

MACHINE VISION FOR INDUSTRY AND AUTOMATION 2018

Market & Technology report - February 2018

Machine vision is at the heart of the automation revolution.

KEY FEATURES OF THE REPORT

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- Market forecast for machine vision cameras through 2023
- Market forecast for machine vision image sensors through 2023
- Market shares for PC-based cameras, smart cameras, data capture camera modules, and related image sensors
- Description of machine vision applications
- Description of machine vision technologies
- Focus on food sorting, license plate recognition, and robotic vehicles

OBJECTIVES OF THE REPORT

- Market trends and forecasts
- Key players for cameras and image sensors
- Application diversity
- Synergy between image sensor technology, camera technology, and other technologies
- Technology trends
- New applications such as food sorting and robotic vehicles

MACHINE VISION IS AT THE HEART OF THE AUTOMATION REVOLUTION

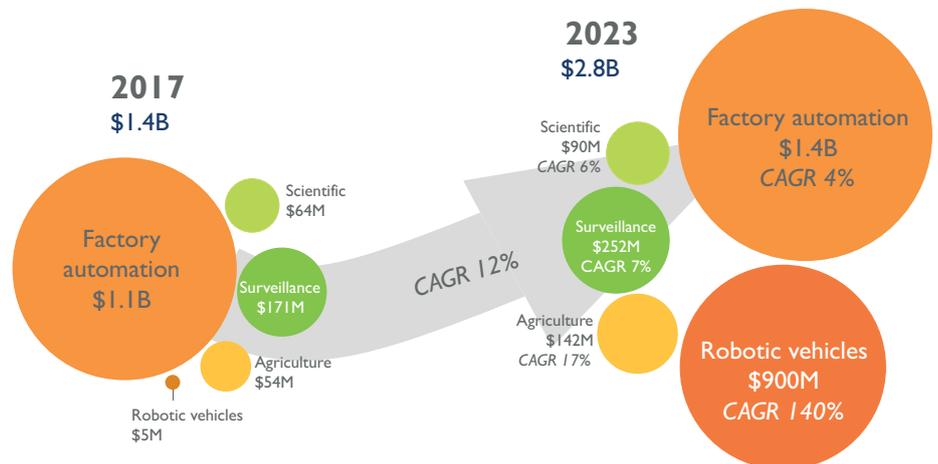
There is a silent revolution going on in factories. The transformative forces we are facing are similar to what happened during the previous industrial revolutions. But this transformation is not about steam or electricity. Today's trend is autonomous and on-demand processes, for humans and machines alike. Inside factories the transformation is about automation and machine vision is often the key enabling technology.

Machine vision (MV) is at the heart of this automation revolution. The MV camera market will grow from \$2B in 2017 to roughly \$4B in 2023, with a 12% Compound Annual Growth Rate (CAGR). Machine vision for industry and automation is not limited to robotics, but is involved in almost all machines and aspects of the manufacturing cycle. The need for quality has boosted MV in the automotive, electronic, semiconductor, food, and packaging industries. Food sorting is an interesting example of this push toward automation. The ability to sort

fruits and food in general has helped to grow agro-food business revenues, especially in Asian markets. Indeed, MV has moved out of the factory. It is now on farms, on roadways for license plate recognition, and more recently in autonomous cars, the market for which we expect to grow at 140% CAGR starting this year.

These dynamics are here to stay. At the time of our last report, in 2014, the Swatch Group announced its Sistem51, the world first mechanical watch whose manufacturing is fully automated. Since then, other companies have made similar moves, such as Canon in camera manufacturing and Foxconn who announced the deployment of a million robots for manufacturing consumer electronic goods. Sales of automation products are therefore surpassing the growth of industrial production. The trend could accelerate in the future while cheap human labor is scarce in western countries and China is also increasing wages.

Forecast for machine vision cameras market in its main applications



Area is proportional to market size. The forecast MV market in 2017 is \$2B and \$4B in 2023, only the main applications are included in this graph.

