DISCUSSION NOTES

Synthetic Aperture Contour Camera

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Discussion by Dr. Sidney Bertram

The Synthetic Aperture Camera described by D. R. Craig is interesting because of its radical approach to the measurement of height from optically prepared photographs. The basic idea used in the camera is not, however, new; this note describes an alternative configuration that might be easier to mechanize. It is the subject of two patents by J. S. Barnett (U. S. Patents 2,933,008, April 19, 1960 and 2,988,953, June 20, 1961).

Barnett's patent is based on the idea that if one superposed two transparencies made from normal vertical stereo photographs, with an offset to correspond to a given desired elevation contour, then an observer could examine the combined imagery and pick out the line along which the imagery is in registry—i.e., the desired contour line. It will be noted that if a succession of photographs were taken along the line of flight so that a number were available covering the normal stereo area (perhaps six taken at a spacing of one-tenth of the altitude), these could all be superposed so that the imagery on a given contour line is in registry, with all other imagery out of registry and so blurred; the result would be essentially equivalent to that obtainable by the Synthetic Aperture Camera. Because the only change in the conventional airborne equipment to achieve this alternative configuration would be to provide a camera with a rapid cycling capability, it would seem to be more atrractive. The configuration has the additional advantage of being more flexible with respect to the choice of contour interval.

Barnett's patents describe equipment to scan stereo pairs electronically and to display the differences between the images on a TV monitor. Assuming appropriate control of image contrast, "areas of equal elevation (at one elevation) will register and will be presented on the master monitor as areas of uniform grey, since the two camera signals will cancel out in these areas. Areas which are at other elevations will not be in register and will be presented as out-of-register double images on the monitor." The patent describes a magnetic memory unit to record the contour information determined by the operation.

The current automatic map compilation instruments, typified by The Bunker-Ramo Universal Automatic Map Compilation Equipment, all use electronic correlation to locate homologous imagery. These devices have generally been designed to yield high accuracies from conventional photography and are not optimized for low accuracy work. It should be realized, however, that a reduction printer (or shorter focal length camera) could reduce the operating time of the equipment on particular stereo pairs; it will be observed that the potential accuracy is reduced in proportion to the scale reduction, but that the compilation time is reduced by the square of the scale reduction. This should make perhaps one-minute compilation times practical—with computer accessible information as the output. It should be appreciated that an effective contouring time of "seconds" could never be achieved without automation; there is just too much data to be correlated.

With new techniques available for use at many places in the mapping operation, it is not obvious that a low-accuracy device would be useful. If compilations to one-foot accuracy were desired, they could be obtained from 1,000-foot photography with

operations of one-part-in-a-thousand accuracy, or from 10,000-foot photography with operations of one-part-in-ten-thousand accuracy—but a hundred low altitude photographs would have to be handled for each high altitude photograph!

I personally expect that the art will be moving in the direction of higher accuracy compilation equipment which make extensive use of electronics. Significant economies in instruments of this type will come about as a result of the revolution now taking place in electronic packaging, permitting operations now considered very complex to be handled in a simple and reliable manner. I believe that it will be found to be quite economical to handle even low-accuracy mapping work on these instruments, providing that there is sufficient work to be done.

Reply by D. R. Craig

The note to the Editor from Mr. Sidney Bertram of Bunker-Ramo regarding the Synthetic Aperture Camera contains the enchantingly brief observation that the camera is "interesting because of its radical approach". The remainder of the note describes an alternative configuration for superposing a finite number of stereo images in ground equipment to achieve contouring. He uses six images to illustrate Barnett's patents. Six sharply defined and superposed images exhibit a very "jittery" pattern to the eye and also to photocells. The jitter vanishes when the number of superimposed images approaches infinity, as in the Synthetic Aperture Camera. (See Figures 1 and 2.)

The costs of the alternative configuration in terms of set-up time, access time, complexity, space, weight, power and just plain money are appalling when compared to a Synthetic Aperture Camera which can provide better image correlation, in real time, using an elegant analog computer no larger than a piece of film. The film captures the image and also performs the correlation.

Bertram implies that flexibility and accuracy are benefits of the alternate configuration. The younger generation rejects flexibility and loudly demonstrates that the guitar is far easier to master than the more flexible violin. The accuracy benefit is more a promise than a threat when attributed to an automatic stereo plotter which is equally satisfied whether correlating the top of a tall tree or the ground from which it grows. With the probability of such gross ambiguities, the desire for one-foot contours becomes an insatiable whim, whether system accuracy is 1:1,000 or 1:10,000. The Synthetic Aperture Camera does not permit such ambiguities.

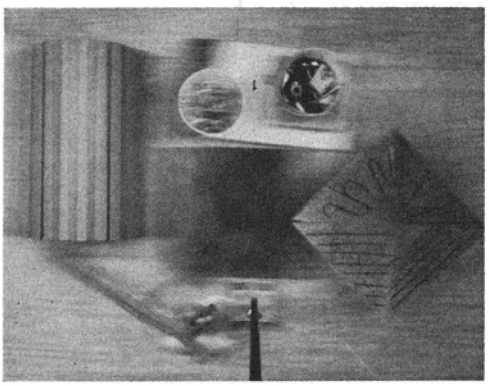

FIG. 1. Synthetic aperture integration of an infinite number of images. Note the lack of "Jitter" and the smoothness of the imagery.

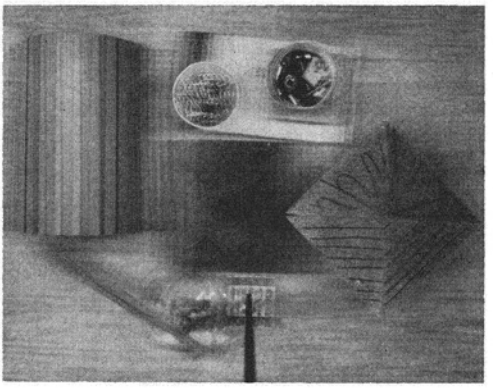

FIG. 2. Six superposed images. Note the "jittery" image pattern.

I am a champion of automation and applaud the progress of automatic stereoplotters toward relieving man from dreary jobs of boredom. Large sums have been spent on their development. Said sums may prevent the investors from retreating soon or gracefully to any radical new approach—no matter how promising the potential. Even revolution takes time—plus bruises. Neither should daunt the search for newer, faster, simpler, cheaper ways of doing old jobs. Extensive use of electronics is not the only way.

In summary, I am glad that Mr. Bertram read my article, but regret to disagree on every point in his note.