems, concentrated mostly on medical issues, are already developed by the graduating students of the Automation and Applied Software Dept. of the "Aurel Vlaicu" University of Arad [11].

The aim of our application is to evaluate the emotional characteristics and the compatibility of two persons by a questionnaire type procedure and to give them personalized behavior advices in order to build a best possible mutual relationship.

4.2 The Psychological Approach

Adapting the classification proposed in [12] by D. Keirsey we considered the classification of the human action patterns (temperament correlated) into four dimensions, each one with four sub-dimensions:

1. *The Idealist* (melancholic): *conscientious*, *sensitive*, *vigilant* and *dramatic*.
2. *The Rationalist* (choleric): *aggressive*, *idiosyncratic*, *inventive* and *solitary*.
3. *The Traditionalist* (phlegmatic): *leisurely*, *serious*, *self-sacrificing* and *devoted*.
4. *The Hedonist* (sanguine): *artistic*, *self-confident*, *adventurous* and *mercurial*.

The 16 temperamental sub-dimensions are the inputs of a FIC, named ET, which infers the psychological evaluation of a questioned person by a new index: *the emotional tension*. The numbering of the action patterns is done in descending order of ET. *Hedonist* gives the lowest ET.

A second FIC named *Advice* has the role to infer the *degree of compatibility* between two persons and to choose among a database of possible advices the one that has the highest degree of confidence. The two inputs of *Advice* FIC are *My*ET and *Interlocutor* ET. The basic structure of the expert system rule base is presented in figure 1.

The membership functions of the action patterns are furnished by the questionnaire module that embeds a similar 3-layered FIC structure, considering each pattern's psychological features:

- Conscientious: *Hard work, Order and detail, The right thing, The right way, Perfectionism, Perseverance, Prudence, Accumulation;*
- Sensitive: *Familiarity, Concern, Circumspection, Polite reserve, Role, Privacy:*
- Vigilant: *Autonomy, Caution, Perceptiveness, Self-defense, Alertness to criticism, Fidelity;*
- Dramatic: *Feelings, Color, Attention, Sexual attraction, Appearance, Engagement, The spirit is willing;*
- Aggressive: *Command, Hierarchy, Tightship, Expedience, Guts, The rough-and-tumble;*

