UKIVA

machine vision conference & EXHIBITION

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Arena MK, Milton Keynes, UK

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www.machinevisionconference.co.uk

Industrial Machine vision is an enabling technology in many industry sectors and consumer markets.

Here we look at just some of the applications in the automotive, sport, food, packaging, medical diagnostics, pharmaceutical, solar energy, traffic and transport industries.

MEDICAL DIAGNOSTICS

Cameras are used in many areas in the medical diagnostics field, for example on optical microscopes used in diagnostic laboratories, blood analysers, endoscopes used for internal examinations and general imaging in the operating theatre. 3D imaging is used in many orthopaedic investigations. In recent years, the development of small, high resolution cameras including board level cameras using low cost consumer interfaces has helped medical OEMs create even higher-performance medical imaging systems.

Away from the medical centre

These compact cameras offer excellent performance with lower noise and high resolution. Connection to analysis processors is often through consumer interfaces such as USB2 and USB3. This has also allowed the development of equipment that is portable and affordable enough to be used away from a hospital or medical centre. This includes equipment for dermatology or diagnostic and cosmetic skin analysis, live blood analysis and ophthalmology. In addition, there has also been a move towards the use of embedded systems which makes the equipment even lower cost and more portable. In the developing world, for example, people are now able to have examinations, screening, diagnosis (and even treatment) in the field where none were possible before. In fact the equipment can be used in any remote area where it was too difficult or expensive for the patient to get to the hospital.

On the high street

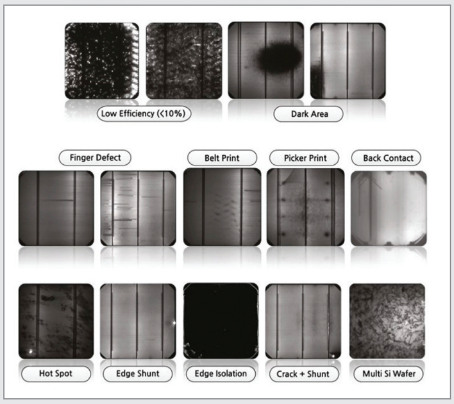
There are also many examples of these types of camera being used in routine healthcare environments that might be found on any high street, such as the dentist or optician. Cameras on flexible probes allow dentists to keep records of patients' teeth over time to see if any changes have taken place between appointments. For spectacle wearers, routine eye inspections utilise these type of cameras. In addition they are used to in table-top systems to measure the position of an individual's eyes in a new spectacle frame for accurate positioning of the lens – especially important for varifocal lenses.

Eye inspection - Courtesy IDS

SOLAR ENERGY

The solar energy market is one of the newest markets to benefit from vision. Solar power is a clean and attractive alternative source of electricity, so there has been an increasing demand for photovoltaic modules to be cheaper and become more efficient at solar energy conversion.

Solar cells are crystalline silicon devices and a variety of imaging techniques can be used during manufacture. Cell breakages resulting from micro-cracks, degradation and shunted areas on cells are proven to cause major problems and affect module performance. Many such defects cannot be observed with conventional imaging systems. However a measurement method known as the Electroluminescence (EL) imaging is providing a solution.



Solar cell micro cracks and defects - Courtesy Allied Vision

Electroluminescence imaging

EL imaging consists of applying a direct current to the solar module and measuring the photoemission using an NIR camera. The system is able to accurately detect numerous failures and ageing effects in very short times. Based on the severity of the defects, the cell will either be accepted or rejected. In addition, the amount of light a cell generates for a given applied current can also serve as a measure of the solar cell's conversion efficiency.

Edge isolation

Edge isolation is used to provide electrical separation between the active front side of a solar cell and the rear side. In the edge isolation process, a laser cuts a small groove along the cell edges, the depth of the groove depending on the cell doping. The groove needs to be positioned as close as possible to the outer contour of the cell in order to maximise the active surface and thus the efficiency. By using a line scan camera and customised LED illumination to measure the outer contours of the cell and feed them back to the control system of the laser, the edge cutting can be carried out automatically to within preset tolerances.

