Section A: Overview of the Research Project Proposal

1. Title of the research project: Eigenspace decomposition used as feature extractions for classifying RFI sources
2. Broad field of research: Engineering
3. Academic level of research project: Doctoral
4. Abstract of research project:

Various important machine learning techniques are based on Eigenspace decomposition. Most relevent to frequency analysis is the MUSIC algorithm and Dynamic Mode Decomposition. The aim if this study is to develop new feature extraction methods based on Eigenspace decomposition, specifically for the identification of radio frequency interferers, where the interfering sources consist of narrowband signals, wideband signals, or a combination of narrowband and wideband signals.

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Section B: Details of Research Project

1. Scientific/Engineering merit:

Various important machine learning techniques are based on Eigenspace decomposition. To name a few: Principal Component Analysis, the MUSIC algorithm, Dynamic Mode Decomposition, and many more have their roots in Eigenspace decomposition. The aim of this Doctoral study is to use Eigenspace decomposition as a feature extraction method, to be used with machine learning in order to perform classification of various Radio Frequency Interference sources.

The MUSIC algorithm is specifically developed for narrowband signals (applied to either direction-of-arrival estimation or spectrum estimation), and can thus be used as a feature extraction process for narrowband signals. Dynamic Mode Decomposition (DMD) is used on signals with fixed oscillation frequencies together with fixed decay or growth rates.

However, RFI sources can exhibit a narrowband nature, a wideband nature, or a combination of narrowband and wideband signals. The aim of this study is then to specifically develop feature extraction techniques based on Eigenspace decomposition for both narrowband and wideband signals. Initial studies will analyse and investigate the application and performance of the MUSIC and the DMD algorithms when applied as feature extraction methods to narrowband and wideband signals. From these analysis, ways will then be explored to generalise Eigenspace decomposition techniques to be used as feature extraction.

2. Feasibility

This project consists of a combination of theory, mathematical analysis, computer simulation and implementation and verification of the algorithms on an actual hardware prototype platform. Matlab simulations will be used for initial testing and verification of the proposed algorithms. Two software defined radios (USRP B210s) are dedicated to this study for actual hardware testing and verification. All the necessary research facilities and resources required to successfully fulfil this project is available.

Project milestones:

Literature Survey and PhD proposal (6 Months): The first six months will be devoted to the theory and analysis of Eigenspace decompostion and machine learning. Specific attention will be given to

the MUSIC algorithm, DMD algorithm, and also adaptations of these algorithms to wideband signals.

High-Level Algorithm design and evaluation using MATLAB (6 Months): After the mathematics and theory has been studied, the study will progress to implement and compare the various identified algorithms using a high-level simulation such as Matlab. Write-up of findings in a conference or journal paper.

Year two is devoted to analysing short-comings in MUSIC and DMD when applied to wideband signals. Ways to overcome this is investigated and new algorithms is proposed, simulated and verified. This is an iterative design process. The newly developed algorithms is written up in a journal/conference article.

Year 3 – First semester: Prototyping and verification of algorithms on the USRP B210 Software defined radios: The various algorithms will then be implemented on the SDR system. Research activities here include the efficient implementation as well the effect of real-life data on the performance of the algorithms, as well as ways to mitigate these effects.

Year 3- Second Semester: Write-up of thesis. The last 6 months will be spend on verifying results and write-up of a thesis. A journal paper is written encapsulating all the relevant theories and results.

3. Priority areas addressed

This project addresses Engineering areas 2 and 3, namely Real-time digital signal processing instrumentation for radio astronomy (FPGA) as well as Hardware and data analysis systems for detecting, monitoring and locating source of Radio Frequency interference.

4. Special requirements

None.