Deep Learning for Advanced 3D Printing

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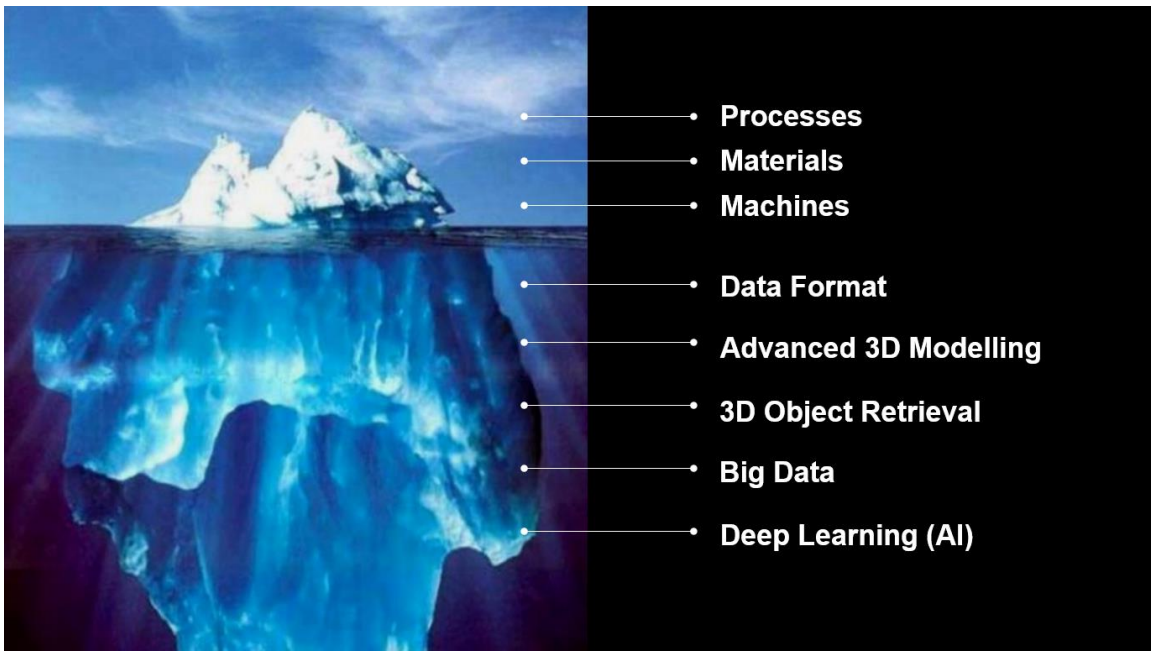
“Deep Learning” is a new area of Machine Learning, based on neural networks. Deep learning currently provide the best solutions to many well-known problems in computer science, such as image recognition(2D), speech recognition(sound), natural language processing(text) and so on. However, there are only few trials of deep learning for 3D Processing.

From the viewpoint of 3D Printing, deep learning has lots of potential contributions. In this paper, we introduce our research project on deep learning for advanced 3D printing, especially sketch-based 3D modelling as one of practical applications.

