BitRefine GROUP

HOW MACHINE LEARNING BOOSTS MANUFACTURING INDUSTRY PROFITS

Meet the Source of Growth in Today's World

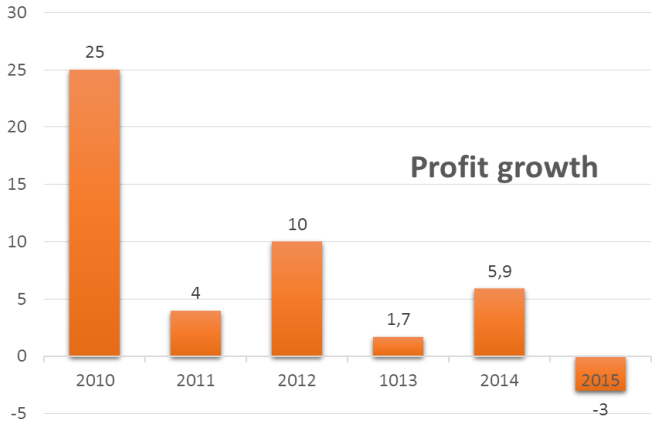
BitRefine group shows that machine learning has the potential to save costs and increase profitability by an average of 8% and to lead to an economic boost of $1 trillion across traditional manufacturing sectors.

Artificial Intelligence (AI) technology, including machine learning, is projected to have a favorable impact on the global economy. A recent PwC report stated that, due to AI capabilities, the global GDP will be 14% higher by 2030. Machine learning (ML), also commonly known as machine intelligence or advanced expert systems, will enable industries and businesses to advance their current capabilities.

MACHINE LEARNING'S VALUE FOR INDUSTRY

Declining profits

The latest research conducted in 2017 by the Bureau of Economic Analysis and Organization for Economic Co-operation and Development Statistics reveals worrying effects of decreasing investment, slowing innovations in the manufacturing sector, and inability to meet market expectations.



Investment growth has declined to -5.2% in 2016 in the United States and to -6.6% in the United Kingdom. Innovation indicators are also showing negative dynamics: growth of R&D spending in European countries equally has been falling. For instance, in Germany, R&D growth indicators fell from 6.6% in 2008 to -2.6% in 2013.

While almost all traditional sources of innovation have been utilized, there's a new growth factor, Artificial Intelligence, and its particular branch—machine learning—that is capable of reversing the trend of falling profits.

New business value from machine learning

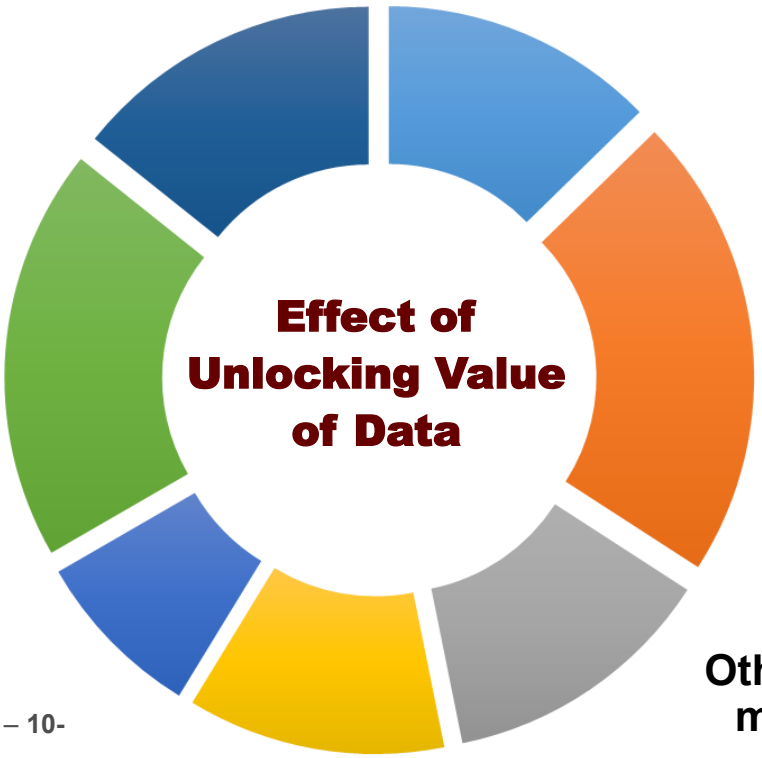
BitRefine Group believes that for traditionally capital-intensive industries such as manufacturing, the impact of ML on profitability will be dramatic. As computing costs decrease and Big Data technologies mature, machine learning that unlocks the trapped value of accumulated data has come to the main scene. Due to its ability to evolve over time, machine learning is bringing us benefits such as predictive quality control, intelligent optimization of process parameters, mature inferential sensors, and predictive maintenance.

