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20. ABSTRACT *(Continue on reverse side if necessary and identify by block number)*

This report discusses limitations of algorithms with respect to operator training. Operators can improve algorithm performance thru use of unmodeled data (weather, history of variance, etc.). As an example fixing bias is discussed in detail.

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U.S. ARMY INTELLIGENCE CENTER AND SCHOOL
Software Analysis and Management System

Extension Of Computer Based Algorithms By Operator Analysts

Technical Memorandum No. 27

28 April 1987

Author:

Michael W. Rennie

MARC
Mathematical Analysis Research Corporation

Approval:

James W. Gillis, Subgroup Leader
Algorithm Analysis Subgroup

Edward J. Records, Supervisor
USAMS Task

Concur:

A. F. Ellman, Manager
Ground Data Systems Section

Fred Vote, Manager
Advanced Tactical Systems

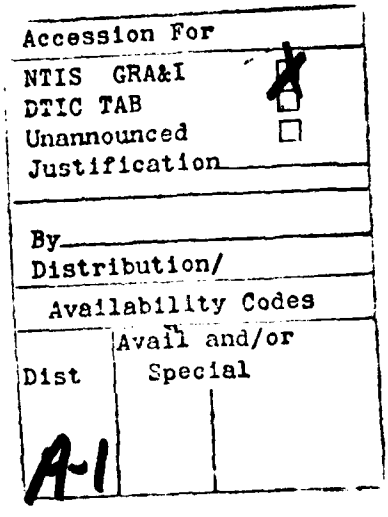
JET PROPULSION LABORATORY
California Institute of Technology
Pasadena, California

JPL D-4624

PREFACE

The work described in this publication was performed by the Mathematical Analysis Research Corporation (MARC) under contract to the Jet Propulsion Laboratory, an operating division of the California Institute of Technology. This activity is sponsored by the Jet Propulsion Laboratory under contract NAS7-918, RE182, A187 with the National Aeronautics and Space Administration, for the United States Army Intelligence Center and School.

This specific work was performed in accordance with the FY-87 statement of work (SOW #2).



EXECUTIVE SUMMARY

This Technical Memorandum was prepared to summarize the results of work preformed under both the FY-86 and FY-87 Statements of Work and was funded by the FY-86 funds.

The purpose of this Technical Memorandum is to clarify the desirable interactions between computer-based algorithms and their operators nessary to optimize their combined effectiveness.

Extension Of Computer Based Algorithms By Operator Analysts

SUMMARY

Algorithm development should have two phases. The computer portion and the portion to be incorporated in operator analyst training.

A knowledgeable operator analyst should be able to perform analysis beyond the means of any particular computerized algorithm available to that analyst. This follows from the fact that humans can understand the consequences of the limitations of particular computer implementations and correct, in part, for them.

Computer based algorithm limitations may have different causes:

1) ~~i)~~ The algorithms may be based on incomplete or inaccurate models;
2) ~~ii)~~ The algorithms may not be flexible enough to adapt to the need for changes in analysis criteria;
3) ~~iii)~~ The algorithms may take shortcuts because of limitations in computer storage or speed;
4) ~~iv)~~ There may be refinements in the analysis which could be computed but are not because they depend on parameters which are insufficiently well known; and
5) ~~v)~~ Computer output formats may be restrictive.

Keywords:

It is out of the scope of this memo to illustrate the multitude of variations on the limitations discussed above. Instead one example will be discussed at some length in the sections that follow.

INTRODUCTION TO THE EXAMPLE- BIAS IN FIX ALGORITHMS

Intuitive Definition of Bias-

For simplicity assume there is no difficulty deciding which bearings to use in a fix. If there were no angular error in bearing measurements, then the fix location would be the true location in any reasonable algorithm. A given fix may be near or far from the true emitter location depending on the particular set of angular errors that one actually observes. This set of angular errors is only one of many possible combinations, each yielding a different fix. One hopes that the average[1] of the fixes that might have occured is near the true location of the emitter. Sometimes it isn't. Whether it is or isn't the difference between the average expected location and the true location is called the bias of the fix.

[1] Weighted by their likelihood of occurence.

Minimizing Bias

Zero bias is not a realistic objective. Small bias may be possible, however. Bias may be considered small if either

1) it is much smaller than typical random error
2) it is much smaller than application requirements (targeting, fusion or whatever)

Bias size can be made smaller by either

1) using a better fix algorithm
2) using more accurate bearings
3) using bearings at a wider range of angles relative to the emitter (often accomplished using a longer base-line) and not permitting the bearings from the middle angles to dominate the fix

In practice there are limits to the extent that these three approaches can be applied. In the case of algorithms for example, the limiting factors are of two types:

1) Speed and storage requirements for an algorithm exceeding hardware capabilities.
2) A parameter (angular standard deviation) used in models which is not really known but also not sufficiently unknown to be treated as coming solely from the data. Corrections for bias would be possible if this parameter were known.

ANALYST CONTRIBUTIONS

Even though knowledge of factors causing bias is not exact enough for calculating corrections, the analyst can get a rough feel for it based on:

1) The analyst can know the factors affecting the accuracy not incorporated in the model (such as weather).
2) The analyst can know more about the angular standard deviation parameter than is used in the calculation. He knows, for example, the history of accuracy.
3) The analyst can know patterns in the behavior of the fix algorithm, for example,
   a) The most commonly used algorithms are biased short.
   b) Fixes with narrower ellipses have larger bias.
4) The analyst may be able to imagine a range of possible biases and qualify decision making on it without actually knowing how large bias actually is.