



H2S

BHARATIYA ANTARIKSH HACKATHON 2026



Team Name : Developers.

Team Leader Name : Shivam Maurya

Problem Statement : Developing and optimizing algorithms for Wavefront reconstruction and turbulence characterization using Shack-Hartmann Wavefront Sensor (SH-WFS) time-series data.

Team Members

Team Leader:

Name: Shivam Maurya

College: Arya College Of Engineering

Team Member-1:

Name: Shreya Gupta

College: Arya College Of Engineering

Team Member-2:

Name: Suraj Kumar Tiwari

College: Arya College Of Engineering

Team Member-3:

Name: Santanu Dubey

College: Arya College Of Engineering

Opportunity should be able to explain the following:

How different is it from any of the other existing ideas?

- Hybrid **Physics + AI** based wavefront reconstruction.
- Predicts turbulence **before distortion occurs**.
- Faster than traditional Zernike/Fourier-only methods.
- Optimized for **real-time (<10 ms)** adaptive optics.

How will it be able to solve the problem?

- Detects SH-WFS spot centroids with high precision.
- Reconstructs accurate wavefront phase maps.
- Estimates **Fried Parameter (r_0)** and **Coherence Time (τ_0)**.
- Generates optimized **Deformable Mirror (DM)** actuator maps for real-time correction.

USP of the proposed solution

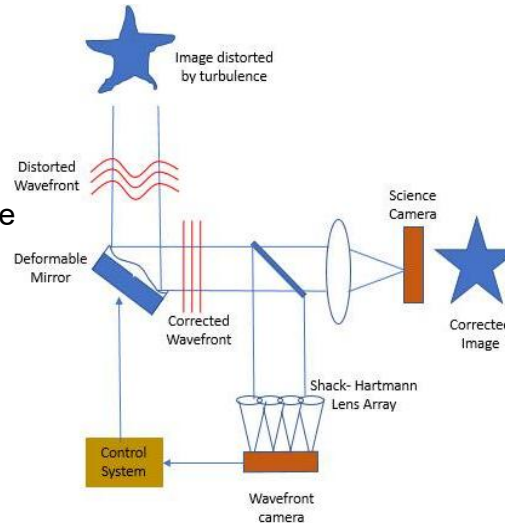
- Hybrid Physics + AI Framework
- Ultra-Low Latency Processing
- Predictive Turbulence Correction
- Real-Time DM Optimization
- Scalable for Future ISRO Adaptive Optics Systems

- ✓ **Physics + AI Hybrid Reconstruction**
- ✓ **Ultra-Fast Real-Time Processing (<10 ms)**
- ✓ **Predictive Turbulence Estimation**
- ✓ **Accurate Turbulence Characterization (r_0 , τ_0)**
- ✓ **Scalable for Future ISRO Adaptive Optics**

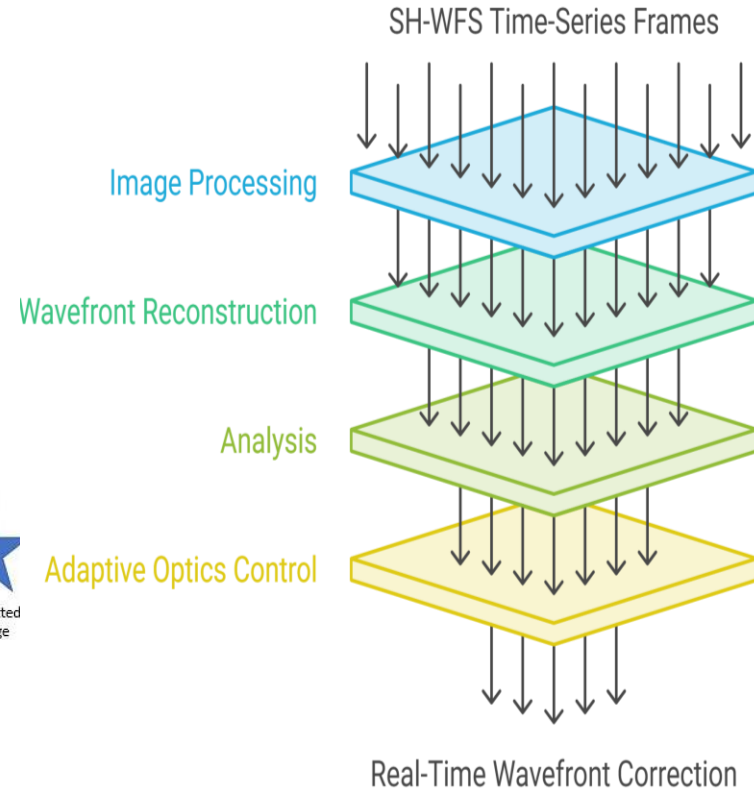
➤ Adaptive Optics Closed-Loop System:

