

Computer Vision Market Overview

Lab 58 Market Research Brief

August 2021

Computer vision (CV) uses machine learning algorithms to mimic how we see and visualize objects. When combined with artificial intelligence (AI), it can even automate human sight for tasks such as inspections. CV has many significant applications across different industries—including disease diagnoses in healthcare, biometric analysis in security, quality inspection in manufacturing, and obstacle detection and guiding for autonomous vehicles (AVs) in transportation. In fact, the global market for CV software was valued at \$10.6 billion in 2019 and has grown to \$11.4 billion* in 2020. With all these applications across different fields, the value of CV is expected to continue to grow 7.6% from 2020 through 2027.¹

Different Types of Computer Vision

CV may refer to several subprocesses, including image classification, object recognition, and image segmentation. One such category, object detection, is particularly useful for its ability to both localize and classify objects in an image or a video. For example, when presented with video of a person and a cat, object detection algorithms can not only report the existence of both the person and the cat in the footage, but also pinpoint where those objects are at any given time. Many of the world's top companies are interested in CV because of how it can assist with business practices, such as quality control, security, and marketing.²

For more information about how CV works, see the Lab 58 technology research brief, [Computer Vision for Object Detection](#), as well as the article, [Making Better Museum Exhibits with Computer Vision](#).

Key Takeaways:

The federal government has an estimated \$4.9-billion investment in the CV market.

CV is applicable in many industries including healthcare, international development, and manufacturing.

There are many imaging technologies that are relevant to the success of the CV market, such as X-Ray, LiDAR, and Thermal Imaging.



The CV market was estimated at **\$11.4 billion*** in 2020, and the market is expected to grow at a rate of **7.6%** through 2027.

Pictured above: A Lab 58 CV project that observes museum visitors' movements.

*Different reports show varying values: \$4.6B (2019)³, \$13.74B (2019)⁴, and \$11.98B (2019)⁵

¹ Grand View Research. (2020). Computer Vision market size, share & trends analysis report by component, by product type, by application, by vertical, by region, and segment forecasts, 2020–2027. Grand View Research, Inc.
² Corporate Strategy Research Team. (2019). Artificial intelligence trends: Computer vision (2019). Gartner, Inc.
³ Business Wire. (2019). Global \$4.6Bn Vision Sensor Market Insights & Outlook to 2024. ResearchAndMarkets.com
⁴ Verified Market Research. (2019). Global computer vision market size by application, by geographic scope and forecast. Verified Market Research.
⁵ PR Newswire. (2020). The global computer vision market is expected to grow from USD 11,981.88 million in 2019 to USD 19,398.97 million by the end of 2025 at a compound annual growth rate (CAGR) of 8.36%.

Major Companies in the CV Market

CV comes in many forms, making the market for this software broad. However, CV requires advanced hardware alongside cutting-edge software. To harness the power of this diverse technology, companies must invest in powerful semiconductor chips designed to handle these complex AI algorithms. Two examples of companies impacting the CV market include Intel and NVIDIA.

Intel

Established: **1958**

Application: **Open VINO Toolkit⁶**

Competitors: **NVIDIA, IBM**

Intel has sat atop the semiconductor market since 1971. Semiconductors are an important part of CV; semiconductors and other graphics processing unit (GPU) hardware support CV software. In recent years, Intel has curated high-powered trademark platforms that allow programmers to train, test, and run AI algorithms for CV more efficiently than ever. New developments from Intel—such as the Edge Software Hub, DevCloud, and the OpenVINO toolkit—are among leading software packages designed to handle this level of computing, giving Intel a competitive edge.⁷ These “toolkits” benefit companies such as Betterview, a startup using aerial drones and CV algorithms to diagnose roof damage, tree overhang, ponding, and other structural weaknesses.

NVIDIA

Established: **1993**

Application: **GPUs, DRIVE⁸**

Competitors: **Intel, AMD, Samsung**

NVIDIA’s semiconductor market share has grown exponentially in the past fifteen years and has branched out from that success. NVIDIA provides hardware within the CV market only, but companies have looked increasingly to NVIDIA for processors that balance top-notch graphics with smooth performance because many CV algorithms output on a display monitor.⁹ As such, NVIDIA is the GPU of choice for major companies such as Google, Amazon, and Microsoft.¹⁰ The NVIDIA DRIVE PX is a newly developed AI platform for Audi’s self-driving cars that “uses trained AI neural networks to understand the surrounding environment, and determine a safe path forward.”¹¹

CV Startups

In 2021, billions of dollars will be poured into startups in the CV market alone.¹² Startups receiving hundreds of millions of dollars in funding, or even multibillion dollar buyouts, is not uncommon in this sector. Intel acquired Mobileye, a CV startup for self-driving cars, in 2018 for over \$15 billion—an early success story highlighting the massive value this technology will bring.

