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ASTRAPAT-VT

AI-Assisted Virtual Testbench for Predictive Acquisition & Tracking

Predict. Point. Lock. Recover.

Problem Statement ID	**26169**
Problem Statement Title	Development of an AI-Based Virtual Camera Tracking System for Coarse Alignment of Mobile FSOC Terminals
Theme	**Smart Automation**
PS Category	**Software**
Organization	**ISRO / Department of Space**
Team ID / Team Name	ZIH020/ Coders Hub



Core Idea: 3D Panda3D FSOC/PAT testbench for virtual camera tracking, predictive lock recovery and benchmarked telemetry.

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IDEA TITLE: ASTRAPAT-VT

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PROPOSED SOLUTION

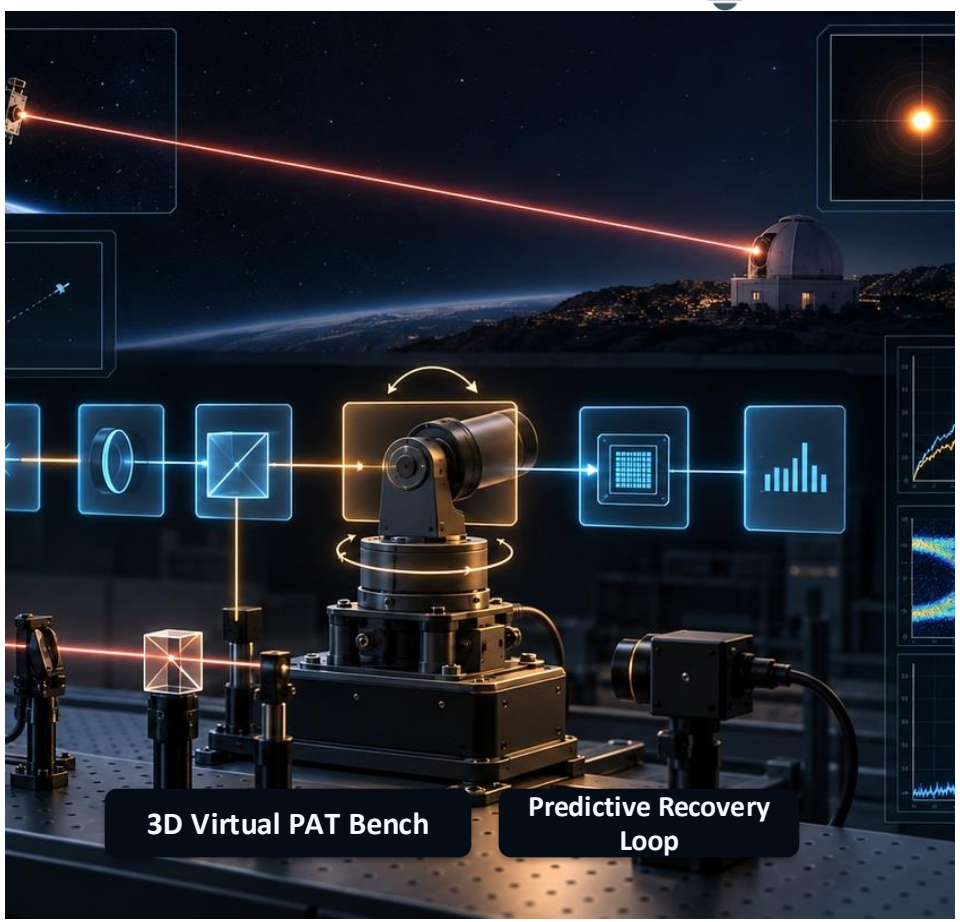
A 3D software-defined FSOC/PAT virtual testbench that simulates moving optical terminals, platform dynamics, virtual camera/gimbal geometry, sensor disturbances and autonomous coarse-alignment algorithms.

HOW IT ADDRESSES THE PS

Panda3D 3D world with moving optical beacon/terminal
Dual views: observer world + tracking sensor feed
AI/CV beacon detection and target verification
Real-time pan-tilt camera repositioning for coarse alignment
Disturbance injection: vibration, noise, blur, occlusion, frame drop
Live statistics: error, latency, FPS, lock quality and reacquisition time

UNIQUE VALUE

Predictive Lock Recovery: target lost -> predict -> local search -> reacquire -> locked
Benchmark Arena: same scenario, same random seed, algorithm-to-algorithm comparison
Ground-truth logging turns the prototype into a PAT research/training platform
Panda3D simulation keeps geometry and sensor view technically meaningful



