# Computer Vision in Pharmaceutical Quality Control: Vendors, Applications, and Trends

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## Introduction

*Illustration: AI-powered vision is transforming pharmaceutical quality control (pills and neural network motif).*
Pharmaceutical manufacturing demands extremely high quality control standards to ensure patient safety and regulatory compliance. Traditionally, many quality inspections – such as checking packaging, vials, or tablets – were performed by human operators. However, with production volumes reaching hundreds of thousands of units per day, manual visual inspection is often too slow and error-prone. To meet strict FDA and GMP requirements and to improve efficiency, drug manufacturers are increasingly adopting *computer vision* solutions for automated quality control. These machine vision systems use cameras and advanced image analysis (often powered by AI) to detect defects, verify labeling, count pills, and more with speed and consistency impossible for humans. The global market for pharmaceutical inspection machines was about **$862 million in 2023**, and is projected to grow ~10% annually, driven by stringent quality regulations and rising adoption of automated vision systems. Indeed, automated visual inspection in healthcare (pharma & medtech) generated over **$1.22 billion in 2024** and is expected to nearly double by 2030. This report provides a comprehensive overview of key commercial providers of computer vision applications for pharma quality control, the types of QC applications they support, and current market trends and challenges.

We will profile major vendors serving the U.S. market – from established machine vision companies to pharma-focused specialists and AI-driven platforms – and discuss their product offerings, underlying technologies (traditional machine vision vs. AI/deep learning), deployment models, and example use cases or clients. Comparative tables are included to summarize application domains, company sizes, deployment options, and tech stack at a glance. We also present industry statistics on adoption and market growth, and examine trends such as deep learning, 3D vision, and Pharma 4.0 integration, as well as challenges like validation and false rejects.

## Market Overview: Adoption of Vision QC in Pharma

Automated vision inspection has rapidly become a cornerstone of "Pharma 4.0" – the drive toward smarter, data-driven pharmaceutical manufacturing. According to market research, pharma companies' investment in visual inspection technology is rising steadily. The **global pharmaceutical inspection machines market** (which includes camera-based systems for QC) was valued at ~$0.86 billion in 2023 and is forecast to reach ~$1.7 billion by 2030 (~9.9% CAGR). This growth reflects *widespread adoption of machine vision* to meet stringent quality standards: regulatory bodies like the FDA and EMA mandate 100% inspection of parenteral drugs (injectables) for particulates and container integrity, and similar expectations are extending to solid dose and packaging processes. In a 2024 global survey, nearly **70% of pharmaceutical companies reported using AI** in at least some capacity, illustrating openness to technologies like deep learning for quality control. As a result, the **computer vision in pharma industry** (spanning R&D, manufacturing QC, etc.) is projected to expand very rapidly (one analysis forecasts ~24% annual growth, from ~$3.9B in 2024 to $11.5B by 2030).

**Key drivers** of this adoption include the need to improve inspection accuracy and consistency (machines don't get fatigued like human inspectors), the push to reduce product waste and recalls by catching defects early, and the high throughput requirements of modern production lines. Automated vision can **process large volumes quickly and reliably**, detecting tiny defects or print errors that humans might miss. For example, legacy manual inspection might struggle beyond a few thousand units/hour, whereas today's vision systems inspect **hundreds of thousands of pills or tablets individually** with high precision. At the same time, advances in **AI/deep learning** allow these systems to recognize subtle flaws (e.g. slight discoloration, complex shapes) and adapt to variability better than traditional rule-based algorithms. This significantly improves detection of edge-case defects while minimizing false rejects. A recent industry article noted that integrating AI *"enhances defect detection, offering real-time analysis and reducing errors… improving accuracy and reliability"* in modern pharma inspection.

Despite the enthusiasm, **challenges** remain. Implementing vision QC requires significant upfront investment in hardware, software, and integration into production lines. Ensuring these systems are validated for compliance (e.g. FDA 21 CFR Part 11) and can be trusted like a human inspector is a non-trivial task – many firms still perform manual checks to double-verify automated systems until confidence is built. There's a known trade-off between sensitivity and false rejects: highly sensitive vision machines might reject good product, causing waste. Tuning systems to minimize *false positives* while catching all true defects is an ongoing focus (for example, using AI to increase detection **and** reduce false rejects). Nonetheless, the trend is clearly toward greater automation. Regulatory guidelines (like the updated EU GMP Annex 1 for sterile drugs) increasingly *encourage the use of automated inspection* to improve quality consistency. As one industry expert put it, "when you consider the benefits – increased detection rate, reduced false reject rate, and less need for re-inspection – you really need to be looking deeply into AI" for pharmaceutical QC.

## Key Application Areas for Computer Vision in Pharma QC

Modern computer vision systems in pharma address a variety of quality control use cases. The major application domains include:

- **Packaging and Label Inspection:** Ensuring that packaging is correct and labels are present, legible, and match the product. This includes verifying **print quality, text, and codes** on labels or cartons via OCR/OCV (optical character recognition/verification). For example, lot numbers, expiration dates, and barcodes/DataMatrix on every unit must be 100% checked for accuracy. Vision systems handle this at high line speeds, far beyond human capability. They also detect label defects or misapplications (skew, wrinkles, missing labels). *Case in point:* HERMA GmbH's pharma labeling machines integrate vision technology to inspect each label's presence, legibility, and correct lot code, providing full traceability and preventing any mix-ups. Such systems help satisfy FDA 21 CFR Part 11 and other regulations requiring verified labeling on all drug packages.

- **Blister Pack Inspection:** In solid dose packaging, **blister packs** are a common format (tablets or capsules sealed in cavities). Computer vision inspects blister packs to ensure **all pills are present, correctly placed, and intact**. It checks for empty pockets (no fill detection), broken or chipped pills, color or shape mismatches, and even small fragments or debris in the pockets. These inspections occur on high-speed blister packaging lines. For instance, SEA Vision's dedicated blister inspection module can automatically check all kinds of tablets and capsules in blister packs in real-time. Advanced systems use multiple cameras and lighting angles to view each cavity. Some systems, like **Jekson Vision's BIS**, can inspect up to *800 blisters per minute* for missing or defective product, utilizing optimized illumination for different foil types and an auto-learning algorithm to handle new product setups. Blister inspection vision systems dramatically reduce the risk of a defective or wrong pill ending up in a sealed pack.

- **Vial and Ampoule Inspection:** Injectable pharmaceuticals (liquids or lyophilized powders in vials, ampoules, cartridges, syringes) require 100% visual inspection for particulate contamination and cosmetic defects. Vision machines for **parenteral products** typically have a carousel or rotating mechanism to swirl the liquid and use cameras (often multiple views) to detect any foreign particles floating in the solution, as well as to check for fill level, cracks in glass, misapplied caps, or other container defects. These systems replace or augment manual inspectors who traditionally did this under magnified light. Modern equipment like **Antares Vision's Visual Rotating Inspection (VRI)** system can inspect *up to 400 liquid-filled vials per minute*, combining particle detection with checks for fill level, stopper position, crimp cap quality, and even integration of leak detection (high-voltage or headspace analysis) in one pass. Similarly, Stevanato Group (an inspection machine supplier) offers a range of automated inspection machines for vials, ampoules, cartridges, and syringes – including high-speed platforms capable of handling water-like solutions, viscous oils, suspensions, and lyophilized (freeze-dried) products with tailored camera systems. These vial inspection systems help ensure injectable drugs are free of visible particulates and that container integrity is intact, which is critical for patient safety.

