

LiRA-Align: A LIDAR-Based Real-Time Misalignment Detection System
for Fixed Radio Telescopes

Deemah Alshammari, Rahaf Almutairi, Sadeem Alyousef, Reem Alajraa, Rahaf AlQahtani, Arwa Aba Hussian, Jood Alhumaidi, Njood Alshalawi
Eng. Ibrahim Almohaisin
Department of Electrical Engineering, College of Engineering, Princess Nourah bint Abdulrahman University, P.O. Box 84428, Riyadh 11671, Saudi Arabia

Abstract

This project introduces LiRA-Align, a compact and cost-effective LIDAR-based system designed to detect structural misalignments in fixed radio telescopes. The system continuously monitors distance variations between key telescope points to identify mechanical shifts caused by environmental or structural factors. A simulation was conducted using MATLAB to model real-time misalignment under both ideal and noisy conditions. Results show that the system successfully detects deviations and triggers alerts when thresholds are exceeded. LiRA-Align offers a practical solution for educational observatories requiring reliable alignment monitoring without complex infrastructure.

Problem statement and Gap

Radio telescopes require precise alignment of structural components such as the feed and horn. Factors like wind, temperature, and mechanical wear can cause small but significant misalignments that degrade signal accuracy. Most traditional alignment systems depend on manual methods or low-precision sensors, lacking real-time response. This creates a critical gap for fixed educational telescopes that cannot afford advanced adjustment systems. LiRA-Align bridges this gap with a lightweight, real-time LIDAR-based solution.

System Methodology

The system simulates structural alignment monitoring using MATLAB. Time-series data is generated for telescope position with and without mechanical disturbance. Gaussian noise is added to represent real-world sensor behavior. A 1.5 mm threshold is defined for triggering alerts. The simulation tracks deviation, compares it against the baseline, and visualizes misalignment over time.

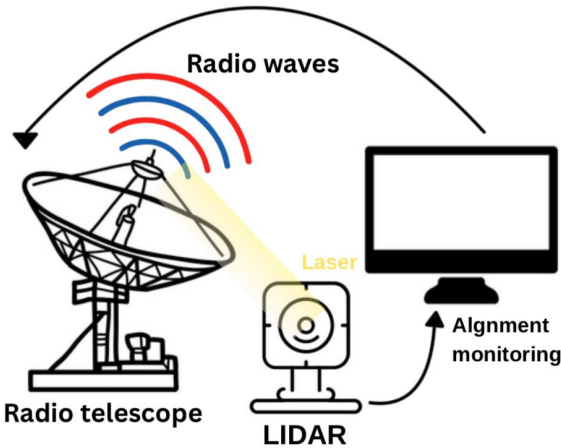


Figure 3

Conclusions

LiRA-Align offers a promising, low-cost approach to monitoring structural shifts in radio telescopes. The system’s simplicity and real-time capabilities make it ideal for academic and field observatories. Future development may include physical deployment and automatic alignment feedback.

Proposed Solution

LiRA-Align monitors structural movement by tracking the distance between a fixed LIDAR sensor and a reflective target on the telescope. When the distance deviates beyond a preset threshold, the system sends an alert to indicate misalignment.
System Components:
- LIDAR Sensor
- Reflective Target
- Microcontroller
- Alert Unit

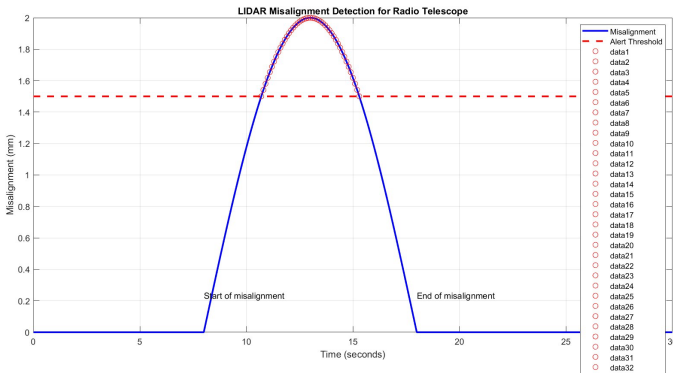


Figure 1 : The Simulation shows a perfectly aligned telescope with no misalignment throughout the observation period.

