Implementation of Machine Learning (ML) in Mechanical Engineering Application using Artificial Intelligence (AI)

[1]Dr. C. Dhandapani,

[1]*HOD, Department of Mechanical Engineering,*
Rajagopal Polytechnic College, Gudiyattam-632602, India
Email: dpani123@gmail.com.com

[2]Dr. R. Sivaramakrishnan

[2]*Professor, Department of Production Technology,*
Madras Institute of Technology, Chennai - 600044, India

Abstract: The economic world is during a constant state of amendment. Machine learning can change mechanical engineering and so several user industries. Implementation has already begun; currently the main focus is on concrete application situations and their implementation. Machine Learning brings several new and exciting approaches, particularly for mechanical engineering application. The potency, flexibility, and quality of the systems will be considerably improved with the assistance of the obtainable knowledge. New business models for user area unit developed. Machine Learning ensures that software system and data technology area unit progressively turning into the key drivers of innovation in mechanical engineering application. In several industries, the increasing changeableness of individual machines can mean that in future not solely the machine itself are going to be sold-out, however especially supplementary services. It additionally explains why machine learning is on the agenda in management and plenty of specialist areas of engineering science application. Machine learning is a vital a part of artificial intelligence (AI) technology and computer science. Tools already established on the market facilitate to search out the algorithms. "New frameworks and platforms support a broad application victimization VDMA software system. The characteristics of machine learning additionally dissent with the products: on the one hand, these area unit settled within the product itself, and on the opposite hand within the method surroundings of the machine, for instance within the kind of maintenance or further added services.

Keywords: Machine Learning (ML), Mechanical Engineering Applications, Artificial Intelligence (AI), VDMA software system

1. Introduction

Machine learning (ML) and artificial intelligence (AI) present within the media within the workplace and private life. Digitalization is dramatically ever changing all aspects of society, as well as the production industries. The German mechanical engineering industry, specially, can address the ensuing challenges if it is to take care of and expand its current world product leadership role in several sectors. Machine Learning (ML) supported computer programs will use algorithms to several noticed solutions to new and unknown issues. The artificial system "recognizes" patterns and laws within the learning information it receives. The technology offers undreamt-of prospects for machine and plant construction: Existing business and production processes may be optimized. The machines become intelligent and virtually self-sufficient method service supplier. Several companies are inquisitive about machine learning victimization VDMA software system. They are collected in associate "Industry Podcast". Machine learning may be wont to optimize product characteristics further as internal processes.

One field of application of ML is machine operation. This is often simplified by knowledgeable systems. The system guides the operator victimization optical signals that seem directly within the work field of view. Within the total version, the machine operator edges from well-rounded visual support from the intelligent system. As a result, the machine builder's experience time, training effort and set-up time area unit reduced, whereas the machine operator's potency is enhanced at the same time. Machine learning so allows both: the machine builder and his customers to optimize processes. Fig. 1 shows the application of mechanical engineering using ML/AI.

Also, Machine Learning allows technical systems to find out from expertise. Algorithms are used for the system to knowledge patterns and structures with example information provided by humans. Machine Learning then applies this new information to new, unknown cases. The VDMA Software system and Digitization helps companies to success from trail of machine learning with VDMA software system. In its network, the association future includes a large amount of companies that have already got technical information from machine learning. This knowledge should be used profitably for machine and plant construction. The Machine Learning Expert Group has been working on develop and assistance using VDMA software system to implement on mechanical engineering application.