Other success stories include Athena Security and Standard Cognition. Athena Security is an Austin-based CV startup, awarded \$5.5 million from Pathfinder in 2019 for its cutting-edge defense solutions.¹³ In an age in which national security is a growing concern, Athena is developing AI that integrates CV and Forward Looking InfraRed (FLIR) thermal imaging to detect persons with elevated body temperatures, spot weapons, and notify authorities of threats. Standard Cognition, on the other hand, is based within the retail market. Their team combines CV technology with product radio-frequency identification chips to automate inventory updates and analytics for customer interactions. Most notably, the service auto-charges customers for products as they exit Amazon Go stores, paving the way for checkout-free shopping. In February 2021, Standard Cognition announced a \$150-million round of financing from the SoftBank Vision Fund.¹⁴

Federal Opportunities

The U.S. federal government has taken a strong interest in CV technology. In 2020, the federal government announced plans to invest \$4.9 billion in research and development (R&D) of technologies involving machine learning and AI.¹⁵ Most of the use cases are directed towards facial recognition software for security purposes; however, some object detection has been used to identify and detect things such as weapons and license plates. The federal government has created partnerships with companies such as Accenture, Amazon, and Trueface. There are also many opportunities for grant funding found on websites such as [grants.gov](https://www.grants.gov). For example, of almost 3,000 posted grants, close to 750 are related to CV.¹⁶

⁶ Intel. (n.d.). Making a success of computer vision.

⁷ Intel. (2021). Intel® Vision Products for Computer Vision Solutions.

⁸ Jhonsa, E. (2018). Why tech giants like Amazon are designing their own chips -- and who benefits. *TheStreet*, n.d.

⁹ NVIDIA. (n.d.). Supercharged computing for the Da Vincis and Einsteins of our time.

¹⁰ NVIDIA. (2017). NVIDIA, AUDI Partner to Put World’s Most Advanced AI Car on Road by 2020.

¹¹ Martin, S. (2020). What is computer vision? NVIDIA.

¹² Toews, R. (2021). A wave of billion-dollar computer vision startups is coming. *Forbes*.

¹³ SSI Staff. (2019). Athena security secures a \$5.5M seed round led by pathfinder. *Security Sales & Integration*.

¹⁴ Albrecht, C. (2021). Standard cognition raises \$150M series C for its cashierless checkout. *The Spoon*.

¹⁵ Yahoo! Finance. Global AI in computer vision market forecast to 2027—COVID-19 impact and analysis. (2021).

¹⁶ Grants.gov. (n.d.).

Healthcare

The healthcare industry uses AI-aided CV to detect abnormal conditions in the body, ranging from tumors to broken bones to tooth decay. Computed tomography (CT) scans, magnetic resonance imaging (MRI) images, and X-rays are included in the conventional medical imaging equipment used to detect irregularities. Advancements in AI systems have taken CV imaging hardware beyond merely detecting and classifying abnormal conditions in the body to taking actions based on the findings from the detected image. For example, GE Healthcare's 4-dimensional (4D) CT scanner has combined advancements in AI-aided CV technology to improve the accuracy of targeting tumors during radiation therapy. The 4D CT scanner provides an image of the true shape of anatomical objects in motion to reduce structural distortion.¹⁷ Accurately targeting radiation optimizes treatment of the tumor while decreasing damage to healthy tissue.

Advances to conventional CT scanners, such as cone beam computed tomography, will improve image quality and lead to increased market growth.¹⁸ The global CT scanner market is expected to reach \$6.2 billion by 2022, an increase from \$4.76 billion in 2017, at a compound annual growth rate of 5.4% during the forecast period. Major factors driving CT scanner market growth include the growing need for effective and early diagnosis, an increasing preference for minimally invasive diagnostic procedures, and technological advancements in CV. Major players in the CT scanner market include General Healthcare (United States), Siemens (Germany), Philips (Netherlands), Toshiba Corporation (Japan), Hitachi (Japan), Shimadzu (Japan), Samsung (South Korea), Neusoft Medical Systems. (China), Medtronic (Ireland), Shenzhen (Hong Kong), and Accuray (United States).¹⁹

Augmedics

Established: **2014**

Application: **xvision**

Startup Funds: **\$15 million Series B**

Augmedics is another company integrating CV into their technology. Based in Chicago, Augmedics developed the xvision Spine (XVS) System technology in 2020. The system combines CV with object detection and other cutting-edge technologies to address unmet clinical needs resulting from traditional freehand surgical procedures.²⁰

In June 2020, the first U.S.-based augmented reality (AR) spine surgery using Augmedics XVS System was completed at Johns Hopkins Hospital in Baltimore, Maryland. The XVS System headset combines the AR technology of 3-dimensional (3D) spinal anatomic images and 2-dimensional (2D) CT scan images. The images from the patient's scans are directly projected onto the surgeon's retina and superimposed over the patient's surgical area. This process has the effect of "X-ray vision," allowing the surgeon to see through the patient's skin and tissue and to navigate surgical instruments and implant screws accurately. Beyond this "X-ray vision," the surgeon does not have to look away from the patient to a remote MRI screen during the surgical procedure. The system gives the surgeon better control and visualization, which may lead to more effective and efficient surgeries.²¹



Photo by TechCrunch

Figure 1. Augmedics' predecessor to the XVS System, the Visor, was displayed during competition at TechCrunch's annual tech event held in September 2017 in San Francisco. The Visor placed 6th in the Startup Battlefield Disrupt SF 2017 competition. From thousands of potential candidates from around the world, the Visor was 1 of 22 top innovators hand-picked by TechCrunch to participate in the competition.²²

¹⁷ GE Healthcare. Advantage 4D. (2021).

