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Encoding and transmission of information based on radial carpet beams and convolutional neural network detection

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Abstract

Radial carpet beams are a novel form of structured light that falls under the category of combined half-integer Bessel-like beams. This study introduces the radial carpet beam as a means of information transmission and a solution for expanding the information encoding freedoms. The method employed for detecting and classifying these beams is the convolutional neural network (CNN). To conduct the study, a dataset consisting of 16 different classes of radial carpet modes was prepared. These modes were propagated through underwater turbulence conditions over a distance of 120 cm. The convolutional neural network used in the study was based on the widely recognized DenseNet-201 architecture, utilizing transfer learning techniques. The trained model achieved a 97% accuracy in mode detection and classification. Subsequently, the performance of the proposed model was evaluated by transmitting and receiving a 4-bit grayscale image measuring 150 x 200 pixels through an underwater communication link based on radial carpet modes. The evaluation results clearly demonstrate the potential for achieving new encoding options with radial carpet beams. Moreover, the convolutional neural network method proves to be an optimal approach for detecting and classifying structured light beams. This method alleviates the challenges of using multiple optical components in coherent detection techniques, which traditionally rely on diffraction gratings. In addition to simplifying optical system configuration, it also reduces implementation costs and volume, particularly in optical communication applications.

Keywords: structured light, convolutional neural network (CNN), optical communication, inhomogeneous optical detection

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