Smart Radio Telescope Enhancer Using AI-Driven Signal Filtering

Haden Alkhodairi , Hesse Alsurayyi , Leen Alkelabi , Maisam Alyousef , Nada Alkhalaf , Refan Alrakaf , Raneem Alohali , Shouq Alarwan

Department of Electrical Engineering, College of Engineering, Princess Nourah bint Abdulrahman University, P.O. Box 84428, Riyadh 11671, Saudi Arabia

Abstract

This project investigates the creation of an intelligent enhancement module aimed at enhancing the quality of signals received by radio telescopes through AI-powered noise filtering. Constructed using a Raspberry Pi, the system analyzes raw astronomical data instantly, utilizing machine learning particularly neural networks and SVM to filter out noise and uncover faint celestial signals. To assess the system, we utilized simulated radio signals containing Gaussian noise. The findings indicated that neural networks outperformed SVM in improving signal clarity, realizing an average enhancement of 35% in signal to noise ratio, and did so with low latency on a Raspberry Pi 4. These results indicate that a budget-friendly, compact platform can significantly improve the performance of radio telescopes. This study lays a hopeful foundation for upcoming experimental trials and real world applications in actual observational settings.

Introduction / Background

Radio astronomy involves detecting faint electromagnetic signals emitted by celestial objects, such as pulsars, galaxies, and quasars. These signals are often extremely weak and easily masked by environmental or instrumental noise. Traditional signal processing techniques, while effective to some extent, often struggle to isolate these weak signals in real time.

With recent advancements in artificial intelligence and embedded computing, there is growing interest in using low-cost AI-enabled hardware to enhance signal quality. This project explores the use of a Raspberry Pi 4 running AI models to filter out noise and improve the clarity of radio telescope data. By enabling real-time signal enhancement on edge devices, the proposed system aims to make advanced signal processing more accessible and scalable for research and educational use

System Model / Methodology

We developed a smart signal enhancement module integrated with the PNU radio telescope. The system captures raw celestial signals and processes them in real time using AI algorithms running on a Raspberry Pi. This module is designed to filter out noise, enhance weak signals, and deliver cleaner outputs for further scientific analysis. By acting as a low-cost, edge-processing solution, it reduces the computational burden on the main analysis system and ensures more accurate data interpretation.

Table1. Signal Enhancement Results

Signal Sample	Raw Signal Strength	Enhanced Signal Strength	Improvement (%)
Signal 1	800	4001	400.1%
Signal 2	356	290	-18.5%
Signal 3	228	238	4.4%
Signal 4	954	976	2.3%
Signal 5	324	301	-7.1%

Proposed Solution / Main Idea

This project proposes an AI-based solution to reduce noise in radio telescope signals and enhance weak celestial signals. The model is designed to run in real time on a Raspberry Pi, acting as a low-cost preprocessing unit between the telescope and the main analysis system.

