Steps Required to Process Data Collected by LRO into a Bistatic Image for Making CPR Calculations

Daniel Wahl
David Yocky
Ireena Erteza

Sandia National Laboratories

The LRO data are from a bistatic experiment with a transmitter on Earth (typically Arecibo) and the receiver on the LRO in orbit of the moon. In order to process the bistatic radar data into H and V images which can be then used to calculate the CPR, we need three “data sets”: (1) the bistatic radar data; (2) the ephemerous data; and (3) the timing data. The radar data collected is stored in packets. These data packets contain portions of the H and V received channels. The data are in a 3 bit data format (using compression). Ephemerous data which describes the transmitter location, the receiver location and the roll, pitch and yaw of the satellite receiver are contained in a comma-separated-values (CSV) geometry file. Finally, the timing data required, which specifically states the start time of the 3-bit collection (of radar data) and an estimate of the PRI (pulse repetition interval), is typically given in a powerpoint file describing the experiment. Following is a description of the steps required to process the data.

1) Data packets are received in the 3-bit format. These packets need to be concatenated, uncompressed and then converted into (i, q) pairs for subsequent processing. This results in one file each for the Horizontal and Vertical channels (Out_H_BAQ_1 and Out_V_BAQ_1).
2) The channels are processed separately. Each channel processing uses the same ephemerous data file and the same data start time.
   - The first step in processing is to use one channel (either H or V) and to determine the exact timing information (PRI). Basically, a code is run which plots the range compressed data (raw data which has been convolved with the chirp, whose characteristics are known) for several

PRI intervals. This is done for pulses that span the entire collect. The direct path signals are easily identifiable in this type of plot. If the timing information is accurate, then the direct path signals are aligned vertically. Parameters are adjusted to the PRI estimate to make the estimate accurate. These values are then used throughout the subsequent processing. These parameters are valid for both the H & V channels (i.e. this can be done once and used for both channels).

- The next step is to figure out the phases of the direct path correlation peak. We need the exact timing information (initial phase) of the transmitted chirp to properly form the radar images. There are several ways to come up with this estimate. The quality of the image is directly affected by the accuracy of this phase estimate.
- The third step is to apply the timing, phase and ephemerous data to the raw data to create a wideband (phase history data) file and a narrowband file (containing transmitter location, receiver location and other collection parameters). These are the inputs to the image formation process, along with a grid upon which to form the image (see next step).
- The fourth step is to generate a grid that is used in the back projection ("beamforming") image formation algorithm. The grid is a set of points on the moon where the radar image is reconstructed. The grid assumes a spherical model for the moon's surface. The grid pixel spacing can be chosen arbitrarily, but typically it is somewhat prescribed by the resolution supported by the data. Typical range spacing is 40m, and typical azimuth spacing can be as low as 2m.
- The final step is to run the beam forming code. This is done for both the horizontal and the vertical channel of data. Both channels are formed using the same grid (in ECEF coordinates). The final images created are then converted into separate real and imaginary channels of data, and resampled on a grid that is in lat/long coordinates. The images are then sent to APL for the final CPR calculation.