Three-dimensional synthetic aperture radar imaging using optimized, complex trajectory of the radar carrier movement

Synthetic aperture radar (SAR) imaging is performed by ‘scanning’ the area of interest by use of radar attached to a carrier (e.g. an unmanned aerial vehicle (UAV), an airplane or a satellite) and flying over this selected area in a straight line or in circles. Methods of SAR imaging, known since the 1950s, are widely used in several scientific disciplines. Contrary to optical imaging (with the use of a camera), radar ground imaging and surveillance can be performed day and night, regardless of weather or visibility conditions (i.e. clouds, rain, fog, smoke or dust).

Nowadays, two-dimensional imaging which consists in obtaining an image as a projection of a three-dimensional area on a plane is widely used, while Three-dimensional imaging is a valuable, useful and highly needed method as it provides a lot of additional information. However, because of the limitations of the existing 3D techniques, such imaging is performed almost exclusively with satellite as a carrier.

The aim of this project is to develop a novel method of obtaining three-dimensional synthetic aperture radar imaging, which would allow the use of small radars with a single antenna, mounted on small carriers such as UAVs or small aircrafts. To achieve this goal the carrier will have to move not in a straight line or in circles but along a trajectory specially designed by calculating initial information about the area. The use of an untypical trajectory requires complex signal processing techniques that would allow for 3D image formation.

The scientific research within a scope of the project will be divided into three phases. First, a model of imaging with the untypical trajectory will be developed by use of analytical methods. Next, this model will be implemented into computation environment and finally computerized simulations will be carried out. During simulations the model will be iteratively tweaked up to the point where the optimum is reached. The project results will consist of both mathematical and numerical models of the developed method as well as characteristics of those models and suggestions for further research. The results will be published in recognized international scientific journals.

By introducing a new quality in the field of 3D radar imaging research, the novel method will change the approach to 3D imaging and significantly enrich state of the art.

Proposed method will facilitate an enhancement of 3D radar imaging as a whole, leading to its significant cost reduction, hence, resulting in its increased practical availability. This, in turn, will contribute to improved environment monitoring and protection (i.e. detection of mining damages, illegal logging, monitoring of dike conditions), balanced water use and fertilization in farming, fault detection and/or monitoring of large industrial plants, among others.

Results of the project, leading to an emergence of new 3D radar imaging technology, may benefit Poland, both directly and indirectly, by stimulating national economy, increasing the national innovation index and competitiveness of the Polish industry worldwide.