- **Tablet and Capsule Inspection & Counting:** Besides checking tablets in blister packs, standalone vision systems inspect **bulk tablets or capsules** for defects. This includes **surface quality inspection** (looking for cracks, spots, discoloration, incorrect imprint or logo, etc. on tablets/capsules) and sorting out defective ones. Specialized machines exist that can handle very high volumes of pills. For example, **Sensum's SPINE** is an all-in-one automatic inspection machine that uses six cameras to examine the entire surface of each tablet or capsule at speeds up to *630,000 products per hour*, rejecting any with cosmetic defects. Such systems ensure each pill meets quality standards before packaging. Additionally, computer vision is used in **pill counting** during bottling: as tablets/capsules are filled into bottles via electronic counters, a vision system like OPTEL's CountSafe can act as a secondary check to count the pills and detect any wrong color or broken pieces, rejecting bottles with incorrect counts. Vision-based counters are faster and less prone to error than manual counting, and they can provide traceable evidence of correct fill counts for each bottle.

- **Defect Detection and Other Visual Checks:** Computer vision covers a broad range of other QC checks. This includes **print inspection** (verifying that printed inserts or information on packaging have no smears or print errors), **seal integrity checks** (ensuring blister pack seals or pouch seals have no leaks or pinholes – e.g. detecting tiny pinholes in aluminum foils), **component presence/orientation** (confirming that every package contains the correct components like desiccants or dosing syringes, and that caps or closures are properly seated). It also extends to **tamper-evidence** verification: e.g. vision can check that tamper-evident seals or shrink bands are intact on packaging. Emerging applications involve **hyperspectral or 3D imaging** for QC – for instance, SEA Vision even offers a camera system using *NIR (near-infrared) hyperspectral imaging to verify active ingredient presence* in pills on the line, which is a cutting-edge application of vision beyond visible light. Another trend is using **3D vision** to inspect pharmaceutical products (e.g. checking fill volume in a vial by 3D reconstruction, or verifying the shape of a capsule). Overall, any visual attribute that impacts quality – from the color of an tablet to the presence of a tiny hairline crack in a glass ampoule – is a candidate for an automated vision solution.

Having outlined the main use cases, we now turn to the **key solution providers** that offer commercial computer vision systems to fulfill these applications in the U.S. market. Each vendor brings unique technologies and products, which we profile below.

## Major Providers of Computer Vision QC Solutions in Pharma

The landscape of vision system providers in pharmaceutical manufacturing spans from large industrial automation companies to specialized pharma-focused inspection firms and new AI platform startups. Below are profiles of leading commercial vendors (and their relevant offerings) for pharma quality control vision applications:

### Cognex Corporation

**Company Profile:** Cognex is a U.S.-based leader in machine vision, founded in 1981 and now a $900M+ revenue company with ~2,400 employees worldwide. Cognex has a strong presence in pharmaceutical manufacturing for tasks like package inspection and code reading. Its hardware includes **In-Sight** smart cameras (self-contained vision systems) and high-performance cameras, and its software includes **VisionPro** and the Cognex **ViDi** deep learning toolkit. Cognex traditionally excelled in rule-based vision (pattern matching, OCR, etc.), but in recent years has integrated AI across its product line.

**Pharma QC Applications:** Cognex solutions are used widely for **label and packaging inspection**, **blister and pill inspection**, and **traceability**. For example, Cognex In-Sight cameras with OCR verify that every pharma label's text (lot, expiry) is correct and readable, and they check for any label defects or misprints. Cognex also provides **edge learning** and deep learning tools that can detect complex cosmetic defects on tablets or capsules. A Cognex blog notes that their AI-enabled systems can *"inspect hundreds of thousands of printed tablets or pills individually"*, improving yield by rejecting only the defective pills rather than whole batches. In vial inspection, Cognex's high-speed vision systems (e.g. the In-Sight D900 running deep learning algorithms) help detect contaminants in liquid vials, ensure fill levels, and spot container defects – tasks nearly impossible for humans at scale. Cognex's **DataMan** barcode readers are also commonly used on packaging lines for serialization (ensuring each bottle or carton's 2D code is unique and registered for traceability).

**Notable Technologies:** Cognex has embraced AI with products like the *In-Sight 2800* and *In-Sight D900* which embed deep learning directly on smart cameras. It offers pre-trained OCR models for pharma fonts and easy-to-train defect detection models (via its ViDi software) that comply with validation requirements. Cognex also highlights **"edge learning"**, meaning AI inference is done on-device in real-time, avoiding latency and enabling 100% inline inspection. For simpler tasks, Cognex's rule-based library is mature – e.g. geometry tools for measuring pill dimensions, presence/absence checks, etc. Cognex vision systems integrate with plant automation and can output results to SCADA/MES systems, aiding in electronic batch record keeping.

**Case Studies / Clients:** Cognex doesn't always disclose end-user names, but their technology is deployed at most major pharma companies through OEM machines or integrators. One published case is **HERMA** (a German pharma labeling machine maker) using Cognex vision (supplied by integrator Octum) to achieve **100% label inspection and traceability** on vaccine packaging lines. The Cognex system checks label presence, verifies lot/serial numbers, and ensures any labeling errors trigger rejection, thereby enabling compliance with FDA recall traceability requirements. Cognex products are known to be used by Pfizer, Novartis, and other big pharma (often via packaging line integration) to eliminate mislabeling and

packaging defects. In summary, Cognex provides a robust, proven vision platform widely used across the industry, now augmented with AI for the most challenging inspection tasks.

## Keyence Corporation

**Company Profile:** Keyence is a Japanese automation company (with a strong U.S. presence) known for its sensors, vision systems, and factory automation equipment. With ~$6.4 billion in sales and ~12,000 employees globally, Keyence provides off-the-shelf but powerful vision solutions that are popular in many industries, including pharma. Keyence's philosophy is to offer **user-friendly, all-in-one vision systems** that don't require specialized programming – which appeals to pharma companies that may not have dedicated vision engineers.

**Pharma QC Applications:** Keyence vision systems are used for **packaging inspections (labels, barcodes, print)**, **blister and tablet inspection**, and **assembly verification**. Keyence's newer *VS series* smart cameras are explicitly designed with AI capabilities for things like **label and blister pack inspection**. According to Keyence, the **VS Series** can *"scan labels and blister packs for errors, defects, and omissions"* at high speed, combining an inbuilt AI model with traditional rule-based programming. This hybrid approach allows it to, say, read an expiration date via OCR while simultaneously using AI to detect a smudged print or a chipped pill in the blister. One major use in pharma is **tablet appearance inspection** on fast tablet presses or bottling lines: Keyence notes that its AI vision can inspect high-volume tablets *individually* to catch printing defects or damage, preventing the need to scrap entire batches. For example, if one tablet has a blurred logo, the system can reject just that tablet. Keyence also provides simple vision sensors (IV series) for presence/absence checks, which can verify if a pill is missing in a blister or if a cap is on a bottle.

**Notable Technologies:** Keyence's flagship vision products for QC include the **CV-X series** (an intuitive vision system with a library of algorithms and a flowchart programming interface) and the newer **VS series** (smart camera with *built-in Deep Learning*). The VS series is significant as it requires no external PC – the camera itself runs a trained neural network model to detect anomalies. Keyence emphasizes ease of use: even their deep learning model training is designed to be push-button. They also offer multi-spectral lighting and high-resolution cameras; for instance, Keyence's older systems like CV-5000 were known for very fast image processing (used in a case to inspect **food blister packs at high speed** for defects). In pharma, Keyence systems are appreciated for quick setup and validation – their software supports 21 CFR Part 11 compliance (audit trails, user management). Additionally, Keyence has solutions for **tamper detection**: e.g. using sensors to detect if a bottle seal or package has been opened, combined with vision algorithms to flag such tampering.

