Industrial Machine Vision - Looking Back on the Past Decade

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Abstract

In the latter part of the 1970's, a great deal of interest and enthusiasm was generated about the application of machine vision technology to industrial problems. This enthusiasm resulted in the formation of numerous companies directed at the application of vision and robotic technologies in industrial automation.

By 1985 it had become obvious that the initial expectations were not being met. Many of the vision companies started in the 1970's were already bankrupt or in serious financial difficulty. A central cause of this failure is that machine vision technology is not a single, uniform engineering discipline.

Each application requires custom engineering for the design of lighting, optics and image processing strategy. It is difficult to recover these development costs over the small number of duplicate units required for most applications. It is also the case that many applications with high economic leverage are simply too difficult for current machine vision technology. A good example of this case is the automatic visual inspection of metal castings. The complex casting shapes and subtle defect conditions produce intractable part manipulation and image analysis problems.

Even with these difficulties, industrial vision technology has reached a certain level of stability. One solution is to identify a niche application which has attractive economic payback. The company can then concentrate on solving the specific problems of that application and produce a specific inspection machine for the niche customers. The automatic visual inspection of printed circuit boards is a good example of this strategy.

Another strategy is to produce vision processing components which can be used in a wide variety of applications. In this case, the emphasis is on image processing architecture. The success of this strategy depends on the existence of a widely accepted set of image processing functions. There is reasonable agreement on functionality for low level image processing and image region analysis. There is little or no agreement on the best approach for higher level scene analysis functions, nor for vision programming language definition.

Neither of these two strategies have resulted in a large and rapidly growing market for vision technology. It is this author's belief that vision technology will not be used pervasively within industry until the following system requirements have been met:

- Robust recognition and detection without elaborate attention to lighting and part fixtures.
- Learning and adaptation to define defect classes and operational context.
- Throughput ranging from ten to a hundred times faster than human performance.
- Cost no more than $100,000 (US) for most applications.

Indeed, these capabilities were always desirable. It is now clear that they must be achieved in order for industrial vision products to become as common as machine tools.

Although much research remains, there is an emerging approach to these requirements. Rapid progress has occurred recently in the use of three dimensional geometric models for the recognition of objects in unstructured scenes. The constraints provided by the geometry of objects and the constraints of image projection are powerful enough to overcome the complexity associated with the segmentation of images acquired from natural industrial environments.

Another technical force which is likely to expand the capability of vision algorithms is the maturation of fine-grained SIMD architecture. The concept of cellular processor arrays has been around for several decades, but the use of VLSI technology has made possible the construction of SIMD machines of practical size. Early experience with object recognition algorithms on these machines has been quite promising.

Finally, the ability of vision systems to adapt and learn has proven the slowest to develop. It is now clear that such adaptation and learning cannot take place without rather extensive environmental context. Perhaps the major unresolved issue is an effective representation for the structure and functional nature of the industrial environment. Again it is argued that a reasonable beginning is to focus on the geometry and geometric constraints that characterize an inspection task.