Recovering a signal with deconvolution and the importance of phase in a signal

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Overview

Deconvolution effectively removes an unwanted quantity from a signal as is demonstrated with a series of digital images. This is especially important in seismic work where one must remove the source wavelet from the earth's reflectivity. It is further demonstrated that the phase of a signal plays an important role in defining that signal and it is proposed that perhaps the phase deserves more attention when a resultant seismic signal is viewed. A digital image is chosen for signal representation; although not a seismic signal a photograph can be thought of as being similar to a matrix of 2-D seismic data where the rows and columns represent inline and cross line data. An image is selected because from a visual point of view a photograph provides an excellent demonstration of the concepts being applied.

Deconvolution and Phase

The expectations of this paper are two fold. First an attempt is made to rid an image of motion blur by deconvolving the blurred image with a box car in the Fourier domain. The image in figure 1 has been blurred with horizontal motion. The image itself is unrecognizable. Figure 2 is the image in figure 1 after deconvolution has been applied; the image is now easily identified as a young girl with a dog. These two images show that in theory a simple deconvolution can effectively remove an unwanted quantity from a signal.

Figure 1: Image blurred with motion

Figure 2: Recovered Image resulting from deconvolution of the image in figure 1 with a box car. The black edge on the left hand side is a result of the convolution operator.

Various results are obtained when the filter length is altered, these are discussed in detail. The conclusion is that it is possible to write an algorithm that could remove from motion blur from an image. Determining the optimal filter is the most challenging part of the algorithm. This will involve starting with a filter that has a short length and iteratively increasing the length of the filter until the proper length is discovered.

The second purpose of the paper is to prove that a significant amount of the defining information of a signal is contained in the phase relative to the amplitude. This is demonstrated with a series of phase only and amplitude only representations of a signal. It will be shown that the phase only, but not the magnitude only image retains many of the features of the original image. Figure 3 shows the phase of one image combined with the amplitude of a different image. The resultant image is clearly most similar to that from which the phase was acquired where changing the magnitude has only altered the intensity of the image.

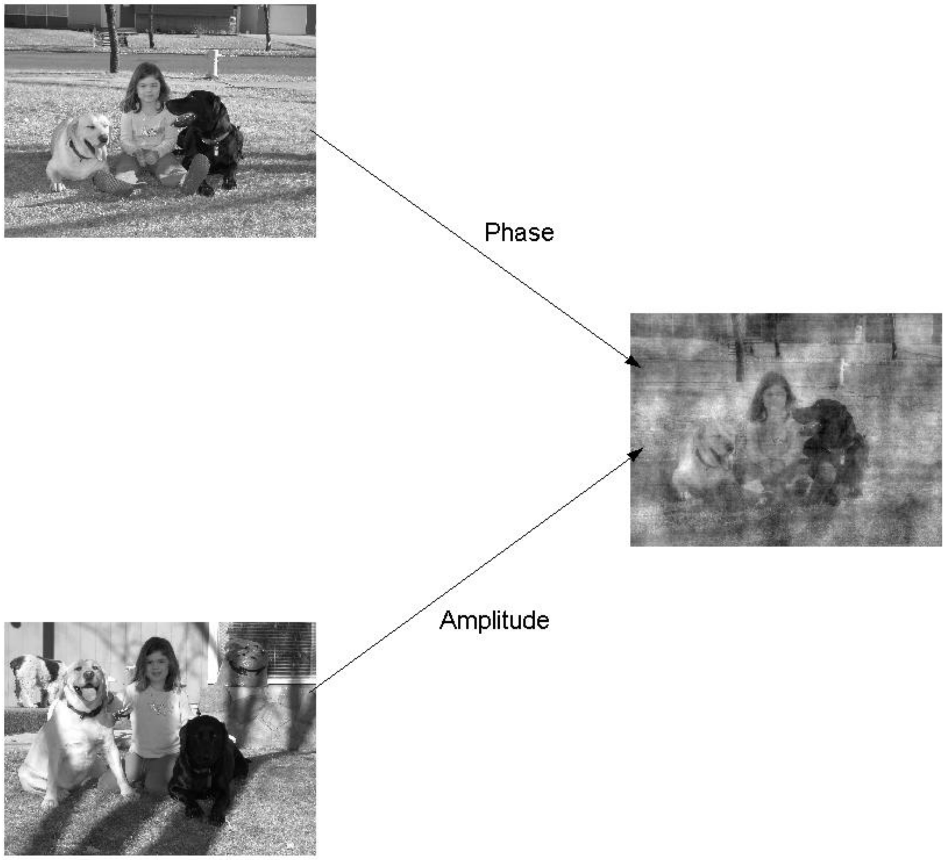

Figure 3: The phase of one image is combined with the amplitude of another to create a new image. The resultant image is most similar to the image with the same phase.

It is thereby illustrated that the phase of a signal plays an important role in defining that signal.