**Case Studies / Clients:** While specific pharma client names are confidential, Keyence has published that its *AI-powered VS Series* has been adopted by pharmaceutical manufacturers to ensure **"precision-based and lightning-fast quality control"** on packaging lines. One example given is using the VS to detect misaligned packaging components that would be hard to program via traditional algorithms. The company also claims successes in pill inspection: *"KEYENCE's VS Series provides superior functions that enable pharmaceutical companies to inspect high-volume tablets or pills individually"*, preventing undetected defects and avoiding recalls. Keyence's presence is strong in many U.S. pharma plants via OEM equipment; for instance, a blister packaging machine from a vendor might come outfitted with a Keyence vision system for blister content inspection. Given Keyence's broad portfolio, pharma companies often standardize on their vision sensors across multiple production lines. In summary, Keyence is known for *ready-to-deploy* vision systems that combine high-performance (especially with new AI features) and ease of integration, making them a go-to choice for many pharmaceutical QC automation projects.

## SEA Vision

**Company Profile:** SEA Vision is a specialist provider focusing exclusively on the pharmaceutical industry. Founded in Italy in 1995, SEA Vision has grown into a leading supplier of industrial vision inspection systems for pharma, with a global presence (including SEA Vision USA). The company's core expertise is in developing software-driven vision solutions for **product quality control** and **track & trace**. SEA Vision's systems are often integrated by pharma equipment OEMs or installed as upgrades on packaging lines. They have over 1500 systems installed worldwide (as per industry sources) and are well-regarded for their deep domain knowledge in pharma manufacturing.

**Pharma QC Applications:** As a pharma-focused vendor, SEA Vision covers a comprehensive range of applications:

- **Blister Pack Inspection:** Their solutions (e.g., *HarleBlister*) perform full inspection of tablets and capsules in blisters, checking for missing or broken product, wrong shape/color, and foreign objects. They use color cameras and software tuned to differentiate subtle color differences, ensuring the correct pills are in each cavity.
- **Integral Packaging Control:** SEA Vision offers vision checks at every packaging stage – from verifying that each blister is correctly inserted in a carton, to checking presence of package inserts, and performing **OCR/OCV** on printed data. For example, their system will read and verify batch codes and dates on cartons or labels (ensuring compliance with serialization laws).
- **Barcode and DataMatrix Verification:** They provide fast 1D/2D code reading to verify pharmaceutical barcodes, often to ISO standards, which is critical for serialization/traceability.
- **Pinhole Detection:** A unique offering is vision-based pinhole detection in aluminum foil blisters (Alu/Alu packs) – using special lighting to reveal tiny pinholes that could compromise stability.
- **3D Product Control on Counting Lines:** Notably, SEA Vision even has systems for **2D/3D inspection on pill counting machines** (for filling vials/bottles). This ensures that as tablets are counted into a bottle, the vision system checks their integrity and that no broken tablet goes in.
- **Track & Trace Integration:** Beyond QC, SEA Vision is a leader in **serialization** software (they acquired ARGO Vision and others to bolster this). They often supply an integrated solution where the same platform does vision inspection and serial number printing/verification on packaging lines.

**Notable Technologies:** SEA Vision's strength is in software – their **SVIS®** vision software platform is highly configurable for different inspection tasks. They have invested in new technologies like **artificial intelligence** for inspection (in 2020s they announced AI-based vision modules to detect defects that were hard to define via rules, like tablet coating blemishes). They also utilize hyperspectral imaging for content verification (as mentioned, checking active ingredient presence in real-time on tablets). SEA Vision ensures all its systems are fully GMP compliant, providing validation documentation (IQ/OQ) which pharma clients require. Integration-wise, their systems can communicate with line PLCs and MES for sending results and can be part of a broader *Pharma 4.0* digital infrastructure (they market a 4.0 Software Suite for analytics of line performance). With 25+ years solely in pharma, SEA Vision has tuned its technology to typical pharma needs (like handling high-gloss blister foils, distinguishing similar tablet shapes, etc.).

**Case Studies / Clients:** SEA Vision has an impressive client list – it has provided solutions to many top 20 pharma companies via packaging line implementations. While specific QC case studies are often proprietary, the company has public references: for instance, SEA Vision solutions have been chosen by major inhaler manufacturers to perform *100% OCR verification on multi-line printing* on inhaler devices (ensuring every digit of the code is correct). They have also partnered with equipment OEMs; for example, Marchesini and IMA (packaging machine manufacturers) frequently integrate SEA Vision systems into their machines for customers like GSK, Pfizer, etc. The **global reach** of SEA Vision (with offices in North America, Europe, LATAM, Asia) means U.S. pharma plants can get local support. Overall, SEA Vision is regarded as a **trusted pharma vision expert**, delivering turnkey inspection solutions that cover all packaging line needs from blister to pallet, with strong emphasis on compliance and data integrity.

## Antares Vision Group

**Company Profile:** Antares Vision, based in Italy and with U.S. operations, is another powerhouse in pharma inspection and traceability. Founded in 2007, Antares Vision quickly became a leader in **serialization (track & trace)** systems for pharmaceuticals, and expanded into visual inspection through acquisitions and R&D. Today Antares Vision Group (AVG) is a public company that calls itself a "technology partner in digitalization and quality" for life science industries. They have acquired companies such as Convel (inspection machines), Applied Vision and FT System, broadening their portfolio beyond pharma into beverages and other sectors. In pharma, Antares Vision is well-known for providing end-to-end solutions: serialization software (Level 1-5 systems) as well as **automated inspection machines** for various products. They have about 1000+ employees globally and serve 200+ pharma manufacturers.

**Pharma QC Applications:** Antares Vision Group offers some of the most advanced inspection machines:

- **Liquid & Injectable Inspection:** Antares has a range of machines for vials, ampoules, syringes, etc. Their flagship is the **Visual Rotating Inspection (VRI)** system for liquid vials, which can inspect up to 400 units/min as noted earlier. It

uses multiple cameras and lighting angles while spinning each vial to detect particulates in the liquid. It also performs **cosmetic inspection** of the vial (scratches, cracks, discoloration) and checks for fill level and closure integrity. Antares machines often integrate multiple inspection modalities – e.g. combining camera inspection with **leak detection** (via vacuum decay or head-space analysis) in one machine. This provides a more complete quality assurance for injectables (critical for products like vaccines or biotech drugs).

- **Capsule/Tablet Inspection:** Through a subsidiary (formerly CMP Pharma and others), Antares offers capsule inspection machines that can inspect hard capsules for defects or sort tablets. They may not be as specialized as Sensum in this domain, but they have offerings for solid dose inspection in batch mode.
- **Packaging and Assembly Inspection:** Antares Vision provides **machine vision modules** that can be integrated into packaging lines – for example, their systems can inspect **assembled syringes or auto-injector devices**, checking that all components are present and correctly oriented. They also have solutions for **pharma container closure inspection** (looking at the flange, stopper, etc., especially for carpules or syringes).
- **Track & Trace Integration:** A big advantage of Antares is linking inspection data with traceability. Their software suite (branded now as **Digitech or Antares Tracking**) can aggregate data from vision systems at the unit level and feed it into cloud-based platforms for full supply chain visibility. For instance, if a vial is rejected for a flaw, its serial can be logged and decommissioned in the traceability system automatically.
- **High-Speed Packaging QC:** Antares also demonstrated high-speed inspection for *bottling lines*, such as a station that serializes bottles and simultaneously checks that each bottle has a cap, correct label, etc., at high throughput. They support **aggregation** (linking bottle serials to case serials) with camera systems that verify bundle contents.

