模型驱动深度学习助力高保真彩色 4K 全息显示

DOI: 10.12086/oee.2024.241001.h02

计算全息三维显示系统可从原理上避免辐辏调节矛盾，具有光路简单、结构紧凑等突出优势，受到了学界和产业界的重点关注，被认为是三维显示的未来形态。当前，计算全息三维显示面临的核心问题是如何高速高质量地生成数字化的二维全息图。

清华大学曹良才教授课题组提出一种基于模型驱动深度学习的神经网络框架，突破了高质量全息图的高速计算技术，实现了高保真彩色 4K 全息三维显示。该神经网络框架被称作 4K-DMDNet，其使用了 U-Net 型残差神经网络框架，并加入了菲涅尔衍射模型作为网络训练的约束条件。

针对网络学习能力有限的问题，4K-DMDNet 引入亚像素卷积策略。在上采样支路中首先通过卷积将通道数扩大 4 倍，再进行像素洗牌得到空间信息，解决了传统转置卷积中为还原图像尺寸而添加大量零参数的问题。针对训练过程约束条件不足的挑战，4K-DMDNet 在菲涅尔衍射模型中引入密集采样操作。论文利用二值及彩色图像对 4K-DMDNet 进行了光学实验的验证。实验结果表明，4K-DMDNet 可实现 4K 场景的高保真全息重建，重建质量优于 GS 迭代算法和数据驱动深度学习算法。

Opto-Electronic Advances, 2023, **6**(5): 220135.
https://www.oejournal.org/article/doi/10.29026/oea.2023.220135.

Using model-driven deep learning to achieve high-fidelity 4K color holographic display

DOI: 10.12086/oee.2024.241001.h02

The computer-generated holography (CGH) has potential applications in a wide range of 3D displays such as head-mounted displays, heads-up displays, and projection displays. How to generate high-speed and high-quality 2D holograms is a key issue and essential research direction in this field at present.

Recently, Hololab at Tsinghua University proposed a model-driven deep learning neural network, called 4K-DMDNet. It realizes the high-quality high-speed hologram generation and achieves high-fidelity 4K color holographic displays.The 4K-DMDNet proposed in this work uses a residual U-Net neural network framework. The Fresnel diffraction model acts as the constraint for the training process. It is capable of high-fidelity 4K hologram generation without transfer learning.

In general, the prediction performances of the network are influenced by both the limited learning capacity of the network and the insufficient constraints in the training process. To address the challenges of the limited learning capability, 4K-DMDNet introduces the sub-pixel convolution method. To address the challenges of the insufficient constraints in the training process, 4K-DMDNet introduces the oversampling operation in the Fresnel diffraction model.

The researchers have validated 4K-DMDNet with optical experiments of binary images and color images. The optical reconstructions show that 4K-DMDNet can achieve the high-fidelity 4K display, outperforming the traditional GS iterative algorithm and data-driven deep learning algorithms.

Opto-Electronic Advances, 2023, **6**(5): 220135.
https://www.oejournal.org/article/doi/10.29026/oea.2023.220135.