BIG DATA AND ADVANCED ANALYTICS DELIVER COMPUTER VISION

Allowing Machines to Hear, Feel and Now See

Why Cloudera

HYBRID AND MULTI-CLOUD

Run analytics on the cloud platforms. Easily and securely move data and metadata between on-premises file systems and cloud object stores.

ANALYTICS FROM EDGE TO AI

Apply real-time stream processing data warehousing, data science and iterative machine learning across shared data, securely, at scale on data anywhere.

SECURITY AND GOVERNANCE

Use a common security model, role and attribute-based access policies and sophisticated schema, lineage and provenance controls on any cloud.

100% OPEN

Open source, open compute, open storage, open architecture and open clouds. Open for developers, partners, and open for business. No lock-in. Ever.

Digital Transformation is Extending to Sight

Manufacturing's digital transformation has produced high profile use cases delivering proven and documented value—predictive maintenance that reduces equipment downtime by 50%[1]; supply chains that respond 8 to 20% faster[2] and fully digitized manufacturing process optimization producing 20-40% more product[3]. By 2025 Industry 4.0 is expected to generate greater than $1 trillion in economic value[4] as manufacturing processes, operations and supply chains become more streamlined, efficient, agile and realize improved productivity, uptime and product quality.

Most of these gains have been driven from sensors that measure manufacturing process and design parameters (weight, temperature, pressure, viscosity, speed and torque). Computer vision, extending to sight, is a high growth extension of this technology. Computer vision's global revenue from software, hardware, and services is projected to grow from $1.1 billion in 2016 to $26.2 billion by 2025[5].

There are three basic types of applications for machine vision. The following provide a simplistic overview:

- Optical Character Recognition (OCR)—Reading and recognizing 2D barcodes, imprinted labels, markings or user defined symbols. This is most often used to sort, pick & pack and record part location within the manufacturing process. Typical objects to be read are known, but vary in form (the objects experience printing distortion, font changes, language, size of object or color). Typically the sensors (cameras) are static and the objects move though its' field of vision.
- Automated Optical Inspection (AOI)—Manufacturers rely upon AOI for both 2D and 3D anomaly or defect detection. Both cameras and objects can move in 3D, but are bound within a specific manufacturing process. Use cases can range from robotic positioning and guidance, anomaly detection to predictive maintenance.
- Unconstrained—Autonomous vehicles best describe this maturity model. The operating environment and camera platform move unbounded, in real-time and in 3D, decisions need to be made in real time for the sake of safety and performance.

99%

Computer vision accuracy has jumped from 75% accuracy to now **over 99%**[6].

Machine vision is impacting Manufacturing in a variety of ways, the basic maturity models are deployed in industrial and manufacturing use cases in these ways:

- Quality Assurance & Inspection—Part fit & finish and anomaly detection are common use cases in discrete manufacturing. Simple applications include judging part fit and finish (screws produced to specifications) or completeness of assembly (electronic circuit board component location). It is highly suited for this application because it can "see" anomalies at speeds no human can.

  Automotive has embraced the use of computer vision in final paint inspection during the assembly process. A typical inspection station encompasses 16 cameras placed strategically within a light tunnel. Precision has improved so that defects in paint can be detected at assembly line speeds down to a size of a quarter of a grain of salt.
- Positioning & Guidance—Machine vision controls the spatial positioning of industrial robotics. Simple applications include ensuring robotically applied welds are correctly placed on an auto body in the automotive assembly line.
- Identification—Pick & pack and sorting are common applications for machine vision. By leveraging KanBan methodology and automated sorting table the correct parts can be delivered just-in-time into a production process; or a wide variety of finished goods can be quickly aggregated, picked and packed for shipment.

- Predictive Maintenance—Along with sensors that actively monitor equipment and processes for temperature, pressure, vibration or acoustic signals, machine vision can be used to monitor wear, such as measuring shaft diameters on rotating equipment, allowing for early warning of wear and failure.
- Navigation—e.g., by autonomous vehicles or mobile robots. The highest maturity application and the most well known application in the news, where machine vision along with other sensors (gps, accelerometers, etc.) inform the navigation module allowing for autonomous decisions for the vehicle.