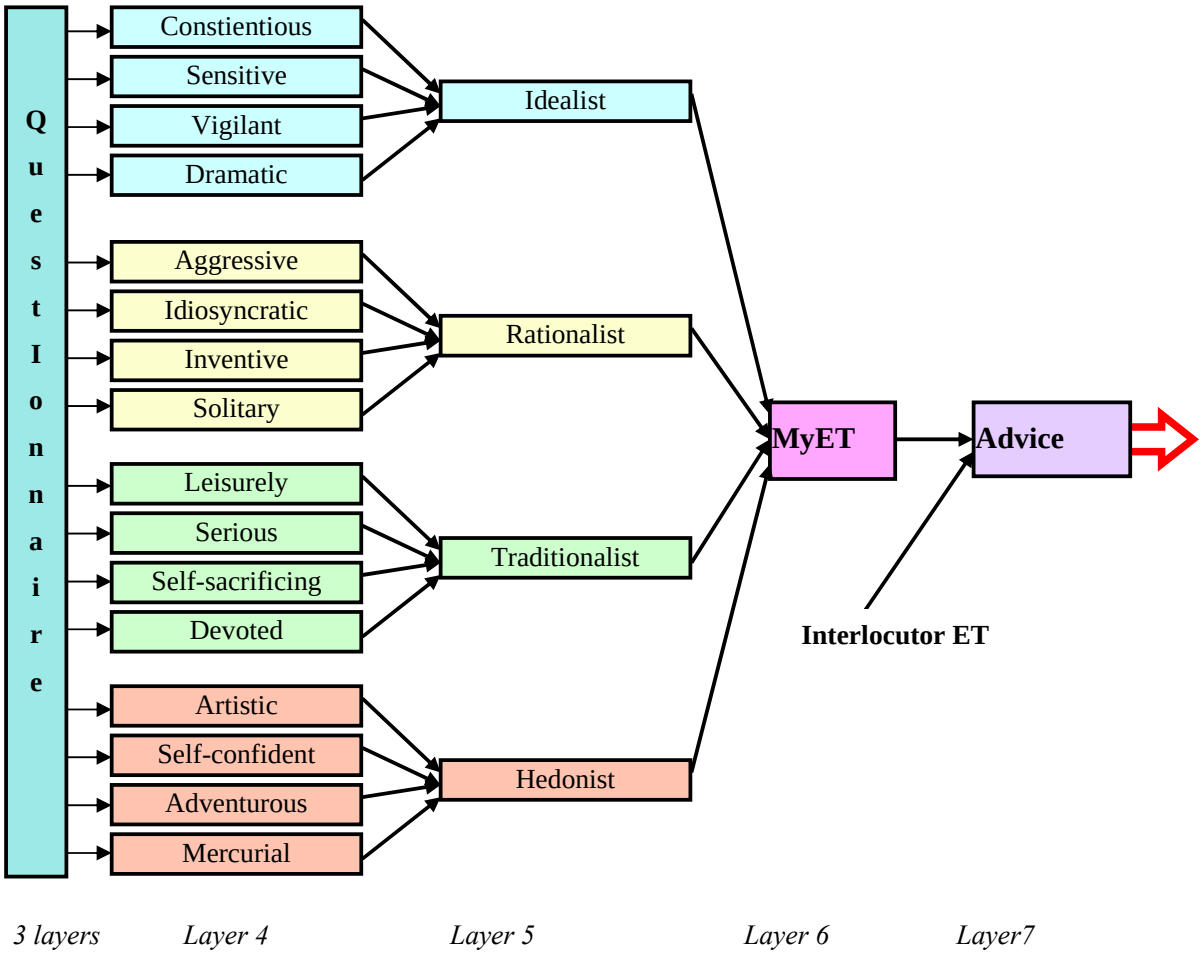

Figure 1. The multi-layered FIC structure of the rule base

- Idiosyncratic: *Inner life, Excentric, Own world Expanded reality, Metaphysics, Outward view;*
- Inventive: *Status, Idealized self-image, Attention, Subdued demeanor, Openness to culture, Competence, Innovation;*
- Solitary: *Solitude, Independence, Feet on the ground, Stoicism, Sangfroid, Sexual composure;*
- Leisurely: *Inalienable rights, I'm okay, Wheel of fortune, Enough is enough, The right to resist, Mañana, Mixed feelings;*
- Serious: *Sober demeanor, No pretentious, No surprises, Accountability, Contrition, Nobody's fool, Cogitation;*
- Self-sacrificing: *Generosity, Service, Humility, Consideration, Acceptance, Endurance, Artlessness;*
- Devoted: *Commitment, Togetherness, Teamwork, Deference, Consideration, Attachment, Harmony;*
- Artistic: *Mood swings, Artistic inclinations, Independent work, Relationships secondary, Great productivity, Disinhibition, Kindness, Keen perceptions; Extrovertion and introversion, Love of nature;*
- Self-confident: *Self regard, The red carpet, Ambition, Politics, Competition, Stature, Poise, Dreams, Self-awareness;*
- Adventurous: *Nonconformity, Challenge, True grit, Mutual independence, Persuasiveness, No regrets, Wanderlust, Wild oats;*
- Mercurial: *Romantic attachment, Alternate states, Intensity, Heart, Unconstraint, Activity, Open mind.*

The questionnaire module has to infer the confidence degrees of the psychological features. The module is designed having in mind the necessity to reduce as much as possible the number of questions. The resulting questionnaire has 82 questions in all.

Statement	Aprove
I am fully responsible for myself and others	☐
I have to depend on myself to see that things get done	☐
If I don't have systems, everything will fall apart	☐
Any flaw or defect of performance may lead to a catastrophe	☐

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I can't cope on my own. I need someone to rely on	☐
People will hurt me, attack me, take advantage of me. I must protect myself	☐
It isn't possible for me to control myself or discipline myself	☐
No one is ever there to meet my needs, to be strong for me, to care for me	☐

Fig. 2. A section of the questionnaire

4.3 The Implementation

Usual expert systems present complicated structures, involving lots of variables, as the fig. 1 is illustrating. The elaboration and the adjustment of such wide rule bases can become very difficult. That is why any strategy that reduces the dimensions of the rule bases and the complexity of the associated code is welcome. The basic strategy used in this issue is to develop hierarchical architectures and/or to apply different rule clustering techniques.

The FIM is bringing in this field the implicit simplicity induced by its interpolative nature. The software's development process and its flexibility, transparency and portability are simply catalyzed by using multidimensional interpolative arrays. Once the fuzzy library and the IDE accomplished, the development of the applications becomes just a routine. In our case the psychological expertise could be transferred into the rule base in about four days. The Microsoft .net Framework 1.1 was used (2.0 beta version). The Fuzzy Logic Library *fuzzy.dll* was written in C# language using the Visual Studio .net 2003 IDE. The fuzzy-interpolative IDE was also written in C#. The FICs are created as ".es" files, presenting a menu command and a toolbar. The advice database was written in Microsoft SQL Server 2000.

The modular FIC macrocontroller used in the Human Relation Mentor includes 145 control rules. The basic cell is fuzzyfied in the same way at inputs and outputs. FOCs (*frames of cognition*) of FP (*fuzzy partition*) type are used, having only three linguistic labels: *small*, *medium* and *great*. The membership function shapes are triangular. This choice is justified by the relative high degree of incertitude of the psychological notions. The following options can be selected:

- Mamdani or Sugeno inference;
- min-max or prod-sum t-norms and aggregations;
- triangular or trapezoidal fuzzyfications;
- COG or MOM defuzzyfication;
- unlimited number of inputs.

In order to facilitate the main purpose of the project the Human Relation Mentor application is *web* and *mobile web* compatible (see fig. 3.)

The validation of the Fuzzy Library was done by comparing some test controllers with equivalent controllers realized in FIS - MATLAB.