It is estimated that, in 2016, tech companies have already invested US$12B in developing AI, and 60% of those investments were ML. Within the next five years, more than 70% of manufacturing companies will start applying AI technologies and machine learning to enhance their processes.

Industry sectors leveraging ML today

Pharmaceutical products
Predictive maintenance – **5-10%** cost savings
Process optimization –
1**5-30%** cost reduction

Refined petroleum products
Predictive maintenance – **10-30%** cost savings
Process optimization –**3-7%** cost reduction



Chemicals and chemical products
Predictive maintenance – **10-20%** cost savings
Process optimization – **5-10%** cost reduction

Rubber and plastics products
Predictive maintenance – **10-20%** cost savings
Process optimization – **5-15%** cost reduction

Basic metals
Predictive maintenance – **10-20%** cost savings
Process optimization – **3-5%** cost reduction

Other non-metallic mineral products
Predictive maintenance – **5-20%** cost savings
Process optimization – **5-20%** cost reduction

Fabricated metal products
Predictive maintenance – **10-40%** cost savings
Process optimization – **3-7%** cost reduction

Machine learning is essential to make sense of Big Data

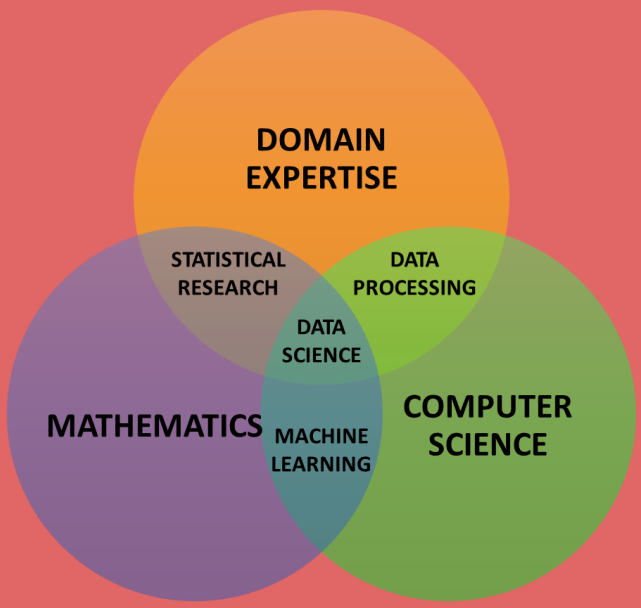
Big data is the term applied to data that has large volume and velocity. A common example would be data obtained from sensors that measure a great number of parameters along the chemical production process. But given the large volume of the data, it is not humanly possible to analyze it all. Machine algorithms can use this data to optimize usage of input such as chemicals, catalysts, chemical agents.

What is Machine Learning?

Machine learning is a fundamental part of Artificial Intelligence that provides computers with the ability to learn without being explicitly programmed. Machine-learning algorithms are employed in tasks where designing static instructions is difficult or even infeasible, such as finding patterns and anomalies, making predictions from large complex datasets.

What is Data Science?

Data science is a multidisciplinary field that studies algorithms and methods to solve analytically complex problems. Data science combines mathematics, statistics, programming, and computer science to uncover insight from data. Machine learning is one of the most powerful techniques that data science employs.

