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Comment on amt-2022-97

Jan Henneberger (Referee)

Referee comment on "Neural network processing of holographic images" by John S. Schreck et al., Atmos. Meas. Tech. Discuss., https://doi.org/10.5194/amt-2022-97-RC2, 2022

Overview: The manuscript presents a novel approach for processing data from holographic imagers called HolodecML. HolodecML utilizes GPU hardware to accelerate the reconstruction of the holograms. A neuronal network is trained on patches of the reconstructed images to detect the position of particles. For training synthetic holograms are created and corrupted to mimic noise that appears in holograms taken by the actual HOLODEC instrument.

The presented utilization of a neuronal network for processing holograms is a very innovative approach, which has great potential to improve the data analysis of holographic images. Additionally, the generation of synthetic holograms with realistic noise is a novelty. As these synthetic holograms can be used as ground truth for validating processing approaches because the position and size of the particles are known, the potential of the synthetic holograms could be discussed more prominently.

In general, the manuscript is well written and the approach is explained in an understandable way. Acknowledging the fact, that the authors have the difficult task of presenting a complicated issue at the intersection of computer science and atmospheric science, it still took some time to understand the main message of the manuscript. In my eyes, the manuscript could be strengthened by focusing on what are the practical advantages of HolodecML in the analysis of holographic data and what is the potential of the new approach. The part of the analysis that is not central to the main points (e.g. analysis with the number of z-slides not equal 1000) should be moved to the Appendix, whereas the performance comparison should be moved to the main manuscript. The standard approach should be described in more detail to be able to understand the changes and results of the HolodecML approach. For clear reference, the training and test datasets could be given a unique name and their properties could be summarized in a table.

Recommendation: Minor revisions are needed.

Comments:

- The HolodecML approach requires the same reconstruction of planes through wave propagation as the standard approach. Could the GPU implementation of the reconstruction introduced by HolodecML also be implemented in the standard approach? If yes, the performance gains would be of great benefit to the community using the standard approach. Therefore, the performance gains during reconstruction should be separately discussed from the computational cost of the neuronal network for particle detection and the discussion should be moved from the Appendix to the main manuscript.
- I have my doubt that the statement that HolodecML improves particle detection by 20% is based on a fair comparison. The particle detection in the standard approach is normally tuned rather loose to ensure that all particles are detected (i.e., minimizing the number of false negatives). Consequently, a higher number of artifacts that are not real particles (i.e., a higher number of false positives) are detected. The reason behind this is, that particles that are not detected cannot be retrieved at a later stage, but artifacts can be sorted out by a classification algorithm (e.g., by a neuronal network as described in Touloupas et. al, 2020). Therefore, the large false-positive rate and low false negative rate presented in Figure 10 is expected in the standard approach and could be improved by a classification algorithm. How was the particle detection optimized in the standard approach? Were artifacts sorted out by a classification algorithm?

Minor comments:

- Figure 1 (a): The interference fringes are almost invisible.
- Line 166: What is the RF07 subset?
- Line 167: Was HolodecML able to detect the few ice crystals?
- Line 201: Is the reference to Figure 3(c)(v) correct?
- Line 203-210: The creation of an independent processing approach is an important motivation for your work and should already be discussed in the introduction section.
- Line 261: In the N = 48648 case the distance between planes is around 3 um. Why did you consider such a large number of planes if you expect limited performance improvement below the in-depth resolution of 57 mm?
- Figure 5: The thresholding in the standard method should detect the particle in all three planes. Why is the mask not visible in all three planes?