Arbitrary Synthetic Aperture Motion Compensation based on Fast Back Projection

Yanghuan Li#1, Qian Song#2, Tian Jin#, Zhimin Zhou#

#*The College of Electronic Science and Engineering*
National University of Defense Technology
Changsha City, Hunan Province, China
[1]poptopli@163.com, +86 0731 84573459
[2]danosong@gmail.com

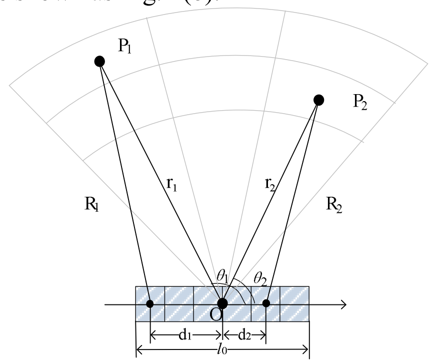
***Abstract*—Back Projection imaging algorithm, whose low efficiency reduces its applications in practical projects, could work with highly nonuniform apertures. According to this reason, many scholars have presented some Fast Back Projection algorithms based on sub-aperture method. But how to compensate the motion error after sub-aperture dividing is awaited for further studying. The motion compensation method for FBP algorithm at different motion error levels is studied in this paper. Three situations denoting different motion error levels, which are only non-uniform in azimuth aperture, tracks of two-dimensional motion error and highly nonlinear even curvilinear flight tracks, are discussed here. Then it comes to a fast back projection imaging algorithm for arbitrary aperture, and this algorithm needs highly precise position information. Finally, an outside experiment is made to prove the algorithm's availability.**

***Keywords*—synthetic aperture radar; nonuniform aperture; motion compensation; synthetic aperture imaging; monopulse radar;**

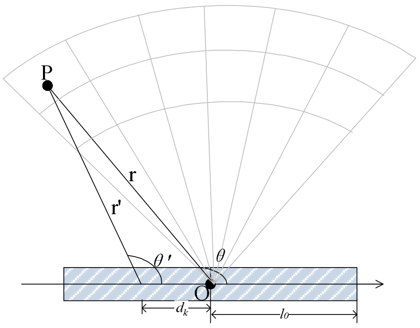
I. Introduction

The frequency-domain algorithms such as RD and $\omega - k$ algorithms [1] need nearly ideal motion state of constant velocity and straight track, which exhibits a uniform and straight aperture. But platform motion errors always exist. Lots of frequency domain motion compensation algorithms, in which a model of nearly linear aperture is assumed have been studied before. These algorithms are only available with motion error to a certain extent. However, small aircraft or drone's flight may have huge deviations, or the aviator drives the aircraft along a highly non-linear track, to an extent that a model of a linear sensor trajectory no longer holds. Then the frequency domain methods are not as available as BP algorithm. Because (Back Projection, BP) algorithm is processed in time-domain, the position information measured could be adopted well by BP algorithm to compensate the motion error. And that some fast BP algorithms which have equivalent efficiency compared to the frequency-domain algorithms are presented in references [2][4][12], then the low-efficiency choke point of BP algorithm has been overcome to a large extent. The most classical fast BP algorithm is called Factorized Fast Back Projection (FFBP) [5] that is capable to excavate the highest computation efficiency. In reference [15] a real-time sub-aperture imaging algorithm adopts some after-processing method. Neither ref.[5] nor ref.[14] present the motion compensation process in detail, and there is scarcely any literature introduce the motion compensation to fast BP or sub-aperture algorithm technically. This paper modifies the FFBP algorithm to get a new motion compensation algorithm which is compatible with arbitrary synthetic aperture including linear, nearly linear, non-linear , highly non-linear aperture.

In FFBP algorithm there is an iterative process including two steps that is generating new sub-images and combining sub-images. The former process is shown as Fig. 1(a), and the latter one is shown as Fig. 1(b).



(a). new sub-images generation



(b). sub-images combination

Fig. 1 FFBP algorithm's process

II. Algorithm Presentation

The FFBP algorithm is presented in reference [3]. If there is only azimuth motion error which means the aperture is linear but nonuniform it is easy to compensate the error. We could replace the true radar position with the ideal aperture in sub-