

Evolving Systems

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One of the important research challenges today is to develop new theoretical methods, algorithms, and implementations of systems with a higher level of flexibility and autonomy, we can say with higher level of intelligence. These systems have to be able to evolve their structure and knowledge on the environment and ultimately – evolve their intelligence. To address the problems of modelling, control, prediction, classification and data processing in a dynamically changing and evolving environment, a system must be able to fully adapt its structure and adjust its parameters, rather than use a pre-trained and a fixed structure. That is, the system must be able to evolve, to self-develop, to self-organize, to self-evaluate and to self-improve.

The newly established concept of evolving intelligent systems is a result of the synergy between conventional systems, neural networks and fuzzy systems as structures for information representation and real time methods for machine learning. The emerging area of *evolving systems* targets non-stationary processes by developing novel on-line learning methods and computationally efficient algorithms for real-time applications. *Evolving systems* are inspired by the idea of system model evolution which is a next step comparing to the adaptation. They focus on the evolution of a family of system models representing the system in different situations and operating conditions. In this sense they differ from the traditional evolutionary algorithms. They use inheritance and gradual change with the aim of life-long learning and adaptation, self-organization (including *system structure evolution*) in order to adapt to the (unknown and unpredictable) environment. Embedded soft computing diagnostics and prognostics algorithms, intelligent agents and controllers are the natural implementation area of evolving systems as a realistic and practical tool for design of real time intelligent systems.

During last few decades, *computational intelligence* has advanced significantly and in particular fuzzy rule-based and neuro-fuzzy models. They have been applied in many areas, where the conventional, first principle models has limited applicability or failed to deliver, such as biotechnological processes, behavior modeling, complex technological processes, systems of systems etc.

Despite the advances made in different sub-areas of the *computational intelligence*, the results were mostly applicable to *off-line* problems where also the structure of the model (a fuzzy rule-base or a neural network) is fixed. At the same time a number of demanding applications require *on-line* and *real-time* adaptation to the external environment and/or to the internal changes in the object of modelling (development of a fault, wearing etc.). While, the conventional adaptive systems and control theory has answers for some of these problems, they concern fixed simple linear structures of the models and made a number of additional assumptions regarding the uncertainties.

The talk will concentrate on the problems and results the author encountered during last several years of research in this emerging area as well as on the approach to on-line identification of a particular type of fuzzy models – so called Takagi-Sugeno fuzzy models including some applications, in particular to mobile robots, mobile communications, process modelling and control, on-line evolving classification intelligent (inferential) sensors.