An algorithm for CGH using gradient descent method

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1 Background

In the field of CGH, there are several methods to compute a holographic phase distribution such as Gerchberg-Saxton algorithm. A new algorithm was proposed to generate high quality holographic phase distribution in this work. The concept of Mean Square Error(MSE) was adopted to optimize the phase distribution.

2 Proposed method

A new algorithm adopting gradient descent method was proposed. The quality of the regenerated image was evaluated by the MSE. The lower MSE generates, the higher quality regenerated image produces. An 1D algorithm was proposed first.

2.1 MSE calculating

The MSE calculating function is shown as below.

$$MSE = \frac{\sum \left(\frac{I_{tar}(i)}{\overline{I_{tar}}} - \frac{I_{reg}(i)}{\overline{I_{reg}}} \right)^2}{n}$$

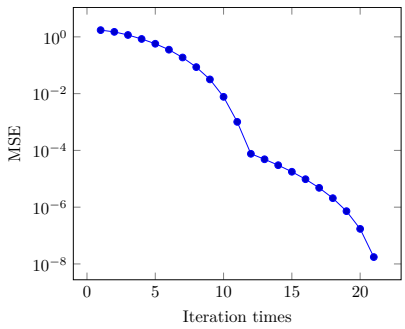
Where the I_{tar} standed for the target image and the I_{reg} standed for the regenerated image. n is the number of pixels.

2.2 Gradient descent iteration

(1). Generate a random phase distribution.
(2). Do the Discrete Fourier Transform(DFT) to this phase distribution and get an regenerated image.
(3). Get the difference of the target image and the regenerated image(ΔI_{reg}) and calculate the MSE.
(4). Calculate the gradient of the phase distribution($\frac{\partial I_{reg}(i)}{\partial \theta(j)}$) and the regenerated image.
(5). Calculate the increment of the phase distribution that satisfy $\Delta\theta \times \frac{\partial I_{reg}}{\partial \theta} = \Delta I_{reg}$
(6). Resize the $\Delta\theta$ to an appropriate value, and add the phase increment($\Delta\theta$) to the phase distribution.
(7). If the $\Delta\theta$ is larger than the preset value, redo the iteration from the step (2).
(8). Output the generated phase distribution.

3 Results

A program was designed as the step proposed. According to the result of the running program, the MSE-iteration graph is shown as below.



4 Conclusion

An algorithm was successfully proposed and did a good job in 1D calculation.

References

[1] J R.Fienup: "Phase retrieval algorithms: a comparison[J]", Applied optics, 21, 15, pp.2758-2769(1982).