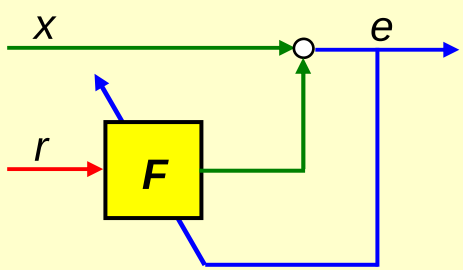
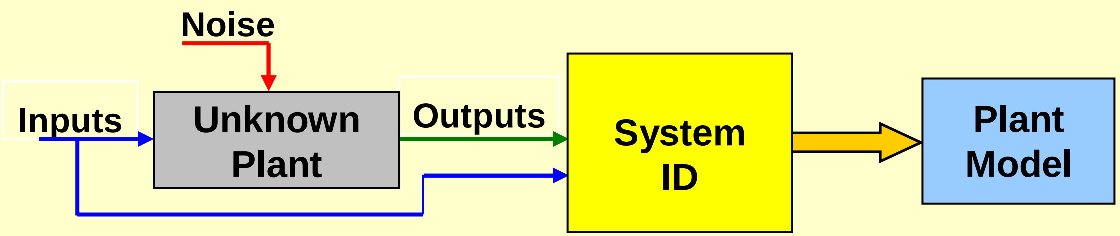
Steve Gibson, Mechanical and Aerospace Engineering, UCLA

