CS460 - Project Proposal

Machine Learning Based Digital Holographic Microscopy

Group – 12
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Idea :

Using machine learning models to study and control the motion of micro-particles in 3D by using the Digital Holographic Microscopy. Digital Holographic Microscopy is technique to study the three dimensional information about the sample by capturing different interference patterns of particles using phase shift.

- By illuminating small areas under focused light beams, heat is locally generated, which induces rapid fluid flows.
- This local heat generation is done through the plasmon heating, a phenomenon where the absorption of light by plasmonic nanoparticles (Gold Nanorods used in our experimental setup) leads to a localized increase in temperature.

Datasets :

Synthetic images will be generated using **DeepTrack 2.0** which corresponds with the details of the our experimental data, and will be used for training and validation of model

Midway Targets:

- To generate synthetic images similar to experimental data.
- To reproduce the existing results and modify the model to test experimental data.
- To study different models like U-Net, RU-Net(Regression U-Net), and MAGIK (Motion Analysis through GNN Inductive Knowledge), LodeSTAR (Localization and detection from Symmetries, Translations And Rotations).
- Implementing a few of the models on the data and analyze the results

Expected Results:

- To track the particles position with accuracy of approx. 80-90% of the existing numerical algorithms.
- To optimize the model to test against the experimental data.

Main References:

- Benjamin Midtvedt, Saga Helgadottir, Aykut Argun, Jesús Pineda, Daniel Midtvedt, Giovanni Volpe. "***Quantitative Digital Microscopy with Deep Learning***." Applied Physics Reviews 8 (2021), 011310. https://doi.org/10.1063/5.0034891
- Ciraulo, B., Garcia-Guirado, J., de Miguel, I. *et al.* ***Long-range optofluidic control with plasmon heating***. *Nat. Commun.* **12**, 2001 (2021). https://doi.org/10.1038/s41467-021-22280-3
- Harshith Bachimanchi, Benjamin Midtvedt, Daniel Midtvedt, Erik Selander, Giovanni Volpe (2022) ***Microplankton life histories revealed by holographic microscopy and deep learning*** eLife 11:e79760 https://doi.org/10.7554/eLife.79760
- Midtvedt, B., Pineda, J., Skärberg, F. *et al.* Single-shot self-supervised object detection in microscopy. *Nat Commun* **13**, 7492 (2022). https://doi.org/10.1038/s41467-022-35004-y