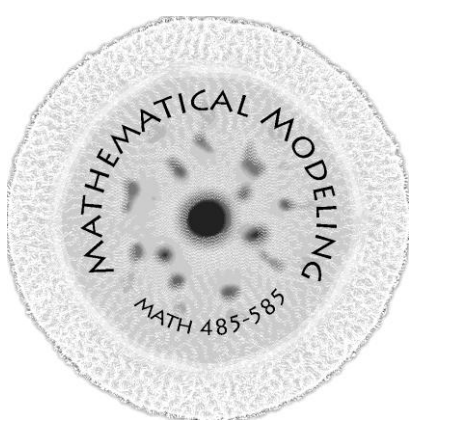




Recognition of Spectral Patterns



Project Description

- **Motivation:** Recognition of spectral patterns through the utilization of an optical correlator.
- **Previous Works:** Correlation filters have been utilized with some success in automatic target recognition (ATR) applications. [1]
- **Reason:** To develop a model for improved target recognition that factors in *prior* knowledge of target IR signature.
- **Goal:** Evaluation of the MACH (Maximum Average Correlation Height) filter for ATR and aim point analysis.

Scientific Challenges

- Strike a balance between **robustness** (with respect to noise) and **simplicity** in order to be realizable in the real world.
- Closing rate of an intercept is (> 4 km/sec).
- Correlation filters are designed (with respect to target class, aspect angle, etc.) to provide the optimal (i.e., the most invariant response) of the filter with respect to the target image.

Potential Applications

- Target recognition; facial feature recognition; mammography (breast tumor detection)



Example Representative Tank Imagery Model Set Up

Team Member:

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Methodology

1. Calculate correlation surface: **cross-correlate** image and each **correlation filter** [1]:

$$g_{k,c,\theta} = \hat{I}_k(u,v) \otimes h_{c,\theta}$$

where: $g_{k,c,\theta}$ represents the correlation image, $\hat{I}_k(u,v)$ represents the k^{th} pre-processed image. The symbol \otimes represents the two-dimensional spatial correlation. Moreover, $h_{c,\theta}$ represents the filter coefficients in the spatial domain.

1. Specifically, the "Fast Fourier Transform" correlation (i.e., FFT) is employed to transform a spatial correlation into a Fourier-domain, element-by-element multiplication.

$$g_{k,c,\theta} = \left(\mathfrak{F}_{2D}^{-1} \left(\mathfrak{F}_{2D} \left(\hat{I}_k(u,v) \right) \bullet H_{c,\theta}^* \right) \right)$$

where: the variables for target class are specified as c . The aspect angle is represented by the variable θ . The function, $\mathfrak{F}_{2D}(\bullet)$, computes the two dimensional Fast Fourier Transform of its argument; the function, $\mathfrak{F}_{2D}^{-1}(\bullet)$ computes its inverse. The symbol (\bullet) denotes an element-by-element multiplication. $\hat{I}_k(u,v)$ is the k^{th} pre-processed image, and H^* is the selected filter.

3. A post-processing function, Peak-to-Sidelobe Ratio (PSR), must be applied to the correlation surface to judge the relative strengths of the correlation peaks. The PSR surface is then searched for the maximum value.

$$PSR = \frac{peak - \mu}{\sigma}$$

where: peak is a peak response in the correlation surface; μ is the mean response local to the peak; and σ is the standard deviation local to the peak.

Results

1. Simulation was performed and the the results of how the target aim point error is affected was graphed.
2. It was found that the target aim point error was similarly affected. Specifically, consistent with the original model, the aim point error is quite good through a -6 SNR. [2]