The shift to machine vision is enabled by the falling prices for industrial cameras and sensors, availability of powerful low cost hardware, the increased accuracy of computer vision systems, the ease of connectivity and now many open source libraries used to build the recognition systems.

Manufacturing companies are turning to machine vision because of the benefits automation brings to the manufacturing floor, the need for businesses to reduce costs and the stringent safety regulations driven by the automotive sector. Machine vision by itself does not improve quality, it merely closes the time that a defect is detected and action is taken. The true power of machine vision comes when it is deployed in a closed loop manufacturing process allowing for real time (process or design) changes to be implemented from guidance of the vision systems.

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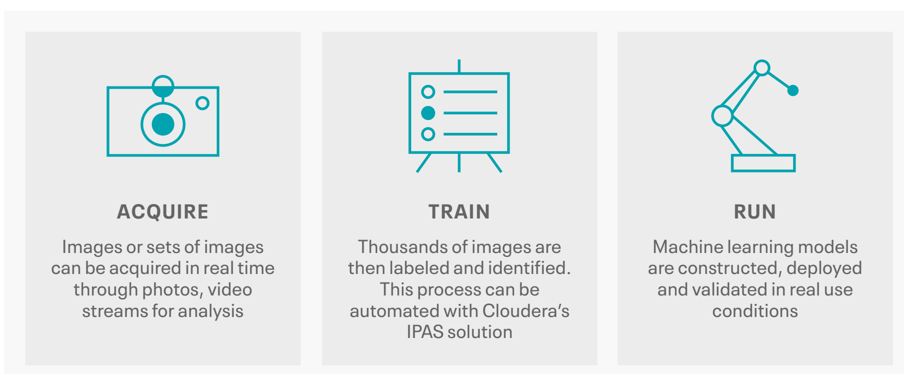
Acquire, Train, and Run

Acquire, train, and run—if only it would be that simple to build accurate computer vision systems. From its birth in the 1970's, simple object recognition algorithms averaged around 75% accuracy. Now through large rigorous data sets, computer vision object recognition accuracy can approach 99%[6]. Why is this? Improved storage and compute power of advanced image recognition models now leverage **hundreds of terabytes** of data for development and training and the refinement of machine learning algorithms.

Shown below is a simple diagram outlining the most basic steps of building advanced recognition models:



Computer Vision is Enabled by Analytics Solutions

Computer vision is enabled by digitizing large volumes and varieties of data from images acting as the source data for machine learning programs. Mobile phone jpegs and computer vision images only differ in that the objects in computer vision images are annovated and contextualized. Training data is dependent upon every relevant object shape or image, annotated for context. To reach the level of accuracy sought, training data demands detail, the greater the annotation and context, the more valuable that visual asset. **An asset that annovates an object as "a girl" is less valuable than an asset anovated as "a girl wearing a baseball hat riding her bike on a Fall day".**

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Did You Know?

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But there are challenges when building new models from scratch. It is estimated to take 90 minutes to fully annotate a single complex image and even for simple computer vision use cases, 5000 images are needed, resulting in an expenditure of 7500 man-hours even before the machine learning models are built.

Added is the complexity of image formats. Data and images are often stored in proprietary formats and standards that are specific to domains and different industries. For example, MDF4 is the predominant standard in the automotive industry, while healthcare and medical imaging information mostly uses DICOM as the standard. In order for image recognition to work, part of the challenge is to unpack the images from these proprietary formats, extract the .jpeg/.png of the images along with all of the metadata.

But, not every project has to start with fresh images when building a new neural network and setting new weights. Once objects are tagged and images annotated, capabilities to aggregate, process, and store massive amounts, often petabytes, of image data for training algorithms is needed.

