FINAL TECHNICAL REPORT

by

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Title of Project

EFFICIENT COMPUTATIONAL METHODS TO STUDY NEW AND INNOVATIVE SIGNAL DETECTION TECHNIQUES IN SETI

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Introduction

The purpose of the research reported here is to provide a rapid computational method for computing various statistical parameters associated with overlapped Hann spectra. These results are important for the Targeted Search part of the SETI Microwave Observing Project.

Parameters, Tables, and Computer Runs

Formulas to evaluate relevant statistical parameters for 50% overlapped Hann spectra have been derived. Details are provided in the attached publication on Computational Problems and Signal Processing in SETI, ref. 1. High precision computer codes to implement the formulas, and thus compute the statistical parameters, have been written and tested. Three independent methods have been used as a cross–check to guard against programming mistakes. The parameters of interest include m (the number of overlapped spectra computed), T_u (the threshold), P_{fa} (the false alarm probability), P_d (the detection probability), and r (the signal–to–noise ratio).

Given m and P_{fa} it is possible to compute the threshold T_u, and then find the r that corresponds to a given P_d. This computation requires an enormous amount of computer time, in some cases 15 or 20 minutes on a VAX 8650. Consequently, the idea is to compute the parameters at several points over regions of interest, and use interpolation methods to obtain results at intermediate points. The tables produced by these rather extensive computations on the VAX 8650 have been published as a NASA Technical Memorandum, ref. 2. These tables cover false alarm rates from 10^{-14} to 10^{-1} and signal detection probabilities from 0.50 to 0.99 for the number of computed spectra ranging from 4 to 2000.

An interactive computer program OHINTERP has been written using the C programming language to do the interpolations in three dimensions. Observe that when using the tables the parameters P_d, m, and P_{fa} can be regarded as representing the x, y, and z axes in a three–dimensional space. The program uses cubic interpolation and runs very fast, yielding output results as fast as one can enter the various input parameters. Four samples of interactive runs are included in Appendix A of this report. The first run simply repro-

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duces what is in the table for $P_{fa} = 10^{-6}$ and no interpolation is required. The second run requires a single interpolation in that same table. The third run yields an interpolated result that made use of a two–dimensional interpolation. The fourth run makes full use of interpolation in all three dimensions.

The accuracy of the interpolation in this three–dimensional space has been tested and found to be at least as good as one significant figure less than the computed values that appear in the tables. For this reason, interpolations generated by the computer program are rounded to three decimal places after doing the calculation to four decimal places.

Summary

A rapid computational method has been developed for computing statistical parameters associated with overlapped Hann spectra. Since accurate calculations to implement the formulas require such an enormous amount of computer time, tables are produced that cover regions of interest. By using the tables in conjunction with very fast interpolation procedures an interactive computer program can be used to obtain additional information. The results of this research are important for the Targeted Search part of the SETI Microwave Observing Project.

Ongoing and Future Work

The principal investigator has accepted an IPA assignment at NASA Ames Research Center for the 1991–92 academic year. During that time he will continue to work on various computational aspects of signal detection associated with SETI; work on editing a book of algorithms associated with SETI will continue. New work on algorithm development and analyses of reports from the CW Detector and the Pulse Detector will begin.

References

1. Stanley R. Deans and D. Kent Cullers, "Tables of square–law signal detection statistics for Hann spectra with 50% overlap," NASA Technical Memorandum 103830, September 1991, Ames Research Center, Moffett Field, CA 94035.

2. Stanley R. Deans, D. Kent Cullers, and R. Stauduhar, "Computational problems and signal processing in SETI," in *Maximum Entropy and Bayesian Methods*, W. T. Grandy, Jr. and L. H. Schick, eds., Kluwer Academic Publishers, Dordrecht, 1991, pp. 67–75.

Appendix A Sample Computer Runs

```
C:\TC\CRUN>ohinterp

Enter M: 500
                              -y
Enter Pfa in the form  x 10    (where y is an integer)
Enter x: 1.0
Enter y: 6
Enter Pd: 0.50


    M          Log Pfa       T          Pd          SNR

   500           -6        0.915       0.50       -6.279




C:\TC\CRUN>ohinterp

Enter M: 500
                              -y
Enter Pfa in the form  x 10    (where y is an integer)
Enter x: 1.0
Enter y: 6
Enter Pd: 0.60


    M          Log Pfa       T          Pd          SNR

   500           -6        0.915       0.60       -5.919
```

```
C:\TC\CRUN>ohinterp

Enter M: 600
                              -y
Enter Pfa in the form  x 10    (where y is an integer)
Enter x: 1.0
Enter y: 6
Enter Pd: 0.60


    M          Log Pfa       T           Pd          SNR

   600            -6        0.838        0.60       -6.348




C:\TC\CRUN>ohinterp

Enter M: 600
                              -y
Enter Pfa in the form  x 10    (where y is an integer)
Enter x: 2.0
Enter y: 6
Enter Pd: 0.60


    M          Log Pfa       T           Pd          SNR

   600        -5.6990      0.814        0.60       -6.479
```