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TECHNICAL APPROACH

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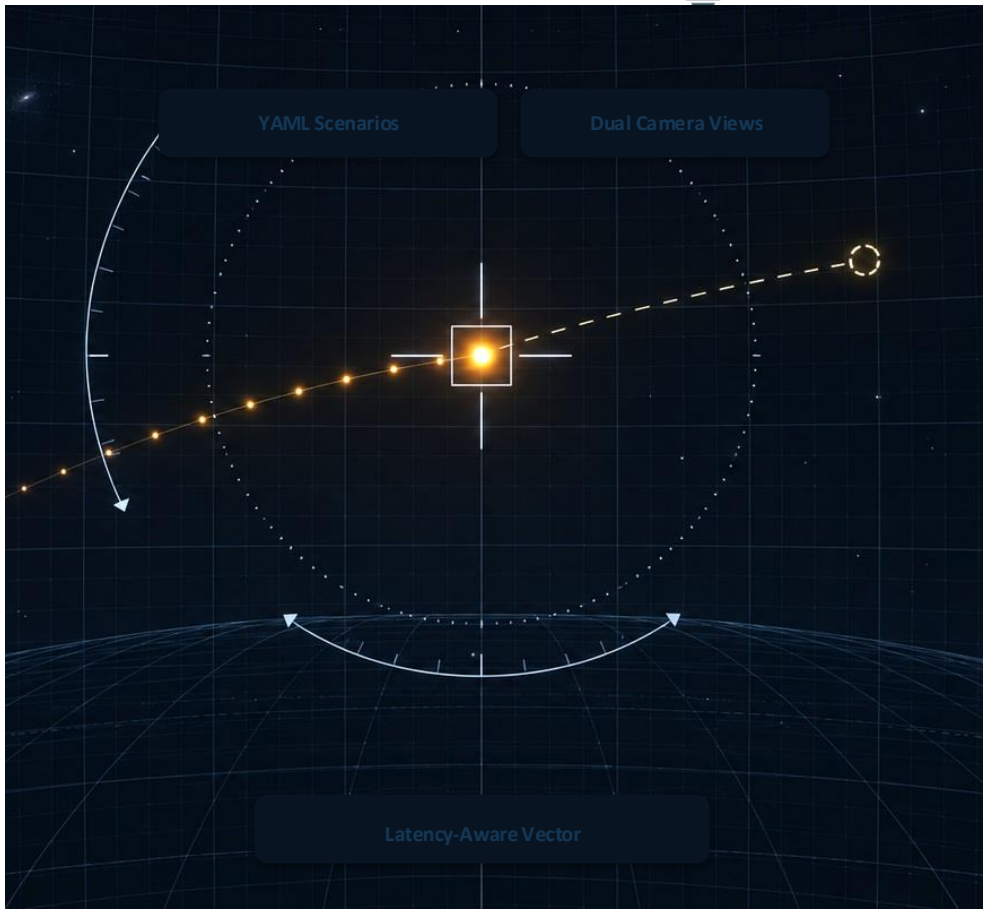
METHODOLOGY: 3D CLOSED-LOOP PAT SIMULATION

Panda3D 3D World → Dual Camera Views → Disturbance Engine → OpenCV Detector → AI Beacon Verifier → Kalman / TCN Predictor → Camera Pose Update → Pan/Tilt Motion → PID Gimbal Control → Tracking Manager → Metrics + Logger

Key working flow: Panda3D renders a true 3D world and sensor-camera feed; each frame is disturbed, detected, verified, predicted, corrected by gimbal PID and logged for objective performance analytics.



TECHNOLOGIES TO BE USED

Python 3.12	Panda3D 3D Sim	OpenCV + NumPy	Kalman + PID
PyTorch + ONNX	PySide6 + Graphs	SQLite + CSV/JSON	

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FEASIBILITY AND VIABILITY

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BUILD STRATEGY

MVP

2D reference simulator completed
Panda3D 3D world + dual camera
Sensor feed + OpenCV detection
Closed-loop gimbal tracking