5 Conclusions

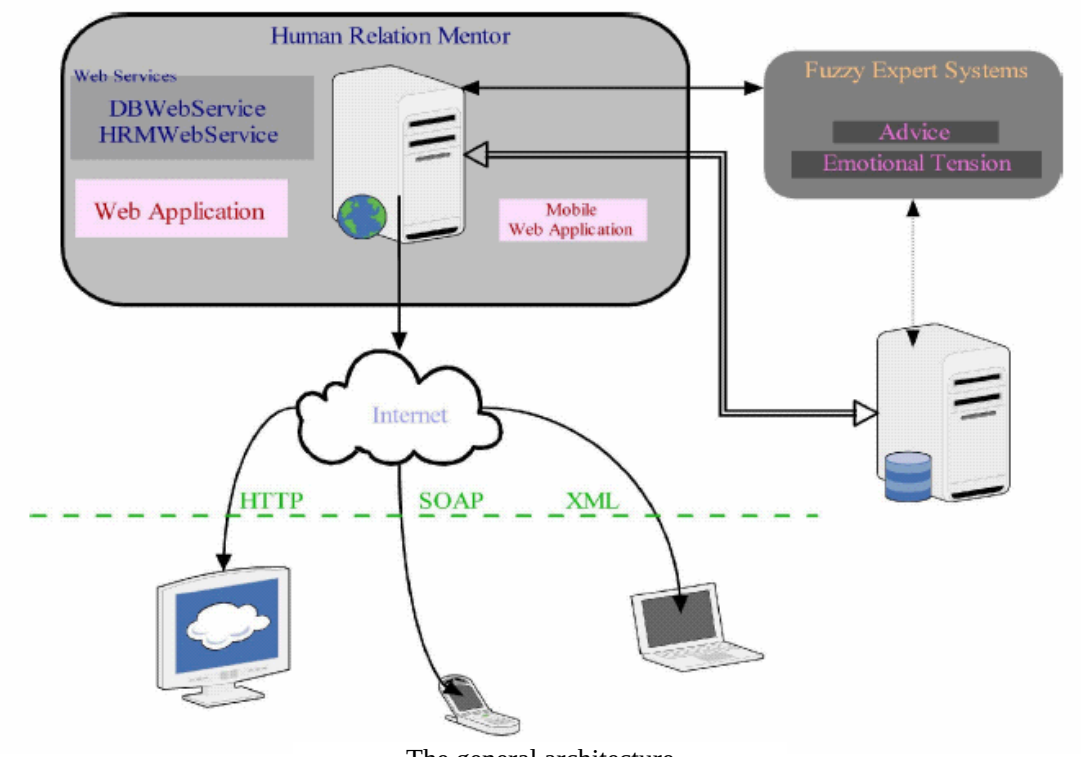
The fuzzy-interpolative methodology represents a most simple yet fundamental approach that is merging the fuzzy systems theory with the linear interpolation network implementations. This methodology is able to develop and to implement fuzzy-expert systems by most simple look-up tables (multidimensional arrays).

The main advantages of this approach are:

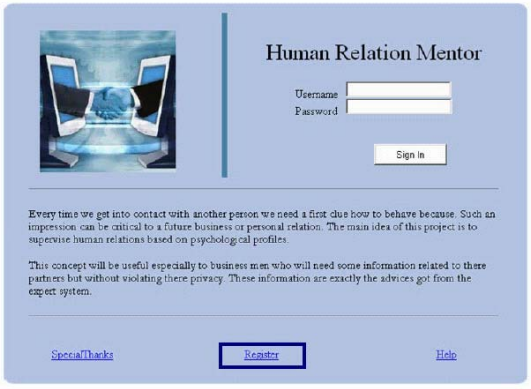
- the extreme simplicity, thanks to the interpolative side;
- the easiness of the development, thanks to the fuzzy side;
- the low costs that are stemming from the previous assumptions;

Besides the implications in the intelligent electronic circuitry, this concept can help the software applications.

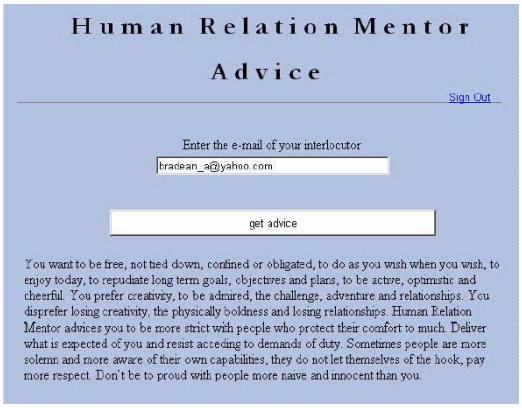
The application presented, namely a psychological expert systems acting as a mentor for the human relations, is able to embed a significant amount of knowledge about human behavior, to estimate the compatibility of two persons and to advise both of them in order to improve as much as possible their relation. Thanks to the simplicity of the fuzzy-interpolative controllers the development of the expert system was extremely efficient and the performance/costs ratio of the whole project was very favorable.



The general architecture



The *Sign In* web page



The *Advice* web page

The *Sign In* and *Advice* mobile web page

Fig. 3. The Human Relation Mentor application

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