Colour Chemical Imaging – Intuitive Hyperspectral Imaging for the Machine Vision Market

Introduction

The use of vision systems in automation has continued to grow and new technologies are continually emerging. Hyperspectral imaging has long been on the radar but until recently there has been a disconnect between the data analysis and traditional image processing techniques. We are now at a stage where inline hyperspectral imaging in an automation environment is viable and this presentation will set out why this is important and provide a number of examples of real applications.

We as machine vision engineers are comfortable working on monochrome and colour images and employ a variety of algorithms to produce results but without the need in most cases to really understand the material we might be working with. Typically, hyperspectral imaging has come from the other side with a focus on analysis and differentiation of materials but as it has been primarily an offline process it was not suited in automation and inline processing.

Chemical Colour Imaging

The two worlds have now come together and offer the possibility for vision engineers to work with hyperspectral technologies and with the results that can be achieved new applications are opening up. Chemical colour imaging, realised through Perception Park's Perception Studio software, builds on the advantages of both spectroscopic and image processing techniques, the hyperspectral data and spatial information being represented by coded colour data.

A typical process of data acquisition, analysis, feature extraction, validation and post-processing can be fulfilled, sometimes without even investigating the hyperspectral data. This opens the chance for vision engineers who have no deep understanding of spectroscopy to work with hyperspectral data.

Working with a colour coded image, where the colours represent different materials, it is straight forward to analyse product and samples manually or via image processing.

Where the need is to separate only one or two materials the hyperspectral system may only be required to identify the relevant bands. A final solution may simply be based on a short wave IR or visible camera with an appropriate band pass filter however the role of a Hyperspectral system should not be underplayed in realising this application in the first place.

In order for hyperspectral imaging to work as part of a production line, the acquisition speeds need to be high, typically 1 to 10kHz so being able to classify the data is only part of the challenge. By analysing the relevant wavebands, it is possible to reduce the required data readout from the camera and thus increase the acquisition speeds. With the right hardware solution and for applications with focussed wavebands it is possible to inspect at speeds of up to 15kHz – this truly matches the speeds of inline processing.

Hyperspectral Inspection in Food Processing

A recent report from the Food Standards Agency highlights that contamination in food is a significant issue, not only to consumer health but also to brand integrity, perhaps the latter is the more sensitive for some commercial organisations. The report also highlights that Hyperspectral Imaging is an under-used technology so we are looking and finding many applications in this area. The most common application is contamination, clearly it is undesirable for food producers to supply product which has foreign bodies, but it is a common issue. Using a Hyperspectral camera and chemical colour imaging we have been able to demonstrate the detection of a variety of contaminants in a variety of produce for which a number of examples will be presented.

[differentiating shells, nuts and skins], [plastic beads in arnica tablets], [different types of meat in minced products]

In the most the image processing element consists of either segmentation or pixel counting, where the coloured images are split into the constituent colour planes, images binarised and then analysed for clusters of pixels. This provides the possibility for a simple presence detection for zero tolerance pass/fail requirements or a threshold pass/fail result where contaminants of a certain size may be acceptable.

Similarly, the same technique can be used as a form of quality control where a ratio of ingredients can be determined. An example here is the evaluation of cereal bars where the ratio of fruit, oats and nuts can be determined. Potentially this is an application for visible cameras but the hyperspectral data provides the possibility to differentiate between similar coloured produce and has the additional benefit of being able to image through the wrappers.

[ingredients in cereal bars], [lean to fat ratio in meat]

Other Areas for Hyperspectral Imaging

Recycling is perhaps the best example of the use of hyperspectral imaging in industrial inline applications. To date these have typically been based on very expensive systems with complex training methods. Again the coming together of spectroscopy and image processing opens further possibilities in the recycling sector with smaller facilities being able to access the technology and all facilities benefitting from a more configurable and therefore dynamic solution.

Similar to the recycling world, the pharmaceutical industry has used hyperspectral imaging for some time but again can benefit from solutions that suit automation. Contamination and quality can be monitored on a live production line.

Conclusion

The hyperspectral community is well aware of the power of this imaging and analysis technique and so it is now necessary for the industrial machine vision sector to work with this community and establish hyperspectral imaging as part of automated inspection. There is no doubt that the immediate opportunities are with the food sector however working with academics who have vast experience and no doubt a large volume of test information and results more and more applications can be discovered.

Over the last 20 years the use of machine vision has increased momentously as hardware costs reduce and ease of use increases and the market is now ripe for hyperspectral imaging to follow the same path.