ADVANCED

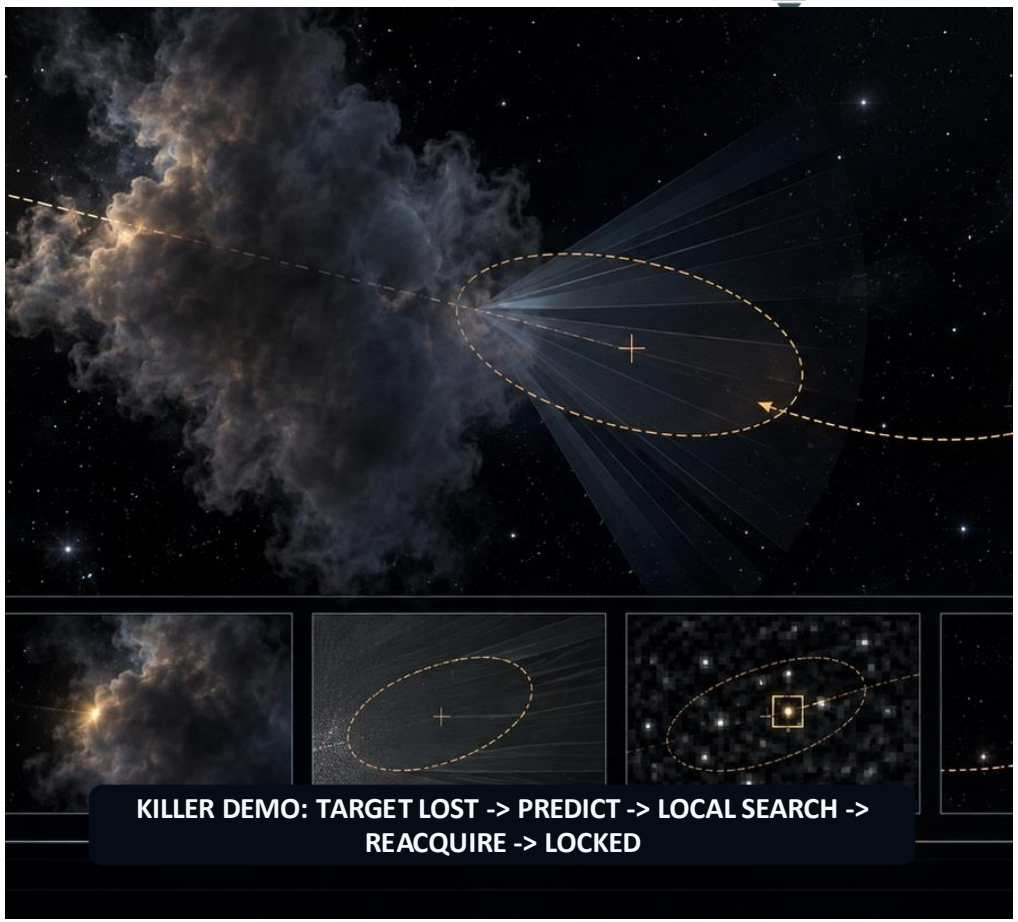
Platform jitter + sensor noise/blur
Kalman latency-aware prediction
AI beacon verifier fallback-safe
Target-loss recovery state machine

FINAL

Mission Control dashboard
Benchmark Arena + Scenario Lab
Synthetic dataset generator
SQLite/CSV/JSON run export

RISKS AND MITIGATION

Panda3D + tracking integration	Single Python pipeline; freeze sensor frame API first
Over-claiming realism	Use source-backed parameters; label approximations clearly
Unstable AI model	Classical detector fallback; AI verifies only ambiguous candidates
Low FPS / demo failure	Offline app; seeded demo; reduce detector/AI frequency



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IMPACT AND BENEFITS

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OUTCOME: A practical 3D PAT research testbench that reduces early hardware iteration, but does not replace final hardware validation.

TARGET USERS

ISRO / aerospace PAT algorithm teams
Students and researchers learning FSOC coarse alignment
Engineers testing CV, prediction and control strategies before hardware trials

BENEFITS

Virtual-first cost reduction
Filters weak algorithms before camera + gimbal + optics + laser bench trials

Measurable R&D
RMSE, angular error, latency, lock retention and reacquisition logs

Repeatability
Same seed enables fair baseline vs predictive comparison

Education
Observer view + sensor view explain PAT clearly

Future Expansion
Real camera, gimbal and hardware-in-loop adapters

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RESEARCH AND REFERENCES

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RESEARCH BASIS

Narrow optical beams require precise Pointing, Acquisition and Tracking.
Coarse alignment keeps the terminal inside camera FOV before fine pointing.
3D simulation enables repeatable stress testing before costly hardware trials.
Hybrid CV + AI verification + prediction + PID is more defensible than a heavy detector alone.
All shown metrics are generated from actual prototype runs, not fabricated values.

REFERENCES / LINKS

Smart India Hackathon 2026 - PS 26169 official problem statement
NASA optical communications / laser pointing references
Research literature on mobile FSO Pointing, Acquisition and Tracking
Coarse-fine pointing and tracking architecture references
Panda3D documentation for Python-based 3D simulation

FUTURE WORK

Real USB/GigE sensor adapter
Physical gimbal / pan-tilt adapter
Hardware-in-loop mode
Fine-alignment simulator
Sim-to-real dataset tuning + domain adaptation
Higher-fidelity atmospheric optical propagation



FINAL CAPABILITY

Baseline vs Predictive Recovery Benchmark

Deliverables: Standalone App + Source Code + Technical Report + User Manual + Performance Logs