Considering the maturity of the technology most companies now leverage large and robust image libraries, introducing fresh challenges in managing the library. How can you **search, identify, and discover** the right set of images for a very specific use case, from millions or billions of images in your inventory, that you can then utilize to develop your training set?

Cloudera Data Platform (CDP) addresses the challenges of storing and computing massive data volumes (terabytes of data), multiple image formats (MDF4, DICOM, or .jpeg), the tedious task of locating relevant data from the millions or billions of images that could be in an image library, and the complexity of data transfer between on-prem, hybrid or cloud platforms with the following technologies:

- Cloudera DataFlow provides scalable, real-time streaming analytics that ingests, curates, and analyzes data for key insights and immediate actionable intelligence. It can ingest and process real-time data from streaming data sources (such computer vision sensors) and also from traditional enterprise data sources such as ERP, MES and QMS systems. It addresses the key challenges enterprises face with data in motion including the ability to:
  - Ingest and process real-time data streaming at high volume and high scale
  - Drive stream processing and analytics on data-in-motion
  - Track data provenance and lineage of streaming data
  - Manage and monitor edge applications and streaming sources
- Cloudera Data Warehouse is an enterprise-grade, hybrid cloud solution designed for self-service analytics enabling organizations to share petabytes of data to drive analytics and BI with the security, governance and availability that large enterprises demand.
- Cloudera Search directly provides the technology to index petascale image data and make it accessible throughout the computer vision data lifecycle. For end-users and analysts this means google-like discovery and analysis, while the search API provides the ability to feed applications and machine learning models with the specific episodes required, rather than flooding them with superfluous and repetitive data. It enables semantic queries and discovery with domain-specific ontologies using a natural (like) language to uncover things, relationships, activities and situations.

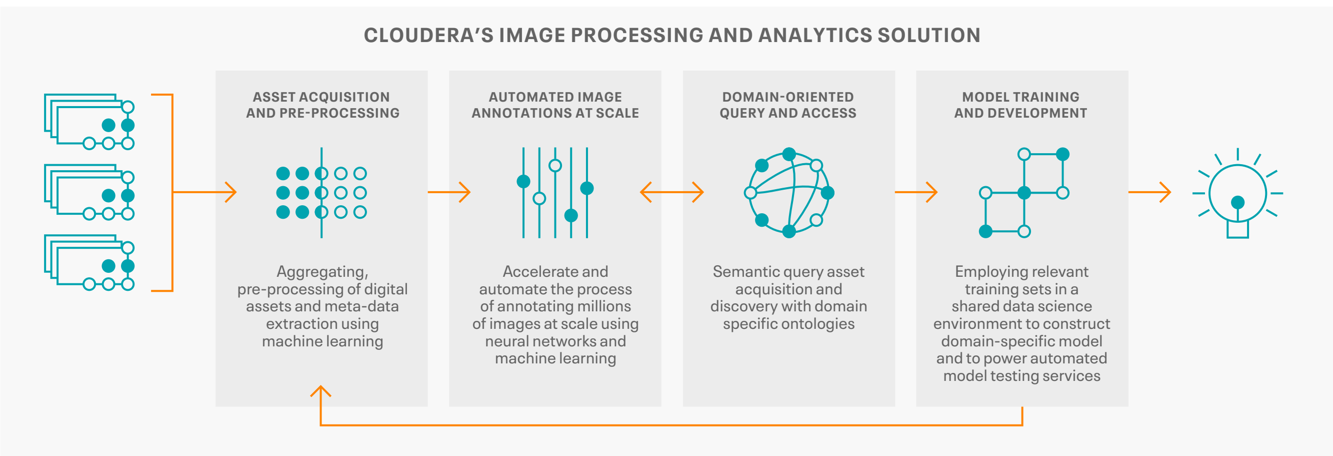
  For example, in the example of computer vision used in autonomous driving, you can easily retrieve relevant images from driving data using queries such as: "show me images where a car appears in front of a truck during a rainy day" or "show me images of person holding a bike and crossing the road".

