INTRODUCTION

Proposed imaging system: The object of interest is probed with speckle patterns through an illumination MMF, while a secondary collection fibre, placed alongside the illumination fibre, transmits the diffuse reflections from the object back to the proximal end to be recorded by an avalanche photodiode (APD).

- Current endoscopes typically have a width of a few millimetres, which is insufficient for practitioners to access highly sensitive areas like the ear or brain without causing damage.
- Multimode optical fibres (MMFs) allow for the transmission of images on thousands of spatial modes simultaneously within a width of a human hair, providing higher resolution and minimally invasive imaging procedures.
- Images transmitted through a MMF emerge as unrecognisable speckle patterns due to dispersion and coupling between the spatial modes of the fibre. Furthermore, speckle patterns change as the fibre undergoes bending.
- I have developed an innovative real time imaging system using flexible MMFs, which, in contrast to previous work, is for the first time robust to bending.

RECONSTRUCTION ALGORITHM

- The probed object is reconstructed from the APD measurements leveraging a deep generative model, namely a variational autoencoder (VAE).
- In contrast to deterministic deep learning approaches, the proposed model learns the overall distribution representing the complicated mapping between measurements corresponding to different fibre configurations and the underlying images of different classes in a low dimensional latent space.
- This allows, for the first time, for real-time reconstruction and classification of images from the APD measurements even when the bend configuration of the fibre is changed to one that was not part of the training set.
- The model training was performed using different fibre configurations by applying two types of bends simultaneously on the fibre. The images used were obtained from the fashion-MNIST dataset, which includes different classes of clothing.

CONCLUSIONS

- This research presents a real time and minimally invasive imaging system leveraging MMFs and VAEs, which, for the first time, is robust to bending and does not require access to the distal end of the fibre during imaging.
- This development will have a significant impact on imaging applications, as the novel imaging system paves the way for flexible, inexpensive and high-resolution endoscopes for use in hard-to-reach areas such as the brain and ear.

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