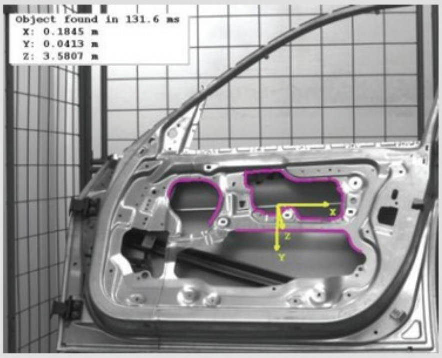
AUTOMOTIVE

Vision drives quality

Vision can benefit the entire automotive supply chain from parts and components, including major subsystems, to automotive manufacture itself. This sector is one of the most demanding in terms of product quality and aversion to component failures. The ability of vision to both measure and classify helps the modern quality inspection approach of differentiating between critical and non-critical defects – those that affect the functionality of the object and those that do not. Although the integration of vision technology into complex 24/7 manufacturing processes can pose many practical challenges, the return on investment timescales for industrial vision systems are very short, especially when the costs associated with product recalls is taken into consideration.

Components and assemblies

Inspection continues to be one of the most importance uses of vision in this industry, ensuring the quality of components ranging from engines, drives, and chassis components to safety-relevant parts such as brakes, steering, airbags and seat belts. 3D imaging has many applications such as measuring flush and gap alignment when vehicle doors are fitted. A multitude of electronic components including cable tracks, switches and displays can be inspected with machine vision during production. Elsewhere in the assembly process, machine vision can be used for robot guidance to position and bond windscreens or other guidance tasks such as fitting of doors.



3D-vision

Raw materials

Vision is also used in the inspection, classification and selection of raw materials. Specific lighting techniques or structured lighting can be used to help expose any typical defects to ensure that defect-free raw metal sheets are used for visible parts of the bodywork. Metal that has been classified as structurally sound but contains blemishes, can be used on non-visible parts of the vehicle.

Other applications

Beyond the manufacturing phase, code readers can track vehicle shipments and optical character recognition systems can read the VIN (vehicle identification numbers) and number plates. High-speed vision systems enable accurate analysis of vehicle behaviour in crash tests to help reduce the impact on passengers in accidents. In car use of vision technology can include parking aids and collision avoidance systems. Perhaps one of the most interesting new applications of vision is its use in autonomous vehicles. And finally, when vehicles reach their end of life and need to be recycled, vision technology is responsible for reliably identifying and separating materials and routing them to the appropriate recycling stations.

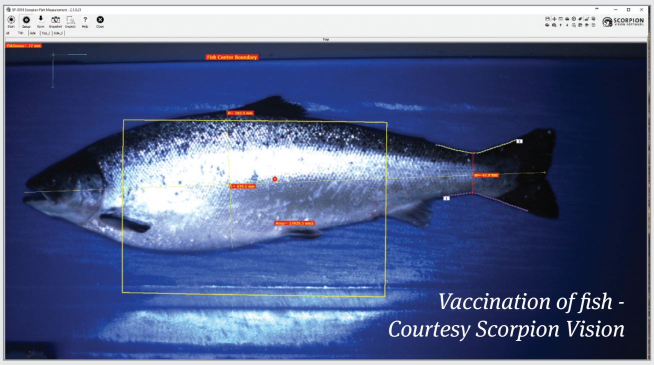
FOOD

Getting things right

Vision technology can offer food manufacturers a competitive advantage. It opens up possibilities in quality assurance that were previously impossible to implement, including inspection of the food product itself, inspection of food packaging integrity to avoid premature spoilage and inspecting food labelling for accuracy. Newer technologies such as hyperspectral imaging are likely to have a big impact in the future.

