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Finite element machine applied in machine learning

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Big Data era has flooded researchers and the whole community with tons of data daily. Multimedia-based applications are in charge of generating an unsurmountable amount of data, which end up at the screens of mobile phones and tablets. Home-made videos are usually referred as the bottleneck of any network traffic analyzer, since they are uploaded to cloud-driven servers as soon as they are generated or forwarded by someone else via the so-called social networks. Active learning is another research area that needs fast techniques for learning and classification. One very usual example concerns interactive and semi-supervised learning tools for image classification and annotation. Suppose a physician wants to classify a magnetic resonance image of the brain, which may contain hundreds of thousands of pixels. The user shall mark a few positive and negative samples (pixels) that will be used to train the classifier, which then classifies the remaining image. Further, the user shall refine the results by marking some misclassified regions for training once more. Notice the whole process should take a few seconds/iterations. In this context, the user feedback is crucial to obtain a concise/reliable labeled image. Considering the aforementioned situation, some techniques may not be appropriate to be employed, since they can hardly handle the problem of updating the model learned previously when new training samples come to the problem. Support vector machines (SVM) are known to be costly, since they require a fine-tuning parameter step, which turns out to be the bottleneck for efficient implementations. Although different variations and GPU-based implementations are published monthly, it is not straightforward to use them, which makes them far from being user-friendly. Additionally, SVM training step is quadratic with respect to the number of training examples. Moving from machine learning to numerical analysis, one of the most widely used approaches for finding approximate solutions to boundary-value problems in partial differential equations is the finite element method (FEM). Roughly speaking, FEM divides the original problem into smaller pieces called finite elements, and the simple equations that describe each element are assembled in a complex one that should describe the whole problem. Therefore, given a set of points, FEM can interpolate them using basis functions in order to build a manifold that contains all these points. In this speak; we borrow some ideas related to FEM to propose FEMa - finite element machine, a new framework for the design of pattern classifiers and regressors based on finite element analysis. Depending on the basis function used, FEMa can be parameterless. It features a quadratic complexity for both training and classification phases, which turns out to be its main advantage when dealing with massive amount of data. In short, FEMa learns a probabilistic manifold built over the training samples, which are the center of a finite element basis. Therefore, the problem of learning a manifold using one finite element basis is broken into a surface composed of several bases, centered at each training sample. In this speak, we show that FEMa can obtain very competitive results when compared against some state-of-the-art supervised pattern recognition techniques.

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