¹⁸ Grand View Research. (2021). Global computed tomography market size, CT industry report, 2026.

¹⁹ MarketsandMarkets Research. (2017, July). CT scanner market by type, architecture, technology, application, end user—global forecast to 2022.

²⁰ Augmedics. (2020). xvision spine system.

²¹ Business Wire. (2020). First augmented reality spine surgery using FDA-cleared Augmedics xvision™ spine system completed in U.S.

²² Ha, A. (2017). Meet the six finalists at the Disrupt SF Startup Battlefield. TechCrunch

Damo Academy

Established: **2017**

CV Division: **4+X**

Startup Funds: **\$15 billion**

Damo Academy is another example of a company utilizing CV in their work. Damo Academy was founded in 2017 as an R&D initiative of Alibaba, a Chinese online retailer. According to the Damo Academy website, the initiative has developed an algorithm for diagnosis that can detect new coronavirus (COVID-19) cases using a chest CT scan. The AI model has been trained with sample data from over 5,000 positive COVID-19 cases.²³

Impact of COVID-19 on Computer Vision Use Cases in Healthcare

The COVID-19 pandemic has created opportunities for CV systems to detect, track, and reduce the spread of the disease. Following are a few examples of these opportunities:

- LeewayHertz is offering technology solutions using CV techniques and tools, such as the Human Presence Detection System to monitor patients remotely and the Face Mask Detection System to identify people without a mask.
- Voxel51 Inc., a U.S.-based CV startup, has created Voxel51 Physical Distancing Index to measure COVID-19's impact on people's social behavior around the world.
- Microsoft's Bing AI tracker provides a global overview of the current statistics associated with the pandemic.²⁴

International Development

International development aims to improve the lives of individuals worldwide through different areas of needs (such as health, education, infrastructure, etc.). CV technology can help automate tasks such as detecting areas and infrastructure in need of repairs, surveying land, and natural disaster relief.

Google (Alphabet)

Established: **1998**

CV Division: **Vision AI**²⁵

Valued at: **\$1.3 trillion**²⁶

Google has partnered with companies to complete monitoring and repair work on wind turbines. They send drones to take thousands of pictures of the turbine, and then they use CV to determine where areas of dirt, rust, and other issues may be. This process allows for a human to only look through hundreds of images, rather than thousands, and determine where to focus repairs.

Alphabet describes their research into CV as research on perception, to better understand images, sounds, music and video. It is incorporated across different Google products such as Google Photos, the camera on the Pixel Phone, and handwriting on Android tablets. Research areas include Health and Bioscience, Machine intelligence, speech processing, and machine perception.



Photo by Dave Clark, Flickr

International Development: Precision Agriculture

Another aspect of international development is Precision agriculture or connected agriculture. Precision agriculture allows farmers to focus on optimal amount of nutrients, seed, and pesticides in the based off of location need, using the right product and right amount to maximize crop yield and save on labor and time. Similarly, Precision livestock farming (PLF) is the use of advanced technologies to optimize animal production. It allows farmers and ranchers to consistently collect information at the animal level to recognize sick animals, increase feed efficiency, and save on labor, feed costs, and time. CV is used in precision agriculture to make operations more efficient.

²³ China Money AI. (2021, February 4). What has Alibaba's DAMO Academy achieved in three years? China Money Network Limited.

²⁴ Grand View Research. Global Computed Tomography Market.

²⁵ Google Cloud. (n.d.). Cloud vision API.

²⁶ Forbes (2021). Google (GOOG).

Precision Agriculture Companies

- Airbus, the aircraft manufacturing company has expanded into precision agriculture by launching AgNeo, a precision agriculture initiative that uses satellite images to deliver information about crops.
- AgriSync is a software company that offers remote mobile and video support for farmers.
- Arable, a firm that refers to their work as decision agriculture, is the world's first information technology managed irrigation tool. Based in San Francisco, California, Arable also focuses on sustainability practices to help farmers have less of an ecological footprint.²⁷
- Ceres Imaging uses high-resolution aerial imagery with advanced analytics to support farms, maximize irrigation performance.²⁸

Manufacturing and Industry

CV technology is making a significant impact at every stage of the manufacturing process, from using CV in warehouses to modern robotics in R&D labs.²⁹ CV expands AI's abilities by allowing machines to not only process data, but also gather information—which unlocks new market opportunities for manufacturing and industry. The global machine vision market is expected to grow from \$9.6 billion in 2020 to \$13 billion by 2025, at a growth rate of 6.1% during the forecast period.³⁰ More than ever, manufacturers are realizing the importance of automation in manufacturing. The COVID-19 pandemic lockdowns around the world caused manufacturing cash flow problems, which led to delays with new CV automation project development. The current and future needs for social distancing in the workplace are driving manufacturing companies across the globe to invest more in automation for our post-pandemic world.

