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PAR 25-6-2

STUDY PLAN

Study Refinements in Applications of
Microdensitometric Data

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PREPARED BY:

S. Perry
S. Perry

APPROVED BY:

E. L. Green
E. L. Green

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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 7044 computer program (SWRDR) for more efficient operation.

3. INTRODUCTION

a. There is an established need for better image quality rating systems for photo reconnaissance material. The existing techniques of resolving power, M.I.P. rating, GEMS, and edge trace computed resolution have various deficiencies. While there may never be a single system answering all requirements, improvements in the existing image ranking systems may answer current needs. As an example, the [illegible] report (see Reference 1) indicated needed improvements in edge trace methods for use by engineering groups, and development of the GEM technique for use by photointerpreters. This proposal (PAR [illegible]) is concerned with investigations leading toward better edge trace methods.

b. The current basic need in the technique of mission image quality ranking by means of microdensitometric edge tracing is that 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 on 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.

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4. DATA COLLECTION

a. 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 Kodak Model 5. A comparison will be made of these two instruments to show their resolution, edge derived MTF, power spectra and stray light control (see Reference 2). From this data, it should be possible to note any systematic differences that would influence edge tracing.

c. The "Crossover" exercise (see Reference 1) consisted of a microdensitometer comparison test in which a series of special laboratory edges varying in sharpness were circulated to interested participants for scanning in several microdensitometers. If a repetition of the "Crossover" exercise is initiated, this facility will cooperate in the edge scanning and data reduction.

d. In processing noisy signals, it is possible to employ redundancy 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.

f. 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 (e.g. resolving power). Both the smoothing and data reduction methods have been developed to usable status. 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 fairing the analog trace of the edge. Proposed methods of computer smoothing via moving polynomials, averaging a reasonable number of traces of a single edge, least squares curve fitting, etc., have not been satisfactory in all test cases. The potential benefits 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.

5. SPECIAL TOPICS

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

(1) Edge trace data is now published as computed resolving power, spread function width, and reciprocal spread function width. Accuracy of this data can be determined by measuring the correlation of the computed values with CORN test objects included in the scene. When these test objects are available, this correlation will be made.

(2) The photographic image is composed of silver grains. Therefore both the signal and the noise of the system are difficult to separate in cases and in imagery near the limit of resolution. A study is planned to determine the characteristics of film grain noise as seen by the microdensitometer. The mathematical technique of "optimum filtration" (see Reference 1) to reduce the grain noise may yield better precision in edge trace measurements.

(3) An attempt will be made to determine photographic system quality by means of edge scans through the use of non-modulation transfer function methods. Direct methods, not involving mathematical transformation, offer the benefits of faster computing time and more intuitive correspondence with "sharpness". An example of such a measurement is acutance. Another way to 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 30% of the total energy) and shape factors (e.g. skewness and kurtosis.)

References

1. R. E. Swing and J. V. Gaven, Report on the Image Quality Evaluation Program, July 1965.

2. Performance Comparison Test Plan for Mann-Data Microdensitometer Versus Kodak Model 5 Densitometer, Contract EB-1492, 20 October 1965.

3. R. Barakat, "Determination of the Optical Transfer Function Directly from the Edge Spread Function", J. Opt. Soc. Am., 55, October 1965, pp. 1217-1221.

4. J. F. Simonds, "Analysis of Nonlinear Photographic Systems". Photo. Science Eng., 9, September-October 1965, pp. 294-330.