**Introduction**

Many scientific fields rely on light microscopy to understand the underlying structural and functional phenomena of living cells on the micro-scale. The resolution, or the distance between distinguishable features of an object, is of utmost importance. Alternative optical techniques such as scanning electron microscopy (SEM) can achieve 1 nm resolution, however, only yield information about the surface topography of non-living, labor-intensively prepared samples. Light microscopy remains relevant due to its relatively low cost, ease of use, and the ability to work with living samples without the need for preparation, despite relatively low x,y resolution. Techniques such as scanning confocal microscopy and fluorescence improve resolution by restricting the amount of light hitting the detector to a single plane and improving contrast of molecules of interest respectively. Using a high numerical aperture (NA) objective lens as well as the aforementioned techniques can achieve 200 – 350 nm x,y resolution. Super-resolution light microscopy techniques have even achieved resolutions as low as 20 – 40 nm (Hell, 2014). Obtaining high-resolution images comes at a high monetary price, requires long-acquisition times, and therefore long exposure times. Trade-offs must be made as some living samples must be imaged quickly or may photo-bleach after long exposure times. Deep learning has been recently applied to the field of optics to limit the number of trade-offs that must be made during imaging. Weigert et al. (2018) performed several proof-of-concept experiments to show how resolution can be restored with a low-photon budget, super-resolution can be achieved using synthetic training data, and how axial resolution can be improved using semi-synthetic training data. Rivenson et al. (2017) recently conducted a proof-of-concept experiment to show how a deep learning model could yield 100X objective lens-equivalent images with 6 times greater field of view from images taken with a 40X (lower-resolution) objective lens. Deep-learning can transform optics, especially for point-of-care applications where low-resolution and low-cost instruments must be used.

**Formal Definition**

One optics-related issue that has been minimally addressed by deep-learning is the improvement of axial (z) resolution with samples of depth (>200 µm). Due to the diffraction-limit of light, the resolvable z-resolution is approximately 2-3 times worse than the x,y-resolution. Furthermore, with the implementation of confocal scanning, only the part of the object near the focal plane is in-focus. Features will become increasingly blurry with increased off-focus distance. In order to get a well-resolved axial slice, many well-resolved lateral slices must be taken and concatenated. Rivenson et al. (2017) claimed that their model significantly improved the depth of field (DOF) of input images, however, their depth-resolved stack consisted of 5 images over 2 µm of total depth. Weigert et al. (2018) used synthetic training data to improve the axial resolution of x,z input images of ~100 µm depth.

**Dataset**

**Model**

**Potential Difficulties**

**Expected Deliverable**

**References**

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