Benefits of CV in manufacturing include efficiency, accuracy, repeatability, and reduced labor costs. These benefits result in improved manufacturing processes, as well as increased productivity and revenue.

CV use cases in manufacturing include the following examples:³¹

- **Vision-guided robots.** The most common use of CV systems is for tool and/or detail positioning on the production lanes. The system identifies the precise location of an object or a tool and sends these coordinates to the robot. Typically, CV is used for pick-and-place applications.
- **Anomaly detection.** CV automation is applied to analyze new images and compare them to a pre-existing dataset to find anomalies and prevent dangerous situations on manufacturing sites, production lines, and similar places.
- **Packaging inspection.** Manufacturers depend on a certain level of quality for their products, thus having a system that can automatically find any deviations from the standard is essential. For example, a CV-based inspection can track whether an item has the desired color, length, and width; whether the edges are intact; or if a package is filled correctly.
- **Barcodes and text label scanning.** Every item with a barcode can be quickly and effectively scanned by CV systems. Introducing CV to a manufacturing site can improve the detail management process, speed up the order processing, and enhance the tracking system.
- **Labeling, tracking, and tracing.** Accurate labeling saves time and money for manufacturers. More importantly, a mislabeled item can be harmful—especially if that item is a food product or medicine. CV helps manufacturing companies identify items (as well as misaligned or wrinkled labels), match the items to the database, and track them.

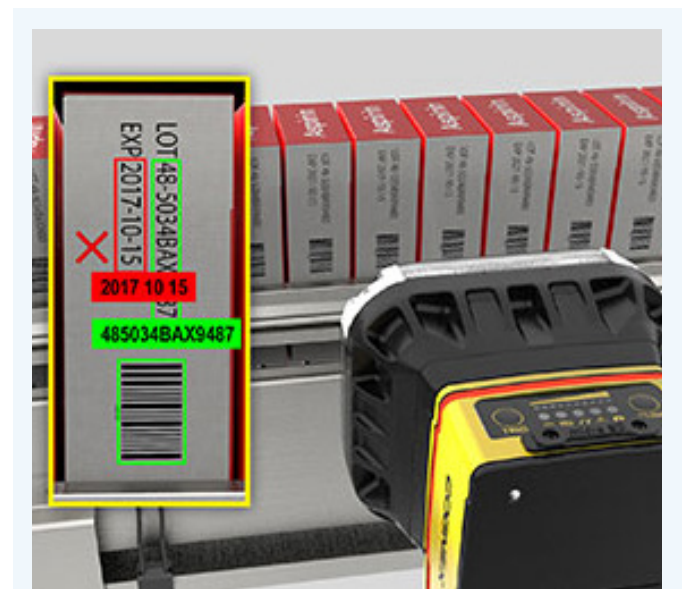


Photo from Cognex.com

Figure 2: Vaccine kit package printing inspection. Cognex® In-Sight® vision system optical character recognition and optical character verification can read and confirm printed information and verify the quality of mandatory printed elements such as logos, date/lot information, and other graphics.³²

²⁷ Arable. (n.d.). About.

²⁸ Ceres Imaging. (n.d.). Ceres.

²⁹ Sysadmins. (2020, October 5). Use cases of computer vision in manufacturing. Computer Vision.

³⁰ MarketsandMarkets Research. (2021). Machine vision market with COVID-19 impact analysis by deployment, component, product, application, end-user industry & region—forecast to 2025.

³¹ Bokhan, K. (2020). Computer vision in manufacturing: What, Why, and How? N-iX LTD

³² Cognex. (2021). Vaccine package printing inspection.

Manufacturing and Industry: Automotive

The application of CV systems for autonomous vehicles (AVs) is expected to boost the growth of the CV market because of CV's decision-making abilities. Although the global AV market reached a high of \$24.1 billion in 2019, the market declined in 2020 mainly due to the economic slowdown related to COVID-19 and efforts to contain it. The market is expected to recover and reach \$37.22 billion around 2023, with a growth rate of 16.84%.³³

Top self-driving car companies include Cruise, Waymo, Voyage, Swift Navigation, Embark Trucks, CARMERA, Zoox, and Nauto. The market forecasts that by 2040, there will be over 33 million driverless vehicles on the road, and around 55% of small businesses expect that they will adopt self-driving car technologies in their operations within the next 2 decades.³⁴