The Adaptive Optics closed-loop continuously senses atmospheric distortions, reconstructs the wavefront, and applies corrective commands to the deformable mirror.

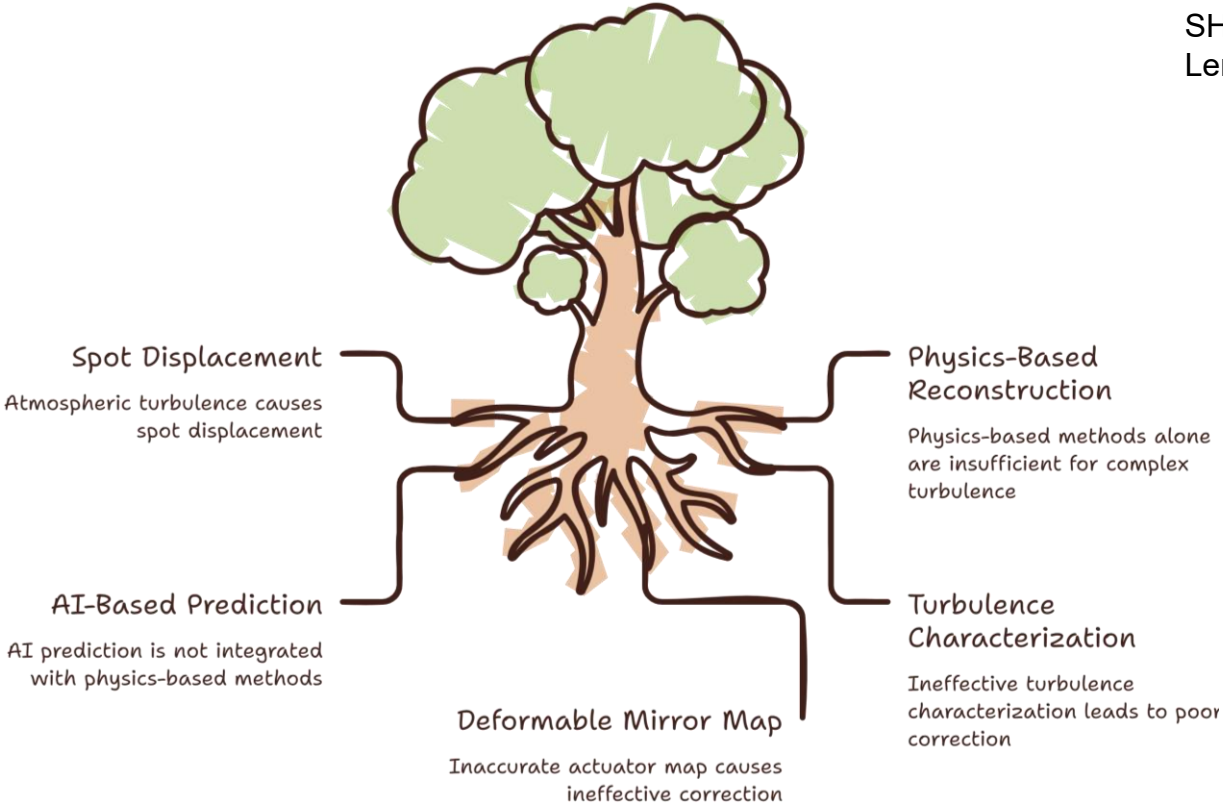
Our Hybrid Physics + AI approach strengthens this feedback loop with predictive turbulence estimation and faster real-time correction (<10 ms)