Controlling the product

Vision can be used in the processing of virtually any food, living, grown or manufactured. In almost every case it is carrying out previously labour-intensive tasks as diverse as the vaccination of live fish to the checking of pizza for shape, size, edge defects, holes, and the presence and distribution of the correct toppings, using both 2D and 3D imaging. Vision can also be integrated into slicing equipment for portion control for products such as bacon, cheese and ham in order to maximise the on-weight percentages and minimise giveaway.



Vaccination of fish - Courtesy Scorpion Vision

Sustainability

Sustainability is a critical aspect concerning food producers in the UK today. A report by WRAP (Waste and Resources Action Programme) has estimated that up to 480,000 tonnes of food is wasted in the UK each year because of poor seals in packaging. Up to 24% of all packs are “at risk of failure” yet only 1% were detected in the factory using conventional means. Not only is this food wasted, but its carbon footprint is made worse by having to be then transported for disposal. Vision can be combined with existing methods to radically improve the detection of poor seals. For example, thermoformed and top sealed trays can be pressure-tested for integrity. However if food has become trapped in the seal itself, the pack may pass that test but leak later as the trapped food dries and shrinks. Vision systems can be used to identify packs with food trapped in the seals.

Food labelling

The correct labelling is vitally important for the consumer with regards to allergen information, ‘use-by’ dates and other data such as price, weight, country of origin etc. With the costly penalties imposed by supermarkets for incorrectly labelled and presented products, there are signs that the food industry will follow the pharmaceutical industry in terms of traceability. Here, however, the entire label needs to be verified. This includes the artwork, any promotional ‘flashes’ as well as 1D/2D barcode verification, overprinted coding, date and time verification and printed text verification. The need for 100% inspection makes vision essential essential and a vision system can yield a very quick return on investment.

PACKAGING

Safety first

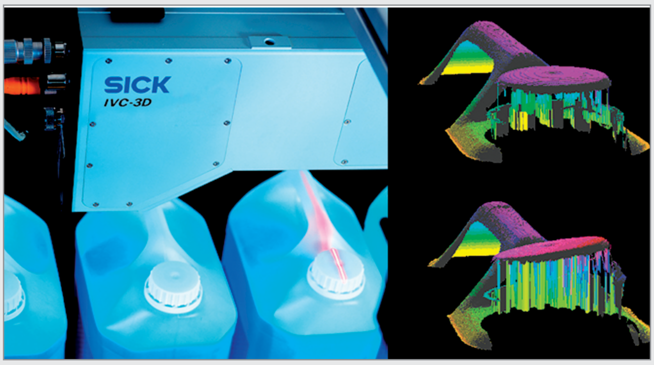
The importance of label inspection and code reading have been covered in the ‘Food’ and ‘Pharmaceutical’ sections. Other packaging applications can range from checking the packaging materials and the packaging themselves for defects to checking fill levels and the integrity of the final packaging for product purity and shelf-life considerations. Examples include the orientation of bottle lids, the integrity of seams in cans and the presence of foil seals in container lids which will ultimately be heat sealed onto the neck of the container.

Developing techniques

Many emerging techniques have facilitated packaging inspection. Smart cameras can be programmed for individual inspections and decision-making anywhere on the packaging line. Thermal imaging cameras can be used to check the correct application of hot-melt glue for cardboard carton assembly. NIR imaging makes it possible to image the contents through some packaging materials at the same time as inspecting the print on the packaging itself. Hyperspectral imaging is a new technique that can inspect the contents of packaging.

The impact of 3D imaging

From its early beginnings, 3D vision required specialist programming expertise to take the raw data output and configure it for different factory control networks. Huge amounts of expensive processing power and bulky equipment were needed. Now, with advances in embedded, smart technologies, 3D is affordable and accessible to many without specialist skills. Instead of a camera or lasers that need complex configuration with a separate PC, new ‘intelligent’ sensors offer all-in-one vision solutions. However, that does not mean that we have arrived at “one size fits all” in 3D vision. Instead, from high-performance cameras, advanced colour, 3D measurement and multi-scanning technology through to stand-alone programmable sensors, we have reached a continuum of choice. With a solution for every application, the challenge now is to match the best technology to the process.



