iJRASET
International Journal For Research in
Applied Science and Engineering Technology

INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

Volume: 14 Issue: IV Month of publication: April 2026

DOI: https://doi.org/10.22214/ijraset.2026.80481

International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.538
Volume 14 Issue IV Apr 2026- Available at www.ijraset.com

Radio Fence: Unauthorized Signal Localization on Amateur Radio Band

Arkay Kudali, Sahil Lotlikar, Harikrishna KM, Vinayak Dewoolkar
Department of Electronics and Telecommunication Engineering Atharva College of Engineering, Mumbai, India

Abstract: Misuse of amateur radio frequencies by non-licensed transmitters leads to interference, problems and security threatsfortheamateurradiocommunicationservices.Inthiswork,weintroduceRadioFencethatisalowcostcompactradio direction finding (RDF) solution that helps locate suspicious radio frequency transmissions in the amateur radio bands. Radio Fenceuses directionalantennas,software-definedradioreceivers,GPSsensor,andsignalangleestimationalgorithms to determine the direction of arrival of RF signals.. With the help of triangulation and trigonometric techniques, the geographical location ofthesignalsourcecanbecalculated.TheprototypeimplementationofRadioFenceincludesrdf(radio direction finder system and host system. Experimental evaluation demonstrates the feasibility of accurate signal localization for educational and regulatory use cases.

I. INTRODUCTION

Amateur radio communication is widely used not just by hobbyists but also in emergency situations and technical experimentation. But one problem that comes up is unauthorizedtransmissions.Thesesignalscaninterferewith licensed users and sometimes make communication unreliable.

Most professional direction-finding systems are not really made for students or small projects. They are expensive, complicated, and not easy to set up. Because of that, we wanted to build something simpler which still does the job.

So the idea behind this project is pretty straightforward — detect the direction of a signal and then try to figure out whereitiscomingfrom.Thesystemusessignalstrengthand antenna movement to estimate direction, and then applies basic geometry to locate the source.

II. RELATED WORK

RadioDirectionFindinghasalreadybeenusedinmanyareas like defense systems, aircraft navigation, and telecom operations.Thereareseveralwell-knowntechniquessuchas phased arrays, Yagi antennas, Doppler-based tracking, and TDOA methods.

These systems are quite accurate, no doubt, but they also come with higher cost and complexity. That makes them difficult to use in student-level projects.

With the availability of SDR platforms like RTL-SDR and GNU Radio, things have become more accessible. People can now experiment with RF systems without needing very expensive equipment, which is honestly what made this project possible.

III. METHODOLOGY

A. Hardware Design

ThesystemisbuiltusingsmallRDFnodes.Eachnodeworks on its own and detects signals independently. A RaspberryPi is used for processing, and an RTL-SDR is connected to receive signals.

For direction detection, we designed a parabolic antenna setup.Theantennaismountedonarotatingplatformusinga stepper motor. This allows it to scan signals from all directions.

AGPSmoduleisalsoaddedsothateachnodeknowsitsown location. All this data is then sent to a central system over network.

B. Signal Detection

The way direction is found is actually simple. The antenna keepsrotatingandateachangle,signalstrengthismeasured. The angle where signal strength is highest is taken as the direction of the source.

It’s not perfect always, but it works good enough in most cases. Small variations can happen depending on environment and noise.

C. Real-TimeDataTransmission

TheRDFnodecontinuouslysendscollecteddatatoacentral host system using UDP/IP communication. The transmitted parameters include:

1) AngleofArrival(AoA)
2) Signalgain
3) GPS coordinates
4) Center frequency
5) Bandwidth
6) Nodeidentification

Thisenablescentralizedmonitoringandsupportsmulti-node synchronization for improved accuracy.

D. Software Implementation

Thesystemsoftwareisbuiltusing:

1) Python-based processing
2) RTL-SDRforsignalacquisition
3) Motorcontrolalgorithms
4) GPSdata processing
5) PyQt-basedgraphicalinterface
6) CesiumJSfor3Dvisualization The host interface provides:

- Real-timeradarsweep display
- Signalstrength monitoring
- Remotecontroloffrequencyand bandwidth
- LivemappingofRDFnodes
- Visualizationofsignalsource direction

At present, one RDF node has been successfully integrated with live map visualization.

