基于超表面的可插拔衍射神经网络

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目前，全光衍射神经网络通常在太赫兹和微波波段实现，仍难以实现集成小型化及缺乏可重构性两大问题。光学波段超表面与传统的衍射光学元件相比更加轻薄小巧，通过改变超表面内超原子的形状、大小和排列方式可以同时控制光的振幅和相位。利用超表面实现深度衍射神经网络有助于得到小型化智能集成光学器件。

北京理工大学黄玲玲教授课题组为解决衍射神经网络的可重构性，提出了一种可插拔的衍射神经网络 (P-DNN)，结合迁移学习算法可完成其内部插件相位参数的训练，通过切换网络中的可插拔组件能够实现手写体数字和时尚物品等多种识别任务的切换。可插拔光学衍射神经网络的调制层可以分为两部分：预处理输入信息的共享层和切换多种任务的插拔层。输入信息使用特定形状的掩模进行调制，入射光通过可插拔光学衍射神经网络后，聚焦到探测平面的子探测区域上，根据能量分布确定输入物体类别。固定共享层插件的情况下，切换插拔层插件能够实现其他识别任务。

未来基于超表面的可插拔衍射神经网络可以作为不同功能的人工智能系统的光学集成组件，为特定任务提供低能耗的高速计算，例如自动驾驶系统中的实时物体检测和显微镜成像中的智能光学滤波。

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Pluggable multitask diffractive neural networks based on cascaded metasurfaces

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Currently, diffractive neural networks are usually implemented in the terahertz and microwave bands, but it is still difficult to achieve integration miniaturization and lack of reconfigurability. Compared with traditional diffractive optical elements, metasurfaces are more compact in the optical band and can be used to simultaneously control the amplitude and phase of light by changing the shape, size, and arrangement of the meta-atoms inside the metasurfaces. The implementation of diffractive neural networks using metasurfaces helps to obtain miniaturized intelligent integrated optical devices.

Prof. Lingling Huang's team at Beijing Institute of Technology has proposed a plug-in diffractive neural network (P-DNN) to address the reconfigurability issue of diffractive neural networks. Combined with the transfer learning algorithm, the phase parameters of internal plug-ins can be trained, and multiple recognition tasks, such as handwritten digit recognition and fashion recognition, can be achieved by switching the pluggable components in the networks.

In the future, the pluggable diffractive neural networks based on metasurfaces can be used as optical integrated components for different functional AI systems, providing low-energy and high-speed computing for specific tasks, such as real-time object detecting in autonomous driving systems and intelligent optical filtering in microscope imaging.

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