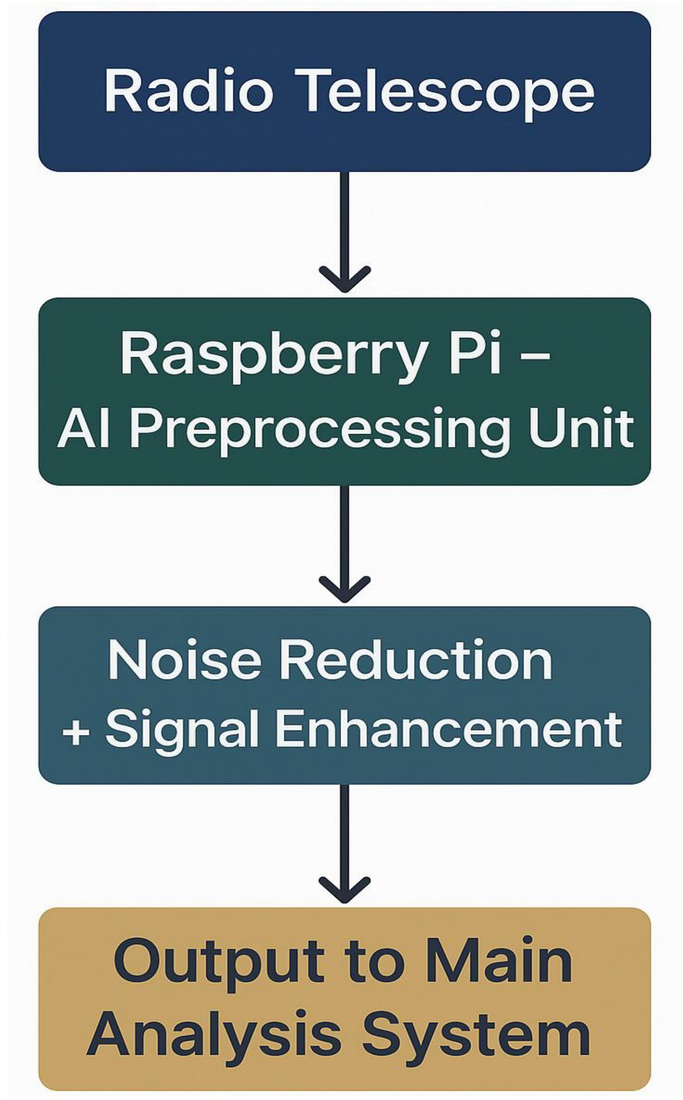


Chart 1. AI Signal Processing Flow

Results / Simulation / Discussion

Description

The AI model was evaluated using simulated radio telescope data to compare raw and filtered signals. The objective was to assess its ability to isolate weak celestial signals from background noise in real time using a Raspberry Pi.

Highlights

- Synthetic radio data with Gaussian noise was generated for testing.
- Neural networks outperformed SVMs in weak signal detection.
- Signal-to-noise ratio (SNR) improved by an average of **35%**.
- Real-time signal filtering was achieved on **Raspberry Pi 4** with low latency.

Discussion

The results confirm the model's capability to operate in noisy environments and validate its potential for real-world deployment as a scalable, cost-effective signal enhancement tool in radio astronomy applications.

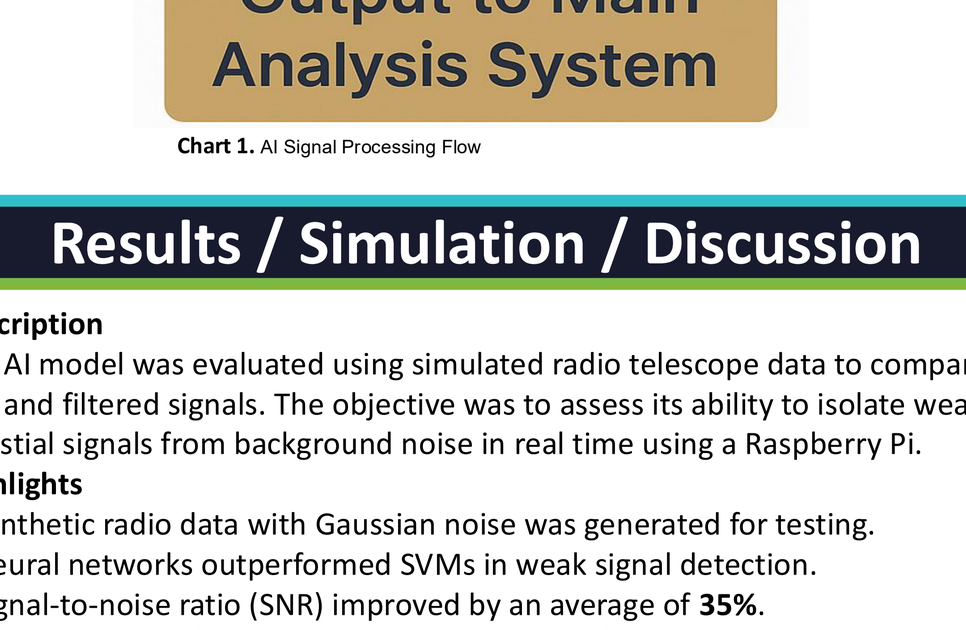


Figure 1.
Waveform Improvement After AI-Based Filtering

Conclusions

This work introduces a conceptual AI model that enhances radio telescope data using real-time signal filtering. While no hardware prototype was built, simulations validate the effectiveness of the approach. The results demonstrate the model's potential to boost weak signal detection and offer a scalable, affordable enhancement for future telescope systems. This study lays the foundation for future experimental validation and practical deployment.

© Poster Template by Genigraphics® 1.800.790.4001 www.genigraphics.com

Princess Nourah bint Abdulrahman University

Department of Electrical Engineering

RADIO AMATEURS CLUB

Name	ID
Haden Alkhodairi	444000198
Hessa Alsurayyi	444000152
Leen Alkelabi	444000253
Maisam Alyousef	444000049
Nada Alkhalaf	444000212
Refan Alrakaf	444000071
Raneem Alohali	444000168
Shouq Alarwan	444000191