E. Triangulation Model

To find the actual location of the signal, we use triangulation.Basically,iftwonodesdetectthesamesignal fromdifferentdirections, wedrawlinesinthose directions.

Where those lines meet is the estimated position of the transmitter.Thismethodworksbetterwhensignalsareclear and there is less interference.

IV. RESULTS AND CURRENT PROGRESS

We were able to build and test a working prototype of the system.Itcandetectsignalsandshowtheirdirectioninreal time.

Someofthemainthingsthatareworkinginclude:

- Signaldirectiondetectionusingantenna
- Continuousrotationscanning
- Real-timesignalstrengthmeasurement
- GPS tracking
- Datatransmissiontohostsystem
- Visualization on map

Thesystemisnotextremelyprecise,butitgivesagood approximation which is useful for this type of setup.

A. Real-Time RadarVisualization

Whileworkingontheantennadesign,weinitiallytriedafew different options like horn and helical antennas. But in practice,theywerenotverysuitableforourusecase,mainly because of frequency constraints and size issues.

Since the system operates in the VHF and UHF amateur bands(around145MHzand435MHz),antennadimensions became a major concern. Larger wavelengths meant physically bigger structures, which were not easy to mount on a rotating setup.

Todealwiththis,weswitchedtoaparabolicreflector-based design. A dual-band antenna was placed at the focal point, acting as the feed. This helped in concentrating signals coming from a particular direction, improving gain without making the system too bulky. Overall, this setup gave a good balance between size, usability, and performance.

Fig. 1. Real-time radar sweep showing signal gain variation with antenna angle

B. Antenna-Based Direction-Finding System Performance

The parabolic reflector plays an important role in improving direction detection. It focuses incoming RF signals onto the feed antenna, which increases the received signal strength when the antenna is aligned correctly.

During testing, we could clearly notice a peak in signal strength when the antenna was pointing towards the transmitter. This made it easier to estimate the Angle of Arrival (AoA) with reasonable accuracy.

Compared to other antenna configurations we looked at earlier, this design turned out to be more practical. It is compactenoughtobemountedontherotatingplatformand stillprovidesdecentdirectionalperformanceforboth frequency bands.