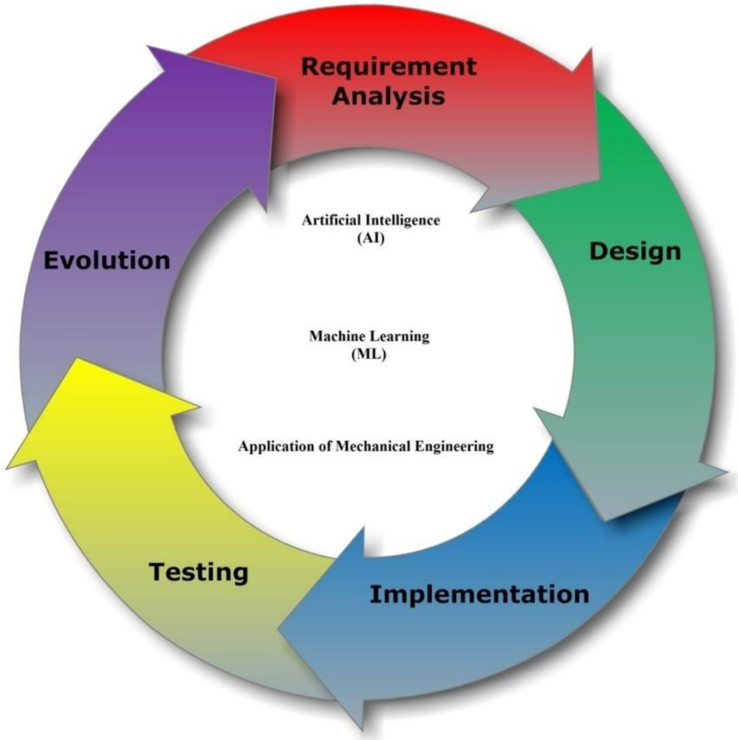

Fig. 1 Application of Mechanical Engineering using ML/AI

1.1 ML Models

A basic concept for learning is the model, which contains the learned information and is used to make predictions. As a rule, models are only designed for a single task. For example, using sensor data as input, the probability of a malfunction is predicted as output. Most important concept is model training, in which the model is taught through information as input. Models are normally trained once and then used for predictions. Machine Learning (ML) algorithms can be varied by the way they learn from data or how their models are trained, with three categories have shown in Fig. 2

- Supervised learning
- Unsupervised learning
- Reinforcement learning

- ***Supervised learning***

In supervised learning, the model is trained with examples from input and output values. For the example of malfunction analysis, one would feed sample sensor data into the system along with information about upcoming malfunctions. The system learns the relationship between sensor data and malfunctions. This learning process is called supervised because the correct output is known for each input and the model can be corrected when predictions are false. To train the model, a large quantity of sample input and output data is needed. Creating this data can be very expensive or difficult since expert knowledge usually has to be learned. The quality of the sample data is also important. If the model is supplied with incorrect sample data, it will learn incorrect correlations.

- ***Unsupervised learning***

In unsupervised learning, the system also learns from sample data, however, the sample data do not include known output data. Instead, the examples are used to learn how "typical" data or data clusters appear. For the example of sensor data, the model would learn how typical sensor data for the machine appear. In the event of deviations from this data, it would assume a malfunction. In a different approach to unsupervised learning, the data are automatically classified into clusters. Examples of such clusters could be "machine producing," "machine malfunction" or "machine standstill." The advantage of unsupervised learning is that the sample data can be created with little effort. The disadvantage is that unsupervised learning is unable to cover all possible cases.

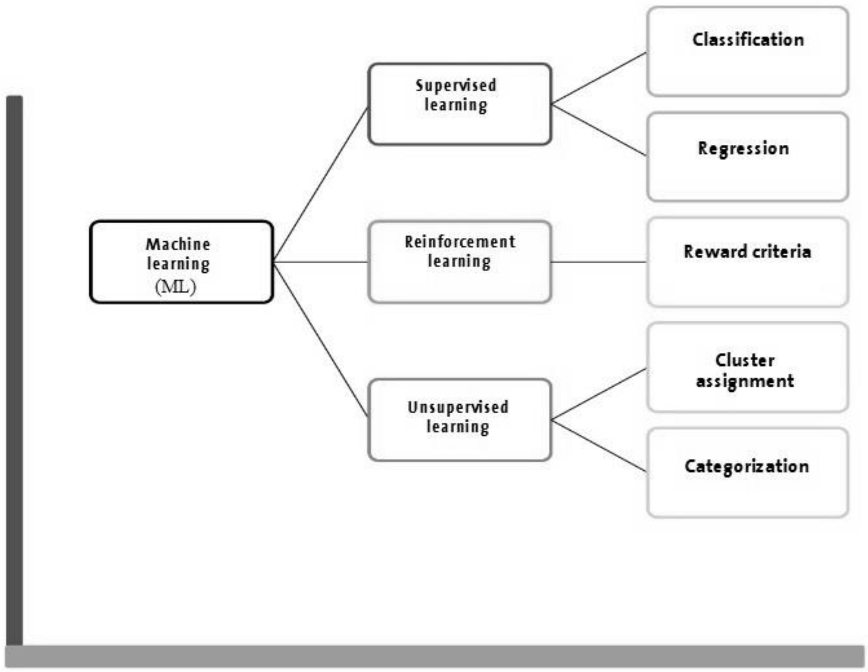

Fig. 2 Types of ML models

- ***Reinforcement learning***

In reinforcement learning, models are trained by reward and punishment. Every solution or step in a solution is typically scored by assigning points. Rewards are expressed by an increase in points, penalties by a decrease. The goal is to maximize the score. During training, trial and error are used to generate new proposed solutions, which are increasingly refined to continuously improve the score. Challenges for reinforcement learning: Suitable reward mechanisms need to be found and short-term benefits need to be balanced against long-term ones. This form of learning is called reinforcement learning because it is reminiscent of human learning by praise and criticism.