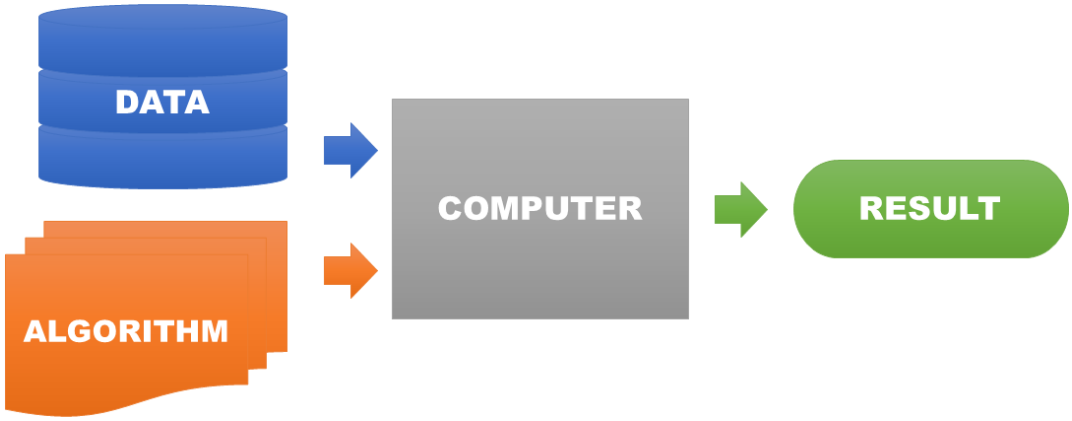


Today, a huge number of applications exist for machine learning. For the manufacturing sector, machine learning effectively solves parameter prediction and optimization problems, which in most cases belong to the supervised learning type. Two popular prediction methods of supervised learning are classification and regression. Classification is a prediction method that assigns each data point to a predefined category—for instance, defining whether a device is going to break down or not. Regression is a method that predicts a real number, representing, for example, future value of material density or viscosity.

UNDERSTANDING MACHINE LEARNING

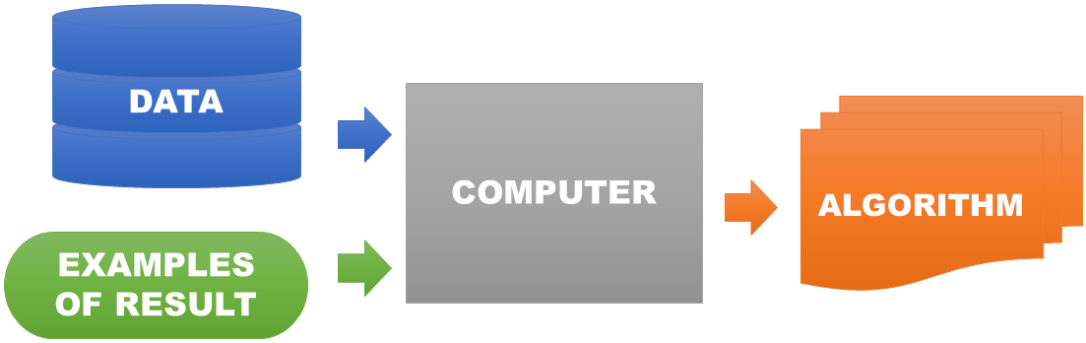
Traditional programming

Programs and data are run on a computer to find "answers." To develop algorithms that will represent real-world processes, two specialists are needed: a domain expert, who has deep understanding of the process, and a software developer, who will put provided knowledge about relations between parameters into form of computer code. After the algorithm is developed, the computer system is able to process incoming data and calculate predictions accordingly.



Supervised machine learning

Data and examples of right "answers" are run on a computer to create a program. To build prediction algorithms, the machine-learning system needs to receive data together with "answers" first. For example, it needs sets of readings from intermediate sensors along a production line together with parameters of the final product. After processing thousands of such sets, machine learning learns complex dependencies between intermediate parameters and quality of the product. In other words, the system builds required prediction algorithms by itself.



Process parameters optimization

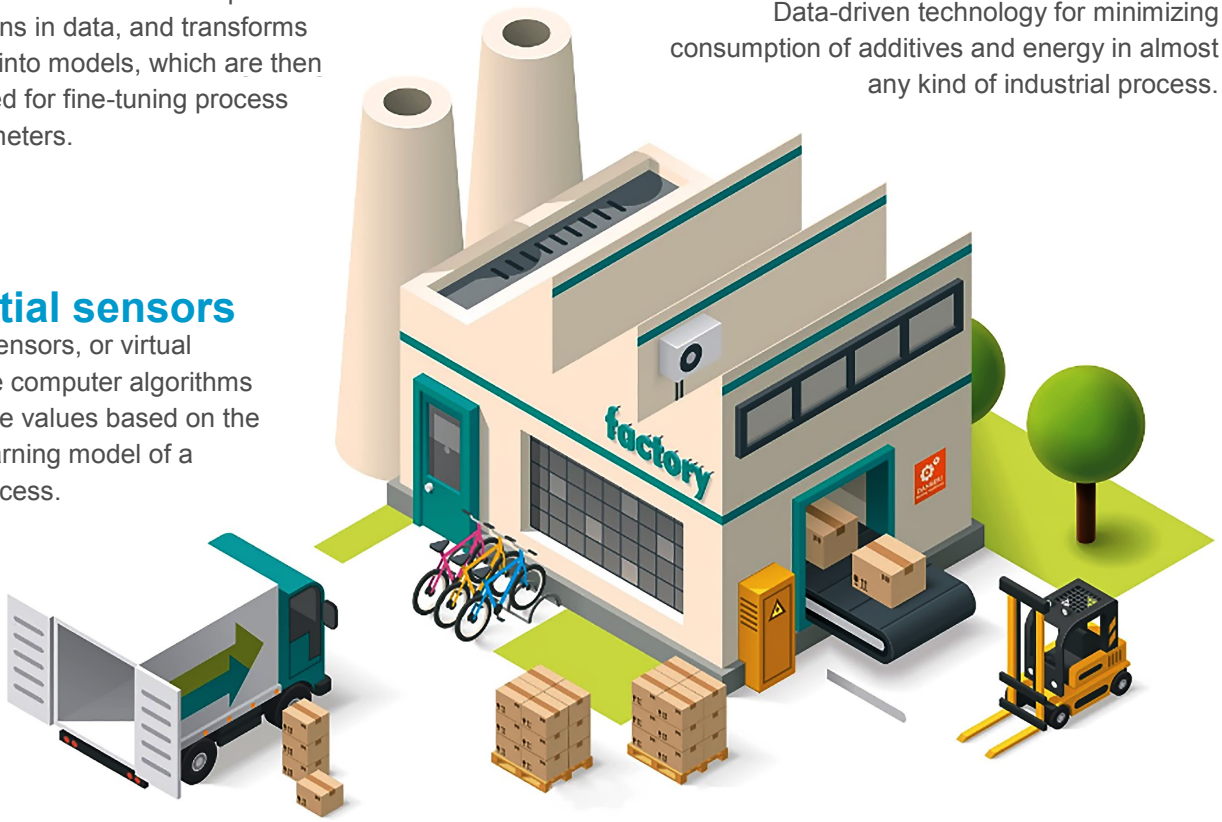
The solution reveals complex patterns in data, and transforms them into models, which are then applied for fine-tuning process parameters.

