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Realities of Automatic Correlation Problems

Problems include poor image quality, variable illumination and reflectance, complex geometry, lack of image content, and terrain cover anomalies.

THE DEVELOPMENT of the automation of image registration, for the purpose of stereo parallax measurement, has been underway since the mid-1950's. The question may be asked, then, "Why is automated instrumentation not more widely used to enhance the productivity and economy of stereo restitution?"

In one sense, the answer is easy. It is quite difficult to produce instrumentation capable of dealing with the complex geometry, variable appearance, and quality problems of real stereophotographic images. Even the human, with his fantastic associative memory, has trouble registering many of the poor and difficult stereo images offered up for restitution. Clearly, the full emulation of human capability is not high on our list of accomplishments or near-term probabilities.

Over the past years, however, a considerable body of good work has been done and realities revealed as guidance to the future. Major among these realities are

- System designers must anticipate poor quality photographic input in terms of both resolution and contrast;
- System design must accommodate stereo images of a model having quite different tonal renditions of the subject terrain; and
- System design must accommodate height-change induced differences in image geometry.

Some examples of design responses to these recognized realities are described as follows.

Most system designers revert, finally, to the same solution for the problem of poor quality photography; that is, to require good photography. This is not an unreasonable solution. After all, the acquisition of photography is usually one of the least costly parts of a mapping program. Additionally, the science of photography is known and predictable. Therefore, requiring proper exposure and the proper camera type for a given type of terrain seems justifiable, regardless of whether or not automated instrumentation will play a part in a program.

The real existence of variable illumination and reflectance effects in the separate images of stereo pairs has suggested to some that the correlation process is better served if the amplitude of brightness is suppressed. The use of the sign of the first derivative of brightness provides this suppression while retaining the structural characteristics of the image. The net gain from this suppression is that the cross-correlation integral, which is monitored as a status estimate and used for adaptive-correction command, remains far more stable and becomes much more proportional to the goodness of the registration process. Additionally, correlation hardware is saved because multiplications now are merely the logical manipulations of binary data.

The existence of differing image geometry in the two images of a stereo pair is unquestioned and is the means to the detection and measurement of height differences. This difference, coupled with the fact that correlation is a process which assesses only the similarity between images, has suggested to most that a feedback-controlled transformation of the image-data collection location and geometry is necessary to the functioning of an image registration instrument, if any reliability or accuracy is to be achieved. Only through progressive transformation toward virtual congruity can the correlation process make use of the highest frequency image content.

The complexity of the transformation capability built into a system is proportioned by the extent of the image areas to be sampled and the accuracy to be achieved when assuming a far from horizontal or planar model surface. In general, the larger the image area processed, the less likely it will be that no textural data will appear in an instantaneous correlation data set. For

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human or machine, the lack of such content spells failure. Consequently, to give away area in order to simplify transformation requirements is a very poor trade which insures a high system-failure rate.

Achieving successfully progressive transformation has been accomplished through the processing of lower frequency data first and then progressing to the higher frequencies. To achieve this end, some system designers have employed multiple, parallel correlation channels. The cross-correlation integrals of parallel channels have been compared to select the most appropriate channel output to be employed at any instant to control the transformation feedback system.

How well these major problems are dealt with will determine the overall reliability of an instrument design. Further, attainment of operating reliability is the only means available to attain enhanced productivity. Inadvertent "correlation losses" owing either to poor photography or to poor system design, or both, very quickly destroy productivity, the only rational goal of automation.

The performance of the Gestalt Photo Mapper, for one, demonstrates that high reliability and high productivity can be achieved. . . . However, our problems are not yet over.

Even if we had a "perfect" automated image registration instrument, we still are faced with the problem that the stereo-model surface being measured is not necessarily the terrain surface. The stereo-model surface also is made up of the crowns of trees and the roofs of buildings. Consequently, the height data collected is perfect for producing orthophotographic rectifications but erroneous relative to terrain surface description.

The human sees, understands, and responds to these "anomalous" model surface conditions. To date, the automated system remains incapable of "seeing," let alone understanding and responding to, these anomalies. Here, then, lies the current challenge in image registration automation. It is to develop the means to detect terrain cover anomalies and to enter cues into the extracted data set so that computerized editing is a possibility; and to do this without markedly impairing overall productivity.

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