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8.7 ATTITUDE TRACKER

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Line array sensors produce data which has no inherent geometrical continuity. Hence, any platform attitude variation will be evidenced as a distortion when the data lines are displayed in the normal Cartesian raster. Ancillary sensing is required to establish the platform attitude to allow geometric rectification. This is normally provided by inertial or star reference attitude sensors. However, in the absence of such sensors or if performance of them is degraded, the required attitude information is lost.

A strawman sensor design is proposed which utilizes small image areas on the ground to provide a series of motion vectors with which the platform attitude can be tracked; this allows the distorted image received by the normal image line sensor to be rectified.

THE PROBLEM

Future sensors of the linear array type will return lines of data which are independent in the sense that there is no data tie between them. It is essential for mapping and stereo work that the data lines used for analysis be in precisely the correct geometrical position. If the sensed image lines are not in the correct positions, interpolation or other compensation must be used before analysis. But there is no information in the data as planned to measure the correctness of position; position accuracy depends on platform attitude accuracy for a sufficiently long period. Anticipated spacecraft control parameters will be (marginally) adequate if all is perfect, but there is not much tolerance for degradation, nor any planned way to work around degradations. The use of ground control points will be necessary for precise tie to the ground, but will be clumsy for continued use for the stereo tracking, and, in any event, surveyed ground control points will not be available for many areas. The problem is exacerbated with an aircraft platform due to the ubiquitous attitude instability.

WHAT IS NEEDED

What is needed is a system for analyzing the platform motion as reflected in the ground distortions, which may be used to 1) verify platform stability and 2) provide the data for correcting the geometric aspects of the image lines, either in parallel with the expected good performance of a spacecraft platform or to compensate for degraded performance. Ideally, the system would be useful on board, but ground calculations and correction would be acceptable. Maximum use should be made of the GCPs and the Global Positioning System, but the system should allow (perhaps degraded) use without these.

STRAWMAN SOLUTION

A system for providing the data for self-tracking could be designed as follows: As part of a separate sensor boresighted to the imaging sensor, a set of small square image areas of, say 64 x 64 or 128 x 128 pixels, arranged as sketched (Figure 1) is imaged on to a set of area array detectors. All are read out simultaneously into a set of memories. For each area, the displacement between it and a previous image, taken a few image lines previously is determined. The sequential set of displacement vectors may be used to model the platform attitude variations, and to generate the geometric correction parameters. The related software will have to bridge gaps in the displacement vector sequence due to clouds or other noncorrelation, and to operate in areas of terrain relief.

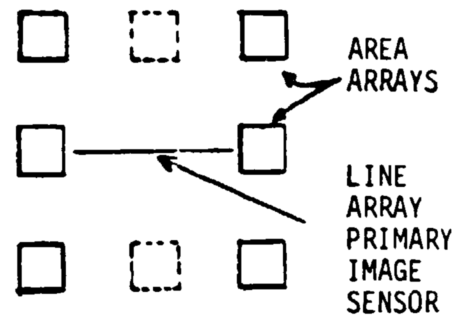
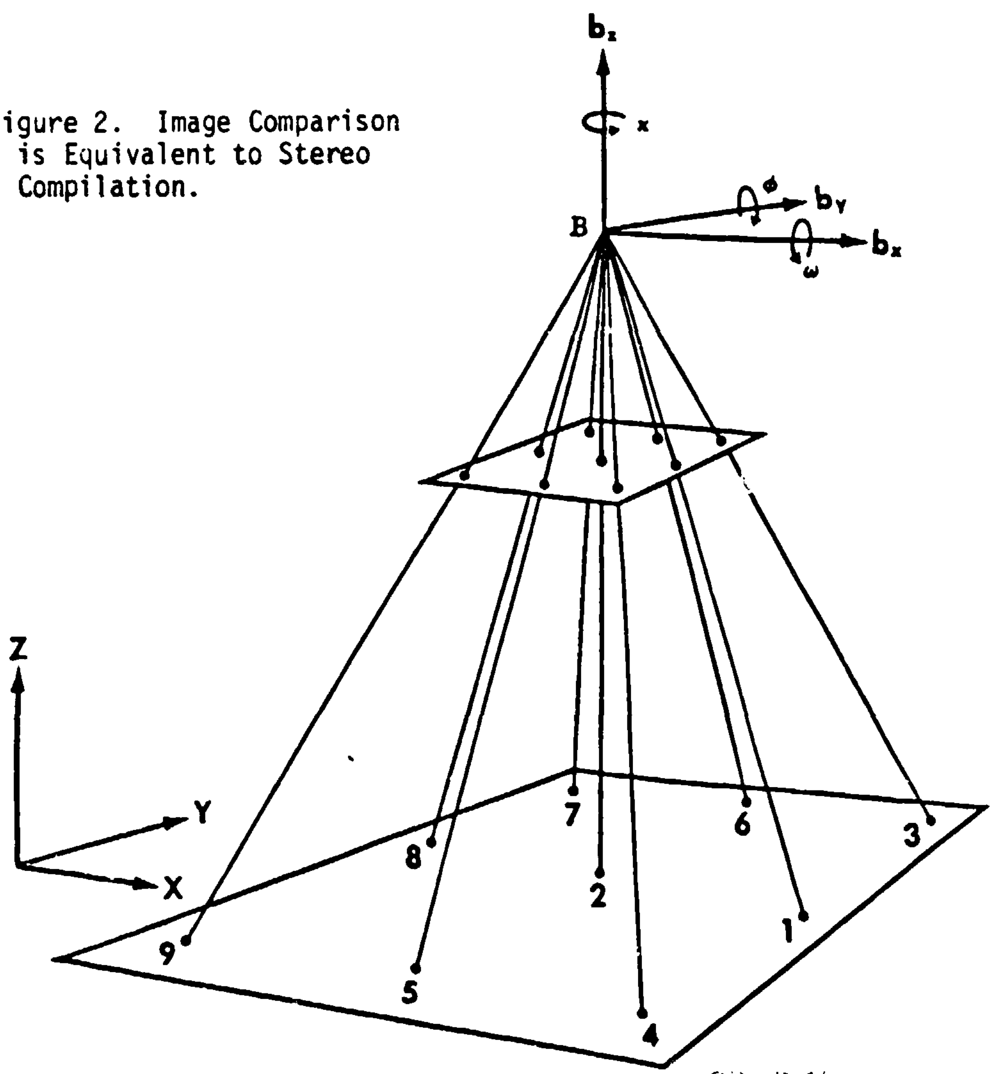


