ECE 278C Assignment 5: Multi-frequency Backward Propagation

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Abstract

In this assignment, I perform image formation by applying the backward propagation technique across a wide band of frequencies at each aperture data point and sequentially combining the reconstructions. As the sub-image range profiles are gradually added together, the reconstruction of the source region is improved. The technique is applied for a source region consisting of three point sources. The magnitude content of Green's function is ignored. I find that the image resolution, aperture size, and spectral coverage are closely related. The requested videos are attached to the submission email.

1. Introduction

In Assignment 4, I saw that using the wideband operating mode lead to an increase in spectral coverage and therefore offered a higher accuracy in the reconstruction. In this Assignment, I instead utilize the wideband operating mode to achieve range estimation by applying the back propagation technique at a single point on the aperture. I find that by combining the range profiles generated by each point across the aperture, the source region is reconstructed with the same result as in Assignment 4. In this way, I realize that the receiver aperture increases the resolution of the source region by providing information about the distance of the source from the aperture itself. With this interpretation, it makes sense that the back propagation method can extract depth information from the source, which was originally seen in Assignment 2. In the following section I explain the results of the wideband reconstruction and its corresponding spectrum for a source region with three point sources symmetrically oriented around the origin.

2. Sequential Combination of Range Profiles

I perform the reconstruction for a source region characterized by three point sources symmetrically oriented around the origin. This is done by computing the range estimation at each of the 241 points along the aperture and gradually adding the estimations together from left to right. Figure 1 shows this sum reconstruction and its corresponding spectrum as n increases.

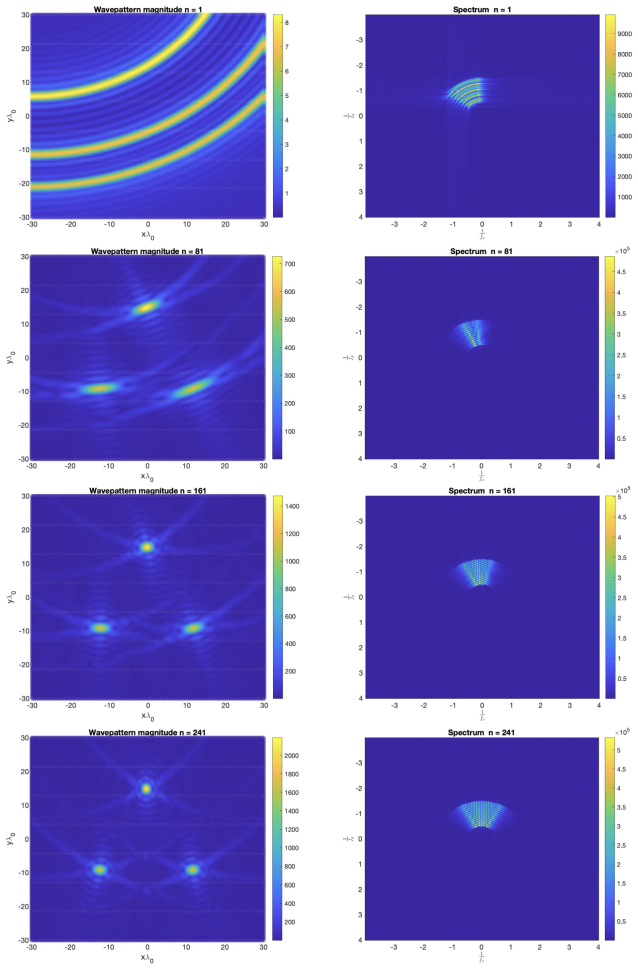

Figure 1. Sum reconstructions (left) and spectra (right) for $n = 1$, $n = 81$, $n = 161$, and $n = 241$ from the top

In the first image, I see that the wideband operating mode achieves the range estimation of the source for a single point on the aperture. At this point, the accumulation-cancellation effect creates peaks along three rings centered

around the aperture point. These rings represent the possible locations of the three point sources. In other words, for $n = 1$, I do not know the locations of the point sources with respect to one another, but I do know their depth from the aperture. It follows that the spectrum of the source region denotes plane waves coming only from the direction of the far left point on the aperture.

As n increases, the accumulation-cancellation effect maintains peaks only at the intersections of the rings created by the range estimations. In other words, the possible locations of the three point sources are reduced as I gather more range estimations across the aperture. By $n = 241$, I notice that the location of the point sources is as accurate as in Assignment 4 and the depth information of the point sources is preserved. Moreover, as n increases, the spectrum of the sum reconstruction gradually resembles the result in Assignment 4.

As opposed to the result in Assignment 4, the sum reconstruction reflects the wideband operating mode for any value of n, as is the result of using the range estimation reconstruction approach. Because of this, the spectral pattern of the final reconstruction is not clear until n reaches its final value. In Assignment 4, I could comment on the spectral pattern even without the wideband operating mode.

3. Conclusion

I have shown that the wideband operating mode reveals range information when applied to a single point on the aperture. Moreover, I have shown that combining the range profiles of each point across the aperture yields the same reconstruction found in Assignment 4. In this way I relate the concepts of wideband spectral coverage and aperture size as they pertain to the resolution of the reconstructed image.