Fig.2.Customparabolicdirectionalantenna

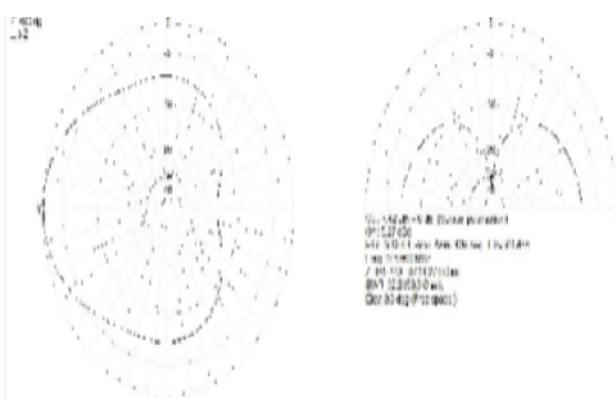


Fig.3.1.Azimuth–ElevationRadiationPatternofthe Proposed Antenna

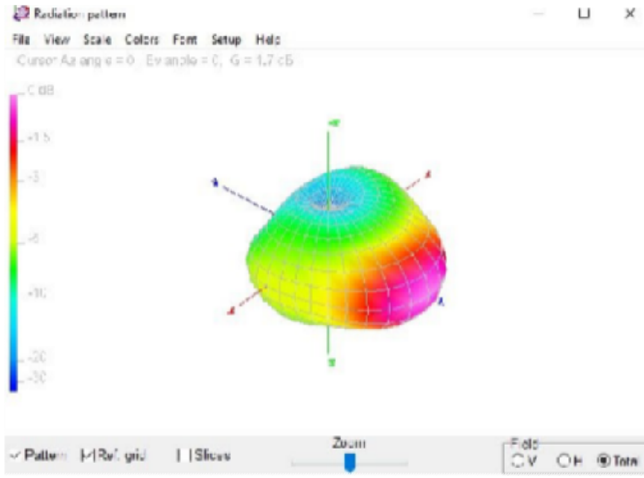


Fig.3.2.Three-DimensionalRadiationPatternofthe Antenna

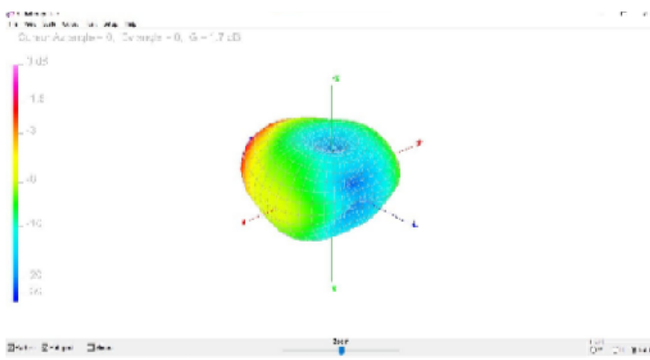


Fig. 3.3. Three-Dimensional Radiation Pattern of the Antenna

C. Real-Time Mappingand Node Visualization

To better understand what the system is detecting, a real- time mapping feature was added. Using a 3D map interface, the position of the RDF node is continuously updated based on GPS data.

The detected signal direction is shown as a line originating from the node. This makes it easier to visually interpret where the signal might be coming from instead of just looking at numbers.

It also helps when observing signal behavior over different locations, which is useful during testing.

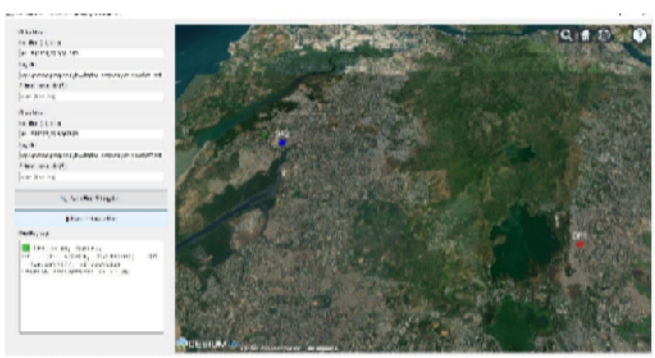


Fig. 4. Live Cesium map visualization of RDF node and detected signal direction

D. Triangulation Simulation

To check how well the system can estimate the source location,triangulationwastestedusingsimulations.Multiple RDFnodes were placed at known coordinates, andeachnode provided a direction based on its AoA measurement.

These directions were plotted as lines, and their intersection point was calculated. The entire process was visualized in real time using the mapping interface.

From the results, it was clear that using two nodes gives muchbetteraccuracycomparedtoasinglenode.Still,small errors can happen depending on signal conditions and alignment, so results are not always perfect.

Fig. 5.1. Real-Time Cesium Map Showing RDF Node Position and Detected Signal Direction

Fig. 5.2. Multi-Node Direction Visualization for Signal Localization on Cesium Map

E. SystemIntegrationandData Communication

Allthedifferentpartsofthesystem—SDR,antennarotation, GPS module, and communication — were integrated and tested together. The node continuously sends data such as signal direction, strength, and location to the host system.

This allows real-time monitoring without much delay. The system runs smoothly most of the time, although sometimes small delays or fluctuations can be noticed.

Overall,theintegrationshowsthatadistributedRFdetection system like this can actually be built using low-cost components. It may not be perfect, but it works well enough for practical understanding and basic applications.

V. DISCUSSION

One good thing about this system is that it is low cost and portable.ComparedtoprofessionalRDFsystems,itismuch easier to build and use. But there are some limitations also. Signal reflections can affectaccuracy,andcalibrationofantennaisimportant.Also withonlyonenode,locationestimationisnotveryaccurate.

Using two or more nodes improves results a lot, so that is something to expand in future.

VI. CONCLUSION

In this project, we built a simple system to detect and locate unauthorizedradiosignals.Theideawastomakesomething affordable but still useful.