Hybrid Adaptive Optics System Process



Inefficient Wavefront Reconstruction due to Atmospheric Turbulence



Input

SH-WFS Frames
Lenslet & Camera Data

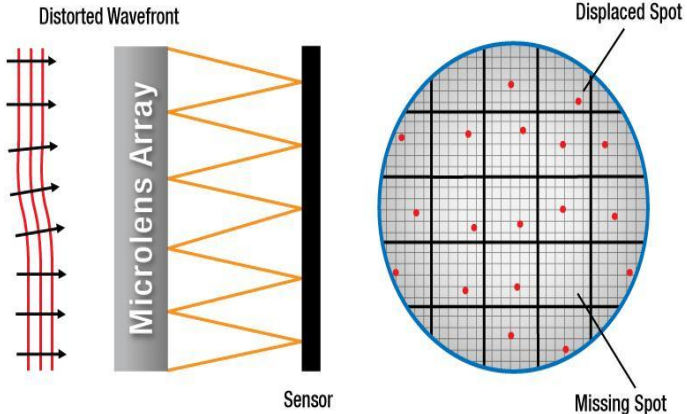
Processing

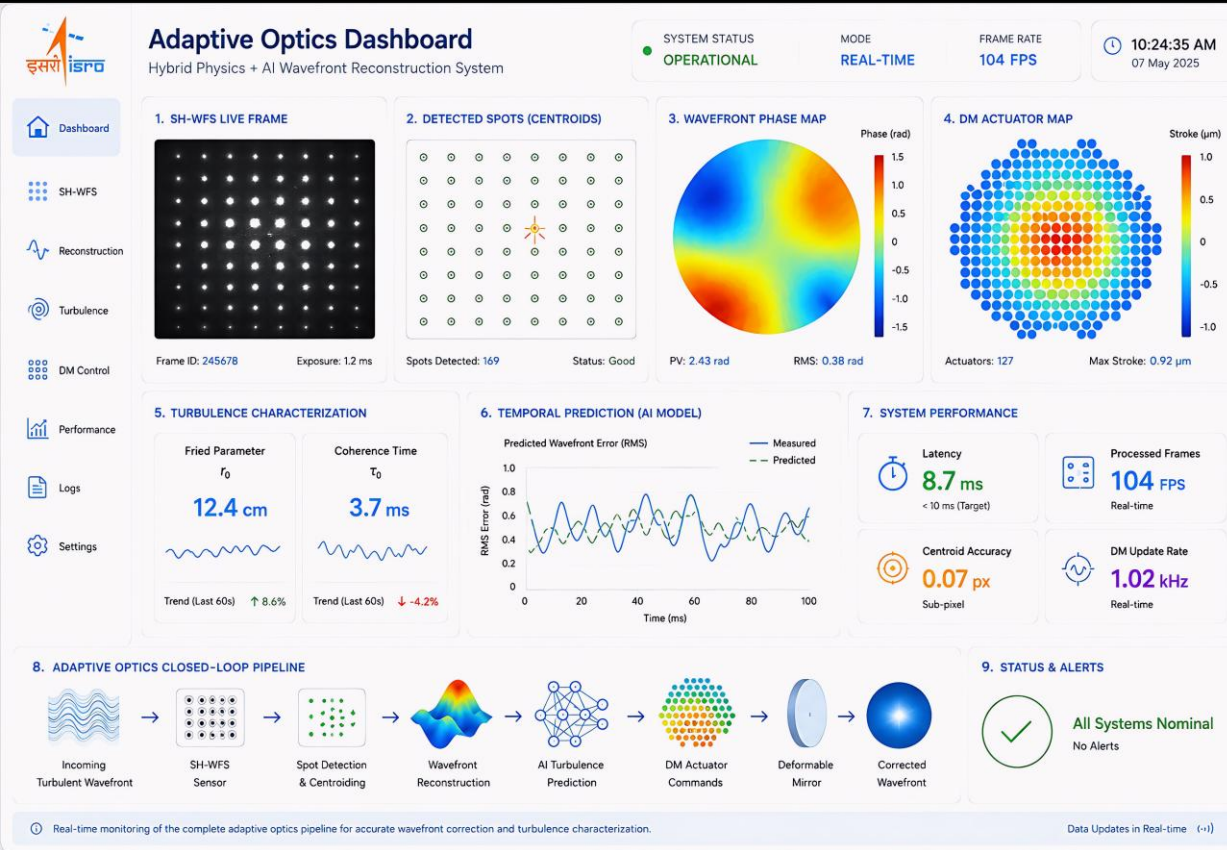
Spot Detection
Wavefront Reconstruction
AI Turbulence Prediction

