Visual appeal

It's not every day that something moves out of a niche and enters the mainstream traffic market, yet that's exactly what machine vision cameras have done. And the best thing, writes **Louise Smyth**, is that this might only be the start of things to come

Illustration courtesy of Tim Ellis

When *Traffic Technology International* first started delving into the world of machine vision and its use in ITS a few years ago, we couldn't have predicted how fast the sector would evolve. The companies interviewed were not household names in the traffic market, the applications of the technology were regarded as somewhat niche, and there was some doubt as to whether the cash-strapped ITS industry would ever be prepared to stump up the extra cost for these sophisticated cameras. But how things have changed! Today, machine vision for ITS is big business. The camera vendors are no longer on the periphery of the sector – they're actively pursuing it and the business case has been established. But what else has happened in the past few years to encourage this boom?

Each vendor proffers a number of reasons for the surge in popularity. Take Andreas Schaarschmidt, CEO of SVS Vistek, for instance. Having spent 15 years at Stemmer Imaging before joining SVS Vistek in 2009, he has been well placed to observe – and indeed encourage – the migration to the traffic market. "Our company still has its roots in industrial applications, the classical machine vision business," he says. "But to enter new markets, we've had to diversify our product offering. For the traffic market, cost is not the driving force. For speed enforcement, ALPR, tolling – or indeed any fixed outdoor application – you need high-quality cameras with long-term stability. You could buy a €200 camera but it will fail and need repairing or replacing. Our customers in this sector expect stability and service, but they're more focused on the total cost of ownership than the initial outlay."

Schaarschmidt describes the technical demands of this sector as the 'traffic triangle'. "Clients are often asking for more resolution, other times they are asking for speed (meaning frame rate), and at other times sensitivity is the most pressing demand," he explains. "If you have high speed, normally the resolution is low. If you have a high resolution, the speed tends to be low. And if you ask for sensitivity, that can have an impact on the speed. If we understand these seemingly conflicting demands, we can offer suitable products that perfectly match this triangle. For instance, lots of customers are asking for cameras with high dynamic range: in a tunnel application, the dynamic between dark and light is tremendous and the camera has to manage this."

Quick thinking

SVS Vistek has been well able to respond to these demands over the years and has

Required reading

Ellis Nugteren from Adimec assesses what's needed for a machine vision camera to conduct ALPR

Advances in digital camera technology enable more sophisticated intelligent traffic management and enforcement systems to better meet governments' objectives to improve road safety, increase traffic flow, and enforce traffic laws with fair payments.

The latest camera technology also improves system performance to minimize detection time in case of accidents, increase the detection rates in cases of violations, and minimize overall costs from police time and traffic jams. These systems also need to maintain reasonable costs and prove their efficacy to gain adoption by government decision makers.

License plate recognition (LPR) is one of the more common needs in traffic systems. There are several performance and system parameters to consider which can be easily solved through the appropriate camera considerations.

LPR requires a crisp, clear image of a license plate to withstand dispute upon issuance of any penalties. This means obtaining an image whenever a car appears, regardless of lighting conditions, weather, the color of the license plate, or the vehicle speed.

An infrared (IR) flash light can be used to illuminate the license plate as it is not visible to humans and the license plate material is reflective at 800nm.

> External triggering is important as images are required exactly when a car drives by, which is unpredictable

Cameras that have significant sensitivity at this wavelength allow for the desired image quality without a complicated and costly workaround.

Blooming and smear are challenges with outdoor vision systems. Bright spots can originate from headlights, reflections off license plates, the sun at certain times of the year, or sun reflecting on the tarmac. Image processing in the system cannot correct these defects so blooming and smear must be managed in the camera to ensure that the license plate is not obscured in the original image data.

Typically, at least two good images need to be obtained on a car traveling up to 250km/h (155mph). With a controlled test, an existing two megapixel traffic camera with a frame rate of 60fps could still obtain a usable image for a car traveling at 360km/h.

