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First steps of numerical simulation using Artificial Intelligence

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As for the thermal simulation of a satellite, its design is crucial. It involves the integration in the thermal and mechanical model of reduced parts of equipment or supports (additive manufacturing) from 3D models finite elements. The goal of the thesis is the drastic reduction of 3D geometric models that minimizes the alteration of the physical properties (here the calculation of the view surfaces) induced by the model reduction during the numerical simulation.

We are currently working on **an approximation guided by view factors**. The aim is to design a geometric approximation method where each atomic simplification or optimization operation is guided by preserving the view factors of the reference model, rather than preserving the geometry. The ultimate aim being a radiative thermal computation on a "small" model made of a few hundreds of facets instead of millions of facets.
The next step consists in **a supervised learning of the geometric error metric** (using **deep learning**). Deep learning is a subset of machine learning (which is also a subset of Artificial Intelligence). In both cases, algorithms appear to learn by analyzing huge amounts of data. Deep learning processes data using computing units, called neurons, arranged into ordered sections, called layers. A stack of those layers form what we call a neural network, which is the kind of model we will use.
When working with supervised algorithms, the input data is labeled and has a specific expected result. We train a model to predict the labels of the given training examples. As training progresses, the predictions or classifications become more accurate. Our idea is to use deep learning as follows : from a database of expertly generated 3D models, we will design a supervised machine learning method using multiple layers to learn the geometric error metric able to govern an automatic approximation algorithm so that the resulting thermal simulation is as accurate as possible to a reference calculation.
We already developed and are still improving a software relying on a new hierarchical geometric data structure for the efficient computation of view factors, which allows us to have a precise reference case.

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