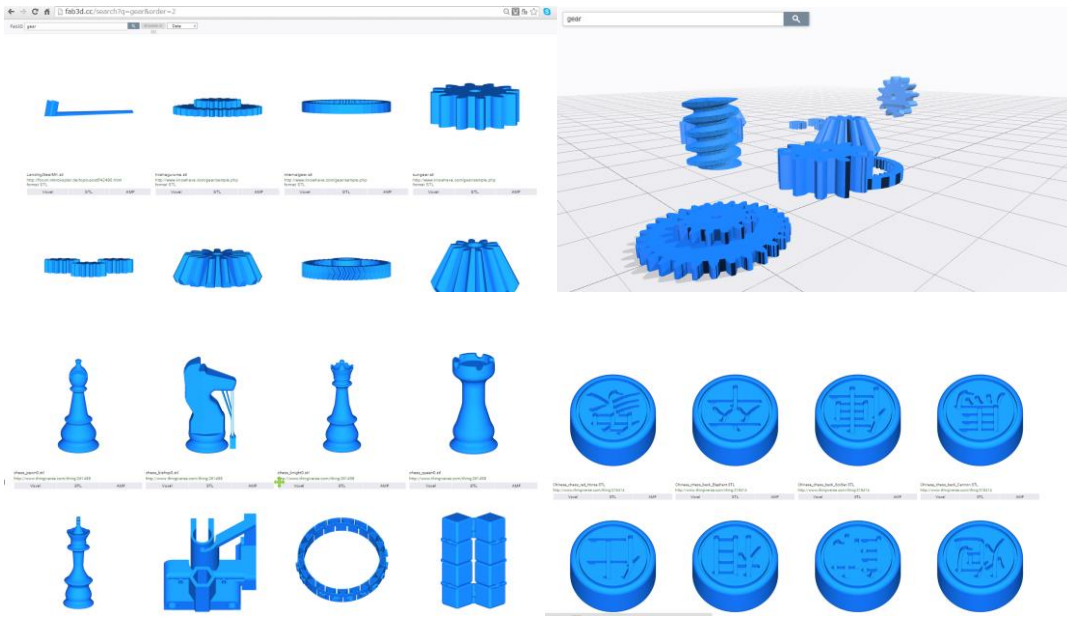
When I explain the technical overview of 3D Printing, it must be easier to understand with a sketch of an iceberg. Visible parts of 3D Print technology (above the water) are about materials, machines and processes, while invisible parts of 3D Print (beneath the waters) are about 3D Modelling, Data Processing, Algorithm and AI. The former part is in physical world, and the latter part is in digital world.



In my observation, there are two major streams beneath the waters. One is focusing on developments

