Objectives
- The Intelligent Optics Laboratory is developing low-power, compact, free-space laser communication systems for real-time high-resolution video transmission.
- These systems must actively mitigate wavefront phase distortion due to atmospheric turbulence over near ground 2 to 5 mile propagation paths.
- To accomplish this, it is essential to develop VLSI controllers that control wavefront correctors such as liquid crystal spatial light modulators, MEMS mirrors and bi-morph piezoceramic mirrors and VLSI sensors that can measure laser beam position and laser beam “quality” in real-time.

Advantages
- can deal with distributed objects (anisoplanatic conditions)
- turbulence can occur over the entire propagation path
- control method is independent of the number of control channels
- accommodates wavefront correctors of all types
- computationally simple

Adaptive Optics VLSI Controller: Metric Optimization by Stochastic Parallel Gradient Descent

Conventional Adaptive Optics Systems
- Model-based approach works well for a point source such as a distant star, but not for distributed objects at “closer” range.
- Measure intensity with a Shack-Hartmann sensor and then reconstruct phase using least-squares or SVD techniques (computationally intensive).

Enormous convergence speedup can be achieved by tailoring the perturbation statistics to match the statistics of the atmospheric turbulence.

Principal of Operation
- The metric should be task-specific:
  - for this particular laser communication task, we need real-time measurements of:
    - Beam centroid location for wavefront tilt/tilt control
    - Beam intensity profile for wavefront focus control
- To this end, we have designed a special purpose imaging and tracking sensor with an optical window in its center. Beam Profile Metric sensor outputs are:
  - Beam centroid location \( \{X_c, Y_c\} \) at 10KHz
  - A 128 by 128 pixel image at a refresh rate of 30 frames/sec.