The global a market has several large companies as competitors, which include Audi AG; BMW AG; Ford Motor Company; General Motors Company; Honda Motor Company, Ltd.; Nissan Motor Company; Tesla; and Toyota Motor Corporation. Technology giants such as Google, Tesla, and Amazon are developing joint ventures with auto manufacturers to advance the future of AVs. Hyundai Motor Group partnered with Aptiv—a global technology company—to develop safer, greener, and more connected AV solutions. In November 2020, Ford Motor Company announced that it would bring its AV technology to Texas and start mapping the streets of downtown Austin for its driverless taxi and delivery services.³⁵

Cruise | Established: **2013** | Application: **Cruise Bolt and Origin** | Valued at: **\$30 billion**

San Francisco-based Cruise, LLC—founded in 2013 and a subsidiary of General Motors since 2016³⁶—combines self-driving vehicle technology with ride share technology to provide passengers with on-demand autonomous transportation options that utilize clean engineering to reduce fuel emissions.³⁷ Cruise forms the core of GM's self-driving efforts.³⁸ Chevrolet Bolt electric vehicles use drive control algorithms as well as light detection and ranging (LiDAR), radar, and CV cameras.

Cruise's automotive products are integrated with cutting-edge robotics and AI technologies.³⁹ In January 2020, Cruise premiered the Cruise Origin, a level 4–5 driverless vehicle (see figure 3) intended for use as a ride sharing service that is accessible from websites and mobile applications. Specifically built as a self-driving vehicle, Origin has no manual steering, no pedals, and no driver. Origin, which is all-electric and has a lifespan of 1 million miles, will be built in GM's Detroit-Hamtramck plant.⁴⁰ In October 2020, Cruise joined the ranks of Waymo, Nuro, Zoox, and AutoX by becoming the fifth company to receive a driverless permit from the California Department of Motor Vehicles. In December 2020, Cruise began testing vehicles without a human driver in San Francisco.⁴¹

During May 2021, GM began assembly of 100 pre-production Cruise Origin vehicles that will be built this summer for validation testing. In June 2021, Cruise secured a \$5 billion line of credit from parent company GM to begin preparations for commercialization of its autonomous ride-hailing business. The credit will be used to purchase Cruise's self-driving Origin shuttles, which GM is expected to begin producing at a factory in Detroit in early 2023.⁴²

Pictured below, the base model Chevrolet Bolt is modified by Cruise into the fully autonomous fourth-generation Cruise AV. The modification process involves adding LiDAR units to the roof of the vehicle, and completely removing the steering wheel and pedals.



Photo from Chevrolet.com

Level 0: No automation	The driver receives no technical assistance and is in full control of the car.
Level 1: Driver assistance	The driver may have some assistance with one automated system, such as cruise control, but they are still in full control over the vehicle.
Level 2: Partial automation	The driver is still in control but the vehicle may take on some of the Level 1 tasks in certain situations. Examples include adaptive cruise control, and automatic braking.
Level 3: Conditional automation	The car can steer, break, accelerate, and navigate autonomously, but still relies on human driver oversight
Level 4: High automation	The vehicle performs all driving tasks, but only under certain conditions and circumstances. The vehicle can safely pull over if something is wrong or a failsafe is triggered, but a human can also still intervene if necessary.
Level 5: Full automation	The vehicle has full autonomy. It can now go on all roadways, under any weather conditions, and at any time of day. No human attention or interaction is required.

Figure 3: The levels of autonomous driving.

³³ GlobeNewswire. (2020). Global Autonomous Cars Market (2020 to 2030)—COVID-19 Growth and Change.

³⁴ Betz, S. (2021). The top 21 companies paving the way for self-driving car tech. BuiltIn.

³⁵ Wired Release. (2020). Autonomous vehicle market 2020 the future of mobility, driving into the future with autonomous infrastructure by 2026. The Associated Press.

³⁶ Ohnsman, A. (2017). GM's cruise poised to add 1,100 Silicon Valley self-driving car tech jobs. Forbes.

³⁷ Betz, The Top 21 Car Companies.

³⁸ Priddle, A. (2020). GM's cruise origin self-driving pod has no steering wheel, no pedals, and no driver. MotorTrend.

³⁹ Hawkins, A. J. (2020). Cruise is now testing fully driverless cars in San Francisco. The Verge.

⁴⁰ Priddle, GM's Cruise Origin Self-Driving Pod Has No Steering Wheel, No Pedals, and No Driver.

⁴¹ Wayland, Michael. (2020). GM's Cruise begins testing autonomous vehicles without human drivers in San Francisco. CNBC LLC.

⁴² Wayland, Michael. (2021). GM-backed Cruise secures \$5 billion credit line as it prepares to launch self-driving robotaxis. CNBC LLC.

Security

Traditional passwords have long been a point of weakness for security systems. Biometrics aims to resolve this issue by linking proof-of-identity to our bodies and behavior patterns. In other words, biometric security means your body becomes the “key” to unlock your access. Biometrics are biological measurements or physical characteristics that can be used to identify individuals.⁴³ Common examples of CV-related biometric security include facial recognition, iris recognition, fingerprint scanning, voice recognition, and heart-rate sensors.