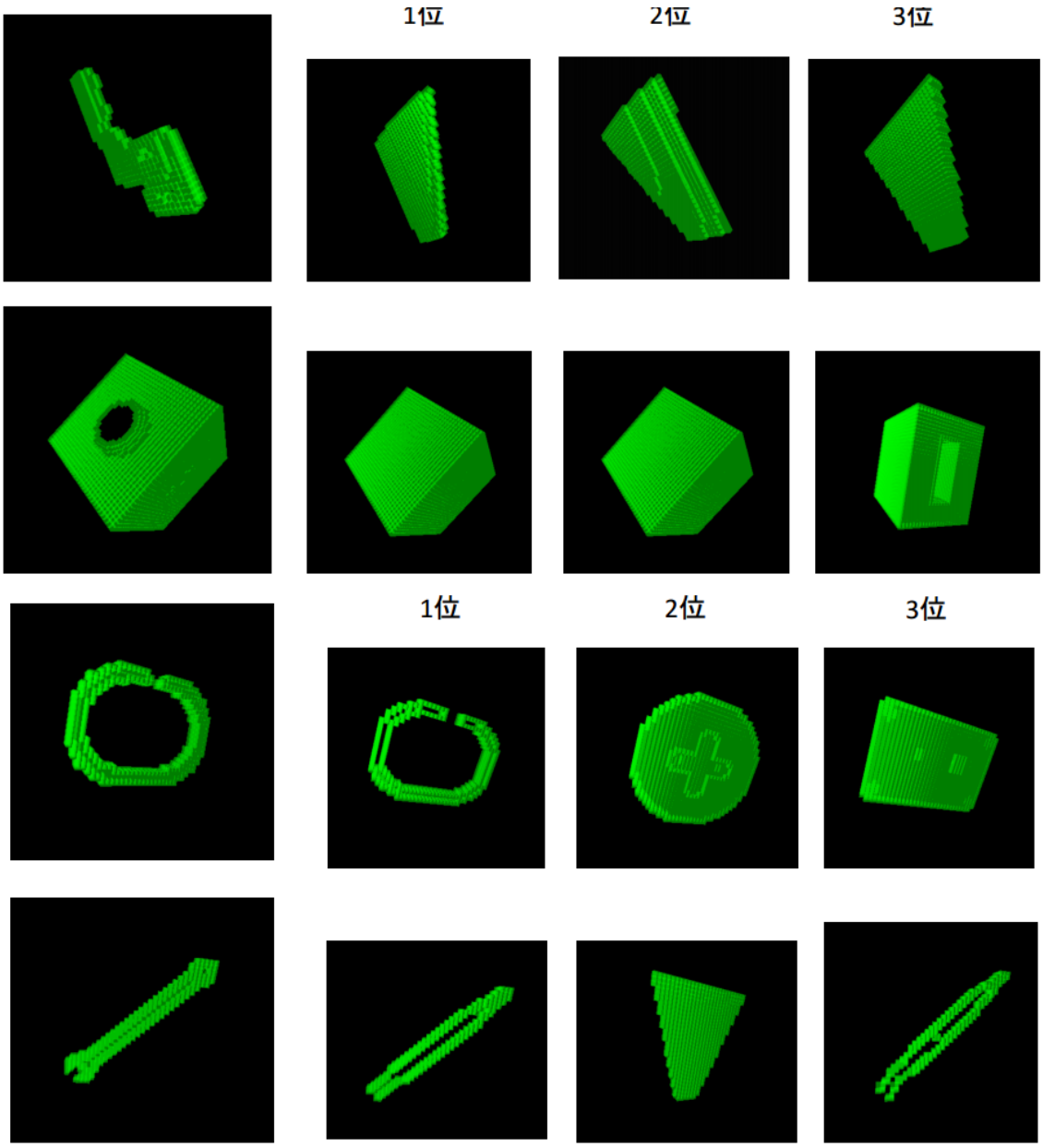
of sophisticated software with new User Interface. Actually, developments on designer/artist-oriented design software, combined among CAD (Computer-aided Design), CAE (Computer-aided Engineering), CAM (Computer-aided Manufacturing) and CAT (Computer-aided testing) are very hot domain. Those trials are usually called as “Computational Design” or “Algorithmic Design” (Sometimes the word “Biomimetic” can be added.)