Output

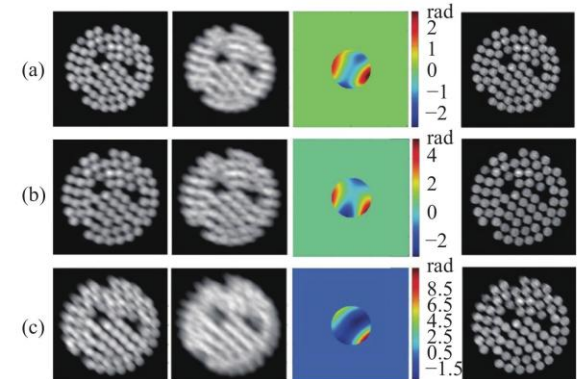
Wavefront Phase Map
 r_0 & τ_0 Estimation
DM Actuator Map

Shack-Hartmann Wavefront Sensor :





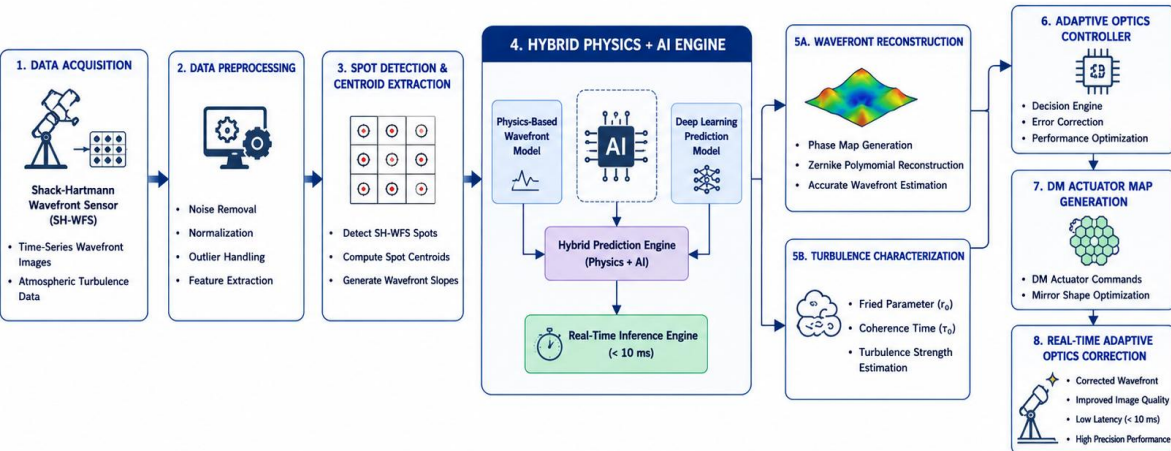
- ✓ Live SH-WFS Frame Analysis
- ✓ Real-Time Wavefront Reconstruction
- ✓ AI-Based Turbulence Prediction
- ✓ DM Actuator Monitoring
- ✓ <10 ms System Latency



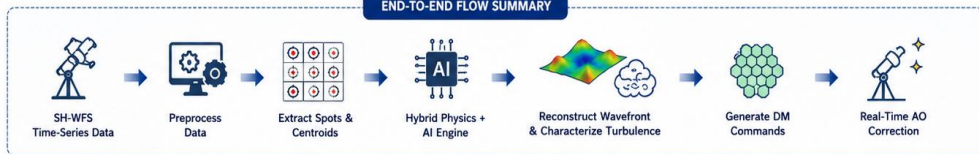
Designed for real-time monitoring, diagnostics, and adaptive optics control in next-generation ISRO imaging systems.

