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Quarterly Technical Report for Grant F33615-97-1-1014
August 1, 1997

A Unified, Multiresolution Framework for Automatic Target Recognition

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This is a quarterly progress report summarizing accomplishments in the research program supported by US Air Force Wright Patterson Laboratory Grant # F33615-97-1-1014. It covers the period from March 1st, 1997 to July 1st, 1997. The principal investigators of this grant are Professors Grimson, Willsky and Viola of MIT. Advisory investigators include Professor Shapiro, Dr. Wells and Dr. Krim of MIT.

In many ways this grant is an extension of the University Research Initiative grant # F49620-93-1-0604 administered by Drs. Healy, Strat and Tsao. One of the most successful applications of the technology developed in the previous grant was the use of multiresolution models for SAR imagery as the basis for enhancing Lincoln Laboratory's discrimination algorithm, resulting in a reduction in false alarm rates by a factor of approximately 6 over Lincoln's baseline algorithm (work by Prof. Willsky, his former student, Dr. William Irving (now at Alphatech), and Dr. Les Novak of Lincoln).

In this grant we have proposed to extend these techniques so that they may be used for target discrimination in an end-to-end fashion. Recall that Irving and Willsky construct a probability distribution over complex images by defining a multi-scale linear model where the distribution for pixels at one scale is a function of the lower scales. In effect for each pixel they construct a Markov Tree, where the the probability distribution for each pixel is a Markov Chain across scale. The parameters of the Markov Chain are estimated by analyzing complex valued "Gaussian" pyramids computed from SAR images. From differing sets of example images, models can be created both for *clutter* and *man-made* classes.

Motivated by Irving and Willsky's work, Prof. Viola and his student Jeremy Debonet have extended this framework in three major ways. First, we propose the use of a more complex multi-scale representation for the SAR imagery. Instead of a multi-scale "Gaussian" pyramid (where each level has the natural interpretation as

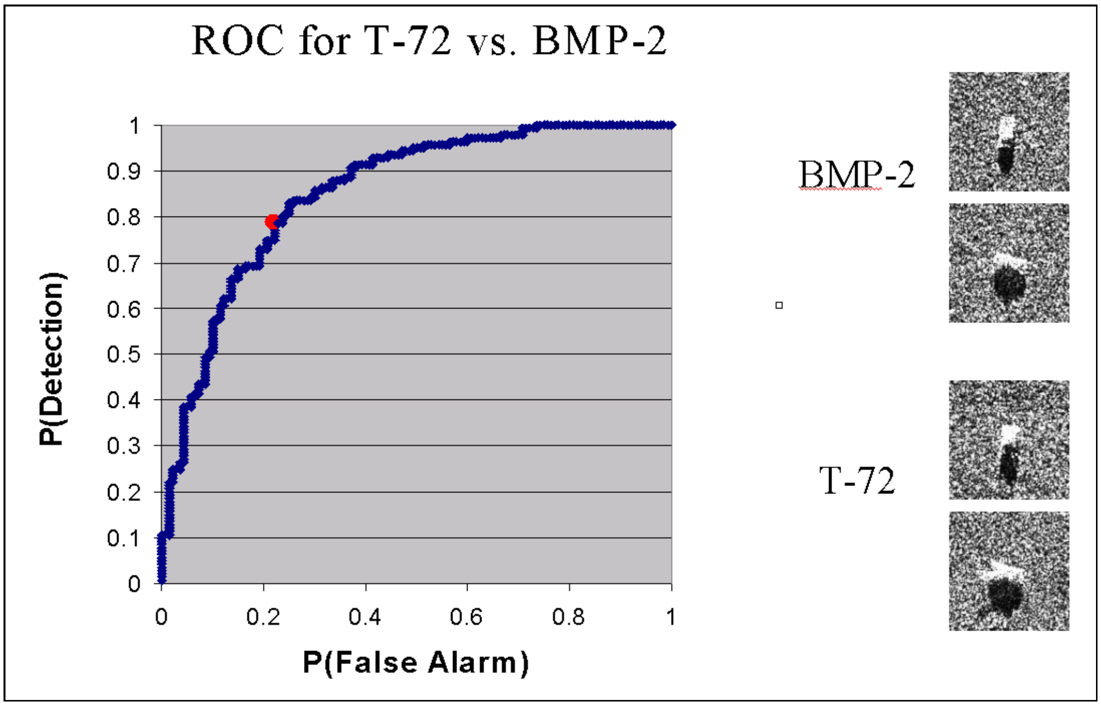

Fig:ROC

Figure 1: Preliminary ROC for the T72 and BMP-2.

low resolution SAR imagery) we instead use a set of feature pyramids which enhance features of the target. Secondly, we have extended the linear models of Irving and Willsky to a non-parametric form. This allows us to model multi-modal distributions in the data. Thirdly, we have made some very preliminary attempts to apply these models to the classification of different target classes – such as tanks and personnel carriers.

Much of the theory underlying this new approach has been worked out. A paper detailing this work is currently being prepared. In addition an initial implementation of this procedure has been written. Using collections of clutter and target imagery we have built a classifier which can label chips as either *clutter* or *man-made*. Our initial results on small datasets are promising, but we have not yet tested it in a realistic fashion. One of our most immediate goals is to measure ROC curves for enough data so that we can predict false alarm rates under reasonable operating conditions. We have also used the code to build an classifier for two classes of target: BMP-2 and T72 from the MSTAR CD's. Initial results are promising, but once again our results are very preliminary. In the next few months we will be able to report classifications results for many targets.

Clearly we must test our software with realistic data. In support of this goal Mr. Debonet is working at Alphatech this summer. There he has been learning practical details about the ATR problem from MSTAR researchers. With the assistance of these researchers at Alphatech Jeremy hopes to test some of our approaches against MSTAR data.