Algorithmic Facets of Human Centricity in Computing with Fuzzy Sets

Plenary Talk

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In information processing we are faced with new challenges and opportunities that can lead to the enhancements of the ways in which the technology of fuzzy sets becomes utilized. More often than before we encounter systems that are distributed and hierarchical in their nature in which there is a significant level of knowledge generation and knowledge sharing. As a matter of fact, knowledge generation is inherently associated with the mechanisms of collaboration and knowledge sharing being realized between participating systems. The aspects of distributed intelligence and agent systems stress the facet of human centricity and human–centric computing (HC^2). In numerous ways of forming efficient conceptual and algorithmic vehicles of human-system interaction fuzzy sets, and Granular Computing, in general, have been playing an important role in the HC^2 domain. We show how this feature gives rise to the paradigm shift.

The intent of this talk to bring into attention several ideas being of interest in the context of the challenges identified above. The feature of human centricity of fuzzy set-based constructs is the underlying leitmotiv of our considerations.

New directions of knowledge elicitation and knowledge quantification realized in the setting of fuzzy sets In the past there have been a number of ways of designing fuzzy sets. The two main directions, that is (a) expert – based, and (b) data – based elicitation of membership functions have formed quite distinct avenues that are visible in the theory and practice of fuzzy sets. We must note here that fuzzy sets- information granules as being reflective of domain knowledge underpinning the essence of abstraction, dwell on numeric, data-oriented experimental evidence as well as perception of the humans who use such information granules. This stresses a hybrid nature of fuzzy sets, which has to be reflected in the foundations fuzzy sets are to be dwelled upon. We elaborate on an idea of knowledge-based clustering, which aims at the seamless realization of the data-expertise design of information granules. We emphasize the need for this unified treatment in the context of knowledge sharing where fuzzy sets are developed not only on the basis of numeric evidence available locally but in their construction we also actively engage the domain knowledge being shared by others. It is also emphasized that collaboration and reconciliation of locally available knowledge give rise to the concept of higher type fuzzy sets along with the principle of justifiable granularity supporting their construction. This principle helps capture the diversity of numeric entities and encapsulate them in the form of information granules where the level of granularity is adjusted to quantify the level of existing diversity. Likewise when dealing with a diversity of information granules of type-1, the concept of justifiable granularity supports a realization of information granules of type-2.

Non-numeric quantification of fuzzy sets and their processing To enhance human centricity of computing with fuzzy sets, it becomes beneficial to establish a conceptual and algorithmic setup in which the predominantly numeric values of membership functions could be interpreted at the qualitative level of membership characterization such as *high*, *medium* or *low* membership, *low* relationship between concepts, etc. We discuss a suite of algorithms facilitating such qualitative assessment of fuzzy sets, formulate a series of optimization tasks guided by well-formulated performance indexes and discuss the essence of the resulting solutions. It will be demonstrated that type-2 fuzzy sets emerge in this setting as a viable conceptual entity with sound algorithmic underpinnings. The concepts of three–valued logic quantification of membership functions are also elaborated in the context of the linguistic quantification of fuzzy sets. Proceeding with fuzzy models, we show how to endow fuzzy modeling with an additional interpretation layer of type-2 fuzzy sets, which enhances the functionality of the existing fuzzy models and their human-centricity. It will allow us to view fuzzy models in a broader context of system modeling and introduce a concept of linguistic equivalence, linguistic stability and other descriptors. We also revisit a plethora of logic operators available in the theory of fuzzy sets vis-à-vis their qualitative interpretation.