Figure 1. Possible Arrangement of Area Array Sensors

Data analysis follows the well known stereo compilation principles. The effects as seen in normal stereo compilation practice are given in Figures 2 and 3 (from D. H. Alspaugh, "Stereo Compilation and Digitizing," Proc. Latin American Technology Exchange Week, Panama City, May 1979, p. 314).

Figure 2. Image Comparison is Equivalent to Stereo Compilation.



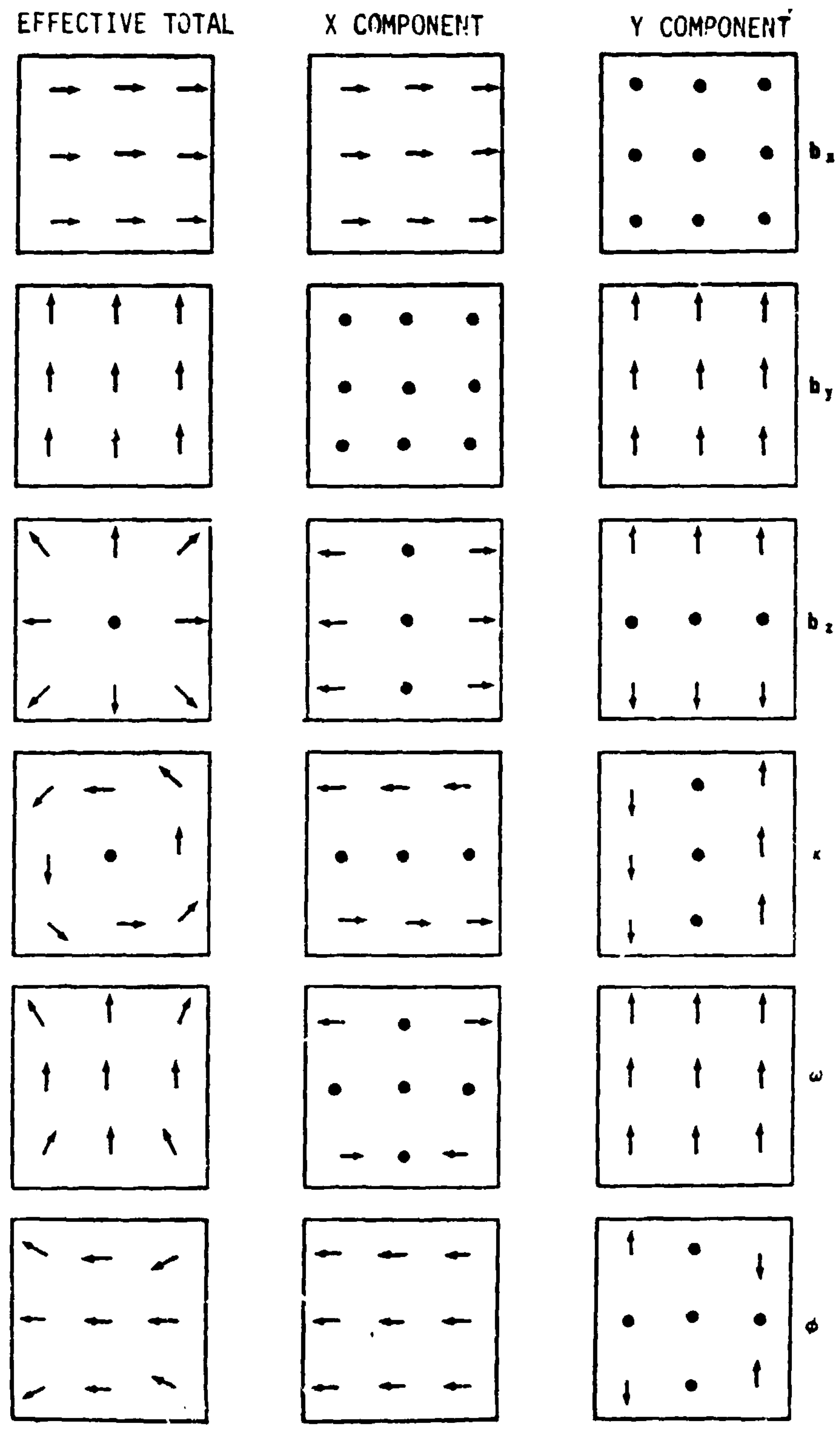


Figure 3. The Image Motion Vector Set as it Reflects Platform Motion

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In the eventual instrument, the data processing would be self-contained (Figure 4), so that only the derived attitude parameters would be transmitted or utilized.