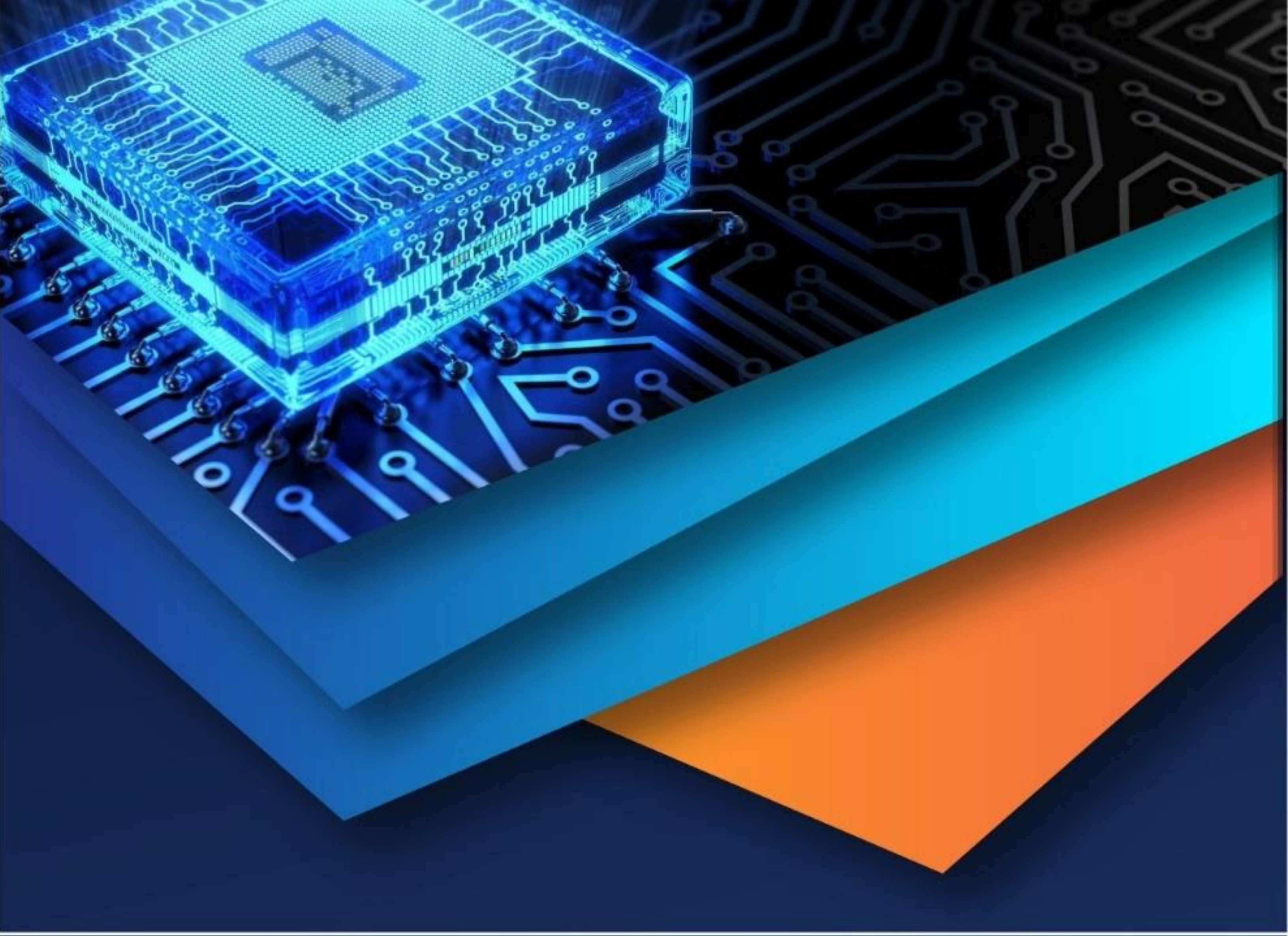
Theresultsshowthatitispossibletoestimatesignaldirection and location using basic components like SDR, GPS and directional antennas. While it is not perfect, it works well enough for learning and small-scale applications.

VII. ACKNOWLEDGMENT

The authors express their gratitude to the Department of Electronics and Telecommunication Engineering and Atharva College of Engineering for their guidance and support throughout the project.

REFERENCES

[1] ARRLHandbookforRadio Communications.
[2] GNURadioDocumentation.
[3] RTL-SDROfficialDocumentation.
[4] ITUGuidelinesonRadioDirectionFindingSystems.
[5] Amateur Radio Regulatory Framework, India.



10.22214/IJRASET

INDEX COPERNICUS 45.98

IMPACT FACTOR: 7.129

IMPACT FACTOR: 7.429

INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY