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Image Sensors
in Era of Smart factories

Industry 4.0 combines digital world and physical world in which Image sensors have established themselves as a sensory organ. As world is heading towards automated manufacturing, some top notch companies are also ready to bridge the gap between the two worlds. Let us read the Technological Advancement, R&D, Trends and Products the image sensors companies have to offer their customers.

Vishal Malhotra
National Sales Head, Automotive
Infineon Technologies, India

Sanjay Jain
Analog Applications Manager
Texas Instruments India

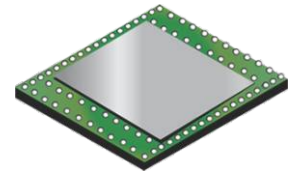
Michael DeLuca
Go To Market Manager
Image Sensor Group
ON Semiconductor

Channabasavaraj Raravi
Senior Solutions
Architect - Software
Sasken Technologies Ltd

TECHNOLOGY OFFERED FOR IMAGE SENSORS

Infineon: Infineon's Time-of-Flight (ToF) based Image Sensor family REAL3 paves the way for numerous applications and innovations not previously possible. The technology is helping us to meet the growing demand in numerous applications in consumer, industrial and automotive segments. REAL3 Image Sensor family brings together all necessary ingredients to establish 3D image. Brightness and the distance from the sensor to objects are measured in every single pixel. The 3D camera emits modulated infrared light and measures the time the infrared signal takes to travel from the camera to the object and back again: "time of flight" refers to the elapsed time. This helps to provide robust and accurate depth data.

Texas Instruments: Texas Instruments has come out with next generation technology of 3D Time of Flight sensing Analog Front End Devices which completely change the gambit of Image Sensing Applications. This technology relies on capturing and processing 3D map (X,Y,Z) of the object; commonly referred to as "Point Cloud". It employs IR (Infrared) as a medium to measure distance by emitting a modulated light and measuring phase delay of returned light, in IR spectrum. This enables to capture the 3D map of the object. This is called as 3D Point Cloud Information. An array of pixels are used to map a region of interest for getting this 3D Point cloud.



On-Semiconductor: ON Semiconductor provides a full portfolio of image sensors based on both CCD and CMOS technologies that are used in applications ranging from machine vision inspection and automotive ADAS to surveillance, consumer, and medical imaging. Our 40 year legacy of image sensor development allows us to leverage technologies such as advanced pixel designs, high bandwidth outputs, electron multiplication, packaging options, customized color filter array patterns, and more to provide unique solutions to our customer's most demanding imaging problems.

Sasken: The current focus from Sasken is in the Automotive and Retail domains. The automotive domain requires real-time processing of images. We are currently focused on making some tiny real-time algorithms to do application specific image processing for Autonomous cars. The current challenge in Autonomous driving is the testing of different image processing algorithms. This also needs special skillset to do verification of different algorithms with various combinations of images. The test automation is another focus area where a larger number of test cases could be tested within short span of time and with good quality. The Retail segment (specifically Fashion) requires the image super imposition capability to realise virtual shopping or virtual trial rooms.

UNIQUENESS OF IMAGE SENSOR

Infineon: ToF method of depth measurement incorporated into the highly optimized REAL3 Image Sensors offers many benefits compared to other depth sensing technologies, ToF offers advantages in performance, size and power consumption of battery-operated mobile devices. ToF based Image Sensor family REAL3 is sunlight robust, highly scalable, and ready for integration. According to the Global Image 3D Sensors Market 2017, Infineon Technologies is the top seller of the 3D Sensor technology.

Texas Instruments: Image Sensor AFEs helps to capture complete 3D Point cloud, it enables solving a wide array of existing challenges in Machine vision with relatively minimal effort in terms of implementation. Rather than implementing a 2D Stereoscopic Image stitch to extract 3D point cloud information, this technology works on IR transmission from a Modulated Light Source and reception through a IR Photo Diode and then extracting object information in a 3D point cloud format. More importantly, if you benchmark this technology on parameters of low light condition imaging, Distance Range, depth accuracy, it performs well as compared to a existing solution set. Also, given the implementation, this solution is lot reliable and can prove boon for SIL certification for Factory Automation Applications. Applications involving privacy concerns would immensely benefited from this technology as it only captures 3D point cloud information and not actual image.

On-Semiconductor: Clearly, the first differentiator is the unique set of base technologies available to develop the image sensors in our portfolio, such as the advanced global shutter pixel architectures and Interline Transfer EMCCD designs mentioned above. These technology components are then leveraged into a broad portfolio of over 1000 different orderable devices, with pixel sizes ranging from 1 to 25 microns, resolutions from VGA to 50 megapixels, and with options for different packaging configurations, optical format, light sensitivity, power requirements and more – providing an unparalleled opportunity to select the most appropriate image sensor for a particular application.

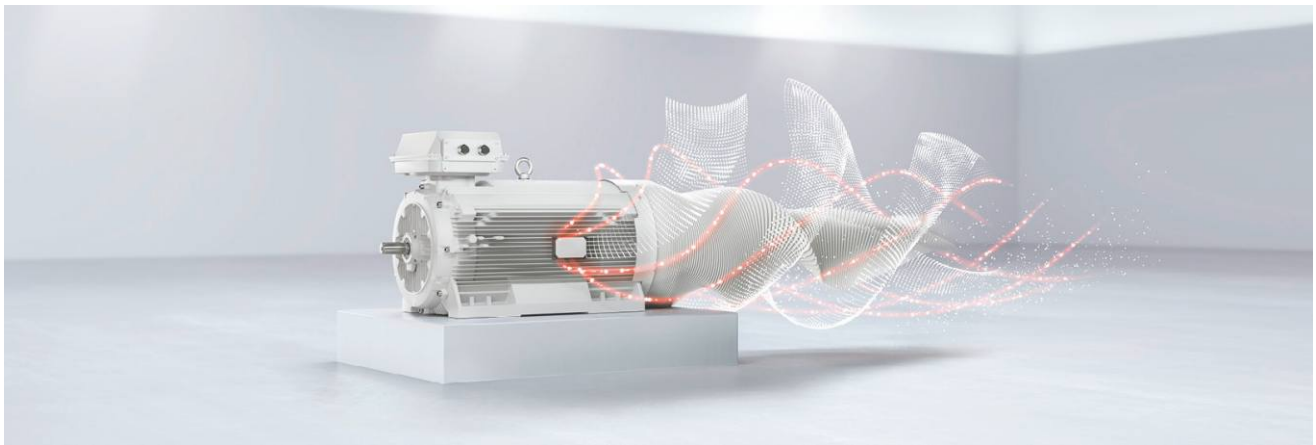
But we then go beyond these separate elements to design product families that leverage these base technology packages into an integrated portfolio – allowing camera manufacturers to leverage a single camera design to provide a full portfolio of cameras with different resolutions, light sensitivities, and package configurations. This family architecture design simplifies the work need by camera

manufacturers to develop and support new camera designs, allowing them to bring cameras to market more quickly and cost effectively.

Sasken: The Image processing, which is done on top of an image, makes a lot of difference in the outcome of a picture. This is key in making user experience better. The analytics on image, specific to use case/application adds lot of value to customer. Sasken's ability to build re-usable blocks and quickly adapt to new requirement/use case/application is a key differentiator. Another unique value is the ability to build real-time image processing algorithm, which could be adapted quickly in Automotive and retail segments.

The amount of time required in verifying image processing algorithms without automation would be significantly higher. It requires execution of lot of repeated test cases and labour intensive job which might lead to poor quality products. Sasken's test automation services enable customers to build quality products and take them to the market faster.

R&D In Era of Industry 4.0



Infineon: Accurate 3D depth data can be beneficial for numerous Industry 4.0 applications such as people or object movement counting in the area of security and surveillance. Another major application field is industrial automation and robotics. Due to high diversity of system requirements, these applications require solutions developed in partnership with customer and camera design-house.

Texas Instruments: Right now, a lot more applications are being explored in Factory Automation by utilizing the advantages of this imaging technology, which were a challenge to implement till date with existing solutions. 3D-TOF sensors can detect objects' shapes and dimensions to help robot understand how to position the grippers, making the whole operation lot less time consuming and efficient. Also, one key R&D effort underway is to come out with relatively lower cost lower pixel array 3D ToF Sensing devices, to enable usage of this technology in cost sensitive applications.

ON Semiconductor: The imaging needs of Industry 4.0 start first with the imaging needs of the application – the resolution, light sensitivity requirements, shutter performance, etc., required for the job in question. Industry 4.0 may impose additional requirements – such as small physical size, low power footprint, or system-on-chip processing – that add to these base product needs. We address these additional requirements through the development of small-pixel architectures, advanced digital processing blocks, and product options that reduce the power footprint required for operation.

But the "smart factory" of Industry 4.0 is enabled by more than just image sensors. ON Semiconductor is also a leading supplier of semiconductor solutions for the Internet of Things, including a broad set of options for sensing, connectivity, power management, motor control, and more. This allows ON Semiconductor to provide the full set of components needed to implement Industry 4.0 – both now and in the future.

Sasken: We are in the process of adapting existing sensors and algorithms/capability in the Industrial domain which would enable us to quickly address use cases in same. Some of the use cases include factory process operation inspection, output quality inspection, equipment health, asset tracking, etc. There is also emphasis on capturing good picture/vision in all environment conditions. Here, real-time action is needed in case of quality inspection and rejection of output products. The algorithm must be tuned to specific needs to address real problems. Image sensors and analytics would help to speed up the manufacturing time and make process more efficient and robust.

Current and Future application areas for Image sensors

Infineon: Within the consumer category, the REAL3 Image Sensor is already integrated in mobile devices. For one, it is playing a key role in the newest innovative Augmented Reality (AR) smartphone by ASUS. Launched in January this year, the ASUS Zenfone AR is the world's thinnest smartphone that is using Infineon's 3D ToF camera for 3-dimensional perception of its surroundings in real-time. AR enriches the perception of the real environment with written text as well as virtual objects that are embedded in correct scale and realistic perspective.

The monocular camera architecture and the compact single-chip design enable the smallest form factor designs. With its scalability to meet different application requirements, the REAL3 Image Sensor family will continue to pave the way into mobile devices like tablets, and head-mounted displays, meeting size and power consumption requirements.

Based on the REAL3 Image Sensor family for consumer electronic markets, dedicated automotive derivatives are in developing stages and aims at addressing automotive requirements like wider temperature range and an imager package with automotive qualification. The TOF system is a total game changer for automotive applications in many ways.

ToF can greatly enhance safety and convenience in cars. Capturing 3D data within the car has and will enable new innovative HMI concepts with complete new user experiences. Here, the possibility of enhanced functionality and performance of many other applications within and around the car is a plus. These include driver state monitoring advantage, Passenger classifications, Touch-less gesture control apart from surround view for sophisticated parking assist and obstacle detection.

Texas Instruments: Some of the key Applications include Machine Vision for Logistics/Auto Dimensioning in Factory Automation, Automated Object Grasping, Occupancy Detection, People Counting, Autonomous Robot Navigation to name a few in Smart Factory Applications.

On Semiconductor: Image sensors from ON Semiconductor are used today in applications ranging from industrial imaging (including machine vision, medical and scientific imaging, aerial inspection and more) to automotive applications such as Advanced Driver-Assistance Systems (ADAS) and through to consumer and security imaging. Our devices are used in award-winning cinematography cameras selected for movie and television productions around the world, and are found out of this world in earth-orbiting satellites and in probes and landers throughout the solar system. Going forward we will continue to leverage our broad technology base and product portfolio to provide solutions for the most challenging imaging applications.