2. Implementation of ML in Mechanical Engineering Industry

In various mechanical engineering based industries, there is still uncertainty about whether ML is relevant to their business. Due to the increasing interchangeability of individual machines in many areas, future sales will involve supplementary services and not only the machines themselves. That will result in fundamental changes for the industry and explains why ML is a very salient issue for management and specialists at mechanical engineering industries.

ML offers unprecedented opportunities for Germany's mechanical and plant engineering industry to optimize existing business and production processes, with the machines maturing to become process service providers that operate almost autonomously. This metod provide a structured analysis of the benefits, opportunities, and risks of important aspects and use examples to place them in a business context. The aim is to assist readers in making an initial business assessment of ML's relevance from which they can derive their approaches and strategies. ML has potential benefits for both product characteristics and internal process optimization. This applies to processing incoming payments and preparing bids, as well as for production planning. The ML properties also differ in productrelated areas, on the one hand in products themselves, for example in expert systems for machine operator support, and on the other hand in machine-related processes such as maintenance or other value-added services.

Since it is not always possible to differentiate the properties effectively, they should be defined in the context of specific application scenarios. It should be possible to clearly describe and quantify the economic benefits in each case. An example of this could be automated comparison of incoming payments with invoices with potential savings of over ten percent. Another example: inquiries about pricing for complex machine configurations. Extensive ML-based automation would enable much faster responses to requests for quotes, with a corresponding increase in the number of new contracts. Scenarios of this type for a business's core processes are already available for use as part of ERP, marketing or sales systems.

Besides its benefits for core business processes, the product leadership benefits of ML as part of a business's products are a further application area. Two potential benefits can be addressed here: On the one hand, direct added value can be created for the customer when operating the machine; on the other hand, the available machine data information can be used for the creation of value-added services.

3. Typical cases for ML in Mechanical Engineering

Each of the use cases for ML in mechanical engineering application is described briefly and a possible implementation strategy explained. Then we discuss the technical implementation of typical cases, benefits, the required capabilities, and the costs, opportunities, and risks.

3.1 Human-like machine vision

Judging surface textures is a task in which traditional image processing systems reach their limits, while the human eye can recognize textures, patterns, objects, and structures and can reliably judge and classify them visually after only a brief training period. With only a few examples, humans can learn to distinguish permissible variations from defects, even in natural objects of which no two are identical.

All kinds of the sensor can be used for the imaging process used with human-like machine vision, including 2D, 3D, ultrasound, X-ray and shape from shading. The ML application works from a training phase with good parts; in contrast, extensive defect catalogs must be used with traditional image processing applications. With ML, the desired result and not the deviation from it is thus the standard. The Process of Human-like machine vision is shown in Fig.3

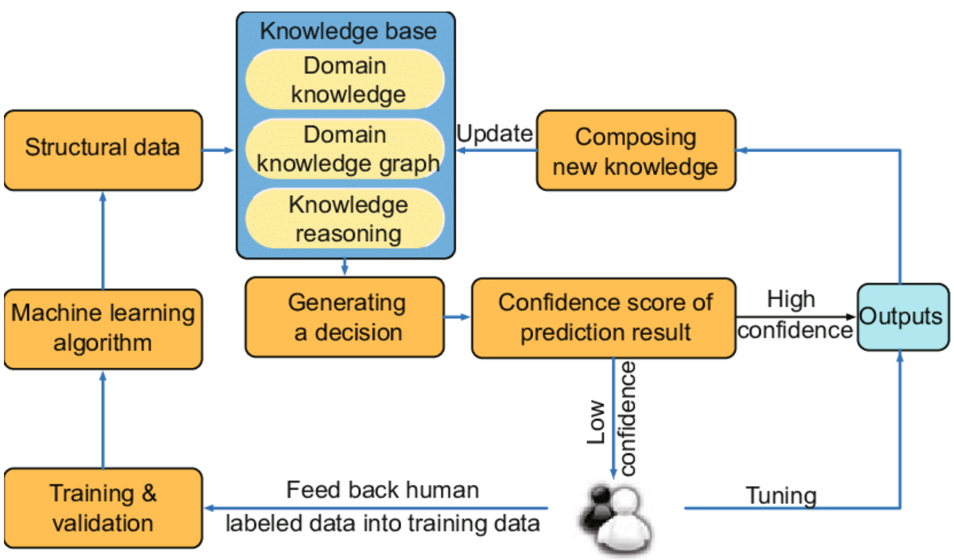

Fig. 3 Process of Human-like machine vision

The process-secure solution for such tasks is ML-based image processing systems which are specially developed and optimized for the industrial analysis of images. The use of such systems based on ML opens up further potential applications for reliable automated inspection with very high detection levels. Where traditional vision systems reach their limits and human judgment is the best solution in spite of its risks and limitations, human-like machine vision based on ML algorithms currently offers a state-of-the-art solution. New products can be learned without great effort and even new and unknown characteristics can be detected without extensive defect libraries, resulting in considerably shorter development and product launch periods.