ARCHITECTURE DIAGRAM OF THE PROPOSED SOLUTION

Hybrid Physics + AI Framework for Wavefront Reconstruction and Turbulence Characterization



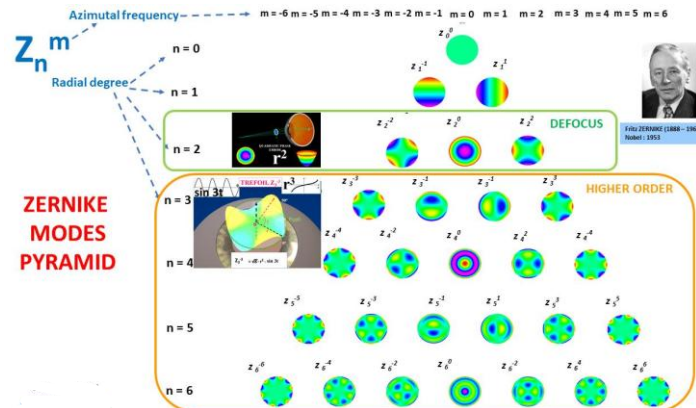
END-TO-END FLOW SUMMARY



LEGEND



Zernike Polynomial Modes :



✓ Orthogonal representation of wavefront aberrations.

✓ Converts SH-WFS data into Zernike coefficients.

✓ Enables accurate wavefront reconstruction.

✓ Supports real-time adaptive optics correction.

✓ Used to derive deformable mirror actuator commands.

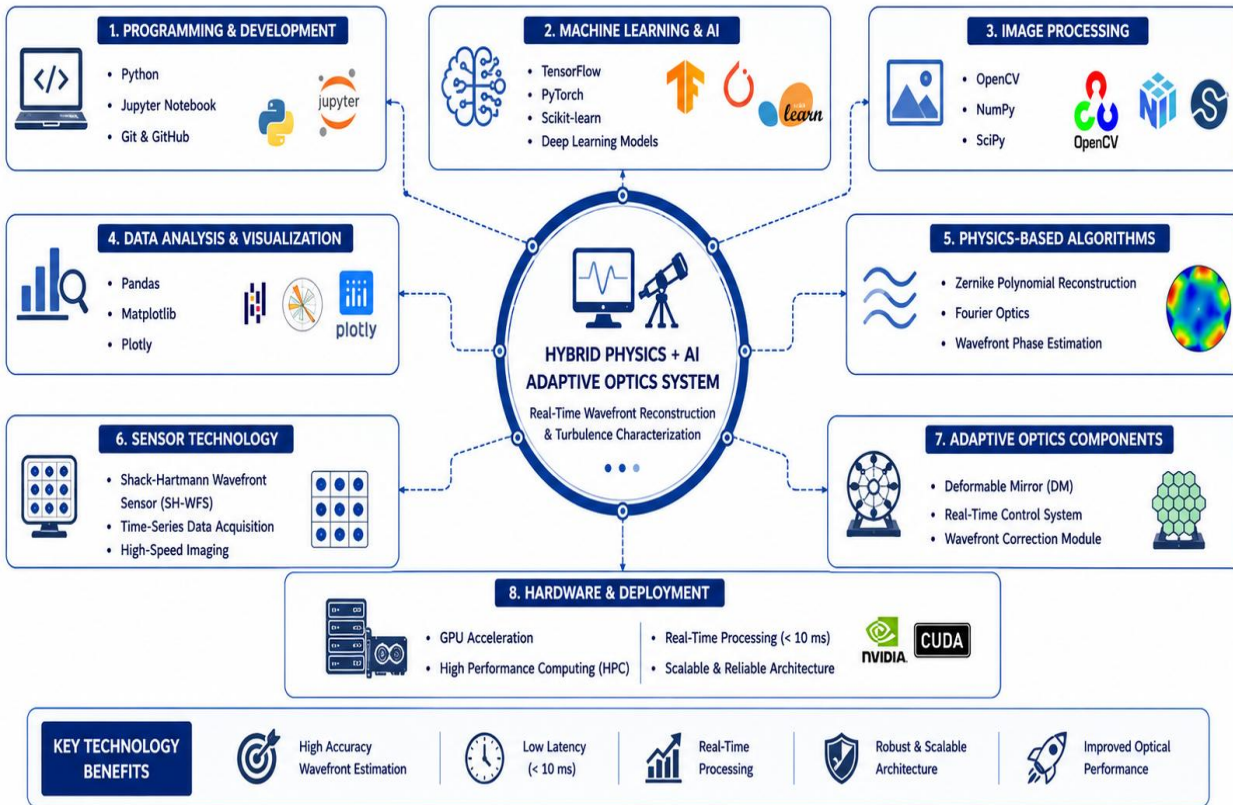
Technical Concepts :