gibson@ucla.edu

ADAPTIVE FILTERING

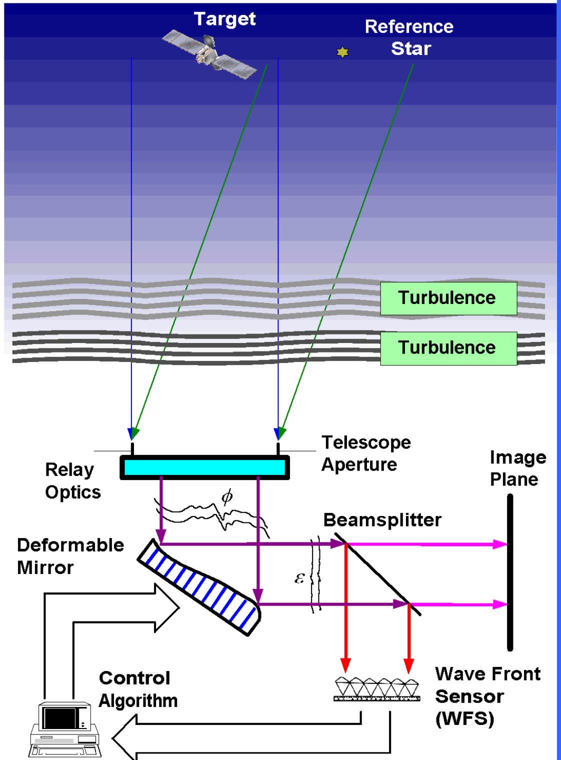


SYSTEM IDENTIFICATION

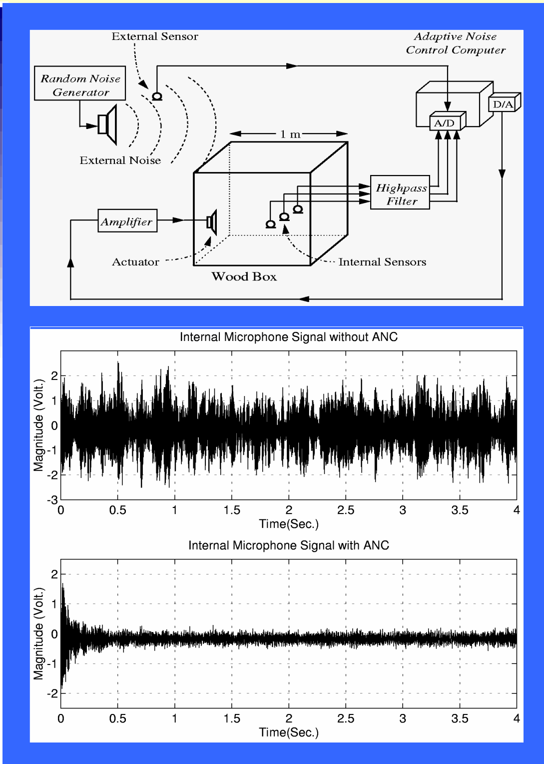


UCLA Algorithms: Multichannel Adaptive Lattice Filters

ADAPTIVE OPTICS



ADAPTIVE NOISE CONTROL



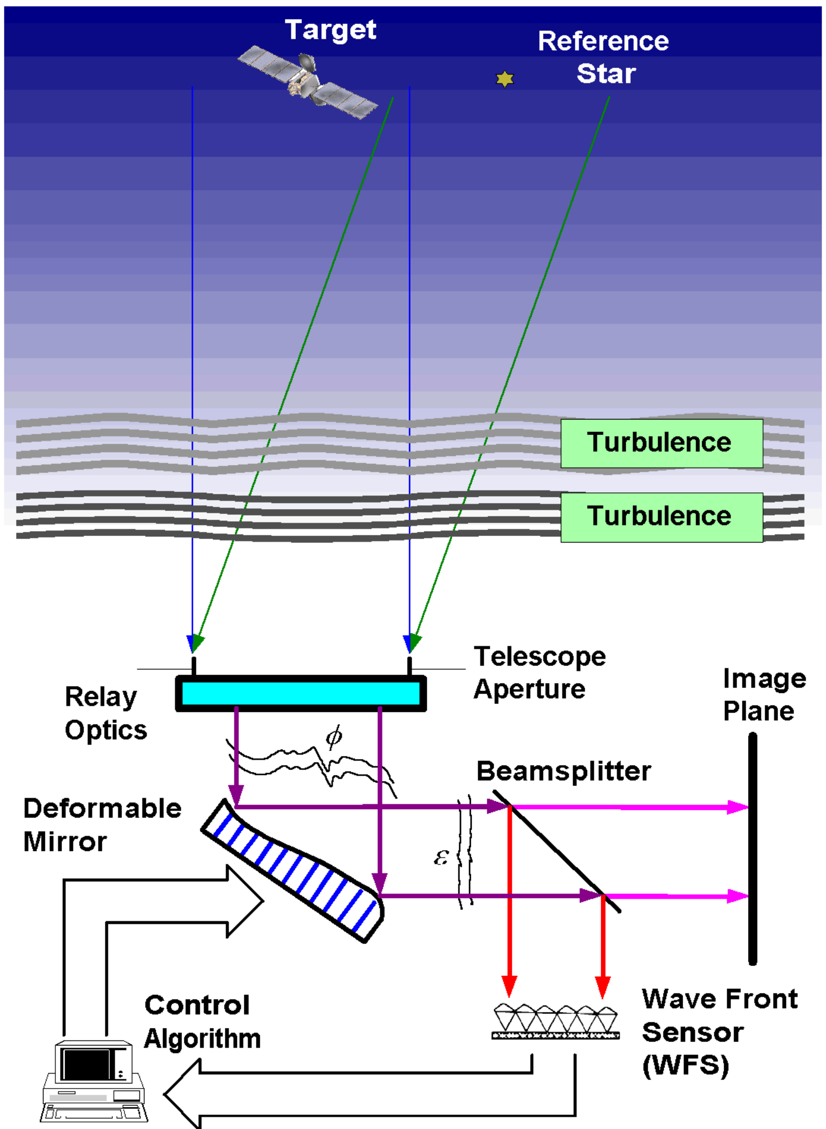
APPLICATIONS

- Adaptive Optics
- Identification and Control of Flexible Structures
- Identification and Control of MEMS Sensors
- Adaptive Control of Noise and Vibration
- Adaptive Channel Identification and Deconvolution