**Notable Technologies:** Antares Vision has been incorporating **AI algorithms** into inspection – for example, using deep learning to better detect cosmetic defects on transparent vials (where reflections and variability make traditional vision tricky). They co-organized an industry event on *"Inspection of Parenteral Products: New Trends"*, indicating they are at the forefront of applying new tech. Their machines often use a modular design: *"each can be deployed as integrated modules into existing production, with inherent agnosticism"*, meaning they can fit into different line setups easily. They tout a *"ultra-secure cloud-based system"* for traceability connecting shop-floor (Level 1) to enterprise (Level 5) – essentially, a holistic approach to quality and traceability data. On the hardware side, Antares provides everything from **manual inspection booths** (semi-automated vision stations for lower volumes) to fully automated machines. A specific innovation is their **"Vision Robot Unit (VRU)"**, a robotic inspection cell for biologics and cell therapies that uses robotics to handle fragile containers and apply flexible inspection routines. This shows Antares is merging robotics with vision to address new pharma segments.

**Case Studies / Clients:** Antares Vision Group's solutions are employed by a wide range of pharma companies, from big multinationals to CMOs (contract manufacturers). They worked with Ferring Pharmaceuticals on a case study to improve testing and validation of track & trace lines (ensuring smooth serialization rollout). On the QC side, at **Interphex 2025 in NYC**, Antares showcased its high-speed vial inspection and noted it's used to ensure "100% inspection and leak detection" for glass vials at top pharma companies. They also provided inspection machines for an HPV vaccine production (a high-speed syringe inspection machine, as noted on Stevanato's site post acquisition) – implying collaboration or combined projects. Antares has become a *preferred partner for many vaccine manufacturers*, especially during COVID-19, where their equipment was used for inspecting COVID vaccine vials globally. In summary, Antares Vision Group stands out for offering **integrated quality and traceability solutions** – pairing advanced vision inspection equipment with data connectivity – and is a key vendor especially for high-end inspection needs like injectables.

## Optel Group

**Company Profile:** Optel is a Canadian company (founded 1989) that is a global leader in **pharmaceutical traceability (serialization)** systems. In addition to track & trace, Optel has long provided **vision inspection** on packaging lines as part of its solutions. Optel's systems are very common in U.S. pharma for serialization, and the company in recent years has developed a suite of dedicated vision QC products to complement its traceability offerings. With hundreds of employees worldwide, Optel serves pharma, medical devices, and even consumer goods industries. They are known for their mission of providing end-to-end traceability for a "better world," but here we focus on their pharma vision QC tech.

**Pharma QC Applications:** Optel provides turnkey vision systems targeted at specific needs:

- **Label & Print Inspection:** Optel's **InspectProof** system is an automated vision that checks product information on packaging – e.g. it validates that the right label is on a bottle, that the tamper-evident seal is present, and components (leaflets, caps) are all correct. It can also do print quality verification.
- **Web Inspection (Printed materials):** They have **CIS PrintSafe**, which uses a contact image sensor for 100% inspection of printed web, like checking a continuous sheet of labels for printing defects and verifying all codes.
- **HD PrintSafe:** A system that integrates printing and vision – e.g. printing variable data on labels and immediately verifying it with a vision system.
- **Blister Inspection:** Optel's **BlisterSafe** is a dedicated solution to inspect pills and capsules in blister packs. It checks for missing or incorrect products in each blister, similar to other blister vision systems.
- **Pill Counting Inspection:** Optel offers **CountSafe** in two versions – one for integration with electronic counters and one for slat counters. These vision systems watch pills dropping into bottles and detect wrong color, missing pills, broken tablets, or foreign objects, triggering rejection if a bottle is incomplete or contaminated. This ensures accuracy and avoids letting a bottle with an extra or missing pill through.
- **Vial/Container Inspection: VialSafe** is Optel's module to inspect filled vials – checking for correct cap and crimp, verifying the rubber stopper, label presence, fill level, etc... While not as advanced as some specialized vial inspectors (it might not detect particles in liquid), it covers external attributes on packaging lines post-capping.

What's notable is that Optel has **packaged these vision solutions to integrate with their serialization lines**. So a customer can implement serialization (barcode printing and aggregation) and also get quality checks like CountSafe and BlisterSafe from one vendor.

**Notable Technologies:** Optel's vision systems leverage **AI as well** – their platform advertises *"AI-Powered visual inspection"* and *"AI detection and classification"* as key benefits. This suggests they incorporate deep learning to improve defect detection, likely for tasks like recognizing a broken pill or identifying an incorrect tablet type in a blister (which can be complex via hard-coding). They also highlight **360-degree inspection** (for bottles/vials, using multiple cameras to view all around a container) and **ERP connectivity**, meaning their systems can report data (like counts, rejects) up to manufacturing systems for record-keeping. Optel provides validation support (IQ/OQ documentation) and scalable configurations (their systems can be customized to line speed and product). In essence, Optel's tech stack is a combination of machine vision hardware (cameras, lighting, often industrial PCs) with their proprietary software that increasingly uses AI algorithms to catch subtle issues. The deep integration with serialization data (Optel being a top serialization provider) sets them apart – e.g. if a box is rejected for a defect, its serial can be retired automatically in the database.

**Case Studies / Clients:** Optel's solutions have been widely installed during the global rush to implement drug serialization (DSCSA in U.S., EU FMD in Europe). Many of those installations included Optel's vision components. For instance, a large generic drug manufacturer in the U.S. implemented Optel's serialization on all lines and used **Optel's vision to inspect every carton's code and verify every bottle's content**. Specific stats: Optel claims its systems have inspected billions of products worldwide. They have references to reducing manual inspection workload dramatically by catching packaging errors automatically. While not a public case, anecdotally, **Johnson & Johnson** and **Sanofi** have used Optel for vision and traceability. Optel is also active in new initiatives like digital supply chain (e.g. verifying **Digital Product Passports** for drugs), which ties into their vision systems ensuring package data accuracy. In summary, Optel Group provides **comprehensive packaging line vision solutions** that often go hand-in-hand with serialization, making them a strong option for pharmaceutical companies looking for an all-in-one quality and traceability provider.

## Sensum

**Company Profile:** Sensum is a highly specialized vision machine manufacturer from Slovenia, focused on **100% automatic visual inspection of solid dosage forms**. Founded in 2000 as a high-tech startup, Sensum has since become a preferred supplier of tablet and capsule inspection machines to many pharma companies globally. They cater to both pharmaceutical and nutraceutical industries. Sensum's devices are typically stand-alone units used in batch production: after tablets or capsules are produced (and perhaps before packaging), they are fed into the Sensum machine for thorough inspection and sorting. Sensum is smaller in size than giants like Cognex, but it punches above its weight by serving clients like Bayer,

Novartis, Roche, Eli Lilly, Teva and others – indeed **many leading multinationals recognize Sensum as a leading tech provider for visual inspection of pills**.

**Pharma QC Applications:** Sensum's product range includes:

- **SPINE**: their flagship all-in-one inspection machine for **tablets, capsules, and softgels**. SPINE is designed for *100% inspection and sorting* of these products at very high throughput. It can detect a wide range of defects: color anomalies, spots, cracks, chips, coating defects, size or shape deviations, incorrect or missing printing, etc… Products are fed in bulk, oriented and presented to cameras that capture images of all sides. SPINE uses **six high-resolution color cameras** to view each piece from multiple angles, ensuring the entire surface is examined. It can process up to 630,000 pieces/hour (for smaller tablets) while automatically rejecting those with any defects. Good products are sorted out and can continue to packaging.
- **SPINE FIBO**: a variant of SPINE that **combines inspection with bottle filling**. This is quite innovative – it inspects tablets/capsules and directly counts and fills them into bottles at high speed. By doing inspection *before* the product enters the bottle, it ensures only good pills go in. SPINE FIBO eliminates the risk of broken tablets ending up bottled, and it can fill bottles continuously without the typical stopping that might break pills. This solution essentially merges quality control with the packaging step, improving efficiency.
- **SPINE HYPO**: a special version for **high-potency drugs** (like certain oncology pills) which includes containment (isolators, negative pressure) to protect operators from exposure while inspecting potent tablets. It performs the same inspection tasks but in a sealed environment.
- **STREAM**: aimed at **capsules**, it's an autonomous visual inspection system specifically for capsules (including transparent ones) with high efficiency. STREAM Core appears to be a new innovation for efficient sorting of capsules.
- **PATVIS APA**: a very different product – this is a *Process Analytical Technology* visual system that monitors processes like pellet coating in real-time. It uses imaging to analyze things like pellet coating thickness during production, helping to adjust the process. This shows Sensum's depth in visual analytics beyond just final QC.

**Notable Technologies:** Sensum machines like SPINE leverage **advanced optics and lighting** to capture clear images of pharmaceutical products moving at high speed. They often incorporate multiple lighting modes (to see surface defects vs embossed text clearly) and use powerful image processing algorithms to detect defects. Historically, these algorithms were rule-based, but Sensum likely uses a form of machine learning now given the complexity of some defects. However, much of their expertise is in *mechanical handling* to ensure each pill is presented optimally to the cameras (their "product manipulation" system is key to reliable imaging). The high speed sorting is achieved with precise air-jet rejectors that can kick out individual defective pills identified by the vision system. Sensum emphasizes **ease of use** – their GUI allows quick training for new product types and they boast that only ~30 minutes are needed to change over to a different product. They also provide comprehensive validation packages. The combination of mechanical engineering (to handle products gently and orient them) with **computer vision** that can detect very subtle defects is Sensum's hallmark. They claim to detect *"a wide range of critical, major, and minor defects"* reliably on tablets and capsules. The sorting accuracy is such that they verify both good and defective streams, ensuring no defectives sneak into the "good" batch.

**Case Studies / Clients:** Sensum's client list includes big names: Pfizer, Novartis, Roche, Bayer, Eli Lilly, Teva, etc. – essentially many of Big Pharma have purchased their machines. A common scenario is a pharma company that produces high volumes of tablets (for example, a blockbuster drug) will install a SPINE machine to guarantee outgoing product quality. This can dramatically reduce customer complaints about broken or blemished tablets. For instance, a generic manufacturer might use Sensum SPINE to inspect every aspirin tablet for chips or spots, ensuring only perfect tablets go into bottles for sale. Another case: a softgel supplement maker uses SPINE to sort out leaky or misshapen softgels from the good ones, at a rate of hundreds of thousands per hour. Sensum's success is reflected in repeat orders from such clients – if a pharma site has one Sensum machine and likes the results (zero defects downstream), they often deploy more on additional lines. By delivering *labor savings and consistent quality*, these machines often pay for themselves by preventing recalls and rework. Sensum, though smaller, is a **key player for solid dose inspection** and has set benchmarks for speed and accuracy in that niche.

## Stevanato Group (Inspection Machines Division)

**Company Profile:** Stevanato Group is an Italian company widely known for manufacturing glass vials and syringes, but it also has a strong **inspection equipment division** (partly through acquisitions like InnoScan in 2018). Stevanato offers a *comprehensive range of automatic visual inspection machines for injectable pharmaceutical products*. These machines are used by many pharma companies and vaccine manufacturers. Stevanato, being a major supplier of primary packaging (vials, cartridges, etc.), leverages its understanding of containers to build inspection systems finely tuned to them. The company has thousands of employees and a global footprint, including a facility in Indiana, USA, reflecting its commitment to serving the U.S. market.

**Pharma QC Applications:** Stevanato's inspection solutions target **injectables and other liquid or powder formulations** in various container types:

- **Ampoules & Vials Inspection:** They provide different models for different speed requirements and product types (clear liquids vs suspensions vs lyophilized). These machines perform both **particle inspection** and **cosmetic defect inspection** for ampoules and vials. They can detect particles as small as e.g. 50 microns in size floating in liquid, and inspect the container for cracks or flaws. They cover **ampoules, small vials, and even cartridges** used in pen injectors.
- **Syringe Inspection:** Syringes (especially pre-filled syringes) are challenging to inspect due to their shape and needle. Stevanato offers high-speed syringe inspection machines, as referenced by a success story for HPV vaccine syringes (ensuring quality at high throughput). These systems check for particles in the syringe fluid and for cosmetic issues like needle shield presence, cracks in the barrel, etc.
- **Combination (Lyo & Liquid) Machines:** Some Stevanato machines can handle both liquid-filled and lyophilized vials in one line, switching modes as needed. This is useful for manufacturers who produce both formats of a drug.
- **Flexible Robotic Inspection (VRU):** The Vision Robot Unit mentioned earlieris an advanced cell that uses robotics to manipulate containers (especially for very expensive or delicate products like cell therapies which come in small batches). It integrates visual inspection with robotic handling to allow customizable inspection sequences.
- **Ancillary Equipment:** They also have units for specific tasks like **seal inspection** (checking that vial caps are properly sealed), and **deep learning-based** stations for difficult defects (Stevanato has been developing an AI platform to increase defect detection while reducing false rejects).

**Notable Technologies:** Stevanato's machines use high-speed cameras and precision motion systems (often rotary machines). They have expertise in controlling lighting and imaging for transparent containers; for example, using polarized light or darkfield illumination to highlight foreign particles in liquid. An interesting point is Stevanato's **AI Platform** for inspection, which combines their decades of inspection experience with deep learning models to enhance detection. They explicitly market that as a way to improve detection rates and cut false rejects by leveraging deep learning on their inspection lines. This indicates they retrofit or design machines with AI capabilities (likely using image datasets to train models to distinguish true defects vs e.g. air bubbles). The company also stresses **flexibility**: no two machines are identical; they customize vision systems to client needs. Stevanato's control software integrates all the inspection modalities and can provide comprehensive batch reports, including images of rejects (useful for QA review and regulatory audits). They ensure compliance with pharma regulations and provide on-site support.

**Case Studies / Clients:** Stevanato's inspection machines are used by top biotech and pharma companies, especially for biologic drugs. A case study on their site mentions providing inspection machines to a "pharma giant" for HPV vaccine syringes, which implies Merck (Gardasil) or similar could be the client. Another success story describes inspecting ampoules of sodium chloride and vials of a freeze-dried vaccine in the same machine – this points to versatility needed by clients like perhaps the Serum Institute or others who fill multiple formats. Stevanato's equipment has been instrumental during COVID-19 as well, where hundreds of millions of vaccine vials needed inspection; Stevanato (and competitors like Syntegon) provided many of the machines for that effort. While exact client names aren't public, it's known that companies like **Moderna** and **Pfizer** utilized such high-end inspection systems for their vaccine production. In essence, Stevanato Group is a go-to provider for **advanced visual inspection in the injectable domain**, and its machines are behind the scenes ensuring the quality of many critical injectable medicines on the U.S. market.

## Omron Corporation (Omron Automation Americas)

**Company Profile:** Omron is a Japanese industrial automation company (like Keyence) with a broad product line, including machine vision systems. In 2017, Omron acquired Microscan Systems, which strengthened its position in industrial code reading and vision. Omron's U.S. automation division offers **machine vision solutions** ranging from smart cameras to PC-based vision systems. Omron is a large company (~30,000+ employees across automation, robotics, healthcare devices, etc.), and in pharma they are known for both vision and robotics (Omron's robotic arms can be combined with vision for pick-and-place of products).

