Chapter 10
Granular Models: Design Insights and Development Practices

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ABSTRACT

In contrast to numeric models, granular models produce results coming in a form of some information granules. Owing to the granularity of information these constructs dwell upon, such models become highly transparent and interpretable as well as operationally effective. Given also the fact that information granules come with a clearly defined semantics, granular models are often referred to as linguistic models. The crux of the design of the linguistic models studied in this paper exhibits two important features. First, the model is constructed on a basis of information granules which are assembled in the form of a web of associations between the granules formed in the output and input spaces. Given the semantics of information granules, we envision that a blueprint of the granular model can be formed effortlessly and with a very limited computing overhead. Second, the interpretability of the model is retained as the entire construct dwells on the conceptual entities of a well-defined semantics. The granulation of available data is accomplished by a carefully designed mechanism of fuzzy clustering which takes into consideration specific problem-driven requirements expressed by the designer at the time of the conceptualization of the model. We elaborate on a so-called context – based (conditional) Fuzzy C-Means (cond-FCM, for brief) to demonstrate how the fuzzy clustering is engaged in the design process. The clusters formed in the input space become induced (implied) by the context fuzzy sets predefined in the output space. The context fuzzy sets are defined in advance by the designer of the model so this design facet provides an active way of forming the model and in this manner becomes instrumental in the determination of a perspective at which a certain phenomenon is to be captured and modeled. This stands in a sharp contrast with most modeling approaches where the development is somewhat passive by being predominantly based on the existing data. The linkages between the fuzzy clusters induced by the given context fuzzy set in the output space are combined by forming a blueprint of the overall granular

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1. INTRODUCTION

Human centric systems and human centric computing are concerned with a functionality that makes systems highly responsive to the needs of human users. We fully acknowledge a fact that there could be a genuine diversity of requirements and preferences that might well vary from user to user. How could we build systems that are capable of accommodating such needs and offering in this way a high level of user-friendliness? There are numerous interesting scenarios one can envision in which human centricity plays a vital role. For instance, in system modeling, a user may wish to model the reality based on a unique modeling perspective. In this sense the data being available for modeling purposes are to be looked at and used in the construction of the model within a suitable context established by the user. In information retrieval and information organization (no matter whether we are concerned with audio, visual or hypermedia information), the same collection of objects could be structured and looked at from different standpoints depending upon the preferences of the individual user. In this case, an ultimate functionality of human-centric systems is to achieve an effective realization of relevance feedback provided by the user.

In this study, we are concerned with a category of fuzzy modeling that directly explores the underlying ideas of fuzzy clustering and leads to the concept of granular models. The essence of these models is to describe associations between information granules; viz. fuzzy sets formed both in the input and output spaces. The context within which such relationships are being formed is established by the system developer. Information granules are built using specialized, conditional (context-driven) fuzzy clustering. This emphasizes the human-centric character of such models: it is the designer who assumes an active role in the process of forming information granules and casting all modeling pursuits in a suitable, customized framework. Owing to the straightforward design process, granular models become particularly useful in rapid system prototyping. All of these features bring a significant component of novelty and uniqueness to the concept of granular modeling.

The study is arranged in a way it made self-contained to a significant extent. We start with some generic constructs such as information granules and elaborate on their origin (Section 2). The context-based clustering presented in Section 3 forms a viable vehicle to build information granules when considering their further usage in some input-output mapping. The proposed category of models is inherently granular and this facet of processing is captured by a generalized version of so-called granular neurons (Section 4) in which the connections are represented as fuzzy numbers rather than single numeric entities. By bringing the concept of conditional clustering along with the granular neuron as some aggregation mechanism we show that granular models are easily assembled into a web of connections between information granules and these architectural considerations are presented in Section 5. The consecutive part of the study is devoted to two further refinements of granular models where we introduce a bias term and elaborate on optimization of fuzzy sets of context. Incremental granular models are studied in Section 7.