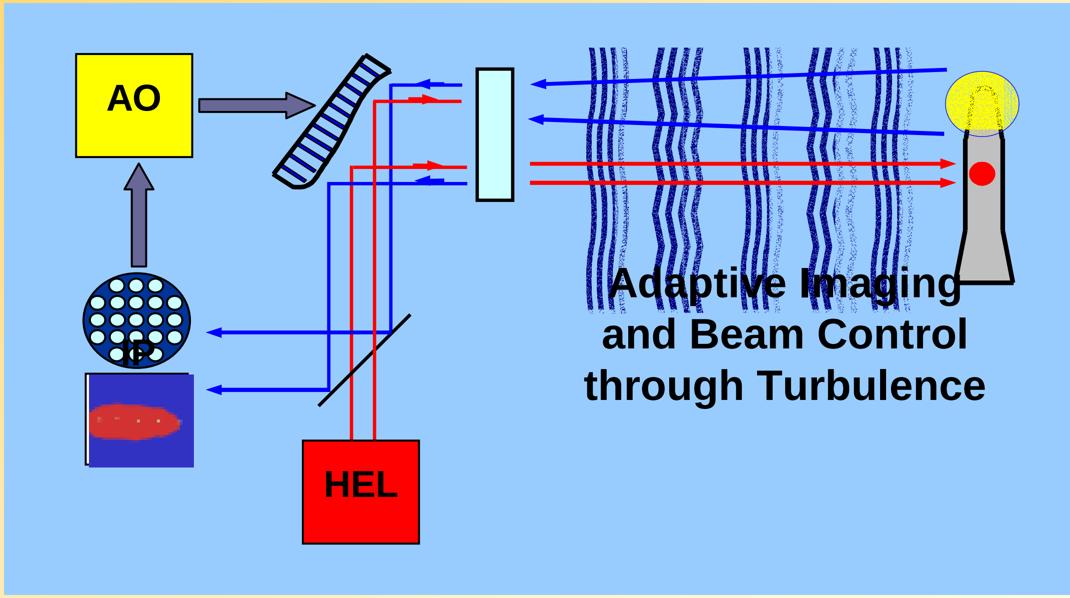
ADAPTIVE OPTICS

Steve Gibson
Chi-Chao Chang, Neil Chen, Yu-Tai Liu

Astronomy



Directed Energy Weapons

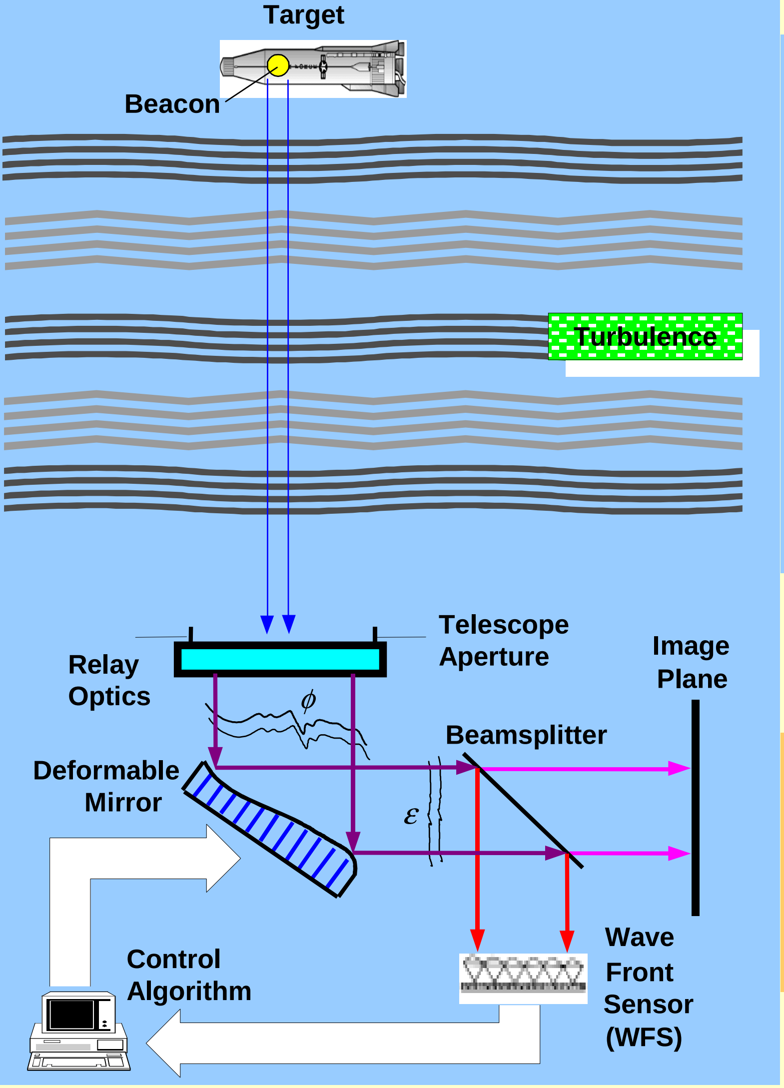


New MRI (JTO, AFOSR)