Biometrics is most often used in security, though there are other applications. Biometrics is separated into three groups based on the type of data obtained and mapped for use in future access attempts:

- Biological biometrics (genetic and molecular traits)
- Morphological biometrics (physical traits)
- Behavioral biometrics (personal activity patterns)

The global facial recognition market was \$4.35 billion in 2019 and is projected to reach \$12.92 billion by 2027, a growth rate of 14.8% during the forecast period. The significant increase in telecommuting during the COVID-19 pandemic has added to the growth of the facial recognition market and other biometric technologies.⁴⁴ Major global vendors of biometric products and solutions include Egis Technology Inc., Fingerprint Cards AB, Fujitsu Ltd., M2SYS Technology, NEC Corporation, Precise Biometrics AB, Qualcomm Inc., Shenzhen Goodix Technology Co. Ltd., Synaptics Inc., and Thales Group.⁴⁵

AnyVision

Established: **2015**

Application: **ABRAXAS Control System**

Valued at: **\$117 million**

In May 2020, Israel’s surveillance and facial recognition company AnyVision⁴⁶ began using its AI-aided CV technology on a microscopic level to detect COVID-19 cells by training the technology to look for the ways the virus diverts healthy cells from their usual function. Traditionally, the AnyVision surveillance technology is used to scan faces at military checkpoints. The AnyVision method of COVID-19 recognition provides results in minutes and has a false-positive rate of less than 5%.

AnyVision hardware such as the ABRAXAS Touchless Access Control solution uses facial recognition, combined with touchless access control, to open guarded points of entry for authorized people.⁴⁷ As organizations look for ways to safely return to work during and after the COVID-19 pandemic, AI is recognized as a powerful and critical tool. AnyVision’s unified visual intelligence platform offers four critical capabilities that are helping companies rethink safety and reimagine the way people access physical spaces and virtual services:

- **Watchlist alerting.** Receive instant recognition notifications on any device based on the detection of known individuals in real time or in historical footage.
- **Contact tracing.** Use historical footage to trace a known COVID-19 carrier and understand in real time who they have come in contact with (and for how long) so that informed quarantine decisions can be made.
- **Touchless access control.** Create safe, seamless entry experiences with face recognition to provide contactless access that is easy to customize by team and zone.
- **Remote authentication.** Easily onboard and authenticate users, creating a frictionless and secure experience through an elegant and quick-to-deploy mobile software development kit (SDK).⁴⁸

In January 2021, AnyVision detailed steps that technology developers need to take to ensure ethical and unbiased facial recognition solutions. In doing so, the company is hoping to create conversations among legislators, the technology industry, and the general public to find a balance that makes people more comfortable with surveillance and facial recognition technology.⁴⁹



⁴³ Kaspersky. (2021). What is biometrics security.

⁴⁴ Fortune Business Insights. (2020). Facial Recognition Market Size, Share & Covid-19 Impact Analysis

⁴⁵ Business Wire. (2020). Top 5 vendors in the mobile biometrics market from 2020 to 2024—COVID impact | Technavio.

⁴⁶ Burt, C. (2020, May 8). New computer vision and biometrics applications from AnyVision deployed in COVID-19 response effort. BiometricUpdate.com.

⁴⁷ AnyVision. (n.d.). Making the world safer through visual intelligence.

⁴⁸ Making the World Safer.

⁴⁹ FindBiometrics. (n.d.). AnyVision emphasizes need for ethical and unbiased facial recognition systems.

CV Devices and Accessories

CV is more than just software. The hardware—which includes technologies such as cameras, scanners, and other imaging devices—makes up most of the CV market, with a 70% share of global revenue in 2019.⁵⁰

Biometric Scanners

Biometrics scanners are hardware used to capture biometrics (i.e., physical characteristics) for identity verification. These scans compare saved information in a database to approve or deny system access. Examples of biometric technology include fingerprint mapping, facial recognition, and retina scans.⁵¹ Increased usage and mass production of biometric systems have resulted in decreased prices of biometric hardware.

The top five uses of biometric technology across the globe are as follows.⁵²

- **Airport security.** For years, biometric technology has been used in several large international airports to verify passenger identities.
- **Time and attendance.** Workforce management companies are implementing biometric time clocks at their work sites to combat fraudulent employee time and attendance activities. The most common biometric features used for employee identification are faces, fingerprints, finger veins, palm veins, irises, and voice patterns.
- **Law enforcement.** Biometrics is used around the world to identify criminals.
- **Access control and single sign-on (SSO).** Organizations across the globe are adopting biometric technology for access control and SSO because traditional authentication tactics, such as passwords, are insufficient for personal identification.
- **Banking and transaction authentication.** As global financial entities become more digitally based, banks are implementing biometric technology to improve customer and employee identity management—helping to combat fraud, increase transaction security, and enhance customer convenience.