Optimization of additives consumption

Data-driven technology for minimizing consumption of additives and energy in almost any kind of industrial process.

Inferential sensors

Inferential sensors, or virtual sensors, are computer algorithms that generate values based on the machine-learning model of a physical process.



Predictive maintenance

The aim of a predictive maintenance system is to raise early warnings of critical failures to avoid downtime.

Quality prediction

A prediction system based on machine-learning models provides information about the expected quality of a future product.

APPLICATIONS OF MACHINE LEARNING IN MANUFACTURING

Manufacturing is growing more complex, as well as more automated. The industrial Internet of Things is generating great volumes of data at incredible speed, forming a foundation of big data for the manufacturing industry. To leverage this new digital asset, organizations need to consider new approaches as well as new technologies. Today, machine learning is becoming an essential technology for the whole industry. Implementing deep data analysis technology helps to unlock a rich spectrum of real, measurable benefits.

Process Parameters Optimization

Machine learning is able to improve efficiency even in such a well-established industry as manufacturing. This data-driven approach allows us to find complex, non-linear patterns in data, and transform them into models, which are then applied to fine-tuning process parameters.

Traditional control systems rely on a rule-based scheme, expertise, and domain knowledge of particular technologists. Today's modern manufacturing facilities are becoming more and more complex with interlinked processes, and we are rapidly reaching the limit of our capacity to include every aspect of the process in a rule-based expertise-based model. Machine learning offers an extremely effective solution that overcomes the challenge presented by increasingly complex processes. BitRefine builds models that "keep in mind" 1000-dimensional spaces of interlinked parameters, and that are capable of finding their optimal combination.

Inferential Sensors

Inferential sensors, sometimes called soft-sensors or eSensors or virtual sensors, are computer algorithms that generate values based on the machine-learning model of a physical process. Thanks to their efficiency and low cost, inferential sensors are attracting the close attention of all branches of manufacturing.

Companies are always striving to increase product quality and production efficiency, and to reduce costs. Environment pollution regulations further elevate their demands. Overall manufacturing performance heavily depends on quality and relevance of measurements coming from sensors. This innovative data-driven approach offers a new, effective way of obtaining accurate readings along the entire processing chain without installing expensive hardware. We build a mathematical model that learns every detail and every interaction of a given process on the basis of a large number of stored historical measurements. After a training process, this model is capable of calculating values for every single sensor at every stage of the production process without touching the physical world.