Atmospheric Propagation of High Energy Lasers: Modeling, Simulation, Tracking, and Control

UCLA, Michigan Tech, Georgia Tech

Tempest Technologies, Mission Research Corp., Trex Enterprises



Current practice in "adaptive" optics:

<u>Non-adaptive</u> feedback loop

Result of this research:

<u>Truly adaptive</u> control loop based on Multichannel Lattice Filter

Control Objective:

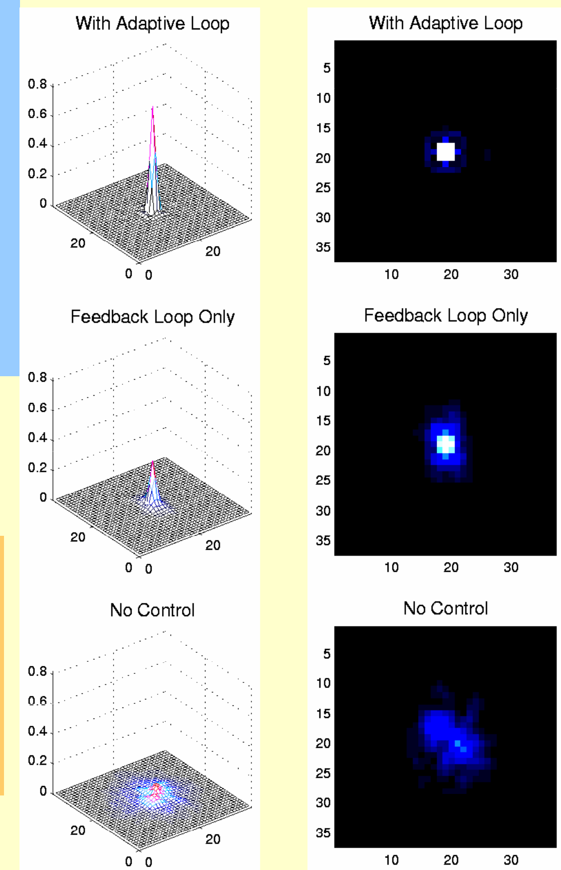
Minimize variance of WFS vector

Optics Objective:

Maximize Strehl Ratio

Point Spread Function (Image of Beacon)

Intensities **Images**



Strehl Ratios

Strehl Ratio = Peak Intensity of Point Spread Function (PSF)

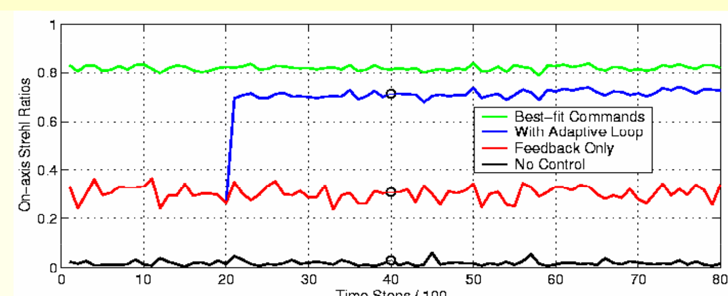
PSF = Image of Beacon = Impulse Response of Optical Transfer Function

