Algorithmic Developments of Information Granules of Higher type and Higher Order and Their Applications
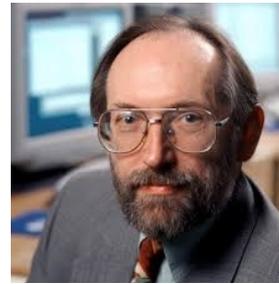**W. Pedrycz**

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Abstract

Information granules are conceptual entities using which experimental data are conveniently described and their processing is realized at the higher level of abstraction. The central problem is concerned with the design of information granules. We show that a principle of justifiable granularity can be used as a sound vehicle to construct information granules so that they are (i) experimentally justifiable and (ii) semantically sound. We elaborate on the algorithmic details when forming fuzzy sets of type-1 and type-2. It is also stressed that the construction of information granule realized in this way follows a general paradigm of elevation of type of information granule, say numeric data (information granules of type-0) give rise to information granule of type-1 while experimental evidence coming as information granules of type-1 leads to the emergence of a single information granule of type-2. We discuss direct applications to the area of data and knowledge fusion (aggregation) and demonstrate an emergence of information granules of higher type when progressing towards higher levels of abstraction in system modeling. We also discuss a way of using information granules of higher order in a referential mode of data description.

Fuzzy methods in clinical research and patient care
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Abstract

Health information technology (IT) systems gather, store, transfer, and display the medical data of patients in a computerized and structured form. To draw conclusions about patient care based on these data in a partly or fully automated manner, one needs what is generally known as medical knowledge. One also needs this medical knowledge in a computerized and structured form. Combining digitized patient medical data with digitized medical knowledge to produce diagnostic, therapeutic, prognostic, or patient management suggestions is currently referred to as clinical decision support.

To digitize medical knowledge, one needs to discern, formalize, and represent medical entities and their inter-relationships. Medical entities such as fever or hypoxemia are characterized by linguistic uncertainty. The unsharpness of boundaries in these linguistic terms is modeled by fuzzy sets. Relationships between medical entities are characterized by propositional uncertainty, which is due to the incompleteness of medical conclusions. Propositional uncertainty is modeled by truth values between zero and one. When measurements map into fuzzy sets, the results are combined with truth values of medical propositions, and logical conclusions are drawn. One method is the compositional rule of fuzzy inference, in several forms and successively. Fuzzy automata offer an interesting way to calculate "fuzzy states" of patients in a clear and clinically comprehensible manner. These states represent physiological or pathophysiological states—based on measured patient data—and allow for grades of "health" or "illness". States are characterized by linguistic terms and state transitions are described by linguistic instructions. If medical devices need to be controlled, but control rules are heuristic, then fuzzy control yields powerful solutions. It might be advisable to follow an open-loop control cycle, with a human physician carefully examining the control output and performing the actual control.

Arden Syntax is a medical knowledge representation and processing language, issued and supported by Health Level Seven (HL7) International, a standard developing organization for health IT standards. In 2013, the Health Level Seven Arden Syntax for Medical Logic Systems, version 2.9, including fuzzy methodologies, was issued by HL7 and approved by the American National Standards Institute.

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Dedicated to Professor Lotfi Zadeh
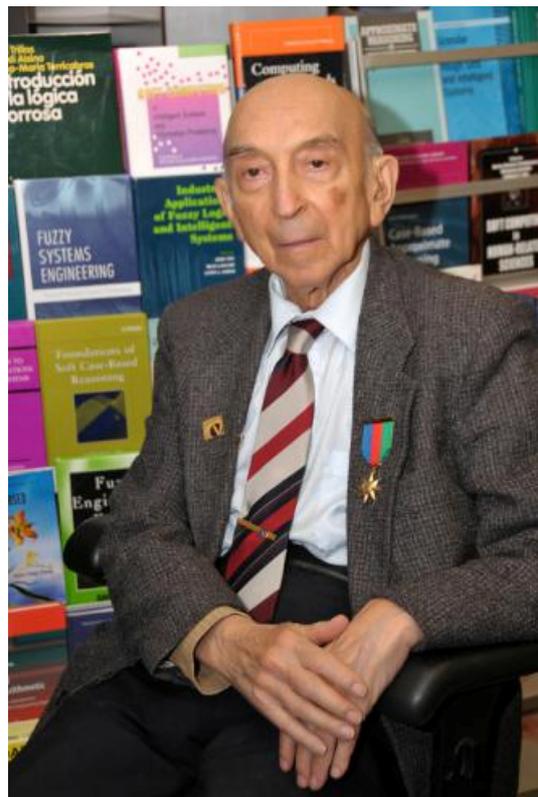
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