A fast imaging for UWB pulse radars

Takuya Sakamoto
Dept. of Intelligence Science and Technology, Graduate School of Informatics, Kyoto University, Japan
t-sakamo@aso.cce.i.kyoto-u.ac.jp

Toru Sato
Dept. of Communications and Computer Eng., Graduate School of Informatics, Kyoto University, Japan
tsato@kuee.kyoto-u.ac.jp

A UWB pulse radar is a promising candidate as an environment measurement technique for a variety of applications including robots. The radar imaging is known as one of the ill-posed inverse problems, for which many algorithms have been studied. However, they require a long calculation time, which cannot be acceptable for realtime operations for robotics. In order to solve this problem, we have developed a fast imaging algorithm for UWB pulse radars, SEABED algorithm, which utilizes the reversible transform between the real space and the data space. This transform directly gives the target image without iterative methods, which is the reason why SEABED algorithm works so quickly. Although this transform is valid only for targets with clear boundaries, this condition is naturally satisfied for most of indoor objects.

We assume a mono-static radar system, where an omni-directional antenna is scanned on the x-y plane. A strong echo is received from (x, y, z), a point on a target boundary, for the antenna position $(X, Y, 0)$ with a delay $Z = ct/2$ where t is the time delay, c is the speed of radiowave. The forward transform, BST (Boundary Scattering Transform) is expressed as

$$\left\{ \begin{array}{lcc} X & = & x + z\partial z/\partial x, \\ Y & = & y + z\partial z/\partial y, \\ Z & = & z\sqrt{1 + (\partial z/\partial x)^2 + (\partial z/\partial y)^2}. \end{array} \right. \tag{1}$$

We have clarified that the inverse transform of BST, IBST (Inverse BST) is expressed as

$$\left\{ \begin{array}{lcc} x & = & X - Z\partial Z/\partial X, \\ y & = & Y - Z\partial Z/\partial Y, \\ z & = & Z\sqrt{1 - (\partial Z/\partial X)^2 - (\partial Z/\partial Y)^2}. \end{array} \right. \tag{2}$$

SEABED algorithm deals with the transform IBST from the data space (X, Y, Z) to the real space (x, y, z), which corresponds to the imaging procedure. First, a set of points (X, Y, Z) in the data space are extracted as equiphase-surfaces from the received signals. Next, IBST is applied to the extracted surfaces (X, Y, Z) to obtain the reconstructed image in the real space. Fig. 1 shows an application example of SEABED algorithm, where the left image is the true target shape, and the right image is the estimated image. The calculation time to obtain the entire image is 0.1sec with a single Xeon 2.8GHz processor.

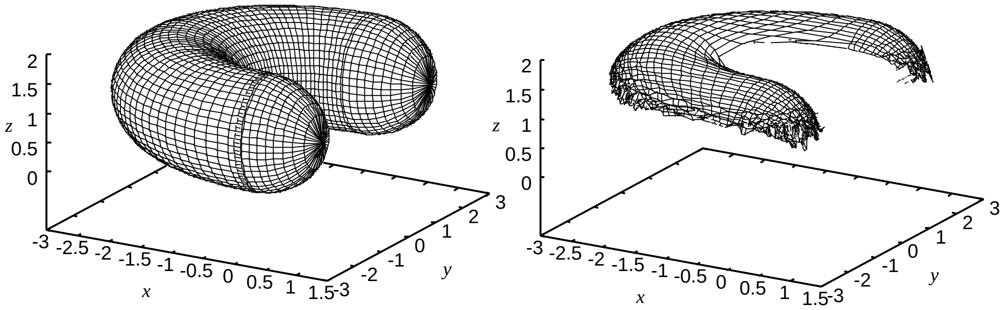

Figure 1: The estimated image by SEABED algorithm (Calculation within 0.1sec).