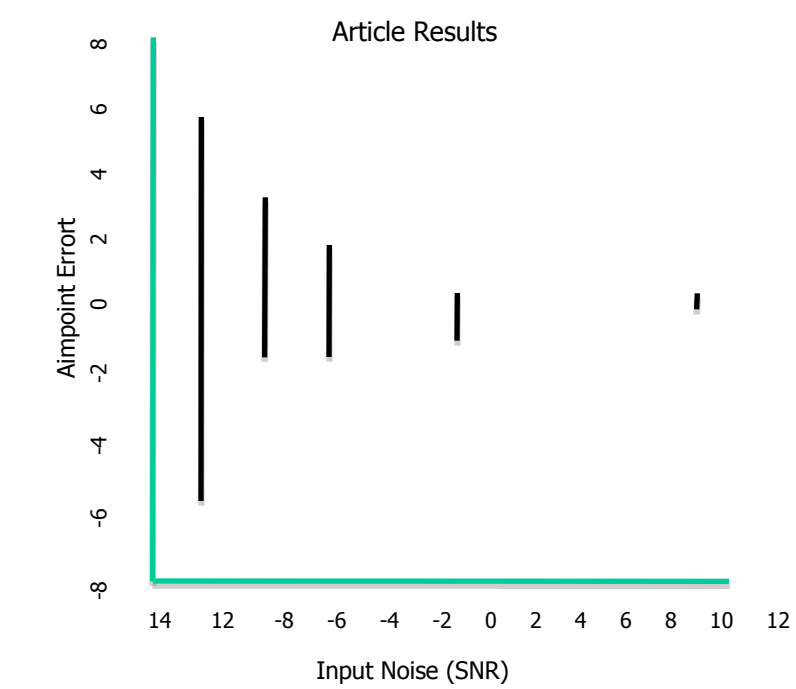


Figure 1 shows the results of the target aim point error. As shown, the aim point error is quite good through a SNR of -6 dB.

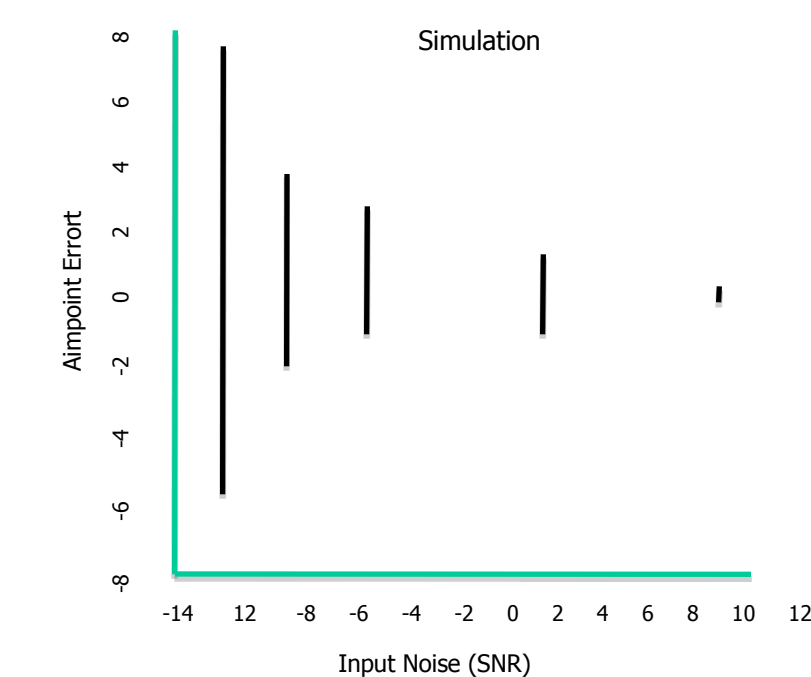


Figure 2 shows the results of the simulation for the project extension; a bipolar threshold condition was examined in the algorithm to permit the option to detect targets that are colder (i.e., minimum value), in which case, the absolute value of the minimum value was computed.

References

1. Mahalanobis, A. "Improving the False Alarm Capabilities of Composite Correlation Filters" *Proc. of SPIE Vol. 3718*
2. Mahalanobis, A. et al "Utilization of Optical Correlator for Automatic Target Recognition" *Proc. of SPIE Vol. 4043*

Acknowledgments

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Glossary of Technical Terms

Correlation filter: a set of carefully designed correlation templates with regard to shift invariance as well as distortion-tolerance.

Fast Fourier Transform (FFT): efficient method to transform spatial correlation into a Fourier-domain element-by-element multiplication.

Cross-correlation: the two-dimensional spatial correlation for the large matrices.