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# Automatic Imagery Interpretation

**Preliminary screening and quantitative computation can serve as aids to the human interpreter.**

## Introduction

Imagery interpretation has as many applications as there are fields in which recorded images are used. Image-producing devices or sensors and image display or recording media exist in wide variety. Every combination of physical image type and field of application has its own unique interpretation problems. Certain very basic problems and concepts, however, are common to nearly all cases.

Whatever its physical source or medium or presentation, an image may be regarded abstractly as a finite plane region over which some type of light variation occurs. The image may be colored (light varying in both frequency and brightness) or "black-and-white" (brightness only); it may be dynamic (variation in both space and time) or static (space only).

The images which are of interest to imagery interpreters are not abstract symbols or arbitrary mathematical constructs, but rather are supposed to represent projections of the real world (or, in the case of some non-optical sensors, certain other geometrical transformations which convert the three dimensions of reality into the two dimensions of the image).

In analyzing such images, the interpreter's problem can be quantitative or qualitative. At the qualitative level, the real-world original of the image is not fully known to the interpreter, who must identify "unknown" portions or properties of the image as representing specific real-world objects or phenomena; this is essentially a pattern recognition task.

At the quantitative level, the nature of the image is qualitatively known, and the interpreter must derive quantitative conclusions about the image's real-world original from measurements made on the image. Qualitative interpretation presents the more challenging problem as regards the possibility of automation.*

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* It is often important to analyze *combinations* of two or more images in order to recapture a third dimension of information about the reality which the images represent. The third dimension in ques-

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ABSTRACT: *For an automatic system, whole-image identification is generally easier than classification of an image on the basis of parts of its contents, and the latter may in turn be easier than the identification and location of such parts. This last type of problem requires discrimination of the parts from the rest of the image. Developments in automatic imagery interpretation are still far from the level at which human interpreters can be replaced, except for the simplest tasks. However, automation can be of use to the interpreter for preliminary screening of imagery and for certain quantitative tasks.*

PATTERN RECOGNITION PROBLEMS IN IMAGE INTERPRETATION.

The difficulty of the recognition problems which arise in imagery interpretation depends to a large extent on how much of the given image consists of the pattern which is to be identified. At one extreme, the image may purportedly represent a single object or entity, the problem being to identify this entity. (Example: A low altitude aerial photograph shows a single type of tree cover; the interpreter must identify the species.) At the other extreme, the objects to be identified may be only tiny parts of the image. (Example: The interpreter must spot military vehicles on a medium-scale aerial photo graph.) In the latter case, the interpreter may only have to decide whether or not the image shows objects of certain given types, or he may also be required to locate them on the image.

Interestingly enough, the levels of difficulty which problems of these types present to human interpreters and to automatic interpretation devices can be radically different. For example, the whole-image identification problem may actually be harder for a human interpreter than the identification of a part of an image, since he sees the latter in context. On the other hand, it is hard to conceive of an automatic interpretation device which would not find the whole-image problem much easier. As another example, it is hard to imagine how an interpreter could know that an image showed objects of a certain type without also knowing where they were on the image. But it is entirely possible that an automatic device might be consistently able to correctly classify an image as showing certain objects without being able to locate them within the image. In short: from the automatic device point of view, whole-image identification is easier than image classification on the basis of partial content, but this in turn may be easier than the identification (and location) of a portion of an image.

tion may be spatial, in which case the problem is one of stereo-photogrammetry, or it may be the time dimension, for example when the problem is that of change detection.

AUTOMATIC INTERPRETATION TECHNIQUES. Any measurement which can be made on a given image is a potentially useful tool for automatic image classification. Real-world imagery is so complex and so varied that no standard approach exists to the selection of measurements for interpretation purposes; new ones are constantly being tried in the hope that they may prove useful. Among the measurements which have been proposed or used in this connection (see, for example, [1–3]) are those that describe the spatial frequency content or "level of detail" of the image, and those that (by convolution of the image with a suitable "mask") may be thought of as measuring the degree to which the image contains "pieces" of given simple shapes. Another approach is that of permitting a self-organizing device to "learn" useful measurements (and/or recognition decision criteria) starting from an initially "random" measurement set.

The range of possibilities is more limited when it comes to the task of identifying and locating a specific portion of an image. Here the crucial problem is that of distinguishing between the portion of interest and the remainder of the image. The analogous problem in automatic character recognition is relatively trivial; the portions of interest are the characters, which are typically "black" while the rest of the document (ignoring noise) is "white." There is no such degree of standardization in the portions of real-world images ("targets" and the like) which it is often important to recognize. Nevertheless, for these portions to be distinguishable at all they must differ somehow in brightness (or "density") from their surroundings.

This difference can occur in either (or both) of two ways:

(a) The brightness *content* of the "target" portion of the image may differ from that of its surround. This does not necessarily mean that the target has a different constant, or even mean, brightness than the background; there may be a more complex difference in the spatial distributions of brightness (the "visual textures") of the target and the background.
(b) The target is *demarcated* from its surround by a discontinuity in brightness or brightness pattern.

The techniques which have been investigated for discriminating brightness and texture differences and discontinuities range from simple level slicing to sophisticated statistical analysis [4].

Once a portion of the image has been selected as being a possible target, a variety of properties (now including shape, size and the like) can be measured as aids to its recognition. For targets of known size and shape, it is sometimes practical to achieve simultaneous detection and recognition by cross-correlation methods [5].

## Prospects

The art of automatic imagery interpretation is still far from the level at which there is any immediate prospect of replacing human interpreters except for the simplest tasks. Certain scientific image interpretation problems, which involve classes of relatively simple images, may have practical solutions at today's level of recognition technology. But the fully automatic interpretation of reconnaissance imagery has yet to be achieved to any practical degree. Perhaps somewhat closer to reality are the concepts of

(1) automatically "screening" imagery for priority of examination by human interpreter
(2) automatically performing tentative, partial detections and identifications and attracting the human interpreter's attention to them for verification
(3) aiding in the decision process by computer-analyzing observations by human interpreters
(4) performing quantitative measurements on images which have been identified by a human interpreter.

In current research on automatic interpretation, at least three different lines of approach are represented:

(a) The interpretation problem is turned over to a self-organizing recognition device in an attempt to "learn" a solution.
(b) New image measurements which seem as though they may be interpretationally relevant are contrived and tested.
(c) Human pattern perception and human interpreter performance are analyzed for simulation possibilities.

With continuing progress on all of these fronts, the goal of full automation of routine imagery interpretation tasks comes ever closer to fulfillment.

## References

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