(Yole Développement, February 2018)

HIGHLY DYNAMIC MARKET AND PLAYER ECOSYSTEM

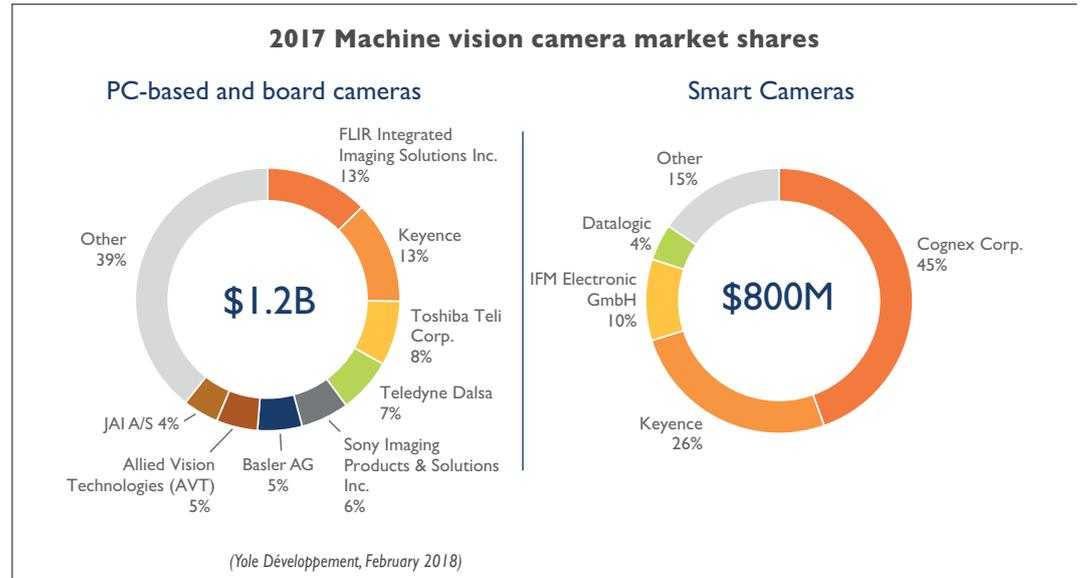
The automation revolution has created a highly dynamic market and player ecosystem. In the three years from 2014 to 2017, merger and acquisition (M&A) activity has accelerated in MV both at image sensor and camera level. Among the latest examples of this trend are FLIR acquiring Pointgrey for \$215M in 2016,

and Teledyne acquiring e2v for \$790M in 2017. Other notable acquisitions are ams' acquisition of CMOSIS for \$235M in 2015, and a little earlier in 2014 ON Semiconductor consolidation of Aptina for \$400M and Truesense for \$90M. Most recently, private equity firm Lakesight aggregated MV camera

makers Tattile, Microtron and Chromasens. The total amount of M&A in this time period is approaching \$1.7B.

The shift from Charge-Coupled Device (CCD) to CMOS has had a profound impact on image sensors for MV, driving this M&A wave. Although this affected other markets years ago, such as consumer image sensors in the 1990s and photography sensors in the early 2000s, it is only now that the shift from CCD to CMOS technology is reaching the high end of the imaging sensor market.

The main direct consequence for companies selling high cost/low volume products is the inability to invest in or sustain manufacturing facilities that require high output due to the large fixed cost. The entry cost to establishing CMOS Image Sensor (CIS) manufacturing has been far too high for previous vertically-integrated CCD players. Therefore, all except Sony have shifted to the fabless business model suited to high-end “specialty products”. Dedicated foundries such as TPSCo, Dongbu Hitek and SMIC, who recently acquired LFoundry’s assets, have therefore emerged.