- Cloudera Machine Learning helps accelerate data science at scale to build, test, iterate and deploy machine learning models in production by taking advantage of massively parallel computing and expanded data streams, delivering a self-service experience to data scientists developing and prototyping new machine learning projects and easily deploying them to production.
    - Accelerates data science at scale to build, test, iterate and deploy machine learning models in production
    - Experiment faster, with on-demand compute and secure data access
    - Enables data scientists to push these models out to the edge to continuously monitor digital signatures from connected data sources and drive action in real-time

Driving Image Processing at Scale

In addition to solving the above challenges through the Cloudera Data Platform, the last challenge addressed is the often used manual image tagging and annotation process. Cloudera's **Image Processing & Analytics Solution (IPAS)**, built on Cloudera Data Platform described above, allows for distributed processing and storage of vast amounts of images in a way that these are readily searchable, accessible and retrievable, e.g. by means of text search or SQL queries. Trained Neural Networks can be added for automated labeling of all images. CDP provides a single unified platform that supports the needs of all teams, without compromising scalability, flexibility and sustainability. Both storage and processing power can be scaled without limit and across a range of infrastructures, covering on-premises, public as well as private cloud and any hybrid combination.

This solution effectively automates the tagging and annotation process and accelerates the time to develop and deploy a number of machine vision use cases.



As a preliminary set of manually annotated images are used to train neural networks, Cloudera has identified a set of AI driven third-party tools that can effectively automate and significantly accelerate the initial manual annotation process. Now, once an initial set of annotations has been done, the IPAS offering can effectively automate the process of annotating **millions of images at-scale** using machine learning models and neural networks in order to significantly accelerate the image processing and model building projects. Depending on the specific domains, trained neural networks can be inserted for **automated labeling** of all images for domain specific attribute extraction and enhancement.

Using distributed processing capabilities and applying machine learning, the Cloudera IPAS solution drastically reduces the time it takes to process and analyze images, by **up to 80%.**

IPAS Value Delivered

By enabling capabilities to easily ingest, store, process, discover and apply advanced analytics and machine learning (ML) against massive volumes of image data, Cloudera Image Processing and Analytics Solution enables enterprises to accelerate the development and deployment of machine vision use cases while driving down manual processing and interventions. Value delivered:

- Accelerate Time to Deploy Machine Vision Use Cases—Doing just the basic processing on millions of images could take up to months on traditional infrastructure. Using distributed processing capabilities and applying machine learning, the Cloudera IPAS solution drastically reduces the time it takes to process and analyze images, by **up to 80%**. This means organizations can cut processing time significantly—from months to just a few hours, to process and annotate images, and iterate and refine machine learning models faster to roll out new capabilities sooner.
- Minimize Manual Effort and Interventions—By automating the process of metadata extraction, pre-processing and annotating millions of images at scale using machine learning, the IPAS solution helps cut out cumbersome and resource intensive manual processes associated with building image recognition models.
- Improve Model Accuracy—More importantly, the solution helps data scientists and engineers **quickly and easily discover** and access the right images for specific unique and fringe use cases, using domain specific semantic queries, thereby increasing the accuracy of the algorithms. The solution also enables data scientists to collaborate and perform data-science at scale, using Cloudera Machine Learning to build and continuously refine models based on the annotated images to increase accuracy and minimize rework.

Customer's Deriving Use Case Value

Leading organizations across the globe are adopting the Cloudera Data Platform, as the data management and analytics platform for driving computer vision and other advanced analytics use cases. Two practical customer use cases are:

DRIVING TOWARDS ZERO DOWNTIME IN INDUSTRIAL ROBOTICS

Customer Overview

Our customer is one of the world's leading suppliers of robotics equipment and factory automation systems helping manufacturers maximize their efficiency, reliability, quality and profitability. In this context, they are providing industrial robotics solutions and services for some of the leading automotive manufacturers.

