Chapter VII

Evolution of Spatial Data Templates for Object Classification

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Sensing devices are commonly used for the detection and classification of subsurface objects, particularly for the purpose of eradicating Unexploded Ordnance (UXO) from military sites. UXO detection and classification is inherently different to pattern recognition in image processing in that signal responses for the same object will differ greatly when the object is at different depths and orientations. That is, subsurface objects span a multidimensional space with dimensions including depth, azimuth and declination. Thus the search space for identifying an instance of an object is extremely large. Our approach is to use templates of actual responses from scans of known objects to model object categories. We intend to justify a method whereby Genetic Algorithms are used to improve the template libraries with respect to their classification characteristics. This chapter describes the application, key features of the Genetic Algorithms tested and the results achieved.

There has been increased interest in the use of sensing devices in the detection and classification of subsurface objects, particularly for the purpose of eradicating Unexploded Ordnance (UXO) from military sites (Putnam, 2001). A variety of sensor technologies have been used including magnetic, electromagnetic, thermal and ground penetrating radar devices. Depending on the technology and terrain, devices may be handheld or vehicular-borne. Scanning of a section of ground produces a two-dimensional data set representing the impulse response at each spatial location. Classifying subsurface objects involves matching a representation or model of each known object against that of an unknown object. Previous classification techniques have attempted to model objects in ways that are independent of depth and orientation. At the recent Jefferson Proving Ground Trials, it was found that current techniques do not provide adequate discrimination between UXO and non-UXO objects for cost-effective remediation of military sites (US Army Environment Center, 1999). Our approach (Dunstan and Clark, 1999) is to use templates of actual responses from known object scans to model objects. Template matching was used by Damarla and Ressler (2000) for airborne detection of UXO from Synthetic Aperture Radar data sets. Their results showed that a single template could correlate well against a range of large ordnance categories for the purpose of identifying sites requiring remediation. Hill et al. (1992) used Genetic Algorithms to match medical ultrasound images against derived templates of the human heart. The Genetic Algorithm was used to find the best match of an unknown ultrasound and a derived template. Our goal is primarily to achieve the capability of discriminating between UXO and non-UXO objects and, if possible, between the various categories of UXO. Our approach to classification of scans of unknown objects is to match the scan data against a model of each known object. Each model consists of a set of templates of scans of objects known to be of that category. A match is based on correlations of each template against the scan data. Two measures are calculated: the Normalized Cross Correlation Value (NCV) —this is the Normalized Cross Correlation as a percentage of the optimum score; and Fitness Error Factor (FEF)—the absolute difference between the area of the object signal response and the area of the template as a percentage. FEF helps to invalidate correlations with good NCV but with templates significantly larger or smaller than the object's response area. We define a Positive Correlation between a template and a scanned object to exist when the $NCV > MinNCV$ and the $FEF < MaxFEF.$ That is, the NCV correlation is sufficiently large and the FEF is sufficiently small. A classification function will then use correlation results from all templates from all categories to return a category type for the unknown object. Therefore, we would wish our template sets for each category to be truly representative of that category, and able to distinguish between objects of its own and other categories. Sadly, our template library is small and not systematic in its coverage of the depth/orientation spectrum. Nevertheless, our existing templates show some promise in ability and we seek to maximize their effect.

The background to this research is the Jefferson IV Field Trials, conducted by U.S. military agencies in 1998 to assess the abilities of current detection technolo-

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