Applying deep learning for improving image classification in fusion

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Deep learning has emerged as one of most encouraged approaches in recent past years. One of the main applications of deep learning is the automatic feature extraction with autoencoders. Feature extraction is a very critical stage in machine learning that can reduce drastically the dimensionality of the problem, making easier the process of classification [1].

This article addresses the assessment of including autoencoders for automatic feature extraction in the massive thermonuclear fusion databases. In order to show the performance of autoencoders in a practical way, the problem of the classification of a set of 981 images of the TJ-II Thomson Scattering diagnostic has been selected. Similar to other pattern recognition problems, in this case there are two main stages: i) the pre-processing of the data, and ii) the application of a classification algorithm to get a model [2]. Thus, the autoencoders are just added between both two stages to extract features from the pre-processed images. The classification has been performed by the algorithm of support vector machines, but it should be clear that the selection of a different method for this step should produce similar results. The work evaluates three main questions of using autoencoders for the classification of images: i) are the models more accurate? ii) are the predictions computed faster?, and iii) are the models better fitted for new images?.

The results show that the use of autoencoders produces models with higher success rates, reaching in some cases up to 96% in average, which is 2% over the performance without autoencoders. The results also show that model predictions can be computed in less time when autoencoders are used. The models can be twice faster than the cases without autoencoders, although it could require parallel programming of autoencoders for operation in real-time. Finally, in order to confirm that the classifiers with autoencoders are more robust and better fitted for new images, a conformal predictor was developed to add confidence values to the classification. The results show that classifiers with autoencoders are able to make predictions for new images with up to 50% more of confidence and credibility.

References

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Image classification by using a reduced set of features in the TJ-II Thomson Scattering diagnostic

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During the past few years, machine learning has been increasingly applied for developing pattern recognition systems in massive thermonuclear fusion databases. Several solutions can be found in the literature for fast retrieval information, classification and forecasting of different types of waveforms [1]. Images in fusion are not the exception, there are some data-driven models that have been successfully implemented to classify Thomson Scattering images in the TJ-II stellerator [2-3]. Most of these image classifiers were developed by using data mining techniques such as neural networks and support vector machines. One advantage of these techniques is that they only require a set of inputs (images) and their corresponding outputs (the class of each image) to learn a function that outputs the class to a new input image. This decision function is so complex and non-linear that it is normally called a black box model, and although this approach could perform a one hundred percent of success classification, it is not able to provide a clue of the reason for such output.

This work proposes the use of boosting algorithms to build models that provides very simple IF-THEN rules to classify Thomson Scattering images. Boosting is a way to improve the model by adding a simple rule that assigns correctly classes to some previously wrong classified samples. Thus, the obtained model is an explicit weighted sum of several simple rules that could provide useful information about why an image has been assigned to a particular class. The article also shows that even using a reduced set of pixels (less than 0.1\% of the original image) the classifier is able to keep a high success rate (over 95\%). As it will be shown, such aspect produces three important benefits: i) a reduction of the computational time for classification, ii) a more robust performance in noisy conditions (stray light), and finally iii) a way to support knowledge discovery from the five different classes of the TJ-II Thomson Scattering images.

References

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