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Electronic Photo-Enhancing of Reconnaissance Photography

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BACKGROUND

Current photo-reconnaissance aircraft operate at altitudes up to 50,000 ft. (9.5 statute miles) and utilize camera lenses of 40 to 50 inch focal lengths. This equipment produces pictures having an over-all photographic resolution of 60 to 100 lines per mm. SAMOS photo reconnaissance satellites will operate at attitudes of 160 and 300 statute miles respectively for the E_5 and E_2 subsystems. This is an increase in altitude of roughly 16 to 30 times current practice. Since the ground resolution in a photo-reconnaissance negative is proportional to focal length and inversely proportional to altitude (or subject-to-lens distance) it is quite apparent that the degradation in ground resolution occassioned by an increase in altitude of 16 to 30 times cannot practically be offset by a proportional increase in focal length. It is estimated that the practical limit in photographic lens-film system resolution is about 150 lines per mm.

The photo interpretation of satellite photographs will be doubly difficult because of the current lack of any aids for the photo interpreter other than poor quality low-power magnification. Accordingly, the detection of pertinent intelligence data under conditions of grain aglomeration and low contrast will be very difficult.

DISCUSSION

Solutions to the above dilemma are discussed below specifically covering the several facets of the problem.

First; a reduction in granularity and better contrast levels are achievable using exposures made at the toe of the sensitometric curve for the film emulsion used. This technique is not currently used because of the non-linear brightness reproduction of the original scene which confuses the interpreter and impedes his recognition processes. An electronic scanning transducer with compensating non-linear characteristics could be used to return a negative taken using the above technique to its original condition.

Second; high magnification cannot be used because of the disturbing effects of film "grain." Actually, the visual phenomena termed "grain" is actually the distraction produced by grain aglomerations. The normal human eye can resolve

about 100 microns (1/10 mm) at the center of the field of vision. The silver particles in photographic emulsions are only 3 to 12 microns in length for the highest speed films and an order of magnitude smaller for emulsions considered for satellite photography. However, groups of particles form spurious and random patterns of 100 microns or greater length and this interfere with the detection of actual patterns. The photographic process converts continuous tone brightness images into digital or quantized information due to the development of images by discrete silver and silver halide crystals. A smoothing process to convert back to an analogue or continuous tone form is needed and could be accomplished by an electronic scanner with an aperture sized properly to smooth the square wave intergranular density gradations. Accordingly, a considerable magnification will then be possible and the picture detail enhanced.

Third; the contrast of many scenes is so low as to unduly mask important detail. The electronic scanning process can incorporate a contrast amplitude enhancement feature which, in addition, can provide variable contrast for selection by the photo interpreter to assure optimum recognition of important intelligence detail.

CONCLUSIONS AND RECOMMENDATIONS

Photo interpretation of current aircraft reconnaissance system output is made difficult by poor image contrast and the lack of high quality magnification. The already difficult task of photo interpretation will be made significantly more so with the advent of large volumes of lower resolution satellite reconnaissance photography. Accordingly, significant gains in the photo interpretation of all reconnaissance photography are urgently needed. The above interpretation aid and the important improvements in recognition clarity which result from its use appear essential to the over-all satellite reconnaissance systems now in development and will materially improve data acquisition from current aircraft reconnaissance systems.

It is therefore recommended that a system of photo enhancement suitable for such use be supported through the experimental evaluation phase. A suggested work statement is given below:

> Develop, construct and test evaluate an experimental electronic photo enhancement system suitable for use with reconnaissance photography from the SAMOS project. System units to be developed and features to be incorporated shall include, but not be limited to:

1. A high resolution scanning system of sufficient quality so as to not degrade the original photograph,

2. A video signal processing unit which shall contain the controls and circuits necessary to provide for variable contrast, variable grey scale expansion, linear and non-linear grey scale reproduction, and the necessary digital and frequency selective filters for "grain" smoothing and various other photo enhancement techniques,

3. A high resolution display unit of 14 inches or larger diameter for viewing the processed photograph. Flexibility of operation controls shall be maximized to facilitate photo interpretation and evaluation of the features provided in the experimental model.

Based on an unsolicited proposal received October 5, 1959, from [redacted] system with the above features can be developed and evaluation tested in about 16 months from contract issue and for an approximate total cost of $135,000. This firm is believed to be responsible and competent in the intelligence data processing field. They have investigated most of the proposed systems techniques in previous work both under contract and with company funds. It is known, however, that several other firms have shown interest in electronic image enhancement. The other principal firms known to be active in this area are [redacted] It is therefore further recommended that proposals be solicited from all of the above mentioned firms to a common work statement similar to the above. The most competent firm or firms to engage in the experimental evaluation phase can then be selected on the basis of these proposals.