

# Adaptive Wavefront Correction Algorithms for Enhancing Transmission Efficiency in Atmospheric Optical Communication Links

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## INTRODUCTION & AIM

Atmospheric optical communication links are promising for high-capacity free-space transmission and quantum communication systems.

The main limitation is wavefront distortion caused by turbulence and scattering: the focal spot becomes wider and less energy passes through the receiving aperture.

Aim: experimentally evaluate adaptive wavefront correction algorithms that maximize transmitted optical power through small apertures using feedback control.

### Problem

Atmospheric distortions reduce peak intensity and increase aperture losses at the receiver.

### Approach

A bimorph deformable mirror reshapes the wavefront, while a photodiode signal is used as the optimization merit function.

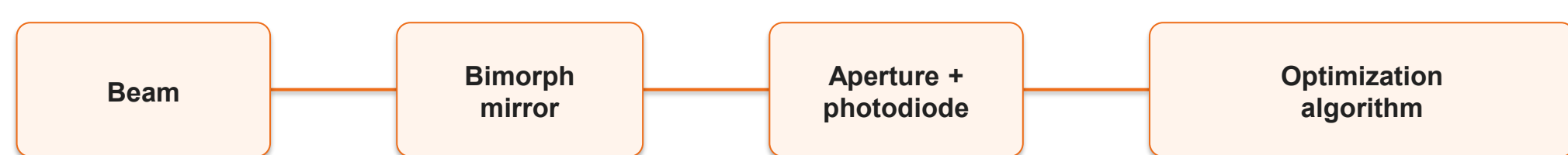


Key words: free-space optical communication; adaptive optics; wavefront correction; deformable mirror; hill-climbing; stochastic optimization.

## METHOD

### Experimental setup

- Laser beam diameter: 45 mm.
- Receiving apertures: 20  $\mu\text{m}$  and 10  $\mu\text{m}$ .
- Photodiode current after the aperture was used as a merit function proportional to transmitted energy.
- The control element was a bimorph deformable mirror driven by feedback from the photodiode signal.



### Algorithms compared

1. Deterministic hill-climbing: sequentially changes mirror electrode voltages and keeps the direction that improves the merit function.
2. Stochastic Bernoulli control: applies random perturbations to accelerate convergence and estimates a better control vector from feedback.

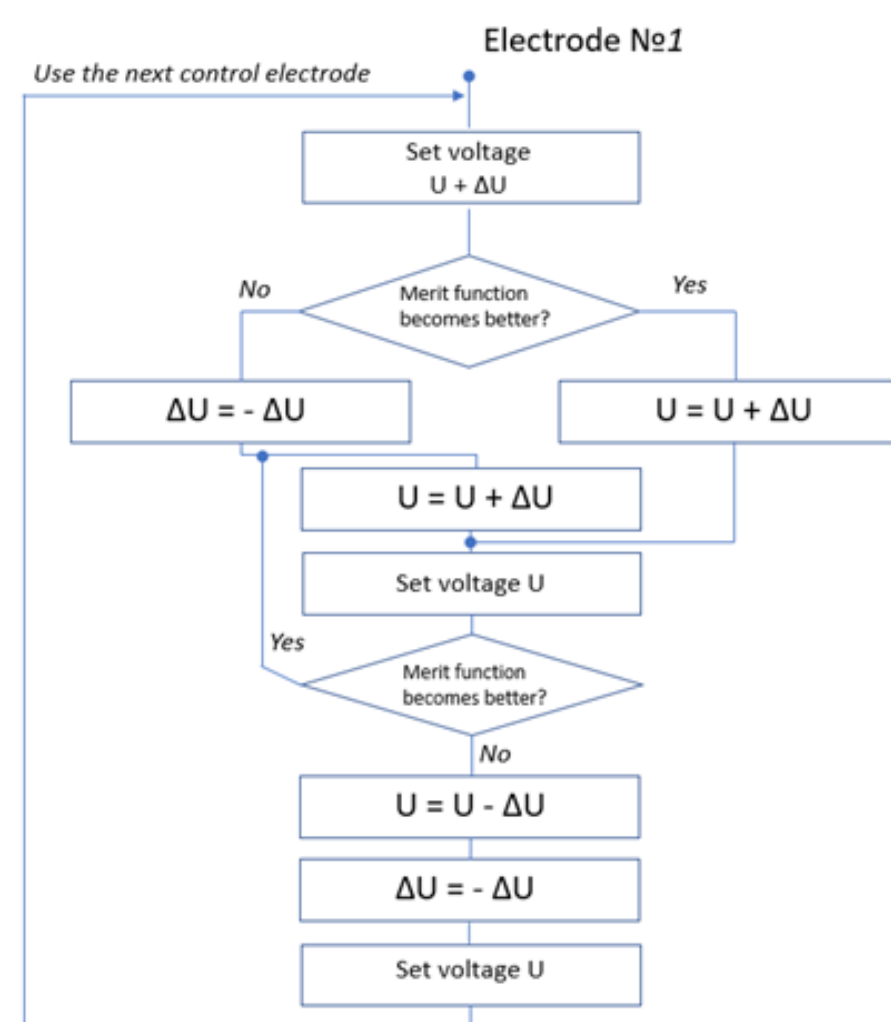


Fig. 1. Hill-climbing algorithm flow chart.

## RESULTS & DISCUSSION

94%  
energy through  
20  $\mu\text{m}$  aperture

90%  
energy through  
10  $\mu\text{m}$  aperture

10 s  
stochastic  
optimization

8 min  
hill-climbing  
optimization