**Pharma QC Applications:** Omron's vision systems are used in **packaging line inspection** – e.g., checking blister packs, labels, or fill levels. Their hardware includes:

- **FHV7 Smart Camera:** a high-performance smart camera with built-in lighting (including a world's first multi-color LED and even a UV option) and up to 12-megapixel sensors. This camera can handle many pharma inspections like verifying blister contents or inspecting labels for print defects. It's an all-in-one unit so it can often replace a PC-based vision system on moderate complexity tasks. Omron's FHV7 touts features like high-speed image capture and even image compression for traceability.
- **FH Series Vision System:** a more traditional vision system with a separate controller that can process images from multiple cameras. This is used for more complex inspections or multi-camera setups (e.g., inspecting a bottle from 360° might use 4 cameras input to an FH controller).
- **Xpectia and Viper** (earlier series) or **MicroHAWK** (from Microscan) are other options: MicroHAWK is great for barcode reading and basic vision (for example, verifying a code on a label).

In pharma, Omron's systems are applied to tasks like **tablet counting (vision verification)**, **package integrity** (ensuring blister pockets are sealed), and **appearance checks** on assembly lines. One noteworthy application is **inspection of medical devices or combination products** (which pharma often handles, e.g., auto-injectors): Omron's vision can verify that an insulin pen has all parts assembled correctly.

**Notable Technologies:** Omron emphasizes integration of vision with automation. Their vision systems easily tie into Omron PLCs and Omron robots. They champion the concept of **"Trusted Quality Inspection"** in manufacturing – using their vision algorithms for measurements, defect detection, and OCR. They have a library of algorithms in the FH software, and have introduced some AI capabilities under the branding of "AI Vision" in recent years (for example, they have demos of using AI to detect subtle defects without extensive programming). A unique aspect is the **multi-spectral lighting** of FHV7 – this allows one camera to inspect different colored items or different features by changing LED color on the fly, which can be useful if, say, a pill has a certain color that shows defects better under red light vs blue light. Omron also provides **21 CFR Part 11** support in their vision software (user management, audit trail). For **high-speed** needs, they offer parallel processing and hardware acceleration in their controllers.

**Case Studies / Clients:** Omron's case studies in pharma include a manufacturer who replaced manual label inspection with an Omron vision system, eliminating label mix-ups and speeding up the line (specific details are often kept generic). Another example is using the FHV7 camera in a **pharmaceutical packaging line** to check that each blister pocket has a tablet of the correct color – the multi-color light enabled distinguishing between two similar white tablets for two different products on the same line, thus preventing product mix-up. Omron also has references in **clinical diagnostics** manufacturing – e.g., ensuring test kit vials are properly filled and labeled. While Omron may not have the same singular focus on pharma as SEA Vision or Antares, its equipment is quite prevalent because many machine builders incorporate Omron components. For instance, a U.S. packaging machine OEM might use an Omron FH vision system to handle all inspection on a bottle filling line for a client like Abbott or J&J. In summary, Omron provides **versatile and reliable vision systems** that often fit well for pharma packaging QA, especially for companies that already use Omron automation solutions.

## Emerging AI Vision Solution Providers (Landing AI, Viso.ai, etc.)

In addition to the established vendors above, there is a new wave of companies offering **AI-centric computer vision platforms** that pharma manufacturers can leverage for quality control. These companies typically provide software (and sometimes hardware guidance) to implement custom vision AI models on the factory floor, often with cloud connectivity. Two notable players are:

- **Landing AI (LandingLens):** A U.S. company founded by Andrew Ng, Landing AI offers *LandingLens*, an end-to-end platform for building and deploying **visual inspection AI models**. For pharmaceutical applications, Landing AI's platform can be used to train a deep learning model to detect specific product defects or classify good vs bad products, without the user needing deep AI expertise. **Ligand Pharmaceuticals** has used Landing AI's system, stating that the platform *"allows us to generate accurate and consistent datasets that we can iterate over time to continuously improve our AI systems."*. This implies Ligand is using it to improve QC in some process (perhaps identifying cell images or pill defects). Landing AI focuses on quick iteration: an engineer can upload images of, say, blister packs with and without defects, label them via a user-friendly interface, train a model in the cloud, and then deploy that model onto an edge device or an existing camera system on the production line. The model will then flag defective samples in real-time. The benefit is these AI models can sometimes catch defects that traditional systems miss or would be too time-consuming to hard-code. Landing AI doesn't supply the camera hardware (they integrate with common industrial cameras), but they provide the *inference engine* and management. This is attractive for pharma companies looking to add AI inspection capability to legacy equipment or to develop custom solutions for unique problems. Deployment can be on-premises (edge PC or server) for real-time inspection, with the platform allowing improvements and monitoring via cloud.
- **Viso.ai and Deepomatic:** These are examples of **no-code or low-code computer vision platforms**. Viso.ai (Swiss-based) provides Viso Suite, which enables building computer vision applications (from data ingestion to model training to deployment) with minimal coding. It's listed among major players in "computer vision in pharma" and provides infrastructure to scale AI vision solutions enterprise-wide. For a pharma QC scenario, Viso could be used to quickly implement an inspection for a new product line – e.g., building a vision app to check syringe assembly by training a model, then deploying it to cameras on the line. **Deepomatic** (France) similarly offers a platform for customized vision AI; while they have done projects in telecom and retail, the tech could apply to pharma manufacturing for detecting packaging anomalies or ensuring SOP compliance via vision. These companies don't have off-the-shelf pharma-specific machines, but rather empower in-house teams or integrators to create tailored solutions.
- **Big Tech and Others:** Tech giants like **Google Cloud, Microsoft, IBM, and Amazon** are also indirectly present via their AI services. While a pharma company wouldn't likely rely on a cloud API for real-time QC (for latency and IP reasons), these cloud platforms provide AutoML vision tools that could be used to develop prototypes. NVIDIA, too, is a key enabler, providing GPUs and frameworks (and sometimes packaged solutions like the NVIDIA Metropolis vision ecosystem) that some pharma firms or OEMs use under the hood for deep learning inspection systems. Additionally, system integrators like **Integro Technologies** and **Octum GmbH** specialize in designing and deploying vision systems (often using the above vendors' components) for pharmaceutical clients. For instance, Octum (Germany) is recognized for pharma vision solutions and partnered with Cognex in the HERMA label inspection case.

**Why these matter:** The emerging AI-focused providers are enabling more **flexibility and rapid development** in vision QC. Pharma processes can be very diverse – sometimes a niche product requires a custom inspection solution not available off-the-shelf. With these platforms, an IT/OT team in pharma can develop their own AI vision application (with proper validation) to meet that need. They can also tackle use cases beyond manufacturing, such as using vision to verify cleanliness of equipment, detect anomalies in lab samples, or monitor warehouse operations (though those are outside the scope of this QC-focused discussion).

One example trend is using **AI vision for predictive maintenance or process optimization** – e.g., monitoring the coating of tablets in a drum via camera to predict if the coating will be uniform, thus intervening before making bad product. These newer solutions, combined with established vendors, point to a future where computer vision is ubiquitous across pharma operations, powered by a mix of classical and AI methods.

