Co-Existence of Communication and Radar Systems

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***Abstract*—Crowded radio spectrum is becoming a serious problem as more and more radio systems are developed to operate in spectrum bands with favorable propagation properties. Moreover, spectrum will be regulated in larger chunks and different radio systems such as radar and communication system need to share the common spectrum. Hence radio systems that are able to use idle spectrum in a flexible manner are being developed, for example, cognitive radio systems and joint radar-communication systems. Situational awareness is crucial for agile use of spectrum and co-existence. The state of the time-space-frequency varying spectrum may be presented as spatio-temporal spectrum maps that may be used to better utilize and share spectral resources among radar and communication systems, manage interference and avoid jamming. Acquiring such awareness is a challenging task because the state of the spectrum varies depending on time, frequency and location. RF measurements made using multiple sensors in distinct locations are crucial in creating such spectrum maps. However, one also needs to know the state of the spectrum between the sensor locations and capture the dynamic behavior of spectrum in order to facilitate agile use of waveforms, interference management and co-existence of radar and communication systems.**

I. Introduction

In this paper we consider a system where communication and radar transmitters share the same frequency band at same time and same geographical area, see Figure 1. Our goal is to generate a spatio-temporal sprectral map of the radio spectrum state by utilizing observations made by multiple distributed radio frequency sensors in distinct locations. Such a map can be used for planning efficient and agile spectrum usage and co-existence of different radio systems as well as interference management.

Creating spectral maps has been considered earlier mainly in the context of wireless communications, in particular, cognitive radios. The developed methods are not directly applicable to co-existing systems, since there are some significant differences how radars use the spectrum. Depending on the radar task, radars may form very narrow beams in order to illuminate targets. Radars may also scan the operational environment periodically using a rotating antenna system which introduces a periodic variation in the state of the spectrum.

We introduce a novel algorithm to estimate how state of the spectrum evolves dynamically as a function of time and location. The method stems from both spatial Kriging estimation method and parametric modeling. The output of the algorithm is a spatio-temporal spectral map which captures the periodic scanning patterns of radar beams and estimates the underlying static spectral map as well.

The idea is to use the measured values, for example the received signal strength (RSS) observed by many spectrum sensors and then estimate or interpolate the RSS values over the whole region of interest. In our system the measured RSSI values depend both on time instance and location of the sensors. Moreover, rapid changes in RSSI may occur. Hence, the assumption of stationarity typically employed in Kriging is clearly violated. In order overcome this problem, we have divided the task of constructing the spectrum map to a dynamic and a static part. The spatial Kriging interpolation is applied to the static part that is assumed to remain stationary over the observation period.

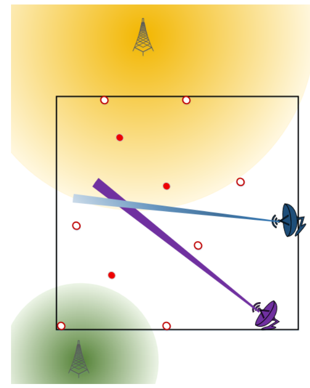

Fig. 1. Overview of the system model. Two wireless transceivers and two radars are sharing the same bandwidth and neighborhood. The solid red dots are intelligent surveillance sensors, and the white dots with red border are simple spectrum sensors with less processing capability. The black square is the area of interest.

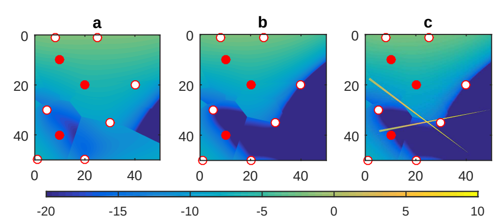

Fig. 2. The subfigure a) shows the situation if dynamics are not taken into account in constructing the map. Subfigure b), static spectral map constructed with proposed estimation method to ignore the dynamic impact. The c) the composite spectral map which captures both dynamic and static behavior.

In Figure 2 is illustrated the contribution of a dynamic component caused by a radar to the spatio-temporal spectrum map. The left subfigure shows output of conventional Krigingin, the middle and right figures show the outputs of the first and second (final) stage of our algorithm.