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Challenges and opportunities from large volume, multi-offset Ground Penetrating Radar data

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The most frequently used survey mode for acquiring Ground Penetrating Radar (GPR) data is common offset (CO) – where a single transmitter and receiver pair move along a survey line at a constant (offset) separation distance. This allows rapid and dense data acquisition, and therefore high-resolution large-scale investigations, to be carried out with relative ease, and at relatively low cost. However, it has long been known that multi-offset survey methods, such as common mid-point (CMP) and wide-angle reflection-refraction (WARR), can offer many benefits over CO: detailed subsurface EM wave velocity models; enhanced reflection sections with higher signal-to-noise ratio (SNR); the potential to adapt well-established advanced seismic processing schemes for GPR data [1-2].

Despite the advantages of multi-offset GPR data, these methods have seen limited adoption as, in the past, they required significantly more time, effort, and hence cost, to collect. However, recent advances in GPR hardware, particularly in timing and control technology, have enabled the development of multi-concurrent sampling receiver GPR systems such as the “WARR Machine” manufactured by Sensors & Software Inc. [3-4]. These newly developed GPR systems have the potential to provide all the aforementioned benefits with considerably less effort and therefore reduced survey cost, as they allow for the fast acquisition of multi-offset WARR soundings.

In this work, we look at the challenges and opportunities from collecting and processing multi-offset GPR data. We demonstrate a processing workflow that combines standard GPR processing approaches, with methods adapted from seismic processing, as well as our own algorithms. This processing framework has been implemented into a GUI-based software written in MATLAB [5], and has been tested using both synthetic [6] and real multi-offset GPR data. Some of the specific challenges with multi-offset GPR that we investigate are time zero misalignments, CMP balancing, velocity analysis, and automated velocity picking. We show how addressing these issues can result in improved velocity analysis, and ultimately in improved subsurface velocity models, and stacked sections.

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