Introduction to the Special Section

The idea for this Special Section on Industrial Applications of Machine Vision is coupled to a workshop on the same subject held in Research Triangle Park, NC, in May 1982. This workshop brought together for the first time 60 researchers from the U.S., Europe, and Japan with the common interest in problems in applying machine vision techniques in the industrial environment. The workshop was very successful in providing an exchange of ideas and the presentation of reports on machine vision projects with important industrial applications. The presentations represented a good balance between theoretical problems and practical considerations. In addition to the papers, a number of roundtable discussions were carried out to define major issues such as sensor requirements, high performance vision machine architectures, and three-dimensional vision. Some of these conclusions are reported by Jarvis [1]. The Proceedings of this workshop is also available [2].

The participants of the workshop were encouraged to present their papers in more extensive form for this Special Section and a call for papers on the same subject was also advertised. The nine papers in this issue represent the combined response to these requests. The mix of papers is very representative of the type of papers presented at the workshop. Before discussing the nature of these papers it is useful to summarize the direction currently being taken in the industrial application of machine vision.

The general character of an industrial application is that strict performance criteria such as throughput, accuracy, and reliability must be maintained. These requirements restrict the choice of methods which can be pursued. Also the application must usually be constrained in order for existing vision method to succeed. For example, there is no existing vision system which can cope with arbitrary illumination and object surface conditions.

The constraint of the environment usually includes special fixtures and part feeding to maintain a known orientation and location of the objects in the workplace. The effort in design and implementation of these constraints can easily exceed that of the vision system itself.

The throughput and accuracy requirements of industrial applications are typically quite severe. In most inspection applications, the processing rate of image data must be at least one million elements per second to reach the throughput needed to economically justify the investment in such equipment. This implies special purpose hardware with a high degree of parallelism which is usually arranged in a pipeline structure. These architectures are not usually transferable from one application to another. Thus the application must be significant or pervasive. The reliability of inspection must be high enough to achieve industrial quality standards. The error rates corresponding to these standards are usually limited to several tenths of a percent.

Because of these constraints the successful applications of machine vision have been largely restricted to high volume applications where high quality levels must be maintained. Examples of these situations are: circuit lithography for integrated circuits and printed circuit boards, simple machine parts in the automotive industry, and pharmaceutical tablet inspection.

The use of vision in robot applications has not achieved extensive practical use although considerable effort is being carried out in development activities. Perhaps the most successful application at the present time is the use of simple optical sensors to guide robot motions during welding. It is likely that the new emphasis on three-dimensional sensors will enhance progress in robot applications. Three-dimensional images are much less susceptible to the specific characteristics of the workplace which allows the development of more general purpose vision systems. This in turn will allow more development effort to be expended on such systems to reduce their cost and improve their performance.

This Special Section documents the state-of-the-art in such applications and identifies the future trends toward three-dimensional vision techniques. It is important to note that several papers describe complete systems and reveal the effort necessary to design and implement such systems as well as the elaborate testing necessary to characterize their performance.

The paper by Suresh, Fundakowski, Levitt, and Overland illustrates the complex economic considerations involved in vision applications. Here one of the main motivations in implementing an automatic inspection of the slabs is to avoid the energy cost incurred in cooling the slab so that it can be inspected by a human. Their paper also details some of the second-order issues which can dominate the effort in developing complete flaw decision processes.

The evolution of a system to automatically identify defects in wood is clearly documented in the paper by Conners, McMillin, Lin, and Vasquez-Espinoza. This problem is quite difficult because of the wide variation in visual appearance of the same wood defects. The paper describes the elaborate testing necessary to evaluate the invariance of features of the range of samples.

This experience is nicely augmented in the paper by Perkins which describes a method for automatically learning important features which distinguish good from defective components. This method shows promise to reduce the design effort in developing a specific vision application.

The papers by Baird and Dyer show the effective use of simple vision techniques to handle a wide range of part types within a family of automobile gauges. This is another way to leverage the design effort by making a simple programming environment so that new part types can be acquired quickly.

The inspection of printed circuit boards is an application which has a long history. It is initially appealing because of the apparent simplicity of the defect patterns and the straight line geometry of the circuit patterns. These benefits are soon obscured by the high throughput and low error rate requirements. Also the economic justification of such equipment is often questionable. The paper by Hara, Akiyama, and Karasaki
shows an excellent balance between these issues and they describe a system taken to a complete implementation.

The remainder of the papers are devoted to issues not involving the development of a complete system. The paper by Ho discusses the important area of the precision of vision systems. These results are very important in selecting the resolution to be used in a specific vision application. The paper by Pau considers some of the theoretical issues involved in combining simultaneous electrical and visual inspection of semiconductor circuits. Finally, the paper by Henderson contains an excellent review of three-dimensional vision representations and the problems associated with the formation of three-dimensional representations from range data.

REFERENCES

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