3-D container lid inspection - Courtesy Sick UK

Applications include checking the contents, content, number and fill of a container. This is useful for products such as chocolates or biscuits in compartmented containers. Not only is the absence of an item noted, the insertion of a damaged or wrong item can also be flagged up. Overfill levels can be a problem, for example where totes, bags and tubs which must meet a safe carrying weight limit or allow safe stacking, or food products such as meat are over-height and filling would interfere with sealing the plastic film cover correctly. Checking the orientation of products like shampoo bottles prior to shrink wrapping can avoid awkward shaped packing that does not fit into outer cartons, resulting in waste and downtime.

PHARMACEUTICAL

The packaging revolution

Whilst there are many applications for vision in the pharmaceutical industry throughout the manufacturing process, more recently there has been a lot of developments with regard to packaging inspection. Packs are no longer merely transport or storage boxes. They are dispensers, information sources, functional extensions of the product and even lifestyle accessories. For optical inspection systems, the resulting requirements are for more pack-specific data and a growing need for high-density code verification and image-based quality inspection on high-speed lines.

The packaging challenge

Mis-labelled products not only present a tangible threat to public safety but have major implications with respect to damage to the pharmaceutical company’s brand and reputation. Since considerable costs can be associated with recall notification, product retrieval and liability, the overall effect on the finances and credibility of a business during and post recall can be significant. For example, cartons inadvertently packed with the incorrect patient information leaflet can result in a product recall. Integrating a vision system into a packaging line goes a long way to eliminating such errors. There are also many logistics and quality control strategies, such as the EU’s Falsified Medicines Directive – the FMD (2011/62/EU) – or the Good Manufacturing Practice (GMP) Annex 1-121. GMP Annex 1-121 requires a check on the plug position on vials. Pharmaceuticals manufacturers have only until this year to comply with the FMD by printing serialised 2D codes on each pack.

Serialisation

These serialised 2D codes will provide traceability from the point of sale back to manufacture. This will allow product authenticity to be checked at any point in the supply chain to reduce counterfeiting of pharmaceutical products. Serialisation requires that the packs are labelled, the labels verified by machine vision and all data passed upstream to the appropriate place, and all at production line speeds. A number of companies have implemented solutions for the inspection of serialised codes. In the past, inline inspection was a compromise between speed, precision, functionality, ease-of-use and cost. That is changing. New, fast pattern-matching capabilities mean image processing speeds are increased and errors reduced. New algorithms address the effects of machine vibration and changing light conditions. They allow fast processing of multi-camera and high-resolution inspections and simplify finding optimal image processing parameters.

Interestingly, the tobacco industry has also begun to introduce serialised 2D verification for its so-called ‘dot codes’. Although the verification of alphanumeric codes – such as date and lot codes – remains standard, many printed promotions have started to use 2D codes.

The 2d DataMatrix forms a part of serialisation - Courtesy Omron

SPORT

Vision now integral to professional sport

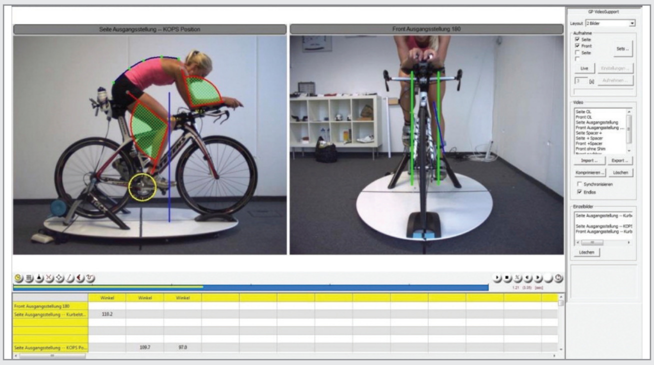
Any follower of sport on TV would at the very least expect 'slow motion replay' and multiple angle view analysis of key action sequences. However, vision technology is now used extensively by sports officials, coaches, developers and amateur performers alike. Applications fall into 3 main categories: tracking the trajectories of moving items, such as balls and people, high-speed imaging to allow frame by frame motion analysis and the use of infra-red imaging to reveal information that could not be obtained from conventional cameras.

