Correlation Matching Approach for Through-Wall Corner Detection

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***Abstract*—We consider the problem of detecting building dominant scatterers using Compressive Sensing (CS) with applications to through-the-wall radar and urban sensing. We use oblique illumination, which specially enhances the radar returns from the corners formed by the orthogonal intersection of two walls. This paper uses a novel type of image descriptor: the intensity correlogram. The intensity correlogram of each through-the-wall radar image pixel encodes information about spatial correlation of intensities. The proposed technique compares the known intensity correlogram of the scattering response of an isolated canonical corner reflector with the correlogram of the received radar signal within a correlation matching framework. The correlation matching procedure directly promotes sparse solution avoiding solving the l_1-norm constrained optimization problem encountered in conventional CS.**

Sensing through building walls using standard continuous wave radar to gain vision into concealed scenes is the aim of Through-the-Wall Radar Imaging (TWRI) [1]. The ability to remotely and reliably detect the presence of humans and objects of interest through opaque structures has numerous applications in civilian, law enforcement and military sectors.

In this paper, we address the problem of detecting building interior structures for TWR and urban sensing applications. Doppler signatures or change detection techniques cannot be applied since targets and clutter are both of the same nature. Usually, stationary target detection is to be performed subsequent to image formation. In general, the TWR image is processed in such a way that the location of strong scatterers is revealed. Image-based detectors performance is linked to image resolution, which is associated to large bandwidth signals and long antenna array apertures. However, this demands acquisition and processing of large amounts of data. Moreover, most of the existing TWRI systems, employ data-independent processing techniques for image formation, whose clutter suppression capabilities are poor impeding the application of simple thresholding detection. Even endowed with an effective imaging method, image-based detection faces many challenges, including strong scattering from the exterior walls and large variety of possible indoor targets which look similar in the TWR image. Thus, classification is usually performed as a post-processing step.

The contribution of this paper is the development of a feature-based corner detector for building interior structure identification which encompasses the two tasks of detection and classification. Unlike majority of the feature detection methods that are applied in the image domain, the proposed approach exploits prior information of construction practices. The building layout is usually composed of exterior and interior walls which are parallel or perpendicular to each other. We assume a flexibility in radar operation which allows proper angular radar illuminations, thereby avoiding the front wall returns and preserving the corner features created by the junction of walls of a room. Estimating dominant scatterers such as corners allows the inference of building interior structure. This same idea was exploited in [2], [3], where a building feature based approach was applied to estimate the type and location of different canonical scattering mechanisms. This paper uses a novel type of image descriptor: the intensity correlogram. The intensity correlogram of each through-the-wall radar image pixel encodes information about spatial correlation of intensities. The basic strategy adopted here is to compare the known intensity correlogram of the scattering response of an isolated canonical corner reflector with the correlogram of the received radar signal within a correlation matching framework. The correlation matching procedure directly promotes sparse solution avoiding solving the l_1-norm constrained optimization problem encountered in conventional CS [4]. The feature-based nature of the proposed detector enables corner separation from other indoor scatterers such as furniture or humans. Simulation results show that the use of spatial intensity correlation makes the detection performance superior to that of using raw signal matching or image matching.

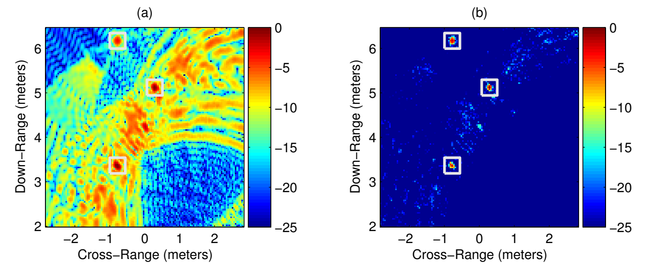

Fig. 1: Resulting images: (a) DS Beamforming, (b) Correlation-Matching.

Simulation results support this paper. Fig. 1(b) shows the image of a room with 3 corners (white circles) and a human obtained with the proposed correlation matching approach. Fig. 1(b) have less clutter compared to the corresponding DS beamforming image shown in Fig. 1(a). Moreover, the point target has also been diminished due to the feature-based nature of the detector.

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