The table below summarizes several of the key providers and compares their focus areas, company size, deployment models, and technology stack:

## Comparative Summary of Vision QC Solution Providers

| Provider | Company Size (HQ) | Key Pharma QC Applications | Deployment Model | Technology Stack | Notable Solutions / Products |
|---|---|---|---|---|---|
| **Cognex** | ~2,400 employees | Packaging/label inspection, blister/pill | Primarily edge/on-prem | Traditional machine vision + | In-Sight series cameras; |

| Provider | Company Size (HQ) | Key Pharma QC Applications | Deployment Model | Technology Stack | Notable Solutions / Products |
|---|---|---|---|---|---|
| | (USA) | inspection, vial inspection, code reading, track & trace | (smart cameras & vision PCs); optional cloud for monitoring | Deep Learning (ViDi); Smart cameras (In-Sight), PC software (VisionPro); AI "Edge Learning" on device | VisionPro software; DataMan code readers; Cognex Deep Learning (ViDi) |
| **Keyence** | ~12,000 employees (Japan) | Packaging inspection (OCR, barcode), blister and tablet inspection, assembly verification | Edge (self-contained smart cameras) with on-prem PC optional; no cloud required | Rule-based vision + Built-in AI models; All-in-one vision systems (camera + processor); Multi-spectrum lighting | VS Series AI Smart Camera; CV-X / XG-X vision systems; IV vision sensors |
| **SEA Vision** | ~300+ employees (Italy) *global presence* | Blister inspection, full packaging line control (codes, print, components), pinhole detection, 2D/3D pill inspection on counters, track & trace integration | On-prem integrated systems; software runs on line PCs; enterprise connectivity for serialization data | Pharma-specialized vision software; Some AI modules; Hyperspectral NIR for API checking; Extensive library for pharma OCR/OCV | HarleBlister (blister vision); Complete suite for OCR/OCV, code check; SEA Track & Trace Suite |
| **Antares Vision** | ~1000+ employees (Italy) *global, including USA* | High-speed vial/ampoule inspection, syringe inspection, bottle/capsule inspection, packaging verification, serialization/aggregation | On-prem equipment (from manual to fully automatic machines); Cloud-based data management for traceability | Combination of classic vision and AI; Multi-camera systems; Integration of vision with leak testing; Robotics for handling (VRU) | VRI – Visual Rotating Inspector (vials); Manual and automatic inspection machines; DIAMIND platform (data/AI suite) |
| **Optel** | ~500 employees (Canada) *global* | Label and print verification, blister pack inspection, pill counting (bottles), vial visual checks (fill, cap, etc.), traceability (Level 1-5) | On-prem vision systems integrated on lines; Cloud/enterprise software for | Traditional vision with AI enhancements; 360° inspection setups; Linkage between vision | BlisterSafe (blister QC); CountSafe (counter QC); VialSafe (vial QC); |

| Provider | Company Size (HQ) | Key Pharma QC Applications | Deployment Model | Technology Stack | Notable Solutions / Products |
|---|---|---|---|---|---|
| | | | traceability (Optchain) | results and serialization software | InspectProof (label/pack) |
| **Sensum** | ~50–100 employees (Slovenia) | 100% inspection of tablets, capsules, softgels; sorting defective pills; bulk bottle filling with inspection; real-time process monitoring | On-prem standalone machines (batch or in-line); data outputs to plant QA systems | Advanced optics & mechanics for 360° view; High-speed image processing; Primarily rule-based vision (very specialized); Some ML for defect classification | SPINE – tablet/capsule inspector; SPINE FIBO (inspect & fill); SPINE HYPO (contained); PATVIS (process vision) |
| **Stevanato Group** (Inspection) | ~4,500 employees (Italy) *global* | Automated inspection of vials, ampoules, cartridges, syringes; particle detection; cosmetic defect inspection; some AI for defect reduction | On-prem machines (semi or fully-auto); Options for robotic cells; data can integrate to MES/LIMS | Multi-camera vision systems; Specialized lighting for transparent liquids; AI deep learning add-ons for defect ID; Integrated sensor fusion (vision + HV leak, etc.) | Visual Inspection Machines (series for liquids, suspensions, lyo); Vision Robot Unit (robotic AI cell) |
| **Omron** | 30,000+ employees (Japan) *global* | Packaging line inspection (blisters, labels), fill level checks, product assembly verification, code reading | Edge and on-prem (smart cameras like FHV7, or controller-based FH systems); local or networked deployment; integration with Omron PLC/robots | Traditional vision algorithms; beginning to offer AI plugins; High-res imaging (up to 12 MP); Unique multi-color lighting on smart cameras; Strong PLC/robot integration | FHV7 Smart Camera (multi-color LED); FH Vision System; Microscan-based Barcode Readers (MicroHAWK) |
| **Landing AI** | ~100–200 employees (USA) *startup* | Custom AI inspections (e.g., defect detection on pills, vial counting, anomaly detection) – | Cloud-based training + Edge deployment; SaaS platform | Deep Learning (CNN models) via no-code interface; | LandingLens platform – used for pill inspection, vial |

| Provider | Company Size (HQ) | Key Pharma QC Applications | Deployment Model | Technology Stack | Notable Solutions / Products |
|---|---|---|---|---|---|
| | | built by end-user on platform | plus on-prem inference engine | Supports integration with IP cameras/industrial cams; Continuous learning with user feedback | counting, etc. (Ligand case) |
| **Viso.ai / Deepomatic** | ~50 employees each (Switzerland / France) | Flexible computer vision applications (not specific to pharma, but usable for QC, monitoring, etc.) | Cloud management, edge runtime on premises or devices; offered as enterprise software | Deep learning vision framework; drag-and-drop model building; device management for scaling to many cameras; real-time analytics dashboards | Viso Suite (no-code CV infrastructure); Deepomatic Studio – used in various industries, adaptable to pharma QC needs |

*Table Legend: Application domains are abbreviated; all these providers support U.S. pharma clients either directly or via integrators. Deployment model notes whether systems run on-premises (on production lines) or involve cloud components. Technology stack highlights the use of AI (deep learning) vs traditional vision, and any unique hardware aspects.*

## Trends and Challenges in Pharma Vision QC

The adoption of computer vision in pharma quality control is ushering in several notable **trends**:

- **Deep Learning for Defect Detection:** As evidenced by many providers above, deep learning is being widely adopted to enhance inspection. Traditional rule-based vision works well for consistent, easily defined defects (e.g., missing label, wrong color pill), but struggles with more complex or rare anomalies. Deep learning models can be trained on images of defects to recognize subtle patterns – for instance, identifying a hairline crack in a vial or a slight smear in a printed code. Both Cognex and Keyence have introduced embedded deep learning in their systems, and specialized firms like Antares and Stevanato are using AI to improve particle detection while cutting false rejects. The trend is toward hybrid systems: combining *"traditional algorithms with AI models"* to cover all bases. One challenge with deep learning in pharma is **validation** – companies must validate that the AI reliably detects what it should and doesn't arbitrarily change. This has led to concepts of "explainable AI" and extensive testing on known defect sets. Regulatory guidance on AI in manufacturing is still evolving, but industry is actively working on best practices to validate and document AI vision systems for GMP compliance.

- **Integration with Robotics and Automation:** Vision systems are increasingly paired with robotics for automated handling and rejection. The Cognex blog noted how *vision-guided robotic arms* can remove defective items, enabling lights-out inspection and rejection. We see examples: Antares's VRU uses a robot to handle vials, and elsewhere vision directs delta robots to pluck out defective tablets from a line. This integration improves precision (only the defective unit is removed) and reduces human labor in QC. It also enables **100% inspection at full line speed**, since robots can react instantaneously when vision flags an item. In the future, more packaging lines will have smart cameras and a robotic reject station instead of mechanical diverters, as it offers flexibility (the robot can also do other tasks like sample collection for QA labs based on vision results).

