ABSTRACT

Any realistic attempt to clear buried landmines during peacetime (humanitarian demining) will require sensors having nearly perfect detection at very low false alarm rates. Currently no single demining sensor can meet the desired performance level, and in this dissertation sensor fusion is considered for this task.

Techniques for conventional sensor fusion include data-level, feature-level and decision-level fusion. All of these standard techniques are unattractive for reasons that include non-commensurate data (i.e., data of compatible format), sensor positioning errors, non-coincident sampling, and generally poor performance.

In this dissertation, we develop a practical feature-level fusion algorithm that can accommodate non-coincidently sampled data. Data acquired with ground penetrating radar (GPR), electro-magnetic induction (EMI), and infrared (IR) sensors at tow mine test sites are used to compare the performance of individual and fused sensors. These studies confirm that for mine detection feature-level fusion provides the best performance possible for this sensor suite. Soft decision-level fusion also 0provides significant improvement, but an optimal hard decision-level fusion provides only a marginal improvement over the best individual sensor. The ad hoc decision-level fusion rules AND, OR, and majority voting are ineffective for this application.

To support the fusion studies a new clutter reduction technique is developed, which can significantly reduce the dominant, ground reflection clutter in GPR data. Unlike previously described clutter reduction techniques, this new method can work successfully even when the target is small and buried at a very shallow depth, even flush to ground. A subspace decomposition procedure is used to reduce additional clutter contributions due to antenna ringing and cable mismatches.

Good features are essential for efficient fusion and considerable effort was devoted to this subject. Using the Fort A.P. Hill data we demonstrate that physical and representation features are ineffective for discriminating mines from clutter. For both GPR and EMI data it is shown that statistical discriminant features provide very good classification.