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Infrared Imagery Mosaics for Geological Investigations

Assembly of strips provides a useful framework for regional interpretation of geologic features.

(*Abstract on page 1379*)

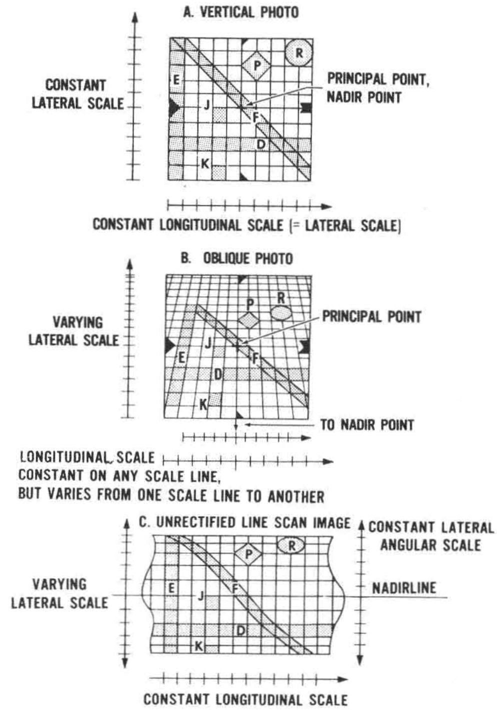


FIG. 1. Comparison of Images.

INTRODUCTION

THE RAPID GROWTH in the development and use of infrared imaging systems in the earth sciences has resulted in the application of many of the interpretation and mensuration techniques that are used with aerial photographs to infrared imagery evaluation. One of the major drawbacks of infrared imagery for mapping and areal interpretation, particularly in geological investigations, has been the "strip" format of the imagery. Nearly all of the published infrared imagery illustrating applications to earth science problems (e.g., Lattman, 1963; Ory, 1964; Slavecki, 1964) has consisted of segments of film strips. However, through careful planning and execution of infrared imagery surveys, it is possible to assemble uncontrolled infrared imagery mosaics that provide broad areal coverage, resulting in a better geologic interpretation and mapping capability.

GEOMETRY OF INFRARED IMAGERY

The common method for producing a thermal image of the terrain on photographic film has been described previously (Lattman, op. cit.; Harris and Woodbridge, 1962). The line-scan method produces a continuous strip thermal image of the terrain and the areal coverage of the strip is a function of aircraft altitude and total scanning angle. In some respects a line-scan image is similar to a low-angle oblique aerial photograph. However, because the image is formed continuously and the scanner is usually hard-mounted to the aircraft, all deviations in the attitude of the aircraft from straight and level flight distort the relative image position of ground features.

Figure 1 compares the geometry of a line-scan image with that of conventional vertical and oblique photographs. Note that the geometry of the line-scan image is similar to that of a low angle oblique photograph except for two important differences: the line-scan image has a nadir line rather than a nadir point; and the scale decreases tangentially in two directions from the nadir line as opposed to the linear scale decrease from the nadir point of the oblique photograph.

Figure 2 illustrates the types of image distortion caused by roll and yaw of the aircraft on infrared imagery obtained with a scanner which has no roll or yaw stabilization. Aircraft roll causes a lateral shift in the nadir line and a lateral shift in the area of coverage.

* Presented at the Annual Convention of the American Society of Photogrammetry, Washington, D. C., March 1967 by Mr. Ory. Mr. Williams is now with the Terrestrial Sciences Lab., U. S. Air Force Cambridge Research Lab., Bedford, Mass.

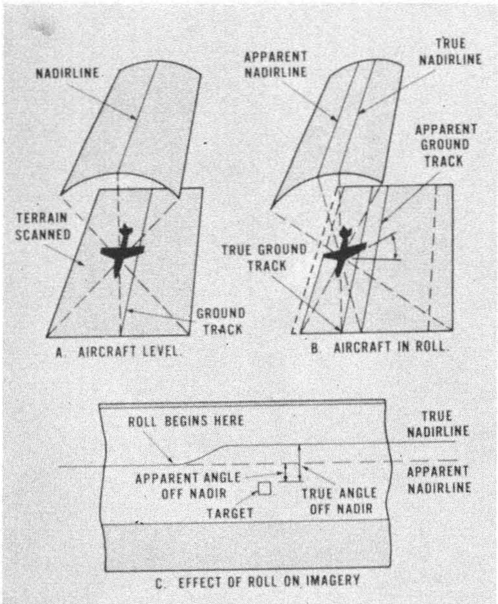


FIG. 2A. Roll Distortions on Unstabilized Imagery.

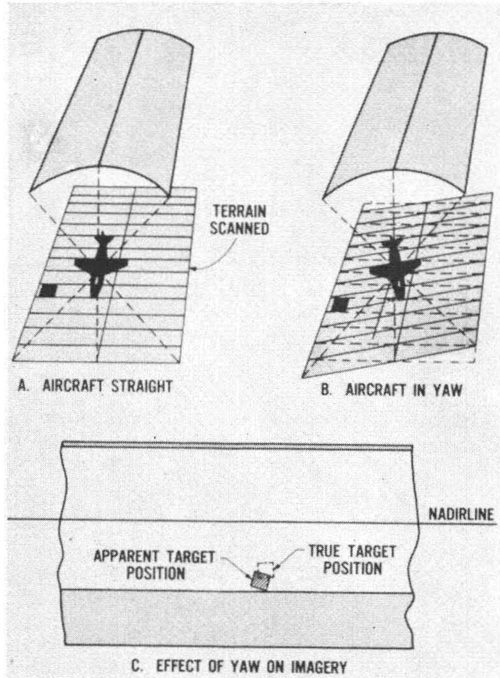


FIG. 2B. Yaw Distortions on Unstabilized Imagery.

