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Adaptive-additive algorithm

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In the studies of [Fourier optics](#), [sound synthesis](#), [stellar interferometry](#), [optical tweezers](#), and diffractive optical elements (DOEs) it is often important to know the [spatial frequency](#) phase of an observed wave source. In order to reconstruct this [phase](#) the **Adaptive-Additive Algorithm** (or **AA algorithm**), which derives from a group of adaptive (input-output) algorithms, can be used. The AA algorithm is an [iterative algorithm](#) that utilizes the [Fourier Transform](#) to calculate an unknown part of a propagating wave, normally the [spatial frequency phase](#) (*k* space). This can be done when given the phase's known counterparts, usually an observed [amplitude](#) (position space) and an assumed starting [amplitude](#) (*k* space). To find the correct [phase](#) the [algorithm](#) uses error conversion, or the error between the desired and the theoretical [intensities](#). The AA algorithm is currently being implemented by Dr. Wendell Hill III, Alex Robel, V. Kotlyar Soifer, and [David G. Grier](#).

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The algorithm [\[edit\]](#)

History [\[edit\]](#)

The adaptive-additive algorithm was originally created to reconstruct the [spatial frequency phase](#) of light intensity in the study of stellar [interferometry](#). Since then, the AA algorithm has been adapted to work in the fields of [Fourier Optics](#) by Soifer and Dr. Hill, [soft matter](#) and [optical tweezers](#) by Dr. Grier, and [sound synthesis](#) by Robel.

Pseudo-code algorithm [\[edit\]](#)

1. Define input amplitude and random phase
2. Forward Fourier Transform
3. Separate transformed amplitude and phase
4. Compare transformed amplitude/intensity to desired output amplitude/intensity
5. Check convergence conditions
6. Mix transformed amplitude with desired output amplitude and combine with transformed phase
7. Inverse Fourier Transform
8. Separate new amplitude and new phase
9. Combine new phase with original input amplitude
10. Loop back to Forward Fourier Transform

Example [\[edit\]](#)

For the problem of reconstructing the [spatial frequency](#) phase (*k*-space) for a desired [intensity](#) in the image plane (*x*-space). Assume the [amplitude](#) and the starting phase of the wave in *k*-space is A_0 and ϕ_n^k respectively. [Fourier transform](#) the wave in *k*-space to *x* space.

$$A_0 e^{i\phi_n^k} \xrightarrow{FFT} A_n^f e^{i\phi_n^f}$$

Then compare the transformed [intensity](#) I_n^f with the desired intensity I_0^f , where

$$I_n^f = \left(A_n^f\right)^2,$$

$$\varepsilon = \sqrt{\left(I_n^f\right)^2 - \left(I_0\right)^2}.$$

Check ε against the convergence requirements. If the requirements are not met then mix the transformed amplitude A_n^f with desired amplitude A^f .

$$\bar{A}_n^f = \left[a A^f + (1 - a) A_n^f \right],$$

where a is mixing ratio and

$$A^f = \sqrt{I_0}.$$

Note that a is a percentage, defined on the interval $0 \leq a \leq 1$.

Combine mixed amplitude with the x-space phase and [inverse Fourier transform](#).

$$\bar{A}_n^f e^{i\phi_n^f} \xrightarrow{iFFT} \bar{A}_n^k e^{i\phi_n^k}.$$

Separate \bar{A}_n^k and ϕ_n^k and combine A_0 with ϕ_n^k . Increase loop by one $n \rightarrow n + 1$ and repeat.

Limits [\[edit\]](#)

- If $a = 1$ then the AA algorithm becomes the [Gerchberg–Saxton algorithm](#).
- If $a = 0$ then $\bar{A}_n^k = A_0$.

See also [\[edit\]](#)

- [Gerchberg–Saxton algorithm](#)
- [Fourier optics](#)
- [Holography](#)
- [Interferometry](#)
- [Sound Synthesis](#)

References [\[edit\]](#)

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- Röbel, Axel, *Adaptive Additive Modeling With Continuous Parameter Trajectories* [↗](#).
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- Soifer, V. Kotlyar; Doskolovich,, L. (1997), *Iterative Methods for Diffractive Optical Elements Computation*, Bristol, PA: Taylor & Francis, ISBN 978-0-7484-0634-0

External links [\[edit\]](#)

- A PDF/Power Point Presentation that describes the uses and variations of the AA algorithm [↗](#) *Berkeley, Ca.*
- [David Grier's Lab](#) [↗](#) Presentation on optical tweezers and fabrication of AA algorithm.
- [Adaptive Additive Synthesis for Non Stationary Sound](#) [↗](#) Dr. Axel Robel.
- [Hill Labs](#) [↗](#) *University of Maryland College Park.*

Categories: [Digital signal processing](#) | [Physical optics](#)

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