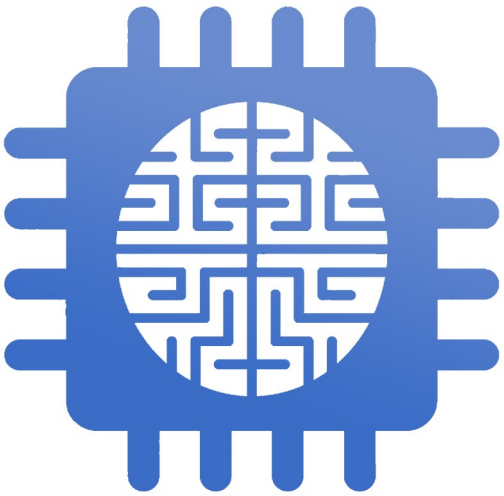
Modern industrial facilities rely on a large number of sensors. The acquired data is recorded and stored for years in company databases. These databases are the starting point for any kind of machine-learning solution. Although real-world raw data generally contains a lot of impurities such as incorrect measurements from faulty sensors or simply missing entries, after the data is preprocessed and cleansed, it still allows us to build a model that will always provide accurate "measurements."

Advanced inferential sensors that are supposed to be included in fully autonomous control processes are being equipped with self-diagnostic capabilities to evaluate their own reliability.

Optimization of Additives Consumption

Machine-learning technology is the new, powerful tool for minimizing consumption of additives and energy in almost every industrial process. Today, traditional manufacturing companies are actively beginning to implement machine-learning models to save costs.

Although most industrial processes have been studied in detail for decades, recent progress in the area of artificial intelligence, in particular machine learning, has opened new horizons for further optimization. A degree of uncertainty is part of any complex process. Due to the uncertainty inherent in chemical processes, technologists have to use extra quantities of costly additives to cover any deviation in processing. Current average suboptimal values give us an opportunity to optimize by replacing them with exact values.



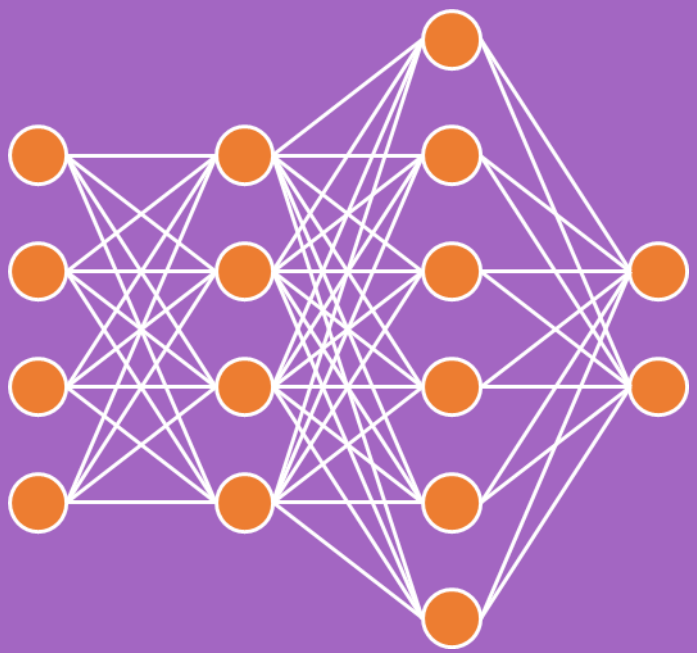
Machine-learning technology lets us build a model that takes into account data coming from different sources: initial material composition, quality of raw materials, readings from hundreds of sensors. The trained model accurately predicts parameters of the final product, and based on this prediction calculates exact amounts of additives needed to achieve the requested parameters for each particular batch.

BitRefine offers technology that increases the efficiency of the process without heavy capital investments. To gain an additional 5-10% of cost savings, our clients don't need to redesign their production lines or install a higher grade of equipment.

Recent advances in machine learning allow us to solve a tremendous variety of problems, and deep learning opens up even greater possibilities. Regardless of the sector, manufacturing companies have the opportunity to apply machine learning and establish new business capabilities for profitability and sustainability. But to achieve the full potential of machine learning, organizations must fully prepare for the attendant transformation.

What is Deep Learning?

Deep Learning is a class of machine-learning algorithms that imitate the workings of the human brain in processing data and creating patterns. Deep learning neural networks are effective in performing complicated analysis of unstructured data such as speech and image recognition.



Predictive Maintenance

One of the most frequently demanded machine-learning applications in manufacturing is predictive maintenance. The aim of a predictive maintenance system is to raise early warnings of critical failures to avoid downtime.

The existing rule-based approach to evaluating the current condition of equipment is often limited to comparing static values of a few sensors with reference numbers. A predictive maintenance system based on a machine-learning model provides complex insight into all aspects related to equipment condition and performance.

The core of a predictive system is a mathematical model created on the basis of a large number of historical values from diverse telemetry sensors. This model recognizes complex relations between different readings, and it recognizes abnormal patterns and patterns that lead to failures. Based on historical data the model identifies degradation patterns and is able to estimate how many more days a particular unit is going to operate before it fails.