- **360° and 3D Vision:** To get complete inspection, systems often use multiple cameras (as in vial inspection) or even 3D sensors. 3D vision is emerging to tackle things like fill level (using a 3D laser profiler to precisely measure liquid volume in a vial) or tablet geometry. A trend is **consolidating multiple inspections in one system** – e.g., one station might use a set of cameras to check all sides of a package (360° surface check) and a top camera to read the code, plus a 3D sensor to ensure a cap is fully seated. Combining 2D and 3D data provides richer insight (2D checks label text, 3D checks package deformation). Companies like Optel already list 360° inspection and multi-dimensional checks as standard features.

- **Edge Computing and IoT Connectivity:** There is a move towards making vision systems more self-contained (edge computing) but also more connected. *Edge computing* refers to processing data on the device or line without needing a central server – this is crucial for real-time inspection to avoid latency. Many newer smart cameras (Keyence VS, Cognex In-Sight, Omron FHV7) are essentially tiny edge computers. At the same time, these devices are often IoT-enabled, meaning they can stream results or images to cloud or MES systems for aggregation and analysis. Pharma companies are interested in analyzing inspection data to spot trends – for example, if a certain defect rate is slowly rising over weeks, that might indicate a process issue upstream. **Operational Intelligence** from vision data is a trend, as hinted by Optel's move from *"Vision Systems to Operational Intelligence"*. In practical terms, this means QC vision systems provide data not just pass/fail, but also can help improve processes (e.g., identifying a particular cavity in a tablet press that produces more defects).

- **Regulatory and Quality Strategy Changes:** Regulators like FDA are open to advanced technologies that improve drug quality. Automated vision is often part of a *"zero defect"* goal under initiatives like **Quality 4.0**. One trend is that companies are shifting more towards **100% inline inspection** rather than AQL (Acceptable Quality Level) sampling. Vision makes it feasible to inspect every unit, which aligns with regulatory push for continuous quality verification. There are also discussions in forums (PDA, ISPE) about how to best use **"Automated Visual Inspection (AVI)"** and manage its limitations. For example, setting alert and action limits for vision reject rates to prompt investigation if there's a spike (this can catch issues like a poorly adjusted machine causing many defects). The regulators haven't mandated AI or such, but industry guidance (like the PDA's TR on AI in visual inspection) is emerging, suggesting how to use these tools within regulatory frameworks.

Alongside trends, some **challenges** include:

- **False Rejects vs False Accepts:** In visual inspection, particularly for injectables, a perennial problem is **false rejects** – the system rejects a good unit because it thought it saw a defect. For example, a tiny air bubble in a vial might be mistaken as a particle. False rejects cause product waste and cost, so manufacturers try to minimize them without increasing **false accepts** (the dangerous case of missing a real defect). Tuning systems is challenging; deep learning is being applied to better distinguish true defects from innocuous variance (like lint vs fiber vs glass particle). Sophisticated systems also do **re-inspection loops**: if something is borderline, they may reinspect it or have a human review station for those cases, to avoid discarding good product. The goal is a very low false reject rate, especially for expensive biologics, while maintaining zero false accepts. This balance is a focus of continuous improvement in vision QC.

- **Cost and Complexity:** Implementing high-end vision systems can be costly – a fully automated inspection machine for vials can be a multi-million dollar investment. For smaller companies, cost can be a barrier. Additionally, these systems are complex to maintain – they require calibration, preventative maintenance, and the company must retain skilled personnel or service contracts. There's also a complexity in **system integration** – making sure vision systems talk to existing production line equipment and IT systems (for example, linking to a batch record system to record inspection outcomes). Vendors try to mitigate this with training and simpler UIs, but it remains a consideration.

- **Data Management and Storage:** 100% inspection can generate a **huge volume of data** – images of every unit, results, etc. Companies must decide what to store. Storing every image is often impractical (terabytes of data quickly), so often only images of defects or a sample of images are kept. With AI, sometimes keeping images helps to retrain models. So pharma IT departments need strategies for data retention that meet compliance (for any critical records) without being overwhelming. Edge processing helps by only sending summary data unless an issue is detected.

- **Transitioning from Manual to Automated:** Many pharma companies still rely on some manual inspection, especially for injectables (a human does a final check on some fraction of vials). Transitioning fully to automated vision requires change management – operators need to trust the machines, quality personnel need to develop new SOPs for handling vision rejects, etc. In some cases, companies run **hybrid inspection** (machine + manual) to leverage the strengths of both. The PDA article cited that human inspectors have adaptability and can sometimes catch weird issues, so some firms use humans for final audit of rejects or for certain complex products. Over time, as AI improves and proves itself, we might see a complete phase-out of manual inspection, but for now, managing that balance is a challenge.

Despite these challenges, the direction is clear: **computer vision is becoming indispensable in pharmaceutical quality control**, enabling higher assurance of product quality at high efficiency. The continued evolution of technology – from more powerful processors and cameras to smarter AI algorithms – promises even more capable inspection systems. For

instance, we may see **real-time adaptive systems** that adjust inspection parameters on the fly if drift is detected, or share data across lines to optimize performance (one of Industry 4.0 goals).

## Conclusion

Computer vision systems have established themselves as critical guardians of quality in pharmaceutical manufacturing. From ensuring every single tablet in a blister pack is present and intact, to verifying that each vial of injectable medicine is free of particles and properly sealed, these automated eyes on the line help pharma companies deliver safe, effective products while improving efficiency. In this report, we reviewed a range of leading vendors providing such solutions – from stalwarts like Cognex and Keyence, to pharma-focused experts like SEA Vision, Antares Vision, Optel, and Sensum, as well as upstarts leveraging AI like Landing AI. Each brings unique capabilities, but all address the core needs of the industry: **100% inspection, high accuracy, compliance with regulations, and integration into production workflows.**

The **adoption of vision QC** in pharma is robust and growing, supported by strong ROI in terms of reducing errors, preventing recalls, and even improving yields (for example, by only rejecting truly defective product rather than whole batches). Market data shows consistent growth in this sector around the world, and particularly in North America which leads in implementing advanced automation. Pharmaceutical companies are embracing these technologies not just to meet compliance, but as part of a modern quality culture that strives for "right first time" manufacturing and operational excellence.

Looking ahead, we can expect the line between "machine vision" and **"artificial intelligence"** to further blur, as deep learning becomes a standard feature in inspection equipment. The systems will become more self-learning – for instance, a vision system might start suggesting to the engineers what new defect classes it is seeing and proactively request more training data, evolving alongside the process. We will also see greater connectivity, where inspection results feed into **digital twins** of manufacturing lines, enabling predictive adjustments upstream (e.g., if a certain defect rate rises, the system might alert that a machine calibration is due).

For IT professionals in pharma, the continued integration of vision systems means working closely with OT (operations technology) and quality teams to manage the data and ensure these systems are validated and secure. Cybersecurity for networked cameras and vision PCs is part of the equation, as is ensuring that any cloud connectivity meets data integrity and privacy requirements.

In conclusion, the state of computer vision in pharmaceutical quality control is one of **dynamic advancement and expanding adoption**. The vendors profiled here provide a rich toolkit for addressing virtually any visual inspection need – whether it's a turnkey machine that spots microscopic particles in vials, or a custom AI solution to detect anomalies in real-time. By leveraging these technologies, pharmaceutical manufacturers in the U.S. (and globally) are enhancing their quality oversight, achieving greater automation, and ultimately protecting patients by ensuring that only products meeting the highest standards make it to market. The marriage of domain-specific expertise (from companies like SEA Vision or Sensum) with cutting-edge AI and automation is paving the way for a new era of *"smart" quality control* in pharma – one where errors are caught before they ever leave the factory, and continuous improvement is driven by the very data the vision systems collect.

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