Wavefront Control in Optical Receiver Systems

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Intelligent Optics Lab

PROBLEMS OF INTRESEST

- Optical wave propagation through atmosphere
- Adaptive beam control

RESEASRCH ISSUES

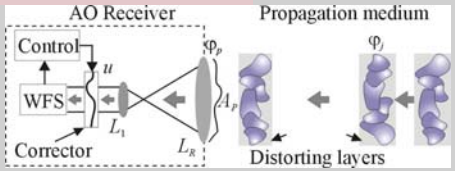
- System architecture
- Control algorithms
- Numerical models
- System performance: resolution, efficiency, field-of-view, …

APPLICATIONS

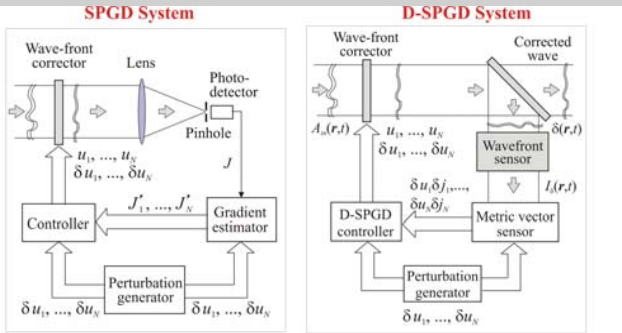
- Directed energy
- Laser communication
- Astronomy
- Atmospheric and underwater imaging

APPROACH

- Analytical analysis
- Numerical simulations
- Experimental study



CONTROL ALGORITHMS



SPGD Controller

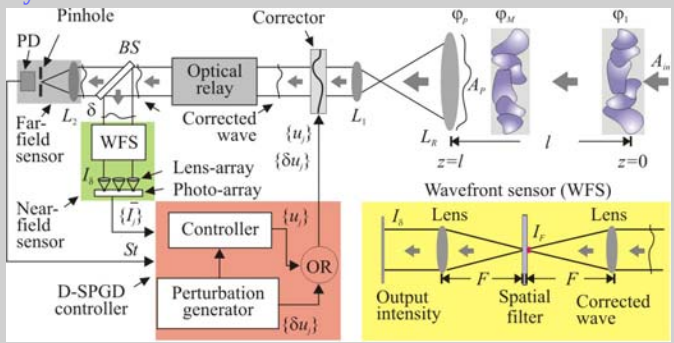
$$u_j^{(n+1)} = u_j^{(n)} - \gamma\, \delta J^{(n)} \delta u_j$$

D- SPGD Controller

$$u_j^{(n+1)} = u_j^{(n)} - \gamma c_j \delta I_{out}^{(n)} \delta u_j$$

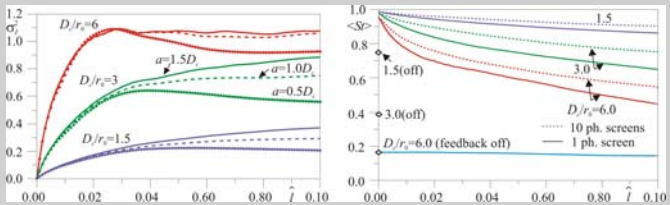
NARROW FIELD-OF-VIEW ADAPTIVE RECEIVER SYSTEM

System Architecture



Representative Results

- Impact of intensity scintillation

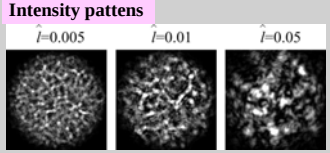


$$\sigma_I^2 = \frac{1}{S}\int_{S_c} \sigma_1^2(\mathbf{r})\, d^2\mathbf{r},$$

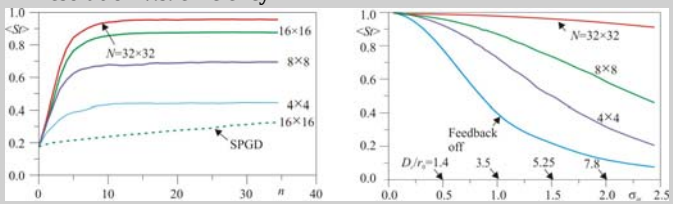
$$\sigma_1^2(\mathbf{r}) = \langle I^2(\mathbf{r})\rangle / \langle I(\mathbf{r})\rangle^2 - 1$$

$$\hat{l} = l / l_d \ , \text{ where } l_d = 0.5ka^2$$

Intensity pattens



- Resolution v.s. efficiency



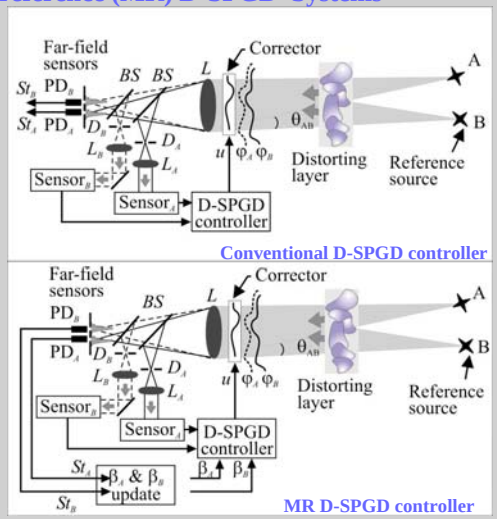
Interference patterns of residual phase after 40 iterations

$$\sigma_r^2 = \frac{1}{M}\sum_{j=1}^{M} \sigma_j^2$$

$$\sigma_j^2 = S^{-1}\int_{S_c} \sigma_j^2(\mathbf{r})\, d^2\mathbf{r},$$

EXTENDED FIELD-OF-VIEW ADAPTIVE RECEIVER SYSTEM

Multi-reference (MR) D-SPGD Systems



MR D-SPGD controller

$$u_j^{(n+1)} = u_j^{(n)} + \alpha_A \bar{L}_j^{A(n)} + \alpha_B \bar{L}_j^{B(n)} - u_j^{(n)}, \ (j=1, \ldots, N).$$

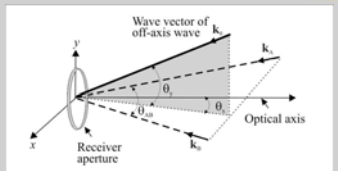
$$\alpha_A^{(n)} = \frac{St_B^{(n)}}{St_A^{(n)} + St_B^{(n)}} \qquad \alpha_B^{(n)} = \frac{St_A^{(n)}}{St_A^{(n)} + St_B^{(n)}}$$

Representative Results

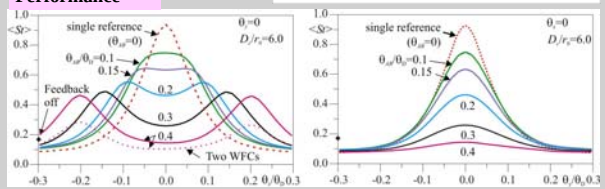
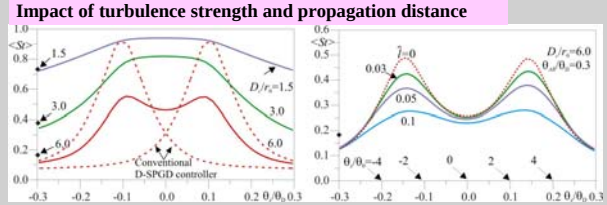
- Two-reference system

$\bar{D} = D_c / l$

$\bar{\theta}_0$: isoplanatic angle



Performance



Impact of turbulence strength and propagation distance