Green: achievable with perfect, instantaneous information

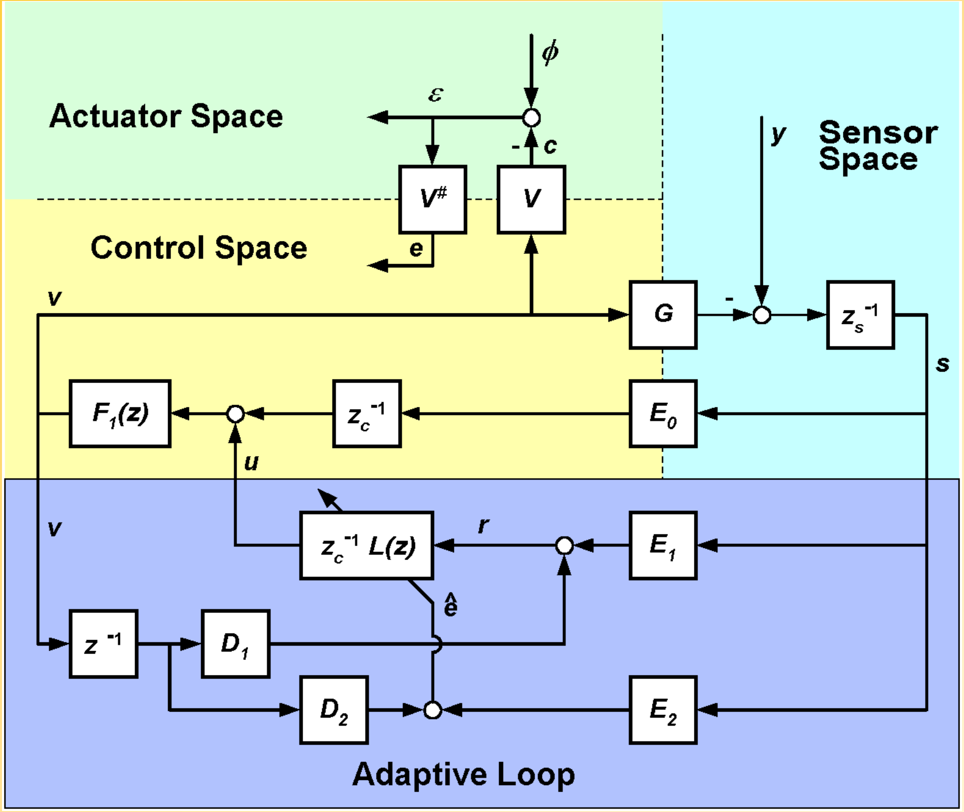
Blue: adaptive loop closed at $t = 2000$

Red: feedback loop only

Black: no control



Block Diagram for Adaptive Optics



REFERENCES

J. S. Gibson, C.-C. Chang, and B. L. Ellerbroek, "Adaptive Optics: Wavefront Correction by Use of Adaptive Filtering and Control," *Applied Optics, Optical Technology and Biomedical Optics*, Vol. 39, No. 16, June 2000, pp. 2525–2538.

C.-C. Chang and J. S. Gibson, "Parallel Control Loops Based on Spatial Subband Processing for Adaptive Optics," American Control Conference, (Chicago, Illinois), June 2000.

J. S. Gibson, C.-C. Chang, and Neil Chen, "Adaptive Optics with a New Modal Decomposition of Actuator and Sensor Spaces," American Control Conference, (Arlington, VA), June 2001.

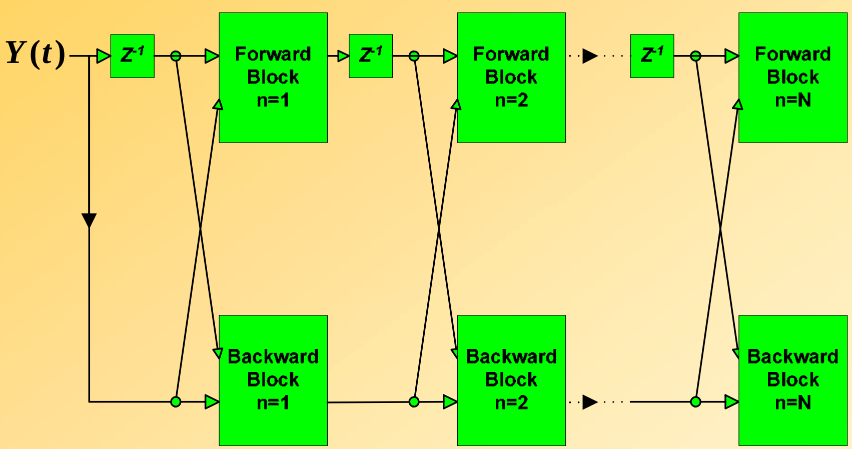
A New Subspace Algorithm for System Identification

