unispectral

This white paper details how advances in camera and filter technology from Unispectral have opened up more applications in hyperspectral imaging across industrial and agricultural use cases.

Accessible hyperspectral imaging: **how can it be achieved?**

Every material is made up of different chemicals, the reflection of which is different depending on the spectral band. This means that an image taken with a standard camera will be similar to the spectrum that can be seen by the human eye (400-700nm). But this is insufficient in scientific applications such as agriculture, environmental monitoring, food processing, and biology, because very different materials can look the same to the human eye.

Hyperspectral imaging, on the other hand, collects and processes information from across the electromagnetic spectrum, as opposed to assigning primary colours (red, green, blue) to each pixel. The light striking each pixel can be broken down into many different spectral bands in order to provide more information about the imaging subject.

It is used to obtain the spectrum for each pixel in the image of a scene in order to more accurately find objects, identify materials, or detect processes.

It was first developed in the 1970s by NASA's Jet Propulsion Laboratory, and in the early 1980s, the organisation developed the world's first aerosol imaging spectrometer (AIS-1), from which the first hyperspectral image was born.

Today, hyperspectral imaging is used in a wide range of applications. Hyperspectral remote sensing is used in a wide array of applications such as ecology, waste sorting and recycling, food processing, eye care and environmental monitoring. There is also increasing interest in agri-tech and industrial use cases, but this is not without its challenges.

Incorporating hyperspectral imaging: the challenges for integrators

Hyperspectral imaging cameras have long been considered too bulky and too expensive, prohibiting their use in certain applications where space is a driving factor, or for smaller outfits wishing to get started with the technology. For example, a single camera can cost anything from $10,000 to $100,000, or considerably more for certain specialist products such as hyperspectral cameras for the thermal IR region, placing them out of the reach of a standard user.

Then there is the size and cost of ancillary products and considerations such as fast computers, sensitive detectors, and large data storage capacities needed for this kind of data. Then there is the data sorting and learning. Once a database has been created with thousands of images between which the user must determine, the machine learning software used for modelling also needs to be highly accurate in order to accurately differentiate between one object and another and be able to recognise the difference going forward.

A better way

Unispectral, the leader in hyperspectral filters and cameras, has taken the trusted hyperspectral technology and developed it to be used in a different way, allowing for a smaller, lower-cost system that can be used in any application for which hyperspectral imaging is desired.

Our miniature tunable NIR Monarch camera and ColorIR hyperspectral technology filter have been designed to remove the barrier for new mass market adoption of hyperspectral IR imaging.

Products are based on the Fabry Pérot proven hyperspectral technology, named after French physicists Charles Fabry and Alfred Pérot, who produced the Fabry-Pérot interferometer (variable-gap interferometer) in 1897. A Fabry-Pérot interferometer (or etalon) is an optical cavity made from two parallel reflecting surfaces, through which optical waves may pass only when they are in resonance with it.

Tuning an optical cavity enables selection of any wavelength within the 700-950nm NIR wavelength range. Light is partially reflected between the mirrors and interferes with itself to determine the transmitted and reflected wavelengths. The transmission spectrum depends on factors such as the coating, gap and angle-of-incidence. The gap between the mirrors must be controlled to ensure that the light goes in, goes back or reflects based on the mirrors.

ColorIR NIR Tunable Fabry-Perot MEMS filter

Unispectral's solution with its ColorIR NIR Tunable Fabry-Perot MEMS filter is to control the voltage of the upper mirror, driving the solution to behave like a capacitor.

Different voltages are applied to the four corners of the filter, causing the upper mirror to move up and down and, in turn, changing the central wavelength of the filter itself. This allows the flexibility to cover the whole of the designated wavelength region.

The filter is designed to enable a unispectral NIR image to be captured using a standard IR micro camera. It can be applied to any micro IR camera (consumer, professional, stationary or mobile) to convert it into a multi-spectral authentication, detection and inspection device. It is cost-effective and small in size, making it more inclusive than traditional solutions, and it is also resilient to extreme environmental conditions, temperature range, noise, mechanical shock, etc.

Figure 1: Unispectral Monarch Camera mounted on smart phone for fruit monitoring

Monarch II - Mobile Multispectral Camera

Once the filter was in place, the company went on to work closely with partner camera manufacturers to develop a camera. The result is the Monarch II – the world's smallest portable tunable hyperspectral IR camera for agriculture, industrial, scientific, and commercial use.

The Monarch II allows the capture of in-field/on-site spectral images in a simple and inexpensive way. There is no need for the kind of expensive, bulky or sensitive equipment that would require a trained operator, while its affordability and simplicity are designed to remove the barrier to wide adoption in many applications and mass-market platforms.
The Monarch II benefits from a high-speed lens and a 680-940nm spectral range, but it measures only 6.0cm x 4.5cm. The 1.3 Megapixel camera has a frame rate of 60fps and a USB 2.0,3.0 interface for data and power.

Immediate analysis and decision making is possible through the AI application that provides diagnostics of produce, merchandise, humans, medical processes etc. The Monarch II can be connected to a mobile phone for mobile use cases or can be embedded in sorting robotics, machine vision platforms, manufacturing lines, QA systems and biometric authentication terminals. It can connect to real-time analysis, inspection and control

Figure 2: Monarch II, world's smallest portable tunable hyperspectral IR camera

systems through a PC interface. Analysis and decision making can be made immediately, either by the operator or algorithm.

When it comes to learning and modelling, Monarch II can also be ordered with the "perClass™" PC analytic application that allows the extraction of any underlying information from the images taken. This feature transforms the Monarch II into a powerful, real-time decision-making system. The camera's SDK is available for Windows, Android and Linux, hence it can be integrated into most foreseeable application environments.

Conclusion

Hyperspectral imaging does not need to be limited to the science laboratory or established operation. With smaller and more cost-effective solutions, there are a number of industries and use cases that are now able to benefit.

The Unispectral solution can be utilised in a multitude of industries where previously there was a barrier. It adds a biometric layer that can diagnose: plant stress in the field; pre/post-harvest produce quality and content such as brix, NPK, firmness, rotten, defects, pest, pesticide. It can also capture defects in products, coatings, electronic and optical parts, detect vital signs for remote medical, improve facial authentication in security camera systems, and many other inspection and classification use cases.

There are also a filter and camera currently in development that will additionally support the VIS 450nm-700nm spectrum. These are due for launch in early 2023 and will open up the ability to classify even more additional use cases.

Get in touch with us or one of our distributors today to find out how we could help you bring hyperspectral imaging to your project or business in a quick, convenient and cost-efficient way.

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