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Adv Robot Autom, 6:3 (Suppl)
DOI: 10.4172/2168-9695-C1-012

4th World Congress on
ROBOTICS AND ARTIFICIAL INTELLIGENCE
October 23-24, 2017 Osaka, Japan

Automatic composition, optimization and adaptation of multicomponent predictive systems

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We are currently experiencing an incredible, explosive growth in digital content and information. According to IDC, the digital universe in 2020 will be 50 times as big as in 2010 and that it will double every two years. Research in traditionally qualitative disciplines is fundamentally changing due to the availability of such vast amounts of data. In fact, data-intensive computing has been named as the fourth paradigm of scientific discovery and is expected to be key in unifying the theoretical, experimental and simulation based approaches to science. The commercial world has also been transformed by a focus on big data with companies competing on analytics. Data has become a commodity and in recent years has been referred to as the new oil. There has been a lot of work done on the subject of intelligent data analysis, data mining and predictive modeling over the last 50 years with notable improvements which have been possible with both the advancements of the computing equipment as well as with the improvement of the algorithms. However, even in the case of the static, non-changing over time data there are still many hard challenges to be solved which are related to the massive amounts, high dimensionality, sparseness or inhomogeneous nature of the data to name just a few. What is also very challenging in today's applications is the non-stationarity of the data which often change very quickly posing a set of new problems related to the need for robust adaptation and learning over time. In scenarios like these, many of the existing, often very powerful, methods are completely inadequate as they are simply not adaptive and require a lot of maintenance attention from highly skilled experts, in turn reducing their areas of applicability. In order to address these challenging issues and following various inspirations coming from biology coupled with current engineering practices, we proposed a major departure from the standard ways of building adaptive, intelligent predictive systems by utilizing the biological metaphors of redundant but complementary pathways, interconnected cyclic processes, models that can be created as well as destroyed in easy way, batteries of sensors in form of pools of complementary approaches, hierarchical organization of constantly optimized and adaptable components. In order to achieve such high level of adaptability we have proposed novel flexible architectures which encapsulate many of the principles and strategies observed in adaptable biological systems. The proposed approaches have been extensively and very successfully tested by winning a number of predictive modeling competitions and applying to a number of challenging real world problems including pollution/toxicity prediction studies, building adaptable soft sensors in process industry in collaboration with Evonik Industries or forecasting demand for airline tickets covering the results of one of our collaborative research projects with Lufthansa Systems.

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