# 3-D Calibration of InISAR Imaging under a Condition of Phase Ambiguity

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***Abstract* - Interferometric inverse synthetic aperture radar (InISAR) imaging is a recently developed powerful radar three-dimensional (3-D) imaging technique, which combines the interferometric technique and the inverse synthetic aperture radar (ISAR). The true 3-D reconstruction of target scattering centers is obtained by interferometric phase processing of different two-dimensional (2-D) ISAR images from the various image planes. However, phase ambiguity is an involved problem in the interferometric process. This paper begins with the discussion on the InISAR imaging principle, followed by the description of three-dimensional calibration technique. By linear fitting phase differences between adjacent scattering centers of the same slant-range cell, the traditional phase ambiguity can be overcame. In the end, simulation results are provided to demonstrate the behavior of the proposed algorithm.**

***Index Terms* – Interferometric ISAR; 3-D calibration; Phase ambiguity; Linear fitting**

## I. INTRODUCTION

Inverse synthetic aperture radar imaging techniques form 2-D images of moving targets, which are 2-D projections of 3-D moving targets. The fine resolution in the slant-range direction is obtained by transmitting a wide band signal and the high cross-range resolution is achieved by exploiting the relative motion between the radar and targets. The absolute scale in the cross range, however, depends on the angular rotation of the target. When the rotation is uniform, the scale depends on the rotation velocity that is usually not known. When the rotation is non-uniform, the scale is even more complicated to determine. In both cases, the scale in the cross range of an ISAR image is not known in the conventional ISAR, therefore the true locations of scattering centers can not be determined even in the image projection plane. Furthermore, in the conventional ISAR, it cannot provide information on the positions in height-range dimension of the scattering centers.

In contrast, an emerging 3-D imaging technique, interferometric ISAR (InISAR) [1-3] , has the advantage of providing the exact position of each scattering center on a complex target in height-range as well as in slant-range and cross-range. InISAR is able to carry out 3-D imaging of a far-field moving target under all-weather condition and any required time [4, 5], so it has shown a wide range of prospects in the field of military and civilian applications, and has been attracting more and more attention.

However, in practical applications, InISAR runs into great difficulties in exact 2-D phase unwrapping [1, 6-8] . The real value of interferometric phase often exceeds the phase interval of $(-\pi,\pi)$ and the reference point on the target used for phase unwrapping with determined location does not always exist. The interferometric phase at this moment cannot correspond with the real size of the target.

To solve this problem, Mu Ling puts forward a method of cross-range calibration under a condition of ambiguous phase, using phase difference between adjacent scattering centers of the same slant-range cell [8] . However, only 2-D image is considered there. In this paper, we consider 3-D calibration of InISAR imaging under a condition of phase ambiguity. Using the phase difference between adjacent scattering centers in the same slant-range cell, the traditional phase unwrapping problem is avoided. The interferometric ISAR images in three different views are acquired.

## II. INISAR IMAGING PRINCIPLE

As shown in Fig. 1, antenna *A*, a transmitter as well as a receiver, is placed in the origin of radar coordinates. The receivers, antenna *B* and *C* are located in the axis *X* and axis *Z* respectively with the same baseline distance *L* to the origin. For simplicity, we illustrate a two dimensional plane, i.e., the slant-range and cross-range dimensions as an example.

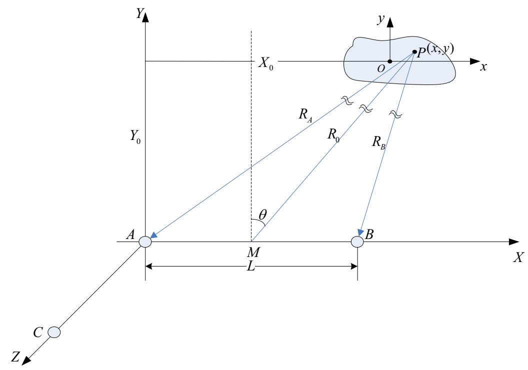


Fig. 1 Geometry of InISAR three-antenna imaging system

The midpoint of *AB* baseline is *M*. The dashed is the perpendicular bisector of *AB*. Point *P* is an arbitrary scattering center of target which is in far-field and the distance from *P* to *A*, *B*, *M* are $R_A$, $R_B$ and $R_0$, respectively. The target central