Improved Image Resolution of Target Near Rough Surfaces Using Generalized Memory Effects of Angular and Frequency Correlations

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It has been noted that angular and frequency correlations of the scattered wave from multiple scattering or rough surfaces exhibit the characteristics indicating that the scattered wave remembers the angular and frequency characteristics of incident wave under certain conditions. This is called the "Memory Effects" and was discussed by Feng in 1988. In July 2014 at URSI meeting in Memphis, we presented a preliminary study of the use of Memory Effects to reduce the clutter from rough surface and to improve the resolution of images of objects located near rough surface.

In this paper, we extend our study to include the Kirchhoff approximations of rough surface scattering. Angular and frequency correlations of the scattered wave are calculated and the resulting Memory Effects and the Memory Lines are discussed to show the images and the reduced clutters. First, we make detailed study of the correlations of the scattered waves at two different angles and two different frequencies when the incident waves are at two different incident angles and two different frequencies. We consider both Dirichlet and Neumann surfaces for scalar waves. Complete polarization characteristics with generalized stokes vectors will be considered. This will include the focused beam on the target and on the rough surface, and the beam spot size. We will first show that strong angular and frequency correlations exist under the condition of phase matching depending on the angle and the frequency of the incident wave. This relationship is shown using Memory Diagram indicating the regions of the scattered and incident angles and frequencies when the correlations are strong or weak. Making use of this relationship, we can find the condition where the clutter from rough surface can be small compared with the target imaging intensity. Further studies include the image of two targets and the effects of correlations between the targets and the conditions where two targets can be separated in time. This study also includes the use of time-reversal imaging technique.