

# DOA-Estimation and Source-Localization in CR-Networks using Steerable 2-D IIR Beam Filters

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**Abstract**—The application of multi-dimensional (MD) infinite impulse response (IIR) space-time beam filters in radio source localization in cognitive radio (CR) environments is investigated. Knowledge of the position of radio sources in a CR network leads to the detection of white spaces in the MD frequency domain, thereby creating more opportunistic links for the secondary users. The use of MD IIR beam filters is motivated by their very low computational complexity and small side lobe levels compared to digital phased arrays. As a proof-of-concept, the two dimensional (2-D) propagation scenario including at least two receiver stations and a data fusion station, which combines the direction of arrival (DOA) estimates from the two receiver stations, to yield a position estimate, is considered. Each receiver station employs a uniform linear array (ULA) of antennas and a steerable 2-D IIR beam filter and provides information pertaining to peak energy directions. First order 2-D IIR beam filters are shown to provide acceptable DOA estimates with a SNR of 6 dB. The peak energy direction information leads to both position and MD white space detection.

## I. INTRODUCTION

We explore the potential application of multi-dimensional (MD) spatio-temporal infinite impulse response (IIR) digital filters in location and direction estimation of radio sources, leading to increasing broadband access to the radio spectrum. Cognitive radio (CR) [1]–[3] offers robust spectrum access toward maximizing utility in the context of diverse applications [4]. Typically, CR “spectrum sensing” is attempted using traditional sensing algorithms such as cyclostationary feature detection based on spectral correlation functions, energy detection, waveform based sensing, radio identification based sensing, and matched filtering [5]–[7]. These traditional algorithms do not provide information about the direction and location information of primary and secondary users [6], [7] as well as the interference.

Here, we envision new applications of MD IIR spatio-temporal filters towards directional and location information estimation within a CR network, leading to enhanced access to radio spectrum (EARS) [4], through directional spectrum sensing [8], [9] and RF source localization. The use of MD IIR filters is motivated by their salient properties such as small side lobe levels and low computational complexity, compared to digital phased arrays [10]. We present the 2-D case using linear antenna arrays.

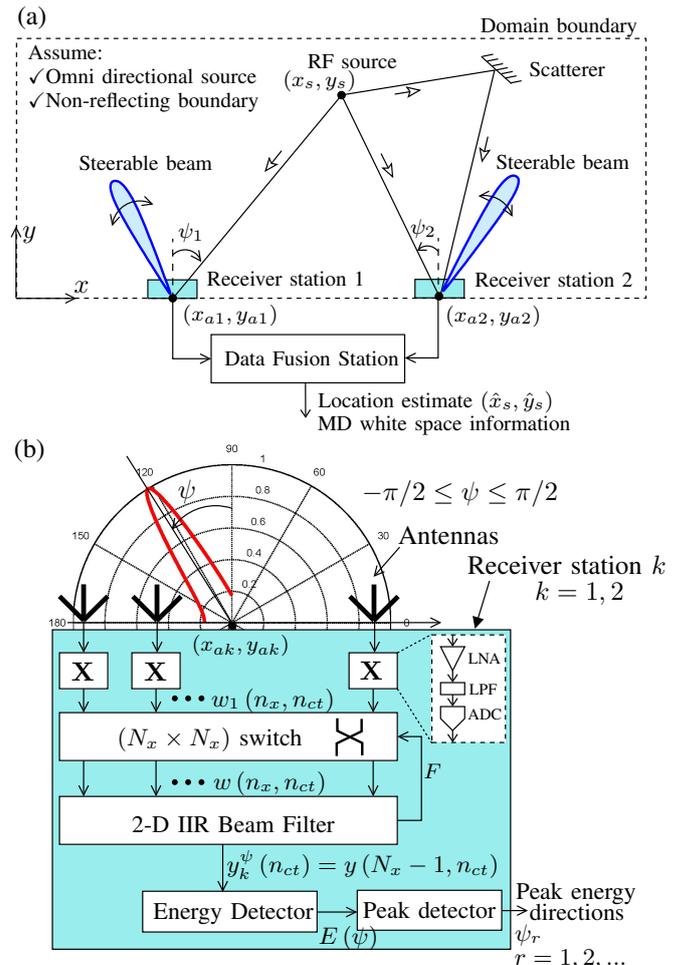


Fig. 1: Overview of the use of 2-D IIR space-time beam filters for source localization towards MD white space detection.

## II. DIRECTIONAL SPECTRUM SENSING USING MD-WHITE SPACES TOWARDS EARS

The concept of directional spectrum sensing takes into account the directional and positional information of the radio sources. Traditional spectrum sensing deals with time-frequency information and detects “white spaces”, which are vacant frequency channels. Recent efforts to include directional sensing [7], [11]–[13], although shown to successfully address some of the issues by fixed relay schemes [14], spatial