Fuzzy-Logic Modeling Approach for System Requirements Management

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Keywords: system requirements, requirements management system, space-trajectory metaphor, fuzzy-logic modeling approach.

Based on the concept of multi-dimensional information space presented in [TSM04], we propose to consider so-called *state space* for system requirements (SR) called further as *Π-space.* The dimensions of *Π* should describe a current state of a SR for any application domain in some *problem-independent* and *unified* manner. In order to establish such a description for any SR, the following three criteria are introduced, namely: *C1-Completeness of Specification*, it defines the degree of requirements completeness in some project; *C2 - Level of Formalization*, it indicates the formalizing degree of given SR; *C3 - Measure of Agreement,* it shows to which degree the stakeholders (domain experts, analysts, programmers, etc.) are agreed from their points of view to SR in project considered. These criteria C1-C3 are really complex and weakly formalized. Basically, the criteria values C1-C3 are *orthogonal logically* because some project’s state is possible, when there is the completed functional description of given SR (it means $C1=C1_{max}$), but the level of it’s formalization is low ($C2=C2_{min}$), and in addition to this the measure of coordination is also very poor (i.e., $C3= C3_{min}$); in the same way all others logical combinations of criteria values C1-C3 could be constructed, etc. If criteria values of C1-C3 are fuzzy defined, the *Π-space* is the fuzzy set, and it could be defined as subset from Cartesian product of those fuzzy sets, namely: $\Pi \subseteq D(C1) \times D(C2) \times D(C3)$ where: $D(C_i), i \in [1,3]$ - is a fuzzy set (a values domain) of the appropriate criteria. Furthermore, because of the criteria *C3: Measure of Consistency*, each point in the *Π-space* represents some *alternative estimation* (further - *an alternative*) for a given SR: a value a_i. We describe the criteria C1-C3 using *linguistic variables* (LV), which are defined in fuzzy set *Π*. In this way the new subspace $A \subseteq C1 \times C2 \times C3$ is constructed into the *Π* –space, and at that $A \subset Ï$. Taking into account some empirical considerations about SR alternative values in a design process, there are *4 different areas* in subspace A which correspond to appropriate alternative values for some SR $a_i \in A$, namely: $A^{(0)} \subset A$ is the area of *initial (or non-defined)* alternatives; $A^{(1)}$ is the area of *well-defined alternatives*, at that $A^{(1)} \cap A^{(0)} = \varnothing$; $A^{(2)}$ is the area of *effectively alternatives*, at that $(A^{(2)} \subset A^{(1)})$ and $A^{(2)} \neq \varnothing$; $A^{(3)} = A \setminus (A^{(0)} \cup A^{(1)})$ is the area of *weakly-defined alternatives*. Here the following rules for main possible kinds of SR-alternatives (SRA) a_i are introduced, namely: (1) if some $a_i \in A^{(0)}$ then it is not possible to have *running* SWS based on its description given in the criteria values C1-C3; (2) if some $a_i \in A^{(1)}$ then it is possible, based on its description, to perform some design procedures and to create *an efficient* SWS; (3) if some $a_i \in A^{(2)}$ then it is possible, based on its description, to perform some design procedures and to gain *an efficient enough* SWS, i.e. some SWS having an efficient level not less some pre-defined value; (4) if some $a_i \in A^{(3)}$ then based on this SR an appropriate SWS could be found with some *degree of risk* only (this is so-called area of *unstable designing* into the subspace A). Taking into account these definitions, we propose the graphical representation for the subspace A as depicted on Fig. 1.

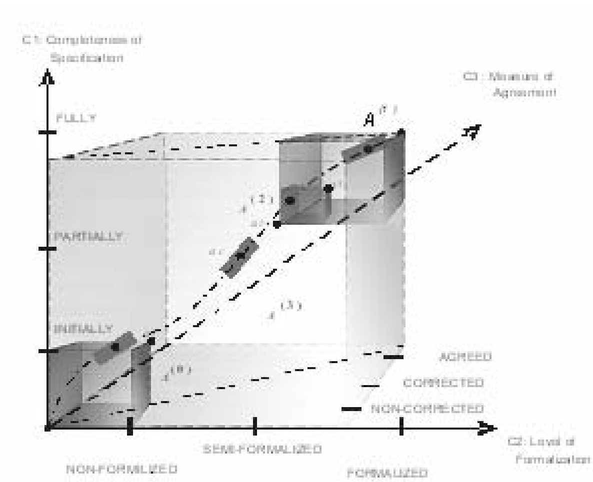

Fig. 1. The geometric understanding of subspace *A*

The common SR's estimation model considers to establish a *trajectory* within the 3-dimensional space stretched by the three co-ordinates *C1-C3* (see Fig. 1). Obviously in real life project such a trajectory is not a continued curve but is a piecewise linear one, because the development process represents decision making process

Then in order to analyze the whole SRA-trajectory we have to elaborate a method for estimation of belonging any given SRA to one of the areas: $A^{(0)}$, $A^{(1)}$, $A^{(2)}$, $A^{(3)}$.

