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BOOK OF ABSTRACTS

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Machine vs Rule-based Learning in Physics: Possibilities and Advantages

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[1]Keywords

Machine learning; expert system; databases.

Summary

Machine learning (ML) is understood to be one of artificial intelligence (AI) fields [1]. Broadly speaking, AI distinguishes rule-based and machine learning techniques. A computer system that achieves AI through a rule-based technique is called rule-based system (expert system as one), while that achieves AI through a machine learning technique is called a learning system. It can be found a hybrid approach which combines both techniques [2]. The general goal of ML is to recognize statistically significant patterns in the available data. ML is widely used in computer science as one continuously developing field with numerous applications [3].

Beside of improvements on some "commercial" technologies such as image recognition, as well as industrial application, ML is becoming very important for many research areas in physics such as the computational study of condensed matter or atomic/molecular/optical physics, quantum information, forecasting meteorological parameters [4], for astronomical data streams [5], etc. New concepts of database set-ups and distributed approach to data entries is prevailing [6] and the number of data nodes is constantly increasing [7], even more traditional and old databases like NIFS [8] are becoming a part of such large networks.

Rule-based learning uses a series of IF-THEN statements to reach conclusions. The whole process is based on expert knowledge and experiences (facts). That is why rule-based system is called expert system. An expert system (ES) referred to as knowledge-based system is computer software that emulates the decision-making ability of a human expert [9].

ML uses experience implemented in algorithms [3] which enable the pattern recognition, i.e. concerning with the automatic recognition of regularities in observed data and classifying them into different categories. Based on that, ML can transform row (experimental) data into structured though the learning algorithms [10].

The comparison between rule-based and ML approach can be found in the many different areas [11,12]. One very illustrative example which explains difference between these two techniques, and at the same time shows limitations of the rule-based, and advantages of ML technique can be found in [12]. In situation when confronted with an unknown sample, researches perform mass spectrometry and compare the observed spectrum with those at a library. Identification can be done in the case of positive match. This is the same principle haw rule-based system works. It can deal only with data in database, otherwise it is useless. This is the major limitation of these systems. On the other hand, ML can, based on existing, predict synthetic spectra which can be used in mass spectrometry to expand the coverage of molecular spectra which can be identified. In many papers this improvement of the classification "skills" is pointed as the main advantage of ML technique. Within the fast process's physics (with which we deal), ML classification technique as referred to as multivariant analysis in order to emphasize contrast to traditionally used approaches [13]. According to [11], a determination of a peak (event) quality can be expected as well.

For both techniques quality and quantity of obtained results is significantly better than classical experimental result analysis, and the process is considerably faster.

The abstract is going to review our previous researches on ES methods in the different fields of collisional atomic and molecular physics. We started with analysis of the atomic and molecular threshold spectra [14,15,16]. Based on some criteria (theoretical and empirical), we developed methodology for classification different physical events, presented by peaks. Moreover, for twoatomic molecules spectra we developed procedures for spectra generation which enable us to analyze spectra in the area where because of big peak density and peak's overlapping, classical methodology, based on subjective estimation of a person that performs an experiment, fails and leads to wrong interpretation of experimental results [14,15,16]. We showed that using ES improve the quality and quantity of obtained results and conclusions, remove the inevitable

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noise influence and measurement errors on experimental data and significantly speed up the process of spectra analysis regarding on the classical approach. Later, we extended our researches on the atomic photoionization process [9] where, for linearly polarized laser field, we observed the influence of the different effects such as ponderomotive and Stark shift, as well as the laser beam shape on the tunneling transition rate for alkali and noble atoms. All mentioned we considered for three theories, Keldysh, PPT and ADK [17,18,19]. But, in spite of all improvements in the process of analysis, caused by using ES methodology, we noticed some limitations basically related to ES impossibility to predict any situation and behavior out of those already involving in ES, i.e. database. The purpose of this abstract is to open (point) new possibilities of ML which could improve results obtained by using ES method in fields of interest.

According to [13, 20] ML enables accurate predictions which are not available in the input data.

On the end, authors expect significant increase of using ML algorithms in many areas of physics, especially in those with a big data analysis [21].

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DAY 1 (October 15)

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17:20 – 17:50	Igor Franović MACROSCOPIC DYNAMICS IN HETEROGENEOUS ASSEMBLIES OF EXCITABLE AND OSCILLATORY UNITS
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