Geometrical systems

Ball tracking systems such as 'Hawk-Eye' (part of Sony) are used extensively in many sports including international tennis, cricket and football, to help the officials verify borderline decisions. The system uses a number of cameras at key locations around the particular arena to track the movement of the ball and a sophisticated image processing system calculates the trajectory of the ball relative to the particular playing area. Other examples include the tracking of a player's movement during football matches for analysis. The systems monitor the position coordinates for every player, the ball and the referee at all times during the game to allow calculation of players' total running performance including average and maximum speeds, number and intensity of sprints and the distance covered, allowing the production of so-called 'heat maps'. A very recent application is a vision based scoring system in a social darts environment using multiple cameras and 3D fitting algorithms to measure the precise position and score of the dart in the board.

High Speed Analysis

High frame rate and high resolution imaging allow complex movements to be filmed and slowed down for analysis. Applications include analysis of racehorses in motion, the analysis of athletes' techniques for sports science and the analysis of golf swings both for professionals and amateurs.



Cycling posture analysis - Courtesy IDS

Infrared imaging

In cricket, a system called 'Hot Spot' uses infrared cameras to help adjudicate disputed catches since the impact of the ball against bat results in a localised heat spot, which appears bright on the IR image. Infrared cameras have been used in the development of ventilation and cooling systems in athletics footwear. Infrared technology can reveal the thermal performance of Formula 1 tyres under race conditions and in different weathers. It can also be used to provide a detailed understanding of how the complex materials used in disc brakes react under load and how heat is dissipated in exhaust systems.

TRAFFIC & TRANSPORT

Keeping us moving

An area that now benefits from vision, that affects us all, is transportation and traffic. Monitoring of traffic and in particular Automatic Number Plate Recognition (ANPR), has changed the face of our roads, but there has also been considerable use in railway applications.

Controlling traffic

Traffic applications are many and varied and can include ANPR, toll booth control, multi-lane monitoring, automatic toll licence validation, red light violation, traffic enforcement systems, vehicle recognition and identification, vehicle occupancy and speed monitoring. Although many will comment on speed detection, ANPR is actually greatly increasing the effectiveness of our homeland security with image data, networked throughout the UK, to detect or find vehicles of interest. This wide range of applications have been made possible by developments in lighting and lighting control technology, the versatility in functionality and triggering offered by modern image sensors and sophisticated software. In particular, high dynamic range cameras are available which can provide more than 1000x the dynamic range of conventional sensors. These cameras can produce high quality images of moving objects in widely varying lighting conditions, for example in the open air where the sun may come in and out at random times, underground car parks, tunnels or traffic monitoring at night (for example checking registration number plates without interference from the vehicle headlights). Cameras can accept trigger signals from motion detectors, barriers being raised, pressure sensors etc. A wide choice of image sensors allow the most suitable resolution to be chosen for the application. For example, resolution choice could be influenced by the field of view necessary, such as the number of traffic lanes to be covered, different sizes of number plates etc. Line scan technology is also used in vehicle inspection applications such as high integrity under vehicle surveillance. This can be used at airports, prisons, border control, and other high security facilities to detect foreign objects such as explosives hidden under vehicles.

Keeping on track

There are many examples of the use of vision technology on the railways both trackside and mounted on the trains themselves, even though the operational conditions are demanding. Cameras and imaging systems can be exposed to extremes of weather, vibration and physical wear. Line scan technology is being used to inspect the rails, sleepers and ballast for early detection of failure at speeds over 100 MPH, to a resolution of 0.8mm. Used in conjunction with cutting-edge pattern recognition software, this can automate the detection of track defects to help increase the safety of the railway network in a way that was previously impossible.

104 industrial camera assemblies on London Underground passenger trains check the condition of the wheel/rail interface and the track - Courtesy Stemmer Imaging