Through the Wall MIMO Radar Detection with Stepped Frequency Waveforms

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***Abstract*— In this paper, we present through the wall (TTW) radar detection simulations with an emerging radar architecture which is the multiple-input multiple-output (MIMO) radar. The urban environment, especially in TTW detection, is very tough for radar detection. With the aim of improving the detection performances, we use several spaced antennas in transmission which gives a spatial diversity leading to different points of view of the scene. So as to keep diversity we choose linearly independant waveforms and more particularly we utilize the hyperbolic frequency hop codes.**
We first begin by introduce the problems and applications of TTW detection. Then we will present the geometric configuration of the scene and the wall attenuation and target modeling. After what, we will expose the waveforms used in transmission and the processing to perform detection. We finish with some preliminary results and conclude about this work.

I. Introduction

Detection through diverses opaque materials and especially through walls and buildings, is of a great interest giving the potential applications for the police, fire, rescue and military operations. Among the various existing technologies allowing TTW detection, it turned out that the most adequate and mature ones are those based on radar principles. First works date from the last past decades, see reference [1].
Radar TTW detection is a relatively complex task. In fact, indoor environment is a rough one because besides the clutter and multipath effects, the strong wall attenuation makes the detection even more complex. Wall attenuation depends on both the transmitted frequency and antennas positions with regard on the scene to analyze and present a kind of random character. To overcome the environment complexity many ways were followed by adding diversity and after having explored frequency diversity [2], we are now interested by spatial diversity with a MIMO radar architecture.
Our research focus on ultra-wideband (UWB) synthetic aperture radar techniques associated with a step frequency waveform. The development and first results in terms of simulation about a MIMO TTW radar are the subject of this paper.

II. Configuration of Simulation and Modeling

A. Geometric layout of the analysed scene

We intend here to simulate the detection of a single human standing in a room with a MIMO radar. The component of the scene are the following:

- $N_T = 3$ transmitting antennas
- $N_R = 15$ receiving antennas
- single human in an empty room

The detailed layout can be visualized in Fig. 1. The 15 receiving antennas are placed along the x-axis and equally spaced by $dx = 0.06$m. The antennas are centered comparatively to the 8^{th} whose position is $[2.75\ 0]^T$. The 3 transmitting antennas are equally spaced too with an inter-element space of $Dx = 1.50$m, parallel to the x-axis. The antennas are centered comparatively to the 2^{nd} whose position is $[2.75\ 0.50]^T$. The room consists in a 4m depth 5.5m width chamber with a 0.2m thick wall as in the scheme and the human target is position is $[1.8\ 3.2]^T$.

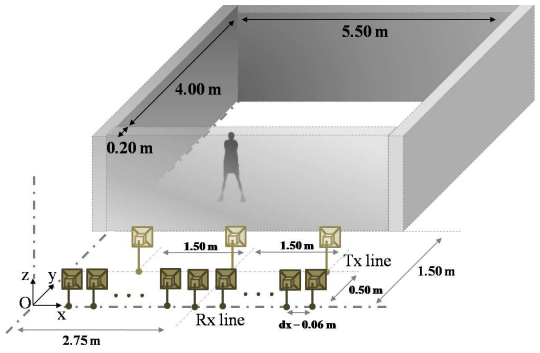

Fig. 1. Geometric configuration of the analysed scene

B. Wall Attenuation Modelling

A deterministic computation of wall losses during the propagation is very complicated. In fact, the wall material, the ordonated structure of the wall and the presence of a multitude of asperity lead to an attenuation that is very difficult