Using An Unwindowed (RLS) Multichannel Lattice Filter

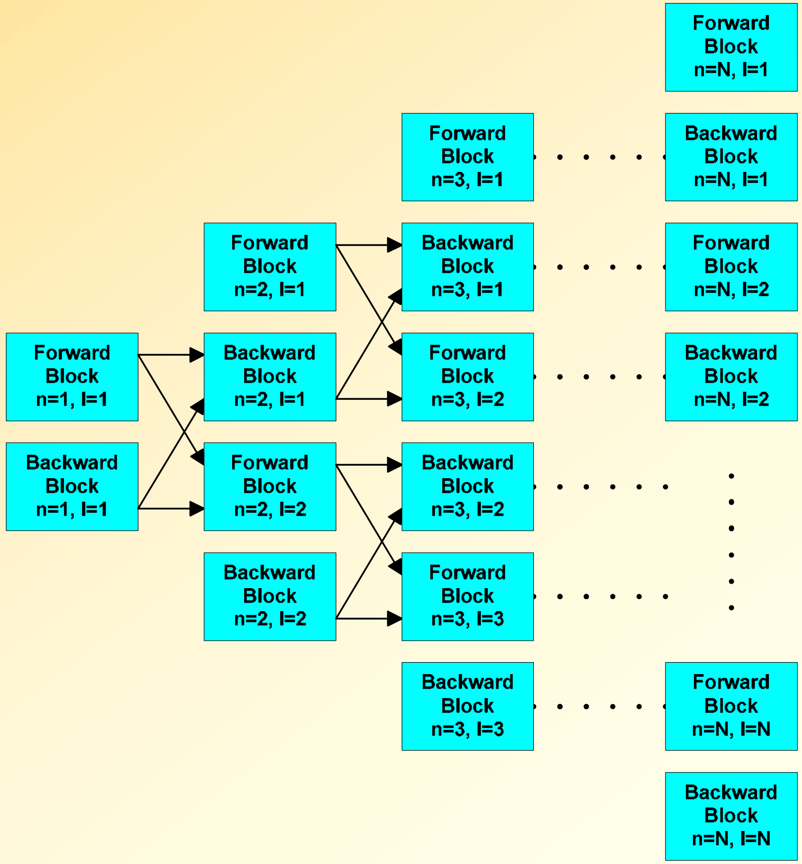
with Orthogonal Channels

(Neil Chen, Steve Gibson)

Residual Lattice Filter



Model-parameter Algorithm



Subspace methods have become the leading class of methods for identifying dynamical systems from noisy input/output data. Subspace system identification methods have two basic steps: identification of a Hankel matrix by least-squares projection of future output data onto past input and output data, and construction of a state-space realization from a singular-value decomposition of the Hankel matrix. To eliminate estimation biases due to broad-band noise in the input/output data, a subspace algorithm must use high-order prediction models and large numbers of data points for identification of the Hankel matrix; the least-squares projection is thus the most computationally intensive part of the algorithm. Recent research at UCLA has produced a new subspace algorithm in which the least-squares projection of future data onto past data is performed by a multichannel least-squares lattice filter previously developed at UCLA. The fact that the adaptive lattice filter is the core computational engine of the algorithm means that system identification from data with high noise levels can be done adaptively; i.e., in real time.

References

N. Chen, "Subspace Methods in Adaptive Filtering and System Identification," Ph. D. dissertation, UCLA, 2001.

S.-B. Jiang and J. S. Gibson, "An Unwindowed Multichannel Lattice Filter with Orthogonal Channels," ***IEEE Transactions on Signal Processing*****, vol. 43, no. 12, pp. 2831–2842, December 1995.**

J. S. Gibson, G. H. Lee, and C.-F. W, "Least-Squares Estimation of Input/Output Models for Infinite-Dimensional Linear Systems in the Presence of Noise," ***Automatica*****, Vol. 36, No. 10, October 2000, pp. 1427–1442.**