

(12) **United States Patent**  
**Doster et al.**

(10) **Patent No.:** **US 10,187,171 B2**  
(45) **Date of Patent:** **Jan. 22, 2019**

(54) **METHOD FOR FREE SPACE OPTICAL COMMUNICATION UTILIZING PATTERNED LIGHT AND CONVOLUTIONAL NEURAL NETWORKS**

(58) **Field of Classification Search**  
USPC ..... 398/118–131, 202–214  
See application file for complete search history.

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(\* ) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 0 days.

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(21) Appl. No.: **15/914,015**

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(22) Filed: **Mar. 7, 2018**

(65) **Prior Publication Data**  
US 2018/0262291 A1 Sep. 13, 2018

(57) **ABSTRACT**  
An apparatus includes an optical communications receiver receiving a turbulence-distorted, optical signal. The turbulence-distorted, optical signal includes a plurality of fundamental modes encoded via a combinatorial multiplexings dictionary. The received optical signal includes a plurality of two-dimensional images. Each two-dimensional image of the plurality of two-dimensional images respectively represents received fundamental modes of the plurality of fundamental modes. The receiver includes a neural network trained to assign to each two-dimensional image of the plurality of two-dimensional images at least one respective active fundamental mode of the plurality of fundamental modes and a corresponding accuracy probability based on the dictionary.

**Related U.S. Application Data**

(60) Provisional application No. 62/467,941, filed on Mar. 7, 2017.

(51) **Int. Cl.**  
**H04B 10/00** (2013.01)  
**H04J 14/00** (2006.01)

(Continued)

(52) **U.S. Cl.**  
CPC ..... **H04J 14/00** (2013.01); **G06N 3/08** (2013.01); **H04B 10/112** (2013.01); **H04B 10/50** (2013.01); **H04B 10/60** (2013.01); **H04B 10/80** (2013.01)

**19 Claims, 3 Drawing Sheets**