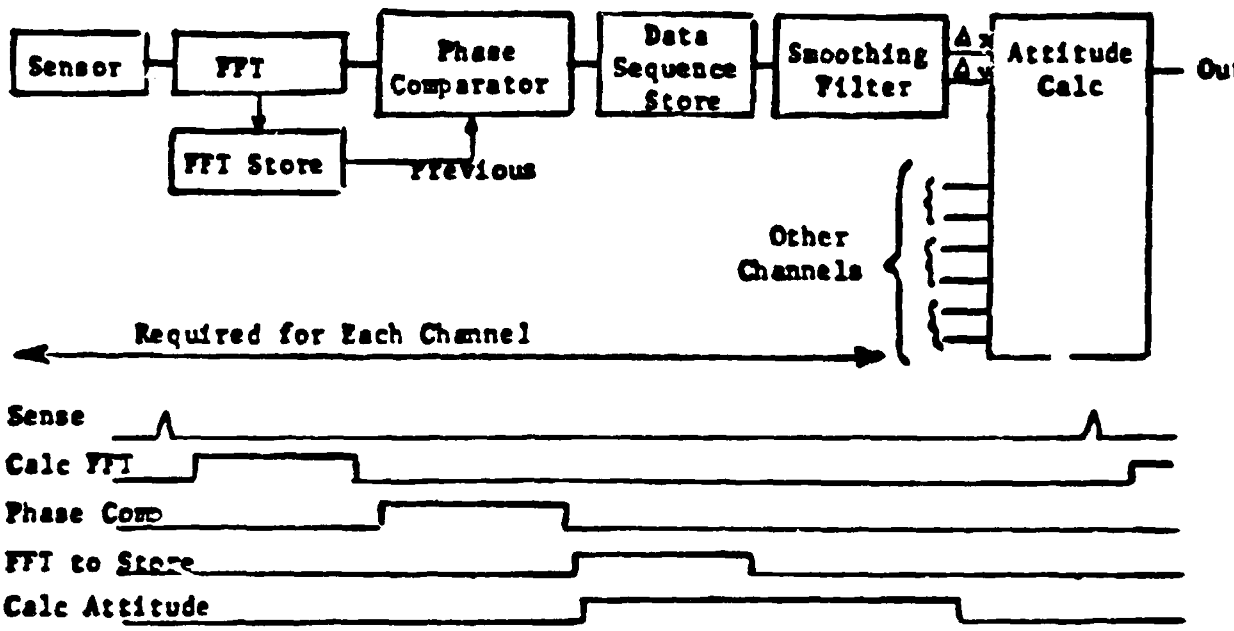

Figure 4. Data Processing Block Diagram and Timing

Lockheed(1 & 2) has built a phase plane comparator, including the FFT, which operates in 1/30 second. Incorporation of this approach could allow this part of the processing to be time-multiplexed.

1. Kuglin, C. D., Hines, D. C., "The Phase Correlation Image Alignment Method," Proc. IEEE 1975 International Conference on Cybernetics and Society, pp. 163-165.

2. Pearson, J. J., Hines D. C., Golosman, S., "Video Rate Image Correlation Processor," SPIE Vol. 119, Applications of Digital Image Processing, IOCC 1977, pp. 197-205.

It may be necessary to incorporate a LIDAR or equivalent sensor to determine the instantaneous altitude.