Improved Phase Unwrapping in Complex Noisy Conditions Based on Deep Learning

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***Abstract*— Phase unwrapping is critical in various imaging applications. Traditional phase unwrapping methods are laborious and noise sensitive. To solve these issues, we propose a robust deep neural network method. A state-of-the-art Convolutional Neural Network (CNN) incorporating Convolutional Long Short Term Memory (CLSTM) for phase unwrapping is presented. The proposed network performed better than traditional methods under severe noisy conditions with a mean squared error score of 0.73%. It does not need a large-scale dataset for training also.**

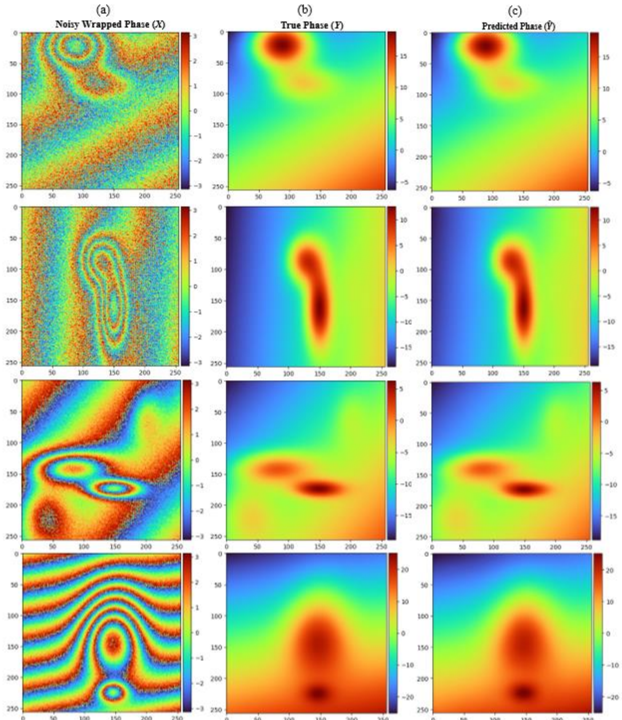
I. Introduction

The problem of phase unwrapping is recurrent in many applications including interferometry, fringe projection, and digital holographic interferometry. In many advanced imaging applications, accurate phase information retrieval is essential for obtaining useful information from the gathered data. A few recent studies [1] have attempted to apply deep learning to address the phase unwrapping problem.

We proposed a Convolutional Neural Network (CNN) architecture that incorporates with a Convolutional Long Short Term Memory (CLSTM) module. This combines the capability of Fully Convolutional Networks and LSTMs for accurate and fast phase unwrapping with a comparatively small dataset.

II. Result and Discussion

In this work, the synthetic phase images with random shapes and their corresponding wrapped phase images make up the datasets. These arbitrary forms are generated by adding and subtracting several Gaussians of different sizes and orientations. This method assures the formation of random and asymmetrical shapes rather than distinct patterns. The proposed architecture consists of a fully convolutional encoder-decoder network where the output of the encoder is passed through the CLSTM module before fed into the decoder. The output feature map of the encoder represents local information of input image. Network learns spatial dependencies because of CLSTM module when encoder output is fed into it. Consequently, the network can learn the spatial relationships between the local features contained in the encoder output. Subsequently, the output of CLSTM module is fed into the decoder network, improving output resolution through transpose convolutional operations. For evaluation, we used Normalized Root Mean Square Error (NRMSE) metric of wrapped phase images. The proposed method achieved better results (NRMSE 0.73%) than previous methods under severe noisy conditions as shown in Fig. 1. Moreover, the proposed network utilized less computation time on average to produce the results, making it ideal for applications where accurate and fast phase unwrapping is required.



[Fig.1] Comparison of phase images; (a) noisy wrapped image (b) true image (c) predicted image.

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References

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