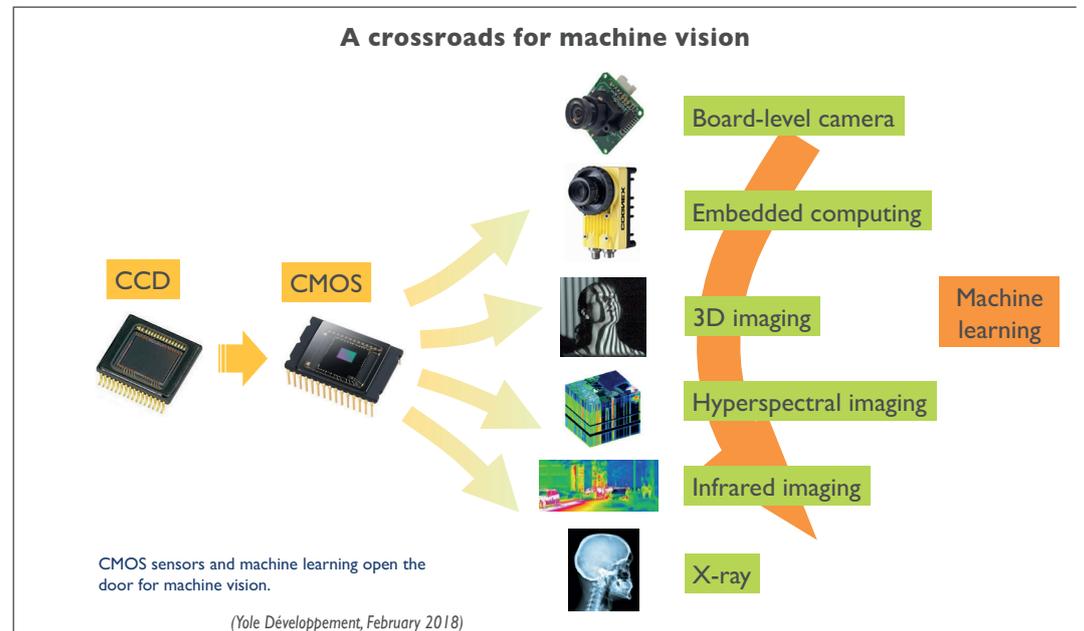


FROM CCD TO CMOS: MAJOR MODIFICATION AT THE CAMERA LEVEL THAT MIGHT LEAD TO THE EMERGENCE OF NEW PLAYERS

On the technology side, the transition from CCD to CMOS image sensors has greatly simplified camera design, trending toward commoditization. The integration of camera functions into the CMOS image sensor has also led to cameras fitting on a single board. This single board camera in turn places MV camera players higher in the supply chain. Consequently, we could see new camera

players integrating these board cameras into new systems, applications, and smart cameras.

Integrating cameras into systems and smart cameras have also been boosted by technologies coming from smartphones. Systems-on-chips (SoCs) and the Mobile Industry Processor Interface (MIPI) make it much easier to develop



intelligent vision systems. One example of the spread of smart cameras is the recent multispectral product from Specim.

Another technology that will enable intelligent MV to spread is machine learning (ML). As an example, in 2017, Cognex acquired Vidi Systems, a deep learning software company, in order to implement ML into smart cameras.

But MV and ML, among other technologies, will have an important impact on robotic vehicles. Annual robotic vehicle production could reach 150,000 units in 2027, and grow exponentially from there. By 2023, the market for industrial cameras for robotic vehicles could be worth more than \$900M, suddenly becoming one quarter of the MV camera market.

COMPANIES CITED IN THE REPORT (non exhaustive list)

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Dr. Alexis Debray is a Technology and Market Analyst at Yole Développement (Yole). As a member of the MEMS & Sensors Business Unit, Alexis is today engaged in the development of technology and market reports as well as the production of custom consulting projects dedicated to the imaging industry.

After spending two years at the University of Tokyo developing expertise focused on MEMS technologies, Alexis served as a research engineer at Canon Inc. Over 15 years he contributed to numerous projects of development, focused on MEMS devices, lingual prehension, and terahertz imaging devices.

Alexis is the author of various scientific publications and patents. He graduated from ENSICAEN, and holds a PhD in applied acoustics.



Pierre Cambou joined the imaging industry in 1999. Following an engineering degree from Université de Technologie de Compiègne in parallel to a master of science from Virginia Tech in 1998, as well as graduating from Grenoble Ecole de Management's MBA, Cambou took several positions at Thomson TCS, which became Atmel Grenoble in 2001 and e2v Semiconductors in 2006. In 2012 he founded Vence Innovation, now called Irlynx, in order to bring to market a disruptive man-to-machine interaction technology. He joined market research and strategy consulting company Yole Développement as imaging activity leader in 2014.

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