The fast frame rate needs to be also combined with high resolution. High-resolution cameras mean that fewer cameras can be used to see more of the road which simplifies the system and reduces the costs. Usually, at least one megapixel resolution is required to limit a maximum of one camera per lane.

There are special considerations for the camera connectivity with regards to optical fit, electrical fit and functionality – regardless of whether it's a system upgrade or a brand-new system.

Ghost images can appear if IR lighting is used in combination with a visible light block filter. The simplest way to prevent ghost images and lens artifacts from interfering with the system performance is to utilize a supplier that also has the expertise to properly integrate the filter and lens with the camera.

It is desirable to have the large, multi-lane processing part of the imaging system in a different location from the camera, such as next to the road rather than close to the cameras above each lane. This requires the use of rugged cables that can transmit large amounts of data over long distances. CoaXPress is the preferred interface that meets all of the requirements and allows for use of existing analog coax infrastructure.

The specific functionality required depends on the system design. External triggering is important as images are required exactly when a vehicle drives past, which is unpredictable. As there is no second chance when the vehicle is gone, effective automatic exposure control is often vital to have properly exposed images.

Adequate color processing with incorporated auto white balance ensures accurate representation of the colors, important for regions where license plates are different colors.

The needs of intelligent transportation systems are different from those of traditional machine vision, and therefore both markets have significantly different camera requirements. Utilizing cameras that are optimized for traffic applications can simplify the overall system design and increase performance while also reducing costs.

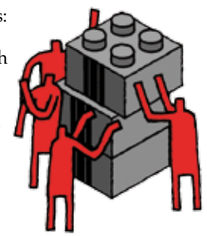
Adimec's technology helps to alleviate smearing and blooming

already gained a significant foothold in the traffic market. In fact Schaarschmidt proudly claims that if you got caught speeding in Germany, there's an extremely high chance it was an SVS Vistek camera that caught you. But as the market has grown, it's got increasingly competitive, so the company has had to up its game in terms of feature sets and products it brings to market. At the Vision show in November 2011, it launched its latest cameras, the BlackLine range. Schaarschmidt describes the cameras as tough, industrial-grade units. "They have a special housing, higher temperature range and new feature sets such as a built-in flash controller," he explains. "Although they are perfect for the industrial sector, the traffic sector sometimes has the same demands. Both sectors want stable cameras and easy-to-use

(Right) **Speed enforcement cameras** (Below) **SVS Vistek's BlackLine range**

connectivity – via a cheap and standard-sized cable. I think BlackLine is the best platform for the future traffic market."

The point about connectivity is particularly relevant to the rise of machine vision cameras in ITS and links to the introduction in 2006 of the GigE Vision standard. Paul Kozik from Allied Vision Technologies (AVT) explains why this standard has been such a driver of progress: "GigE Vision is basically cable length at high bandwidth, and you combine that with low latency. That has been the winning combination in machine vision and we're also seeing it deliver a lot of value in traffic. In a tolling scenario, for example, you can now manage all of your gantry cameras to a single computer. And being able to take this off-the-shelf, low-cost Ethernet networking technology and applying



it to a high-end application means we can offer very cost-competitive products."

Cut-price copies

The demand for cost-effective products is hardly unique to the traffic sector, and Kozik feels AVT is in a good position to be truly competitive: "We have an ongoing challenge with competing manufacturers in Asia," he reveals. "They re-design our innovations and offer them at much lower prices, redefining what we believe the camera should cost. That pressure originated in the machine vision space, so we're more than capable of making lower-cost products for many markets. In fact, as we're a component offering as opposed to a solution-based package, we're definitely competitive.