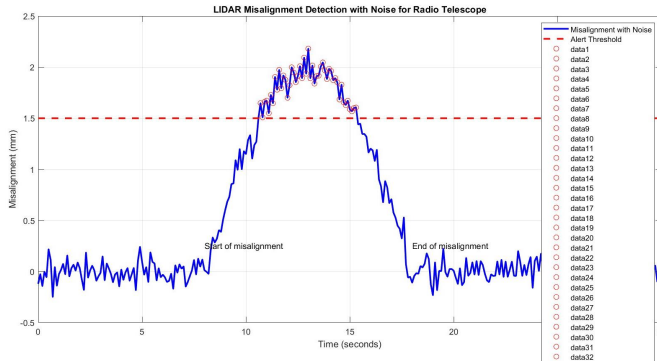


Figure 2: Simulation adds LIDAR noise and models misalignment between seconds 8 and 18 to reflect real-world conditions.

Simulation and Results

Graphical results show that LiRA-Align detects misalignments effectively. Under noise-influenced scenarios, the system maintains reliable sensitivity. Key graphs illustrate how distance measurements rise during deviation and return after stabilization, confirming system reliability.

Table 1 : Table compares true and measured positions under noiseless and noisy conditions. Misalignment begins at second 8; noise introduces fluctuations, reflecting real-world LIDAR challenges.

Time (seconds)	True Position (mm)	Measured Position (Basic) (mm)	Misalignment (Basic) (mm)	Measured Position (Noisy) (mm)	Misalignment (Noisy) (mm)
0	0	0	0	0.009671415	0.009671415
1	0	0	0	-0.01382643	0.01382643
2	0	0	0	0.064788854	0.064788854
3	0	0	0	0.152302986	0.152302986
4	0	0	0	-0.023415337	0.023415337
5	0	0	0	-0.023413696	0.023413696
6	0	0	0	0.157921282	0.157921282
7	0	0	0	0.076743473	0.076743473
8	0	0	0	-0.046947439	0.046947439
9	0	0	0	-0.054250004	0.054250004
10	0	0	0	-0.046341769	0.046341769
11	0	1	1	0.953427025	0.953427025
12	0	1	1	1.024196227	1.024196227
13	0	1	1	0.808671576	0.808671576
14	0	2	2	1.827508217	1.827508217
15	0	1	1	0.943771247	0.943771247
16	0	1	1	0.898716888	0.898716888
17	0	1	1	1.031424733	1.031424733
18	0	0	0	-0.090802408	0.090802408
19	0	0	0	-0.14123037	0.14123037
20	0	0	0	0.146564877	0.146564877
21	0	0	0	-0.02257763	0.02257763
22	0	0	0	0.00675282	0.00675282
23	0	0	0	-0.142474819	0.142474819
24	0	0	0	-0.054438272	0.054438272
25	0	0	0	0.011092259	0.011092259
26	0	0	0	-0.115099358	0.115099358
27	0	0	0	0.037656802	0.037656802
28	0	0	0	-0.060063869	0.060063869
29	0	0	0	-0.029169375	0.029169375

Acknowledgments

We would like to express our sincere gratitude to Eng. Ibrahim Almohaisin for his valuable guidance, support, and constructive feedback throughout the course of our research.

Name	ID	Section
Arwa Aba Hussian	444000266	61O
Reem Alajraa	444000058	61O
Rahaf AlQahtani	444000330	61O
Jood Alhumaidi	444000159	62O
Deemah Alshammari	444000196	61T
Rahaf Almutairi	444000184	61T
Sadeem Alyousef	444000286	61T
Njood Alshalawi	444000319	61T