> Some auto manufacturers estimate that unplanned downtime in a factory can cost them as much as $15,000 – $20,000 per minute and that a single downtime can cost them approx. $2m in lost revenue.

Challenge

For auto manufacturers, operational uptime is of paramount importance. Some auto manufacturers estimate that unplanned downtime in a factory can cost them as much as $15,000 – $20,000 per minute and that a single downtime can cost them approx. $2m in lost revenue. Given the business impact of unplanned downtime, they needed to ensure that the thousands of robotic equipment and machinery that were installed in the auto assembly plants are always up and running and in good operational health. They needed the ability to continuously monitor the performance of the robotics equipment in real-time, while being able to predict and detect issues before they impacted the operations.

Solution

They built the Zero Down Time (ZDT) application and robotics monitoring solution using CDP as the data management and advanced analytics platform. They are using CDP as the data management engine to gather, store, process, and analyze sensor data files from 10,000 robots across manufacturing facilities in real-time. ZDT analyzes data coming from robots throughout its factories to monitor the health of these critical machines and detect potential issues that could lead to failures in the production line. Based on the real-time data collected, if a potential failure is detected, ZDT alerts the customer's service center. Parts and support can then be delivered to tackle the issue before any downtime occurs.

Results

Using ZDT, and powering it with real time data analytics, **they have been able to transform their business and operations, as they edge towards a zero-down time goal for their robotic equipment.** This has tremendous potential to impact both operational efficiencies and their customer satisfaction metrics. Apart from lowering down time, using ZDT, they are able to use the data generated from their robotics equipment to determine how to optimize the manufacturing environment including things such as reducing energy consumption, extending the equipment life, improving cycle time and product quality.

LOWERING THE COST OF QUALITY IN PART INSPECTION

Customer Overview

Our large multinational construction customer has to perform more than 50,000 QA/QC flange face inspections on a typical Oil, Gas and Chemical construction project. Flange resurfacing on problematic flanges is often held up due to quality engineers' availability for inspections causing construction schedule delays. Flanges that fail inspection need to be resurfaced and re-inspected, leading to delays.

Flanges classified as defective are being proactively re-surfaced, which led to a 90% reduction of re-inspections. Our customer observed an estimated 15% reduction in the total number of flanges that were resurfaced.

Challenge

Cloudera partners worked to develop a mobile app and API to collect field images of flange faces. The app enabled engineers and inspectors to annotate images of faulty flanges in the field and stream these images to a central repository for analysis.

The collected images defined and trained a deep convolutional network to classify flanges into faulty and acceptable flanges. For faulty flanges, the network was able to discern various ASME standard violations such as the presence of grooves, rust or foreign objects.

Results

Though the inspection process was not completely automated due to safety and design regulations as planned, as human inspectors are still required by regulation for final inspection, the mobile app was deployed in the field to pipe fitters and general foreman allowing the general foreman to identify defective flanges prior to ordering an inspection.

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Other interesting computer vision use cases based on the Cloudera Data Platform are:

- Computer vision is applied to **enable Positive Train Control**, a system serving our railroads, actively inspecting track joint bars (bars in the track that reinforce the welded joints) in real-time and then controls train speed in response to those insights.
- A large Russian mining and steel manufacturer leverages computer vision to inspect mined ore in the crushing and classification process for excessively large rocks that were wearing and damaging equipment, resulting in excessive downtime. It is also leveraging the technology to **detect surface irregularities** in finished steel (i.e. indentations, scratched surfaces, other defects) improving quality.

Now See The Value of CDP

Replicating human vision is a data intensive endeavour. The benefits are evident in executing use cases that humans are incapable of—as example, anomaly detection of components flying down a manufacturing packaging line at hundreds of feet per second. As we continue to invest in Industry 4.0, most are realizing that data is the solution to successful Industry 4.0 computer vision deployment. Cloudera delivers the data lifecycle solution through Cloudera Data Platform from edge to AI.

Visit our website and learn more at cloudera.com/solutions/manufacturing

Sources

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