Due to their high efficiency and ease of implementation in existing processes, predictive maintenance systems have attracted the manufacturing industry's attention. With the rise of the Internet of Things, manufacturing has started to collect data coming from all types of equipment. The availability of historical data from sensors and telemetry is a key requirement. The machine-learning model is being trained on this data to recognize specific patterns to be able to identify these patterns in real-time measurements in the future.

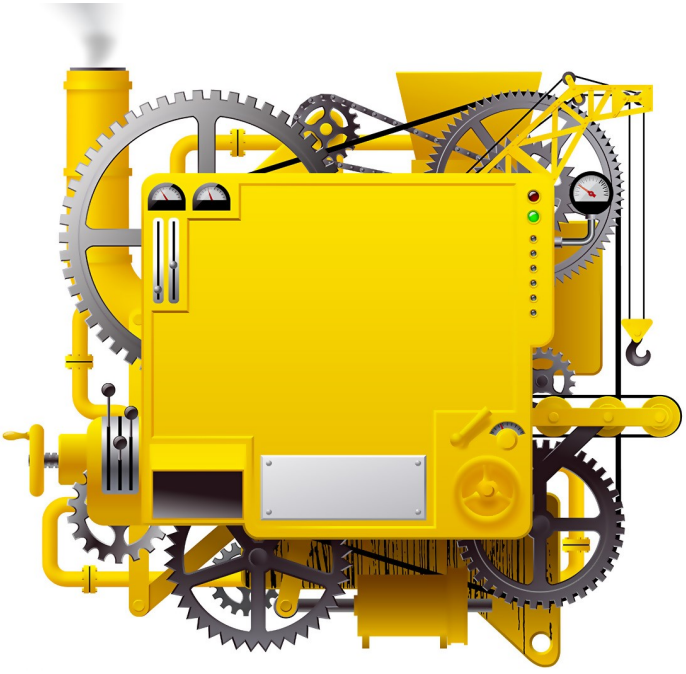
We divide data into two main groups: parameters of machine health status that can show degradation happening over the time of operation; and failure history, which is used to find alarming patterns. Although failure events are typically rare, this kind of data is the most valuable for machine-learning models.

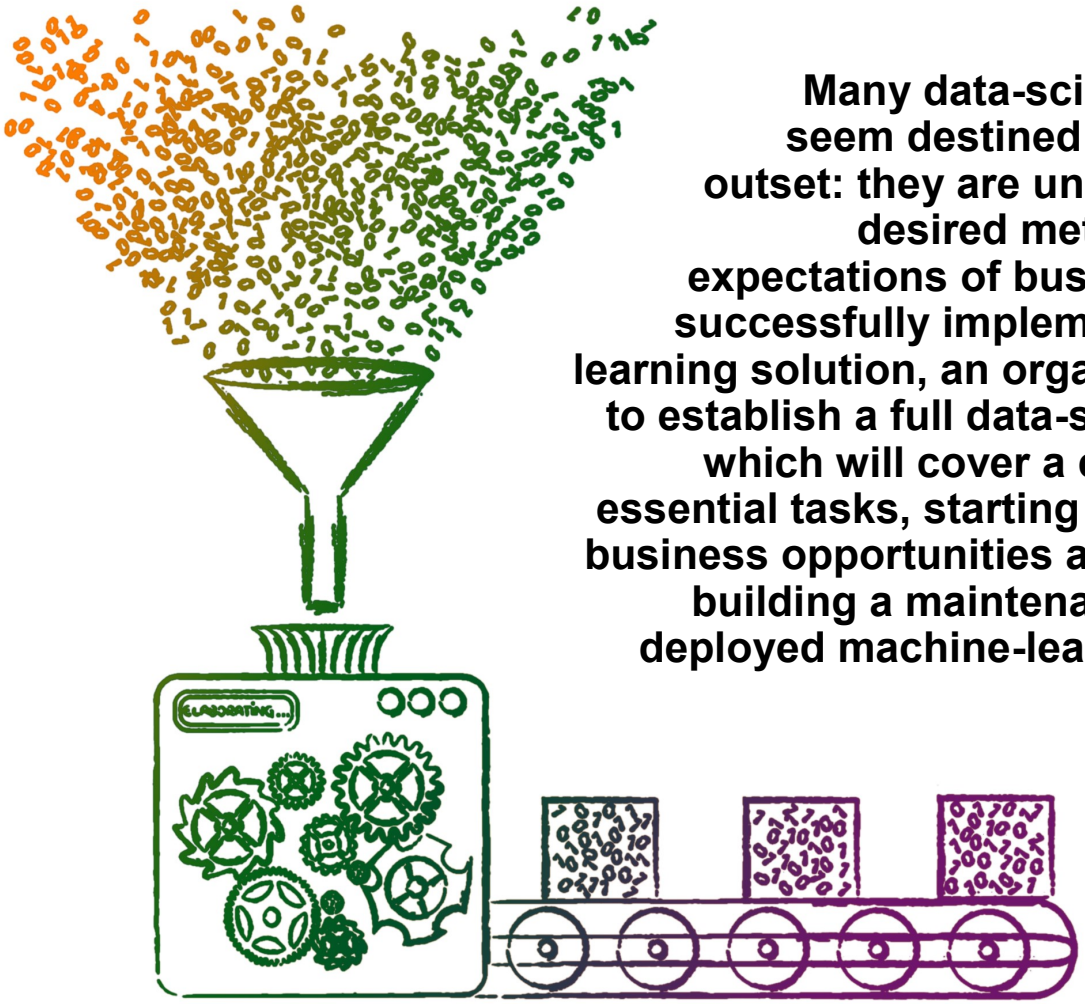
Quality Prediction in Manufacturing Processes

