

Deep Learning in Reciprocal Lattice Space

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Object recognition is one of the core themes of computer vision literature. A great deal of research effort has been made to push the limits of object recognition performance based on vision. Many previous researches have focused on the improvement of recognition methods for several data formats such as RGB images and 3D point cloud data. On the other hand, research on data processing in reciprocal lattice space expressed by frequency representation and holographic pattern has not been done sufficiently. In this paper, we propose DeepHolo, which is a classifier for 3D point cloud object with holographic pattern representation as input, along with DeepFourier, which is a method of Fourier transformation of 2D image to frequency space using neural network.

As a method of conversion data to reciprocal lattice space, DeepFourier focused on Fourier transform. Fourier transformation in digital processing results in discrete. In digital processing, since the discrete Fourier transform is performed, it is impossible to calculate a Fourier transform or an inverse Fourier transform that perfectly matches the underlying image. Therefore, we tried to improve the accuracy with machine learning technology. We used the Encoder-Decoder model and Conditional Generative Advisory Networks(GANs), which attract attention in recent years, in view of the two-dimensional Fourier transform from image to image conversion. In addition, conversion was carried out by neural networks (single-layered neural network) consisting of a single layer which is a simple model. As a result, the single-layered neural network was the most accurate among the machine learning methods, but it did not exceed the accuracy of the conventional DFT. Also, through experiments on IDFT, an interesting fact that the structure is mirrored for the optimal neural network of DFT processing and IDFT processing was discovered.

On the other hand, we focused on object recognition of 3D object as data processing in reciprocal lattice space. We convert 3D point cloud data to holographic pattern by computer generated hologram technology. 3D scene structure can be easily described with holographic pattern expression. Since this data is two-dimensional, an image processing technique such as 2D Convolutional Neural Networks or the like can be applied. In the proposed method DeepHolo, we generated a holographic pattern from a corresponding viewpoint with binary-weighted computer generated hologram for 3D point cloud data. For this pattern, we could obtain the same performance as the conventional method with a network structure with inception modules in multiple layers. Furthermore, it was able to keep far less than the number of parameters included in the network of the conventional method.

In the future, we will conduct detailed analysis of DeepFourier and improve further accuracy of DeepHolo.

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