The other is so-called “Big Data”-based Approach. A development on 3D-Search engine must be the most easiest example to understand this approach. Actually, there are a few 3D-Search engine projects based on a huge dataset of 3D (Mostly, STL) Files. Our research is a part of this stream. Our original 3D-Search-service (fab3d.cc) is already available on the Web as public beta version. We collected more than 1,000,000 STL files with crawling algorithm from the Internet, and created a huge database with an original indexing algorithm described later. Our fab3d.cc offers users to interface to retrieve, search by keywords, and browse in 3D space.



(3D Search Engine http://fab3d.cc)

In parallel, we are using our collected dataset for deep learning research as a back-end processing. We convert all the STL data into 3D Voxel Index (Voxel is a 3D pixel, thus 3D Voxel file is similar to 3D bitmap file). It is easier to apply Voxel Data to deep learning libraries, because deep learning libraries are basically implemented for image processing based on bitmap (photo) file format.

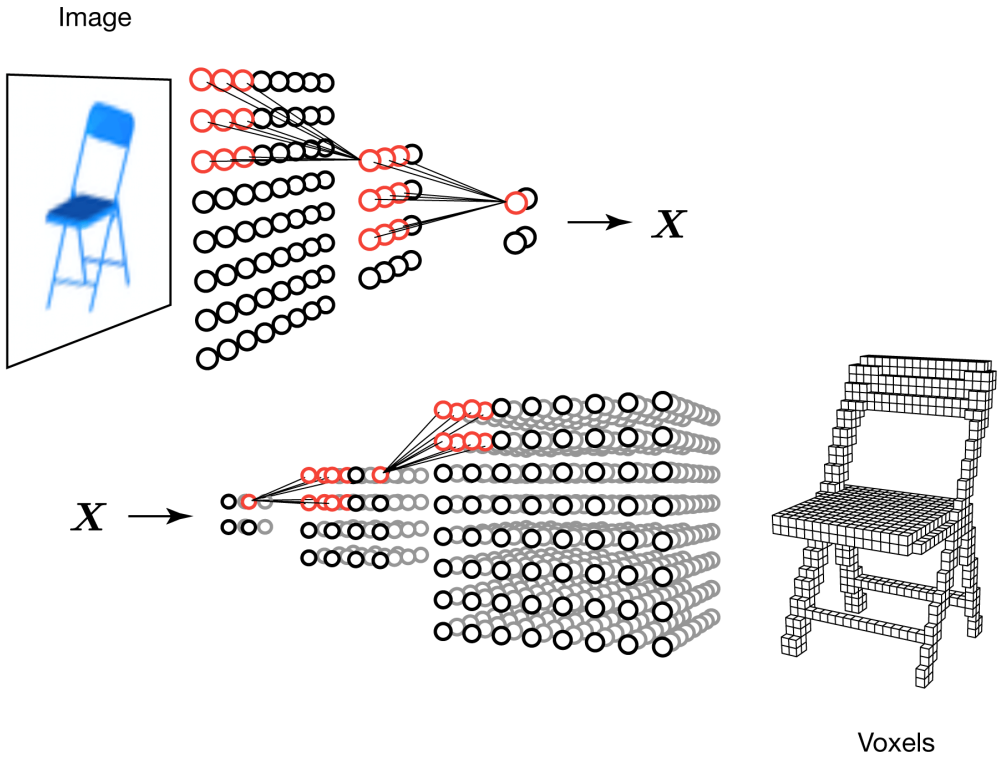


(Voxel Indexing of 3D Data)

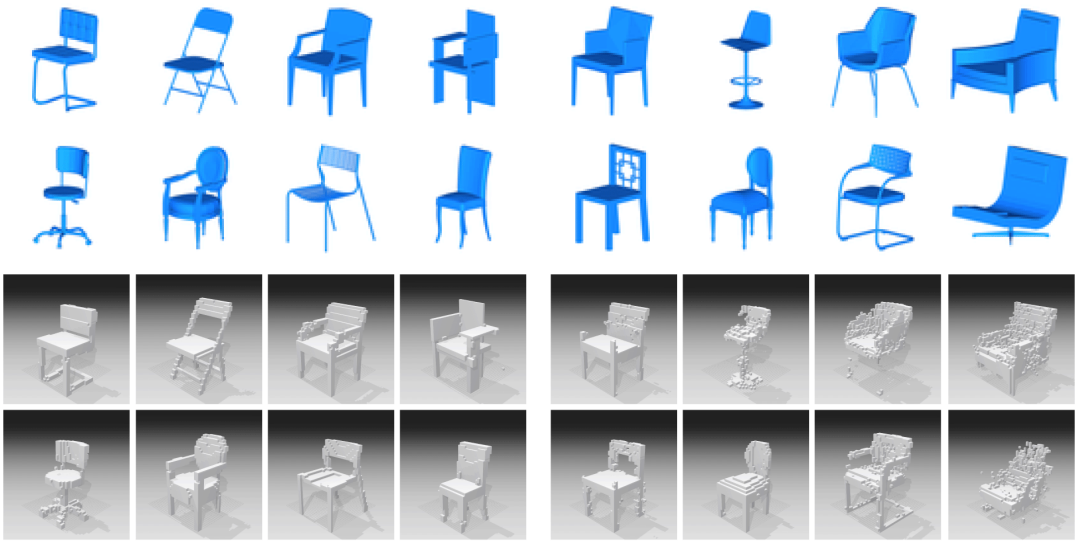
We trained our machine learning algorithm by using 100000 Dataset of 2D profiles and 3D Voxel format. As a result, our machine learning system could become to create new 3D Voxel file (as an output) from a new 2D profile image (as an input).

We are now implementing a sketch-based 3D modelling system, based on our basic achievements described above. Likewise image recognition (2D), speech recognition (sound), natural language processing (text), a handy 2D sketch of a 3D model is one of ambiguous information for the machine. If we could convert any handy sketch to a 3D model, it would cultivate new way to create

3D Data for 3D Printing.



2D convolution layers (encoding) and 3D convolution layers (decoding)



(Left: training dataset of existing 2D Profiles and 3D Voxels,
Right: new data of new 3D Voxels from new 2D Profiles)