Modern prediction systems based on machine-learning models provide information about the expected quality of a future product. This highly valuable information lets us either adjust process parameters or cancel passing through the entire value chain of a particular batch, saving time and reducing costs.

The typical modern manufacturing process is a chain of an automated complex of equipment. The quality of the final product depends on processing parameters. The bottleneck here is that intermediate quality tests are limited to a few parameters and don't allow full physical inspections. The task for the machine-learning model is to detect complex patterns in measurements from distributed sensors at early processing stages and recognize those patterns that are typical for cases when the quality of the final product drops below a defined level. Early detection of a defective batch is one of the most effective methods of saving resources and increasing manufacturing efficiency. Now for a big number of manufacturing processing types, early detection of hidden defects is only possible with methods of machine-learning predictions.

Data-driven technology based on machine learning is an innovative approach in the area of quality control. BitRefine offers a real-time system that identifies quality deviations at all stages of the process without installing any additional sensors.





Many data-science initiatives seem destined to fail from the outset: they are unable to achieve desired metrics or to meet expectations of business value. To successfully implement a machine-learning solution, an organization needs to establish a full data-science project, which will cover a complete set of essential tasks, starting from exploring business opportunities and ending with building a maintenance routine for deployed machine-learning software.

DATA-SCIENCE PROJECT STRUCTURE

A famous quote states, “If you torture the data long enough, it will confess to anything.” Data is a double-edged sword: Because it can be interpreted in different ways, it needs to be handled by the experts. In the late 19th century (and even today), statistics was the branch of science primarily devoted to making inferences from available data. Statisticians had the expertise and rigor to conduct analyses and draw conclusions.

Today, “data science” is in vogue. But how is data science different from statistics? Data science is an interdisciplinary approach to analyzing complex large datasets. It is a method that blends statistics and computer algorithms such as machine learning that, together with business acumen, allow us to gain insights from a large heap of data. Although we refer to it as a science, data science is actually an art comprising a number of techniques for developing creative business solutions from available datasets.

Exploiting enterprise-grade machine learning capabilities focuses on a full-cycle data-science project, from identifying a business problem to coming up with a solution. The roadmap for such an approach comprises five main phases, customized to the needs of each individual organization.

Phase 1:

Define business goals

The ultimate goal is to identify the key business variables that a machine-learning model needs to predict. ML has the potential to meet challenges faced by various departments such as operations, processes, HR, and sales. The target variables need to be matched with available data and definitions of success metrics, as without enough source data along with accurately defined metrics, no model will work. To sort through the possibilities, most manufacturing organizations find it helpful to engage data science consulting services, which can also include a pilot research cycle.

Phase 2:

Data acquisition and preparation

One of the most important and also time-consuming steps is data exploration. Data obtained from manufacturing plants is seldom usable as is: for example, a broken sensor returns a constant value of 500°C temperature, or perhaps it doesn't return any value. Hence, data cleansing or preparing data is a crucial step. Issues such as missing values, incorrect values, constants, and duplicates need to be resolved prior to using the data. After the data is cleansed, the next step is to visualize the dataset to understand its properties. This step helps us find ways to enrich data with additional features, or identify poor fractions that need to be augmented with external datasets.

Phase 3:

Modeling

This phase includes a lifecycle of several steps: building, testing, and tweaking the model. There are many modeling algorithms available. The task is to choose one that fits the data and defined metrics. The chosen model is then trained using a training dataset and evaluated by checking prediction accuracy indicators. After the model is trained and tested, it is often necessary to tweak it further. For this, one needs to check and either start again, defining metrics or rebuilding models or reprocessing data, or with luck, move to the next step.

