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**Denoising 3D TEM tomography via Advanced Neural Radiance Fields**

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**Introduction**

**Background Information**

**Neural radiance field:** A fully connected neural network called a neural radiance field (NeRF) may provide inventive renderings of intricate 3D scenes from a sparse collection of 2D photos. It has been trained to replicate input views of a scene using a rendering loss. It functions by interpolating between input photos of a scene to create a single rendered scene. NeRF is a very efficient method for creating images from synthetic data (Mildenhall et al., 2020).

To render new views, a NeRF (*Neural Radiance Field (NeRF): A Gentle Introduction*, n.d.)network is trained to directly map from viewing direction and spatial location (5D input) to opacity and color (4D output). NeRF is a computationally demanding technique, and it might take hours or even days to process complex scenes. New algorithms, nevertheless, are readily available and significantly boost performance.

**Camera Parameters:**

**Denoising:** (Mildenhall et al., 2021; Pearl et al., 2022)

**Noise Modeling:** (Kniesel et al., n.d.)

**Implicit reconstruction:** (Kniesel et al., n.d.)

**NeRF Math:** (Bian et al., 2022)

**Joint Optimization of Poses and NeRF:** (Bian et al., 2022)

**Neural 3D shape representations:** (Mildenhall et al., 2020)

**View synthesis and image-based rendering:** (Mildenhall et al., 2020)

**TEM**

A beam of electrons is used in transmission electron microscopy (TEM), which generates images of specimens with a resolution that is far higher than that of optical microscopes(Egerton et al., 2004; Tang & Yang, 2017). In transmission electron microscopy, electrons are emitted by a tungsten filament or field emission source and then accelerated under high voltage (typically 100-300 kV) (Gault et al., 2008). Electromagnetic lenses concentrate the electron beam such that it is directed toward the extremely thin sample. Electrons, when they go through the sample, have a variety of interactions with the sample, depending on the density and the thickness of the material. This produces an electron diffraction pattern, which may be interpreted to reveal information about the structure of the material(Tang & Yang, 2017)

Additional lenses concentrate the transmitted electrons so that they may be captured as an image on a detector or camera(Gault et al., 2008). The transmission electron microscope (TEM) may provide magnifications of up to 2 million times (Gault et al., 2008), which enables the viewing of structures and details on a scale as tiny as a nanometer or an angstrom (Egerton et al., 2004). Because of this, it is an extremely useful instrument for study in the fields of materials science, cell biology, molecular structure analysis, and semiconductors(Egerton et al., 2004).

Imaging mode and diffraction mode are the major modes of operation for the transmission electron microscope (TEM) (Adrian et al., 1984). The image that is created by the transmitted electrons is used by the imaging mode. It is possible to examine either the diffraction pattern or the image depending on how the magnetic lenses are adjusted. The electron diffraction patterns are the primary focus of the diffraction mode, which focuses on the crystal structure(Adrian et al., 1984).

The preparation of samples is an essential part of TEM. To facilitate electron transmission, specimens must have a thickness of between 50 and 100 nanometers (nm)(Adrian et al., 1984). Staining with substantial amounts of heavy metal salts is required for biological and polymer materials to produce contrast(Adrian et al., 1984). Imaging of hydrated materials is possible because to specialized methods such as cryo-TEM, which vitrifies the samples(Adrian et al., 1984).There is a possibility that radiation will destroy sensitive specimens, which is one of the TEM's limitations(Egerton et al., 2004). Imaging of living biological samples is likewise not possible due to the vacuum environment(Egerton et al., 2004). Nevertheless, transmission electron microscopy continues to be an essential instrument for high-resolution structural characterization in both the physical and biological sciences(Egerton et al., 2004).

In this study, transmission electron microscopy (TEM) was used to examine Janus-like particles that were created from block copolymers. Transmission electron microscopy (TEM) gives the resolution and contrast necessary to clearly examine the nanostructure morphology and surface topology of the Janus particles(Walther & Müller, 2013) (Tang & Yang, 2017).

**Novel view Synthesis**

The term **View synthesis** refers to the process of generating new photographic viewpoints of a subject from one or more input photographs. This may be done with either a single image or many images. This allows to create unique synthetic viewpoints using only a little amount of photographic data. View synthesis is useful in a variety of contexts, including virtual reality, augmented reality, and the reconstruction of three-dimensional models(Xia & Xue, n.d.).

For view synthesis, a wide range of methods have been utilized. The multi-view stereo approach builds a three-dimensional reconstruction of a scene by piecing together a few photographs obtained with a variety of cameras (Seitz et al., 2006; Xia & Xue, n.d.). Then, this model may be displayed from any perspectives. Image-based rendering distorts and interpolates pixels depending on the original inputs to infer new viewpoints (Chen & Williams, 2023). These methods concentrate on identifying correspondences between different pictures.

The most recent deep learning algorithms develop an implicit representation of the image generation process using neural networks. The neural rendering algorithms directly produce unique views by making predictions about the values of pixels based on the attributes of the scene that they have learnt (Tewari et al., n.d.). Neural radiance fields (NeRF) are a method for efficiently encoding a scene as a continuous five-dimensional function that maps three-dimensional coordinates to volume density and view-dependent brightness(Mildenhall et al., 2020). The continuous volumetric scene representation that NeRF provides has made it possible to do photorealistic view synthesis with only a few photos.

The capacity to implicitly infer a three-dimensional structure and appearance from just two-dimensional supervision is the primary benefit offered by neural view synthesis systems. Because of this, formal three-dimensional modeling or estimate is not required. These learning-based systems continue to increase the realism and flexibility of new view creation across a wide variety of applications, including augmented reality, virtual tourism, and 3D photography (Fang et al., n.d.).

**Related Work**

**Method**

**Datasets:**

**Experiments**

**Results**

**Limitation and Future work**

**Discussion and Conclusion**

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