NAFEMS UK Regional Conference 2018 - Abstract Submission

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Please identify the event for which your submitting?	NAFEMS UK Conference 2018
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Presentation Title	Applying Artificial Intelligence Machine Learning for 3D CAD model searches and classification
Relevant Themes / Keywords	3D CAD, Machine Learning, Search & Classification

Abstract (plain text)

Everyone is talking about machine learning (ML), deep learning (DL), and artificial intelligence (AI). In the consumer space it is used in many applications for our daily activities and conveniences. This technology marks a step change in productivities in virtually all areas of our lives. In this paper we leverage the technology for 3D CAD model searches and classification application. Compared to traditional methods where CAD model metadata and knowledge of CAD systems are required, only the CAD model is used. Previous issues such as not knowing the part ID, legacy models and languages are overcome.

Searching for existing CAD models, their components and associated manufacturing knowhow accounts for a significant part of the time spent by CAD/CAE designers/ engineers [1]. As such, the ability to quickly and automatically locate such elements in large component databases can significantly reduce product design time and increase product quality by allowing designers to concentrate on the most essential, creative parts of the process.

The task of searching and retrieving 3D shapes is a well-studied topic. In the last 20 years, researchers have tried to capture key properties of 3D shapes using various hand-crafted features based on geometrical, topological or statistical properties [1]. Deep learning methods, where features are automatically learned from the data, started being applied 2014 [2] and are continuously being developed and compared on benchmarks such as Princeton Universityâ€™s ModelNet [3].

Following the current DL trend, the method we propose starts with converting each 3D model into a series of images or views taken from multiple angles. This is accomplished by using a rendering camera which remains fixed, pointing to the centre of the model, while the model itself is rotated on all three axes by a present step angle. For models coming from mechanical design, a rotation angle of 45 degrees strikes a good balance between accuracy and computational requirements and results in the generation of 22 images. Following, a deep neural network is used to extract a feature vector from each of the images. The network has been pre-trained with more than 1 million images from the ImageNet [4] database and then has been tuned using images generated from Fujitsuâ€™s own product data. The collection of extracted feature vectors, together with model dimensions, forms a powerful descriptor for the 3D model. A descriptor as the one above is computed and stored for each 3D model in the database.

To search for a new or an existing model a descriptor is generated and compared against the ones in the database. The comparison procedure combines the view features to be independent of the relative orientation of the two models, while the model dimension information is used to restore the scale information and prune models which are very similar in shape but in fact very different in size. The search, which completes in only a few seconds for databases of tens of thousands of models, outputs an ordered list of similar models.

The accuracy of our method is over 96% for several classes of CAD models and the work of adding more classes is ongoing. Besides accuracy, our method is very simple to implement using open-source packages such as Caffe [5] and is independent of CAD format and quality.

References

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[3] Princeton ModelNet, http://modelnet.cs.princeton.edu, Princeton University, 2016
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