There are 4 bordered and qualitatively different areas of some SRA values, which are corresponding in subspace A to the points: $a_1 = \sup(A^{(0)})$, $a_2 = \inf(A^{(1)}) = \inf(A^{(2)})$, $a_3 = \sup(A^{(2)})$ and $a_4 = \sup(A^{(1)})$.

Let's consider the new LV that is defined as: β_1 = "Assessment of Current SRA". To solve our task a *membership function* (MF) for new LV should be determined. We can additionally assume, that all three criteria C1, C2, C3 have the corresponding weight ratio, that defined as LV: β_2=" Importance of SR's Criteria Assessment"; MF should be defined by experts. According to such admissions we can built the criteria assessments for different SRA values: $a_1, a_2, a_3, a_4, a_c^{(k)}$ where: $a_c^{(k)}$ $k = \overline{1,3}$ is some current SRA value.

Assessing of SRA $a_1, a_2, a_3, a_4, a_c^{(k)}$ is defined by criteria *C1, C2, C3,* that are specified by the value of LV $R_i^{(j)}$, where: *i* - is a number of SRA to be estimated, *j* - is a number of criteria, according to which the SRA is estimated. The measure of criteria importance is defined by the value of LV W_j.

The weighted estimation of SRA a_i can be found by establishing of the left side $a_i^{'}$, and the right side $a_i^{''}$ lower bottom of the MF-trapezium, a_i^{*} - the left side and a_i^{**} - the right side of upper bottom of the MF-trapezium. We receive these values using the following well-known formulas:

$$a_i^{'} = \sum_{j=1}^{3} W_j^{'} R_i^{'\,(j)}, \; a_i^{*} = \sum_{j=1}^{3} W_j^{*} R_i^{*\,(j)}, \; a_i^{''} = \sum_{j=1}^{3} W_j^{''} R_i^{''\,(j)}, \; a_i^{**} = \sum_{j=1}^{3} W_j^{**} R_i^{**\,(j)}, \qquad (1)$$

where: n – a total number of alternatives, for which the integral assessment is found. After that we define the new fuzzy set *I*, that is specified on the set of alternatives, and the value of the appropriate MF is interpreted as a characteristic of a measure how one *SR's assessment* (SRAS) a_i is better then SRAS of alternative a_4. This value is equal to the *y-coordinate* of an intersection of any alternative weighted, and the best alternative estimation a_4. And could be found by formula given in [DP88]

$$\mu_i = \sup_{x \geq y} \min(\mu_i(x), \mu_{a_4}(y)) \qquad i = \overline{1,7} \qquad x, y \in X^{\Sigma}. \qquad (2)$$

The values μ_i that have been received using (2), characterize the *distance* between *any current* SRA a_i from the state, where SRA is *not defined* (this is the area $A^{(0)}$ on the Fig. 1). Hence, the values μ_i $\overline{i = 1,4}$ define the positions of border points: a_1, a_2, a_3, a_4 on the new *universe set* for the LV introduced above: "*Assessment of Current SRA*" and used for the building the *new generalized* MF (see Fig. 2). It allows us for any current SRA to define it's location accordingly to the intervals which are corresponded with the areas $A^{(0)}, A^{(1)}, A^{(2)}, A^{(3)}$ in the subspace A (see Fig. 1).

The elaborated approach for SR analyzing and management is supposed to make expertise of them more effectively.

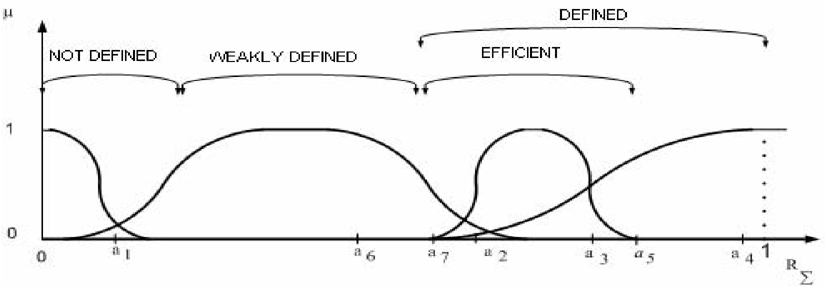

Fig. 2. The integrated MF for the LV: "*Assessment of Current SRA*"

References

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