"If you're doing ALPR, for instance, the price margin is in the software development. We do not currently offer ANPR software, our focus is on providing the best possible image that the customer can use for ANPR processing. We're targeting performance as a way to improve the existing traffic solutions. There's a lot of focus on ALPR accuracy. One way to improve the accuracy is to grab more images per vehicle. You can do that if you have a fast enough camera or a sensor that has a really high frame rate, and that's our game in machine vision, so we can take that and apply it to traffic."

This last point is borne out by a recent ITS contract for AVT. The company's cameras are being used by one of the biggest names in the sector, Q-Free, in its new single-gantry multi-lane free-flow tolling solution. "These are CCD sensor cameras that offer a high quantum efficiency and near-IR response – which are very much machine vision buzzwords!", Kozik says. "But this basically means they can see more in the infrared wavelength that Q-Free is concerned about. This is vital as the more sensitive the camera is, the shorter the exposure value can be; which means they can capture vehicles moving at higher speeds."

The choice of sensors – the ongoing CCD-versus-CMOS debate – is something that AVT is also responding to. In January 2012, it is adding some CMOS-based cameras to its Prosilica GT range. When it comes to selecting the right sensor Kozik says: "For us, it's been a matter of finding a CMOS device that offers good performance and can compete with the CCD sensors. The CMOS sensors we have chosen have more of an HD aspect ratio, which makes them particularly suitable for tolling or speed enforcement applications."

Of course, one way to ensure you have the right sensor for the job is to make it yourself, which is exactly what Teledyne Dalsa does. "We're the only company selling into the traffic market that's integrated in this way. We design our own sensors (for area-scan applications we are focusing more on CMOS sensors) and that gives us an edge on the competition," says the company's Manny Romero. "Our second USP is that we're a camera, software and frame grabber vendor, so in terms of the software-processing side we also have an edge that most of the FireWire camera vendors don't."

(Top) **Machine vision cameras are increasingly popular in ITS** (Above) **AVT's Prosilica GT**

One might assume that these 'added extras' would bump up the price tag, but Romero is quick to dismiss this notion. "The percentage of price drop in the past five years has been dramatic in terms of resolution speed versus price. Moving to digital or FireWire cameras used to be expensive but new technology has created cheaper VGAs. Meanwhile sensor prices have also gone down – prices have dropped across the entire market.

"The parallel is that not only have prices gone down, functionality within products has increased five to tenfold. Although image-capture speed and resolution has obviously increased, so has image quality and preprocessing, which has a snowball effect: more consistent images make the processing algorithms used in the next step work better, too. Something available now that was not a couple of years ago is the capability of having multiple images back-to-back with different exposure times, which means you can have more images with a different contrast. If your processing is for ALPR, for instance, then you've just doubled your chance of having a better image – so the odds of being able to accurately detect the right vehicle have also just doubled."

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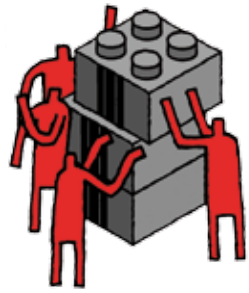
> **Paul Kozik, Allied Vision Technologies, Canada**

Romero also cites the widespread adoption of the GigE Vision standard as

(Left) **Teledyne Dalsa's Genie TS cameras**



having a beneficial effect on the industry. "It is a good thing for customers," he suggests. "They no longer feel they are stuck with one vendor – and for us vendors, it means we are no longer competing on the connectivity side, so we have to differentiate ourselves via functionality. The battle is now between the IP functionality – not the medium. So if I can offer a little twist – such as more IP or a function to control your pan and tilt – then I'll have the edge over my competitors."

This ability to tweak its offerings has enabled Teledyne Dalsa to work on many semi-customized projects, as Romero explains further: "This allows our customers (systems integrators in tolling or enforcement, for instance) to get an edge on their competition. To be successful in ITS you need functionalities that reflect how the cameras are used in the end systems.

