The Design of Computer-generated Holograms for Augmented and Virtual Reality Applications

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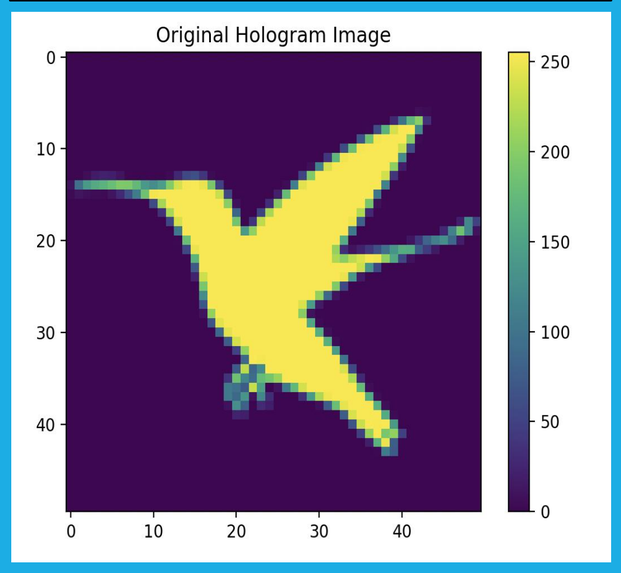
Abstract

Near-field Computer Generated Holography has the potential to revolutionise augmented and virtual reality. Singular variable decomposition with a cost-function minimisation approach can offer high-quality real-time hologram image generation. This approach, though promising, has not yet produced adequate image generation as the minimisation algorithm has struggled to converge to a correct solution efficiently.. With certain improvements such as more appropriate starting conditions, this approach could yield impactful results.

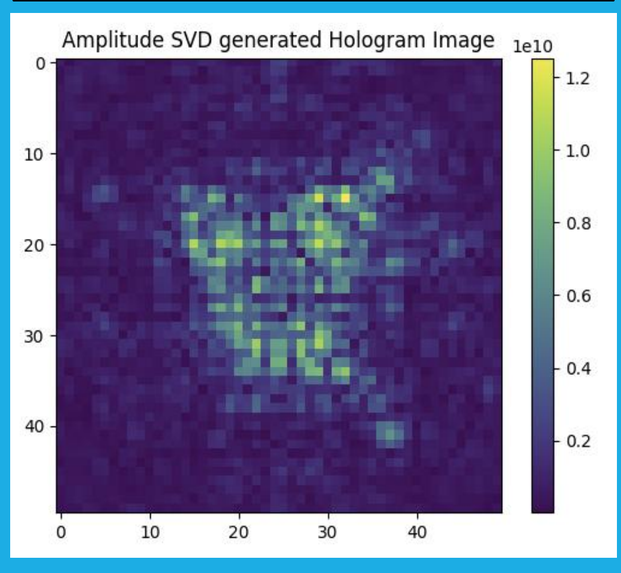
The Algorithm

1. Calculate propagation matrix.
   - This matrix relates input pixels to output pixels.
2. Decompose the matrix to make minimisation more efficient.
   - Used singular variable decomposition with a cutoff value of 0.001.
3. Calculate the cost of a certain set of phases.
   - Cost function measures the difference between a target image and the produced image with the phases and reduced propagation matrix.
4. Repeat step 3 with different phases until lowest cost image is found.
   - Uses L-BFGS algorithm.
5. Generate hologram image with given phases.

Target Image



Calculated Image



Results

- The minimisation suffered from long execution times and incomplete results as the algorithm was unable to converge onto a solution.
- The calculated image here shows the hologram generated with a non-scaling cost function.
  - Some features of the target image are there but the quality is poor.
- A cost function with a scaling factor was built but this also produced poor results.
- The optimisation algorithm could benefit from a better choice of starting variables. An appropriate choice of phase and scaling factor could allow for an early convergence.
- The cost function could also be another potential source of improvement.

Conclusion

Near-field CGH has the possibility to revolutionise AR and VR technology. Whilst this new approach to calculating holograms has failed to realize this, there is potential in these numerical methods to yield significant results. An improved choice of starting variables could result in significant improvement.

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