Price Range:

\$40–\$3,300

Cost Factor:

Brand, type of sensor and waterproofing

Computerized Tomography (CT) Scanners

CT scanners use X-rays to produce 2D cross-sectional images—or slices—of the body's bones, soft tissues, and blood vessels. These images are then layered to create 3D models of specific areas of the body. CT scanners do not use fixed images, like those of X-rays; instead, CT scanners use motorized X-ray technology that rotates around the body and provides more detailed images. Dual-source and AI-enabled CT scanners are expected to be important milestones in healthcare market growth. Included in this category are ClariPi Inc, which received FDA clearance for its AI-enabled CT scanner called “ClariCT.AI.” Also, Siemens received clearance for its dual-source CT scanner, which emits small amounts of radiation and produces high-quality images within seconds.⁵³

Price Range:

\$65k–\$2.5m

Cost Factor:

Image size and speed of image development

Physicians may order CT scans for the following purposes:⁵⁴

- Examine internal and bone injuries from vehicle accidents or other sources of physical trauma
- Diagnose spinal problems and skeletal injuries
- Detect osteoporosis
- Identify many types of cancers and determine the extent (i.e., spread) of the tumors
- Locate infections
- Look for injuries, stroke-causing blood clots, hemorrhaging, and other issues in the head
- Image the lungs to reveal blood clots in the lungs' vessels, excess fluid, pneumonia, or chronic pulmonary obstructive disease
- Determine the cause of chest or abdominal pain, difficulty breathing, and other symptoms
- Diagnose dangerous vascular diseases that can cause stroke, kidney failure, and death

Additionally, CT scans are used to assist with biopsies and other medical procedures—and to help with treatment planning for organ transplants, gastric bypass surgery, and cancer.

⁵⁰ Grand View Research. (2020). Computer Vision market size, share & trends analysis report by component, by product type, by application, by vertical, by region, and segment forecasts, 2020–2027. Grand View Research, Inc.

⁵¹ What is Biometrics Security.

⁵² Trader, J. (2016, August 9). The top 5 uses of biometrics across the globe. (2017). M2SYS Blog.

⁵³ Grand View Research, Inc. Computed Tomography Market Size.

⁵⁴ Bennington-Castro, J., & Carson-DeWitt, R. (2015). What Is a CT scan? Everyday Health Group.

CV Devices and Accessories (continued)

X-Ray Imaging

X-rays are one of the most versatile forms of radiation. The rays can penetrate thick objects without absorbing or scattering, rendering them extremely useful for imaging purposes. X-ray imaging detectors have advanced from photographic-based systems to digital detector types. These new x-ray cameras produce high-resolution, full-framed images in real time within medical and space-imaging industries.⁵⁵

The most common form of X-ray used is X-ray radiography, which can be used to help detect or diagnose any of the following medical issues:⁵⁶

- Bone fractures
- Infections (such as pneumonia)
- Calcifications (like kidney stones or vascular calcifications)
- Some tumors
- Arthritis in joints
- Bone loss (such as osteoporosis)
- Dental issues
- Heart problems (such as congestive heart failure)
- Blood vessel blockages
- Digestive problems
- Foreign objects (such as items swallowed by children)

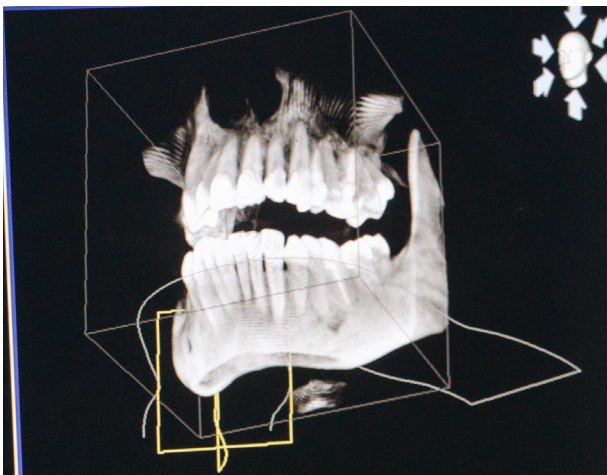


Photo by Cottonbro, Pexels

Light Detection and Ranging (LiDAR) Sensors

LiDAR technology utilizes pulsed lasers to accurately measure distances to a given target or area. Engineers know the speed of light, which means that by pulsing a laser and measuring how long it takes the light to get back to where it was shot from, you can determine how far away something is located.⁵⁷

LiDAR is a useful technology for a number of industries, from forestry to autonomous vehicles. Following are just a few of the many applications of LiDAR today:⁵⁸