"Consider an application that's looking at a road. One person might say the minimum pixels needed is VGA resolution, so 640 pixels wide. Someone else might say the minimum needed is 800. Others might say when building a system, they'd rather have a single camera per lane. Others might prefer multiple lanes per camera. That's why you need a wide range of speed and resolution coupled with a good set of features."

Application-specific cameras

Point Grey is another vendor trying to achieve these aims. It designs products such as its Zebra2 specifically for the ITS market. Mike Gibbons explains how this camera differs from regular machine vision offerings: "It's a very configurable platform that uses a range of CCD sensors and supports both GigE and HDSDI. There's a battle between IP cameras that use the Ethernet interface and the HDSDI platform. Often, for traffic surveillance, a system will have two cameras mounted over an intersection: one using HDSDI or real-time low latency display and the other plugged into a video recording system through the GigE. So we've put both capabilities into a single unit."

As well as offering CCD-based products, Point Grey is not neglecting the trend for CMOS sensors, as Gibbons details: "We're integrating the latest CMOS sensors with global shutter into our cameras. The issue with rolling shutter CMOS sensors is the potential for distortion of moving objects – that's not good if you're trying to do ALPR. With global shutter we achieve the high image quality of CMOS sensors with no distortion. There's a number of low-cost, high resolution global shutter CMOS sensors coming out and I think this technology will prove very popular in the near future."

> We design our own sensors (for area scan applications we are focusing more on CMOS sensors) and that gives us an edge
>
> **Manny Romero, Teledyne Dalsa, Canada**

Delivering good results with today's technology is obviously a prime focus for Point Grey. One of its biggest (and especially happy) customers in the US ITS market is Transport Data Systems (TDS). The company uses cameras to conduct a range of traffic applications from law enforcement to automatic vehicle classification and ALPR. "Machine vision cameras are an ideal choice for TDS for a number of reasons," Gibbons says. "High resolution, the ability to trigger, reliability, ease of use, and price performance. Cameras with higher resolution such as two megapixels or more can cover multiple lanes, thus requiring fewer cameras to buy, maintain and add to the network. The ability to precisely trigger the image capture is important as many LPR systems use a vehicle-position sensor to trigger the camera and lighting at the same instant."

Tom Hasselbring, TDS's president reports that he is reaping the benefits of machine vision. "Our systems are used all over the USA, day in, day out, at night, in all kinds of weather and we depend on the quality and flexibility of these cameras. Over the years, Point Grey has added features important to us such as a serial interface to control the lens and opto-isolation on GPIO ports."

Ultimately, it is traffic customers such as TDS – and indeed the likes of Q-Free – that will determine the future of machine vision in ITS. What these customers demand, the vendors above will have to deliver. And with the triple whammy of the GigE standard and its associated flexibility, the overall price reductions – and the increased performance of these cameras – this future is looking pretty damned rosy.

Visioneering for ITS

The German company Leutron Vision offers a range of GigE and smart cameras for ITS applications. "A lot of basic features that were always important for machine vision are now also necessary for ITS," says CEO Meinrad Simnacher. "These include the need for a wide range of CMOS and CCD sensors that best fit the specific application. For instance, a camera for a one-lane ALPR application will have a sensor with a smaller resolution then a two-lane camera to save costs. Very good image quality is another priority in both sectors: this translates to up to 12-bit resolution, high-dynamic range, global shutter CMOS or progressive-scan CCD without smear effects."

Image data over one cable (PoE) – which allows long cable lengths – is a priority for the ITS market as is low power consumption. But Simnacher also cites the trend for miniaturization: "Miniaturized complete vision systems and smart cameras that include the processing unit have emerged as a result of the use of applications in mobile systems, such as in police cars.

Leutron's CheckSight PC camera, a combination of a PC and a camera ticks all of the above boxes. "It is dedicated for ITS," Simnacher says. "There's a choice of 28 CCD/CMOS sensors, while a dual-sensor option to acquire different images in parallel (i.e. for LPR and color image of the car) is also available."