IDENTIFICATION AND TRACKING OF MOVING OBJECTS IN DETECTED SYNTHETIC APERTURE IMAGERY

This application claims priority from U.S. Provisional Patent Application Ser. No. 60/422,326, filed on Oct. 30, 2002, which is hereby incorporated by reference in its entirety.

FIELD OF THE INVENTION

The present invention relates to synthetic aperture imagery, and more particularly, to the identification and tracking of moving objects by using multiple receive phase centers for a synthetic aperture radar (SAR) image collector.

BACKGROUND OF THE INVENTION

An imaging radar transmits electromagnetic waves to objects within a region of interest that scatter, or reflect, the energy according to the properties of such objects (e.g. physical attributes). When the radar receives reflected waves from the objects a spatial distribution of the reflected energy may be constructed by a processor. This distribution defines a radar image that may be displayed as a 3 dimensional representation of the scene or any 2-dimensional representation thereof.

A real-aperture imaging radar, as opposed to a synthetic-aperture imaging radar (SAR), irradiates each location in the scene in turn. The line-of-sight (range) distance to a location is determined by the round-trip time of the reflected pulse; resolution in the range direction is determined by the duration of the reflected pulse; the cross-range location is determined by the pointing angles of the antenna; the cross-range resolution is determined by the beam width of the antenna. The range resolution can be less than a meter but conventional microwave antenna beamwidths may limit the resolution in the angle coordinate (i.e. cross range limitation).

This limitation may be overcome by synthesizing the effect of a large antenna. That is, the radar may be located on a moving vehicle and the reflected waves of successive radar pulses may be measured and stored in a memory. In this configuration the actual beam is wide enough to illuminate the entire scene at once, and does not have to scan from one location to the next in order to form an image. The stored reflected wave information is coherently processed to obtain a synthetic aperture radar (SAR) image.

In use, SARs may function as all-weather imaging radar systems and typically produce two-dimensional (2-D) or three-dimensional (3-D) images, with intensity as an additional non-spatial image dimension. Data collection and data processing may be performed by a variety of methods. Regardless of method, the location of a stationary point in the scene is determined by the temporal profile of both line-of-sight distance between the point and the collection antenna (however, the information is generally not used directly in this form). The processor attempts to make sense of the collected data by assuming that all points in the associated scene are stationary.

Conversely, a rigid object may be imaged if the collector is stationary and the object moves past the collector. This method is called inverse SAR (ISAR). Similar to the SAR, ISAR also produces two-dimensional or three-dimensional images with intensity as an additional non-spatial image dimension. However, ISARs use the motion of a viewed object to synthesize a large aperture antenna and not the motion of the radar platform itself. Both the translational and rotational motion of the object must be accurately known. Features of SAR systems may be equally applicable to ISAR and, where applicable, the two systems may be referred-to generally as being SAR systems and may be configured separately or in combination.

While conventional systems have been quite successful in presenting images to trained personnel for interpretation, drawbacks have been encountered. Specifically, moving objects may not be visible in traditional SAR imagery due to the fact that radar energy may be widely scattered in the image by the processor. Conventional methods have used special radar systems that are designed to see and/or track moving objects, but which cannot form, using either an integrated process or a separate process, an image of the object's environment. Since such mover detection methods are a part of the image formation process and cannot be readily separated therefrom, special tasking, special collections, or special image processing are conventionally required for detecting moving objects using SAR imaging.

SUMMARY OF THE INVENTION

A primary object of the present invention is to identify the location and nature of moving scatterers in a SAR image.

In conjunction with the primary objective, a further object of the present invention is to avoid special tasking, special collections and/or special image processing.

An additional object of the present invention is to provide a mover-detection process that is separate and distinct from a SAR image formation process, wherein the mover-detection process may be performed at a later time and at a different location.

It is a further object of the present invention to provide a process for detecting and tracking movers in a SAR image that is relatively unaffected by the velocities or trajectories of the movers, wherein high speed and/or maneuvering movers do not require special consideration.

Yet another object of the present invention is to provide a process for identifying movers in a SAR image at a given instant in the collection interval, wherein such identification is independent of any process of identifying movers at any other instant. For example, it is desirable to provide a method where the identification of movers at a single instant indicates the presence of movers and their location at a specified time.

Described herein is a system and method for identifying one or more moving objects in a synthetic aperture radar (SAR) image in a scene of interest. According to the method described herein, an image collector device is configured to include a plurality of receive phase centers. After the image information is collected using the image collector device, a SAR image may be generated. The SAR image may be analyzed to detect one or more signatures indicative of a moving object in the region of interest. The signatures may be detected as a function of image collection time.

In one configuration of the invention, the signatures may comprise one or more low intensity 3-dimensional artifacts generated as a function of the use of a plurality of receive phase centers in the image collection device. The artifacts may have polar symmetry and decrease in intensity with distance from the point of symmetry. Further, the low intensity artifacts may comprise two categories which include category 1 artifacts and category 2 artifacts, wherein the category 1 artifacts represent actual images of a mover in the scene of interest while the category 2 artifacts are extraneous. The category 1 artifacts may be formed as a combination of a plurality of received pulses all originating