- **Agriculture.** LiDAR can help agriculture technology companies pinpoint areas with optimal sunshine for more efficient growing. It also can be used to train machine learning systems to identify crops that need water or fertilizer.
- **Archeology.** This technology has revolutionized the world of archeology, helping experts discover hidden structures around the globe.
- **Climate change.** Climate scientists use LiDAR to study and track changes in the atmosphere. Botanists are using it to track patterns in changes to forested areas. LiDAR also is used to calculate changes in glaciers over time.
- **Land management.** Land management organizations can monitor land resources in real-time, allowing for faster and more efficient mapping compared to aerial surveys.
- **Oil and gas exploration.** New technology, called Differential Absorption LiDAR (DIAL), helps to trace oil and gas deposits.
- **Meteorology.** LiDAR helps meteorologists study clouds and their patterns by using the wavelength to detect small particles in the cloud.
- **Renewable Energy.** LiDAR can be used to identify basic requirements for harnessing solar energy, as well as to calculate direction and wind speed to allow wind farm operators to build and place turbines.
- **Robotics.** LiDAR is used to equip robots with mapping and navigation capabilities. For self-driving cars, the technology is used to train an autonomous system to recognize the distance between the vehicle and other objects in the environment.

Price Range:

\$40k–\$235k

Cost Factor:

Power level, size of flat panel detector

Price Range:

\$500–\$130k

Cost Factor:

Object sight distance, number of image pixels per second

⁵⁵ FindLight. (2017, September 22). X-ray cameras: Imaging body and space using high energy radiation. (2017). FindLight Blog.

⁵⁶ Cunha, & J. P., Shiel, W. C., Jr. (2020). X-rays. MedicineNet.

⁵⁷ Lee, T. B. (2020, October 15). Lidar used to cost \$75,000—here's how Apple brought it to the iPhone. Ars Technica

⁵⁸ Nanette George, G. (2020, October 21). 11 Interesting LiDAR Applications. CloudFactory Blog.

CV Devices and Accessories (continued)

Multispectral Imaging

Multispectral cameras work by imaging different wavelengths of light. Professional multispectral cameras have multiple imagers, each with a special optical filter that allows only a precise set of light wavelengths to be captured by that imager. The output of

the camera is a set of images for that particular wavelength.⁵⁹ The electromagnetic spectrum covers electromagnetic waves with frequencies ranging from below one hertz to above 1025 hertz, corresponding to wavelengths from thousands of kilometers down to a fraction of the size of an atomic nucleus. This frequency range is divided into separate bands, and the electromagnetic waves within each frequency band are called by different names. Long wavelength bands are low frequency and include radio waves, microwaves, infrared, and visible light. Short wavelength bands are at the high frequency end of the spectrum and include ultraviolet, X-rays, and gamma rays.⁶⁰

While Multispectral Imaging was originally developed for military target identification and reconnaissance, it is also used as follows:

- In early space-based imaging platforms to map details of the Earth related to coastal boundaries, vegetation, and landforms.
- In document and painting analysis.
- To enhance inspection capabilities in several industries which use CV cameras such as agriculture and medical industries.

Price Range:
\$6,500–\$65k

Cost Factor:
Resolution and application capability

Thermal Imaging Cameras

Thermal imaging cameras convert thermal energy (heat) into visible light to produce a picture showing the temperature differences of a surface. Images created are called thermograms and are analyzed through a process called thermography. Forward Looking Infrared (FLIR) Cameras are a type of thermal imaging camera.⁶¹

Price Range:
\$600–\$2,600

Cost Factor:
Resolution and sensitive range

Users of thermography include:

- Firefighters use them to see through smoke, find people and localize hotspots of fires.
- Law enforcement uses the technology to manage surveillance activities; locate and apprehend suspects, investigate crime scenes and conduct search and rescue operations.
- Power line maintenance technicians locate overheating joints and parts to eliminate potential failures.
- Building construction technicians can see heat leaks to improve the efficiencies of cooling or heating.
- Physiological activities, such as fever, in human beings and other warm-blooded animals can also be monitored with thermographic imaging.

Work with Lab 58

Thanks for your interest in our work! We want to help you explore opportunities to work with CV.

Please email us at Lab58@rti.org. We will set up a 30-minute, one-on-one chat to discuss opportunities and answer any questions. We are interested in partnering with you to find a solution that meets your needs.

For more information, contact Lab58@rti.org

⁵⁹ MicaSense. (2019, August 16). Multispectral FAQs.

⁶⁰ JAI. (n.d.). Multispectral imaging for medical and industrial machine vision systems.

⁶¹ Grainger, Inc. (2015, September 1). Thermal imaging cameras explained.

www.rti.org

RTI International is an independent, nonprofit research institute dedicated to improving the human condition. Clients rely on us to answer questions that demand an objective and multidisciplinary approach—one that integrates expertise across the social and laboratory sciences, engineering, and international development. We believe in the promise of science, and we are inspired every day to deliver on that promise for the good of people, communities, and businesses around the world. For more information, visit www.rti.org.

RTI International is a trade name of Research Triangle Institute. RTI and the RTI logo are U.S. registered trademarks of Research Triangle Institute.
L58 0003 0821