- SH-WFS
- Wavefront Phase
- Zernike Modes

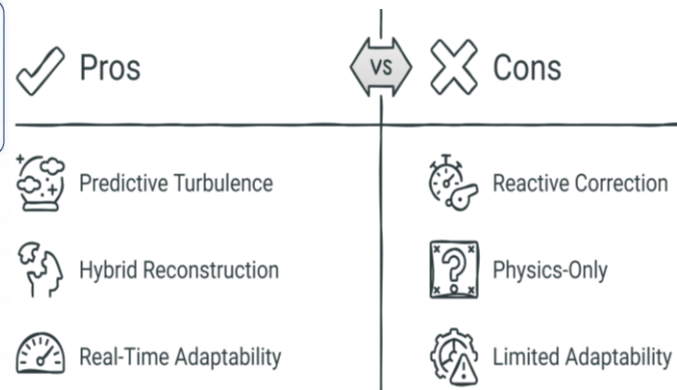
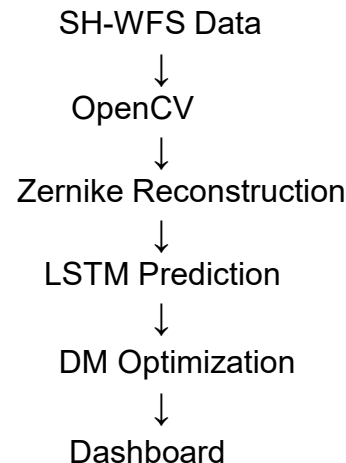
Fried Geometry
Fried Parameter (r_0)
Coherence Time (τ_0)

TECHNOLOGIES USED IN THE SOLUTION

Enabling Hybrid Physics + AI Based Adaptive Optics System



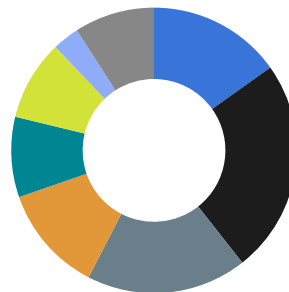
Development Workflow



Estimated Implementation Cost

Component	Estimated Cost (INR)	Justification (Resource)
SH-WFS Dataset Collection & Preprocessing	₹20,000	ISRO SAC / open AO datasets
High-Performance Computing (GPU/Cloud)	₹35,000	Google Cloud / AWS GPU pricing
AI Model Development & Training	₹25,000	Past project costing
Wavefront Reconstruction Algorithm Development	₹20,000	IEEE/SPIE research papers
Simulation & Testing (Python, OpenCV, MATLAB)	₹10,000	MathWorks academic pricing
Software Integration & Validation	₹15,000	Past project records
Documentation & Deployment	₹5,000	Internal estimate
Subtotal	₹1,30,000	—
Contingency (10%)	₹13,000	Standard hackathon practice
Total	₹1,43,000	—

Cost



- SH-WFS Dataset & Preprocessing
- GPU/Cloud
- AI Model
- Wavefront Algorithms
- Simulation & Testing
- Integration
- Documentation
- Contingency

Cost Optimization

- ✓ Open-source tools
- ✓ Public datasets
- ✓ Google Colab/Institution GPU
- ✓ Scalable architecture

Total Estimated Cost
≈ ₹1.30 Lakhs

BHARATIYA
ANTARIKSH
HACKATHON

2026

THANK YOU