Aircraft yaw causes the scan lines to deviate from an orientation normal to the flight track to a different angular relationship depending upon the magnitude of yaw. This results in a relative displacement of the position of imaged ground features.

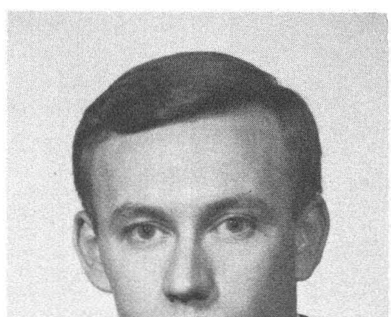
The longitudinal scale of a line-scan image is determined by the relationship between the speed of the film through the printer and the velocity of the aircraft. Thus, any change in the velocity of the aircraft which is not compensated for by a change in film speed results in a change in longitudinal scale.

Most of the distortions caused by the geometry of line-scan imagery and the configuration of conventional scanners have little effect on the usefulness of single strip images. However, if an attempt is made to assemble several strips into a mosaic to provide greater areal coverage, all of these distortions create serious problems.

Reduction of Image Distortion

One of the best methods for reducing image distortion on infrared line-scan imagery is to stabilize the scanner on three axes. Unfortunately, such stabilized systems are not usually available for geological investigations. Rectilinearization of the imagery eliminates those distortions caused by the tangential scale change laterally from the nadir line but has no effect on distortions caused by roll, yaw, or incorrect film speed.

A practical method for reducing image distortion and enhancing the ability to construct infrared imagery mosaics with conventional scanners is the careful planning and execution of the infrared survey to compensate for inherent distortions. As in photographic surveys, distortions caused by roll and pitch can be minimized by an experienced pilot flying under relatively calm atmospheric conditions. As most infrared surveys are flown at night, turbulence is normally less of



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ABSTRACT: *The usefulness of infrared imagery for geological investigations has been handicapped by the "strip" character of the imagery which is generally used in the line-scan technique for recording thermal properties of terrain features. Although the geometry of line-scan infrared imagery presents difficulty in constructing mosaics, many of the distortions can be minimized by careful planning and execution of the infrared survey. The compilation of an infrared mosaic is of considerable value for regional interpretation of thermal anomalies.*

a problem than it presents to photographic surveys. Planning flight lines with spacings with 30 to 40 percent sidelap permits the usage of only the central portion of each film strip for mosaic construction and thus reduces the distortions caused by roll and tangential scale change.

Wind conditions at the survey altitude determine the severity of yaw distortions and longitudinal scale changes. If possible the survey should be flown up and down wind so that aircraft yaw is minimized. If wind conditions are unfavorable for the planned flight line orientation, all lines should be flown in the same direction so that all yaw distortions have the same orientation. This technique results in an over-all distortion of the area scanned but parallel passes can be matched to form a mosaic. A means for correcting the orientation of the scanner to compensate for aircraft yaw can be built into the scanner mount but a much larger port is required due to the large scan angle of most line-scanners.

Changes in ground speed caused by different wind effects on lines flown in opposite directions can be compensated for by adjusting the film speed in the printer. If the scanner operator is provided with ground speed and altitude data, it is possible for him to maintain a uniform longitudinal scale on the film.

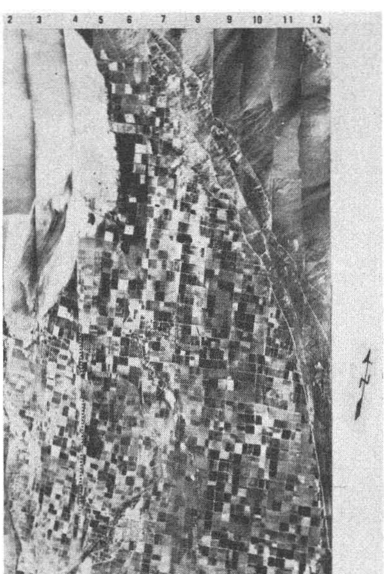

FIG. 3. Infrared Imagery Mosaic.

FIG. 4. Photographic Mosaic.

Infrared Imagery Mosaic

Figure 3 is an example of an uncontrolled infrared imagery mosaic which was compiled from twelve 70 mm. infrared film-strips as indicated by the numbers on the mosaic. Figure 4 is an uncontrolled photographic mosaic of the same 800 square mile area. The infrared imagery was obtained with a hard-mounted line-scanner using the flight planning techniques described earlier. The flight lines were flown at night with no navigation system and, as a result, the lines are not absolutely parallel so that in some cases it was necessary to utilize the entire width of the film instead of the central portion in order to achieve full coverage. Thus, some portions of the mosaic contain more geometric distortion than other portions. In comparing the two mosaics, note that although the longitudinal scales are nearly identical, a lateral scale compression of about 25 percent occurs on the infrared mosaic caused by the tangential scale change of the infrared imagery.

Application to Geological Investigations

The geometric distortions inherent in the infrared mosaic illustrated in Figure 3 preclude the accurate mapping of terrain features. However, the mosaic is invaluable as a framework for detecting regional trends and large-scale changes as expressed by the thermal properties of terrain features. Fractures, faults, and lineaments can be easily traced even though adjoining strips do not establish a perfect fit. In addition, it is a relatively simple task to make point-to-point transfers from the infrared mosaic to the photo mosaic if accurate dimensions and directions are desired. As the application of infrared scanners to geological investigations increases, equipment modifications to improve the mapping characteristics of the imagery will undoubtedly be made.

References

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