STUDY PLAN

STUDY REFINEMENTS IN APPLICATIONS OF MICROMEASURIMENTIC TECHNIQUES

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Contract EB-1492

EB-45-70C121-6
1. **SUBJECT:** Study Plan

2. **TASK/PROBLEM**

   a. Study methods for improving the applicability of the microdensitometric techniques and computation procedures as applied to the evaluation of reconnaissance materials. Studies to include a proposed mathematical technique to determine if hand smoothing of edge data can be minimized or eliminated, complete investigation on the Hermite mathematical technique, and modify the present TCS2 computer program (SWRDA) for more efficient operation.

3. **INTRODUCTION**

   a. There is an established need for better quality military reports for post-reconnaissance material. The existing techniques of retrieving power, M.I.R., rating, M.E.M., and edge-traversal interpretation have various deficiencies. It is not possible to have a single system answering all requirements. Improvements in the existing image ranking systems may satisfy current needs. An example of the first study report (see Reference 1) indicated needed improvements in the existing methods for use by engineering troops, and development of the REM technique for use by photointerpreters. This proposal (PAR 25-6-2) is concerned with investigations leading toward better edge-traversal methods.

   b. The current basic need in the technique of evaluation is a quality ranking by means of microdensitometric edge-traversal techniques of establishing and improving the accuracy, precision, and convenience of the method. In general, any single experiment conducted in this project can be expected to yield information of all three characteristics. The specific study topics planned for PAR 25-6-2 are listed below. The order given is not necessarily that which will be followed since parallel investigations of several topics will be conducted simultaneously where possible.
DATA COLLECTION

The first stage in computing mission quality from edges is that of scanning the edge in a microdensitometer. As may be expected, any errors in the data or method at this stage can be compounded in later data processing, and therefore the accuracy and precision of edge tracing appears to be fundamentally limited by this first operation.

b. There are two microdensitometers engaged in mission edge scanning: the Mann instrument and the Koda Model 5. A comparison will be made between these two instruments to show their resolution, edge derived MTF, power spectra and stray light control (see Reference 2). From this data, it will be possible to note any systematic differences that would influence edge tracing.

c. The "Crossover" exercise (see Reference 4) consisted of an instrument comparison test in which a series of special laboratory edges varying in sharpness were circulated to interested participants for scanning in several microdensitometers. In a repetition of the "Crossover" exercise, this facility will cooperate in the edge scanning and data reduction.

In processing noisy signals, it is possible to apply resiliency to increase the signal-to-noise ratio, assuming that the noise is random. Preliminary testing using multiple scans at random positions along the length of an edge has shown that improvement in the precision of edge tracing is approximately proportional to the square root of the number of tracings of each edge. This study will be extended to include the following topics:

(1) Best method of signal averaging.

(2) Definition of the number of tracings required to give a practical level of precision.

(3) Methods for speeding the accumulation of multiple scans.
e. The microdensitometer illumination optics and slit determine the degree of coherence present in edge scanning. With increasing coherence (decreasing slit size) the modulation transfer technique becomes unusable as an estimator of resolution. An attempt will be made to evaluate the effect of coherence on edges in current mission photography and establish an upper resolution limit for this method.

DATA REDUCTION

a. The digital data obtained in edge scanning requires treatment to smooth out noise fluctuations, and then is computer modified to yield image quality data (i.e., resolving power). Both the smoothing and data reduction methods have been employed to this end. Improvements in the accuracy and speed of execution of both procedures are desirable.

b. The data smoothing technique employed at this facility is that of manually fitting the analog trace of the edge. Procedural methods of computer smoothing via moving polynomials, providing a best possible number of traces for a single edge, least squares curve fitting, etc., have not been satisfactory in all test cases. The potential capabilities of computer smoothing, however, are such that it seems premature to abandon the search. To be investigated are:

1. Multiple techniques combining several types of computer smoothing in serial passes of the data.

2. Cross correlation methods in which a knowledge of the signal shape is used.

c. The edge trace data is now reduced in the computer by means of Fourier transform techniques. While this method appears to be satisfactory, other methods have been proposed. Examples of these are the Hermite functions, Fredholm integrals (see Reference 3), and non-linear regression techniques (see Reference 4). Studies will be made of these methods with the intention of comparing their merits with the standard Fourier method.
SPECIAL TOPICS

a. Several special areas of interest in the collection and use of
electro trace data need investigation. Study is planned for the following
topics:

(1) Electro trace data is now published at computed resolvability
parameters, spread function width, and reciprocal spread function width.
Accuracy of this data can be determined by measuring the correlation
of the computed values with CERN data itself to be included in the text.
When these test objects are available, this correlation should be used.

(2) The photographic image is composed of tiny grains.

Therefore both the signal and the noise of the system are difficult
to separate in order to in imagery near the limit of resolution. A
study is planned to determine the characteristics of the grain
noise of such as the microphotometer. The mathematical treatment
as a "point dilution" (see Reference 2) to redden the equivalent signal
without precision in the trace measurements.

(3) An attempt will be made to determine photographic system
quality by means of edge scans through the use of non-linear
transformation methods. Direct methods, not involving mathematical
transformations, offer the benefits of faster computing time and more
intuitive correspondence with "sharpness". An example of such a
measurement is variance. Another way of describe image quality is
through the spread function. This latter method should yield more
information than is contained in a single width number. The method will
be studied for quality correspondence with area factors (e.g. minimum
image width containing 3% of the total energy) and shape factors (e.g.,
skewness and kurtosis.)
References