Sasken: The current focus is in the area of asset performance management. The challenges here are placement of sensor inside the heavy equipment, getting stabilised image in moving or vibrating equipment and capturing images from all angles. Another challenge is capturing multiple images and joining them to get complete information about the equipment. This is important for big equipment as one camera might not give overall/complete picture about the equipment and the decision cannot be made based on partial knowledge. We are also exploring other advantages along with specific use cases once the image sensors are deployed. There is also focus on reducing the installation cost of plant by taking out conventional transmitters and utilizing the vision sensor to make some of those decisions. Though the adaptation of image sensor or machine vision is important in the industry to improve the efficiency of manufacturing, it is also important to see the use cases where it could also help to reduce some resources in order to get some cost advantage as well. The memory and processing capability in hardware could enable more use cases in the near future.

Future Trends

Infineon: Augmented reality in smartphones - Today, AR is in an early introduction phase representing a niche market. It will be up to smartphone users to identify applications that they desire in the course of their daily life. This may realize a huge business potential: just the premium segment of smartphones is rated to be more than 400 million devices sold each year. Currently, already four of the top five camera module makers for mobile devices and smartphones are actively working on camera module designs using Infineon's REAL3 image sensor. Two of them are already delivering devices in volume quantities.

Intelligent streetlight for the city of the future: Streetlight could be equipped with parking spot detection sensors. Feeding information about the availability of vacant parking spaces to the cloud will create the basis for an intelligent traffic management system. Thanks to integrated radar sensors, the intelligent streetlight can also be configured to adapt to environmental conditions.

Sensors for the car of the future: Depending on a vehicle's category and how it's equipped, it will have between one and three radar systems. Soon up to five will be offered, together ensuring an "all-around view" that makes new functions like the intersection assistant and parking assistant possible. In the autonomous vehicle, which the automobile industry expects to be available from around 2020, at least ten radar systems may be installed.

The market leadership of Infineon in the rapidly growing market for radar chips for driver assistance systems was confirmed by market research company IHS Technology. While Infineon has sold a total of 20 million radar chips in the past few years, the company intends to have shipped a further 30 million chips for driver assistance systems this year alone. Infineon would have thus doubled its radar chip sales annually for five years in a row.

Texas Instruments: Automation would be the Key driving trend leading to implementation of sensors, right from low end position sensors to high end image sensors in Smart Factories. We see end point-of-capture processing as the key change to help implement a distributed computing eco-

system, enabling lesser over-heads and lot reliable implementation. The need to connect all nodes in a typical Factory environment with minimal Wiring running around would also lead to the need for Wirelessly connected end nodes including Sensors, Gateways and control units.

ON Semiconductor: The evolution of image sensor technology is driven at its core by the needs of applications. While these can vary across different markets, a number of commonalities can be found in industrial applications – the ongoing trend toward faster output speeds, higher resolutions, lower noise, improved light sensitivity, smaller optical formats, etc. Unfortunately, these performance vectors are often at odds with each other – while smaller pixels provide higher resolutions and/or smaller optical formats, by themselves they also tend to reduce signal to noise. The challenge, then, is to combine different technologies – whether new pixel geometries, unique color filter array patterns, backside thinning, stacked pixel architectures, or more – in ways that provide improved performance in one or more vectors without sacrificing performance in others. Ultimately this is our goal – not to deploy new technologies as an end unto itself, but to provide products that offer new solutions to the image problems being faced by customers.

Sasken: Making more efficient or quicker edge analytics. The tiny sensor that could be mounted/deployed inside heavy equipment. This would help user to get the inside picture of equipment along with other data from sensors which makes decision making more accurate. The operating range of sensors and product needs to be enhanced to suit different Industrial environment. Integrating more sensors along with image sensor to take out few transmitters on site to monitor process and reduce the cost of automation. Combination of centralised and distributed image sensors and algorithms - The specific task could be done at node level and do more AI based computation in centralised node to build predictive maintenance capability. Battery operated, power efficient cameras which could be deployed with some wireless connectivity to give flexibility to user. Interoperability, connectivity and standards are going to be key things in the area of machine vision. Artificial intelligence adaptation to solve specific problems is a key to manufacturing and process industry. Image sensor and algorithm used for monitoring in current focus in Industry but may be used for controlling in future but may not be near future.