Phase 4:

Deployment

Once the model performs well, it needs to be situated on the machines that will actually execute the code. The model is deployed by linking it with an API interface that allows the model to pass predictive information to other applications such as dashboards or management systems. In some cases, to secure stable performance of the model, deployed models are equipped with telemetry and monitoring systems. These systems help with subsequent tracking of the system health and key metrics. Depending on the business requirements, prediction reporting can be either in real-time or on a batch basis.

Phase 5:

Service the model

Even if a deployed model accurately reflects the complexity of real-world process, it needs to be retrained over time to keep it up to date. The reality changes over time, so the model also needs to change. And as the model continues learning from new data, it will increase the decision quality and the overall efficiency of the target process.

ML applications offer great potential without heavy investing

Business leaders emphasize optimum utilization of available resources. The focus is on improving business processes and increasing productivity. But in the current state of industrial processes, everything is already optimized. This makes it difficult to achieve any further improvements without the need for significant upfront investments. Machine learning, particularly when employed to analyze Big Data, provides a low-cost solution to this problem.

Machine learning has a short deployment cycle that spans a few weeks, and it provides an immediate return on investment. In a recent survey, participants reported that, for machine learning, the return on investment was quantifiable and visible in early stages of implementation .

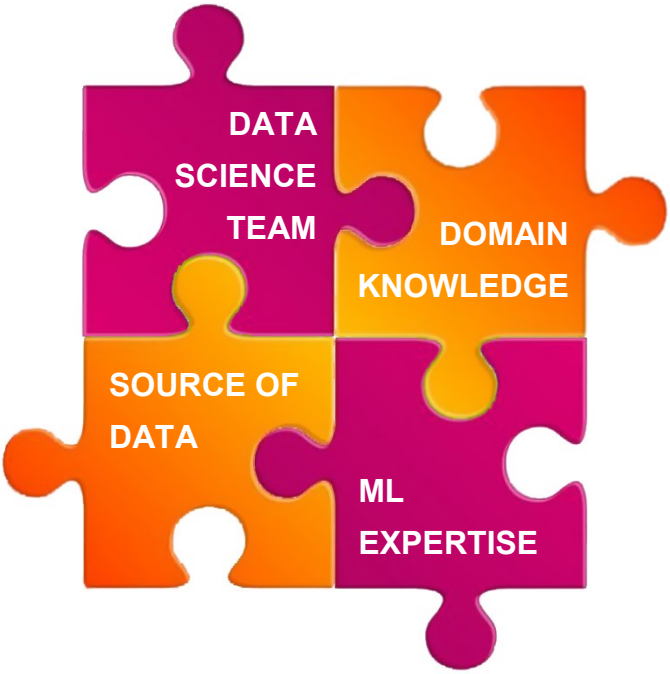
The promise of implementing machine-learning technology and data-driven business transformation is clear: measurable increase of process efficiency in a matter of months. By acquiring a forward-looking strategy with a strong emphasis on open innovation partnerships, manufacturing organizations can strengthen their chances of achieving such improvements. Given this imperative for making an AI-based approach a core competency, manufacturers should seek to maximize the benefits of machine-learning technology by ensuring they have built the requisite data, technology, and teams. The time to start is now.

STRATEGY FOR SUCCESS

The magic of collaborative partnership

BitRefine Group helps organizations apply data-driven methods to significantly increase the accuracy of physical processes. A first step in our collaboration is to understand the available data and reveal points where machine-learning solutions can be applied in areas such as optimization of additives consumption, inferential sensors, or quality prediction.

Within the first months of a collaboration, BitRefine Group provides the organization with clear insight into which processes can be improved and what average cost reduction can be expected after the deployment of a machine-learning pipeline. A strong collaboration between the manufacturer, with their domain knowledge, and BitRefine, with our data-science expertise, results in a focused solution that solves a client's narrowly defined problem with the highest possible level of efficiency.



Manufacturer BitRefine

About BitRefine Group

BitRefine Group is a global professional services company that provides a broad range of solutions and services in data science, machine-learning, and computer vision. Combining extensive experience and specialized skills, BitRefine solves clients' toughest challenges, turning emerging technology into a real-world product. Among the applications that BitRefine develops are deep data analysis, visual information comprehension, robotics, automation, medical image processing, and behavior prediction – this is the short list. Working at the intersection of business and technology, BitRefine helps companies improve their performance, stay ahead of trends, and maintain a competitive advantage in the market. Visit us at www.bitrefine.group

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