Except for experience with traditional image processing and in designing optical camera systems, the modeling requires no additional software development and no understanding of the algorithms.

3.2 Adaptive control for process optimization

In this use case, the optimization of the start-up procedure for an offset web press as a representative example of the optimization of complex physical machine processes. Due to its numerous parameters and influencing factors, the start-up process is complex. An important factor is the fine adjustment of the solid density, which has to be manually parameterized before every production run. The effects of parameter changes can only be evaluated after a full run of the press; this process is associated with a dead time during which waste-quality products may be produced.

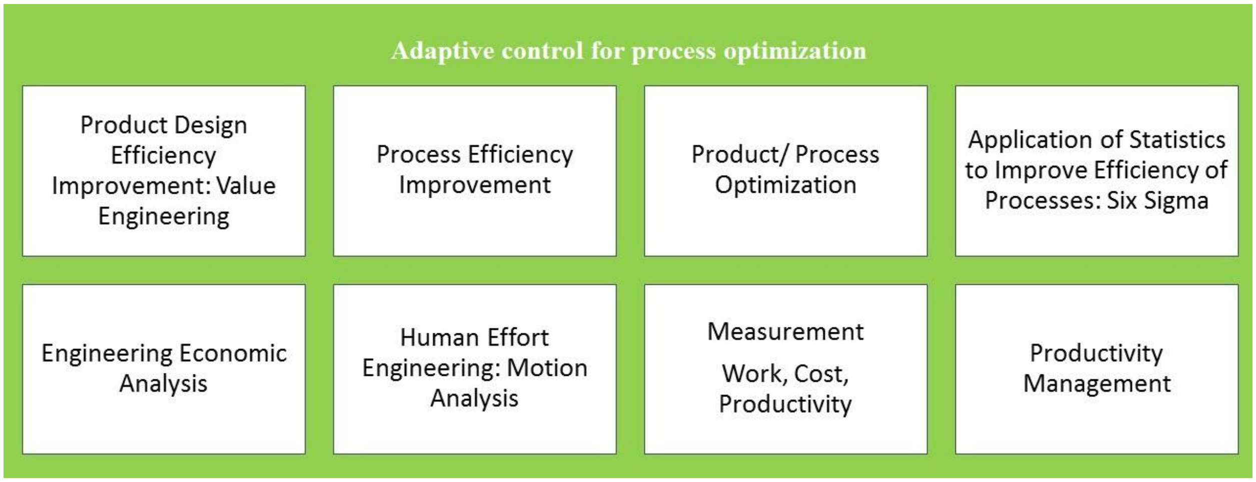

Fig. 4 Adaptive control for process optimization

Meanwhile, other parameters such as consumables, physical factors and the condition of the machine also influence the printed products in an unknown way. Technical systems such as these, with behavior which is influenced by numerous variables and unknown relationships, are difficult to model with physical formulas and thus often defy process optimization. Machine learning processes can be helpful in this case. They learn the system's behavior and can subsequently make predictions about the process, something is known as adaptive control is shown in Fig. 4.

The dead time can be bridged with model-based adaptive control. The relationship between sensor data and the quality of the solid density is learned from historical data and used as a feedback variable in the control system. This enables adjustment of the process parameters even before measured values for the density are available. Use of predictive control increased productivity and resource efficiency significantly. On average, waste during start-up was reduced by 37% and the required time by 39%. This kind of control is called predictive control. Developing an adaptive control system requires an in-depth understanding of the process. It also calls for knowledge about the use of machine learning processes for time series regression. The process of model-based predictive control can be also being applied to other problems. An approach involving machine learning processes is always promising when many measurable variables influence the process in an unknown way. As in the other use cases, sufficient data is an absolute requirement for adaptive control.

3.3 Smart tendering

The current trend of product customization continued over the past decade. With on-demand production and lot size 1 production, product version diversity is increasing disproportionately, and with it, the complexity. This complexity is also reflected in the available machine configurations. A large number of machine models with options and dependencies among the options can quickly lead to a confusing variety of possibilities for both manufacturers and customers.

This variety of machine configurations is also a major challenge for the tendering process. For very complex machines, the tendering process with different machine versions and their pricing can drag on for weeks, often leading to delays in preparing bids and possibly endangering sales. A smart tendering system can automate parts of the tendering process, making it faster and reducing costs is shown in Fig.5. Information and comprehensive data about previous bids, machine configurations, and prices can be used for the semi-automated preparation of future bids. Assuming that a similarly configured product would result in a similar cost structure, ML algorithms are used to train a model that learns the correlations between machine configurations and costs. Then this model is used to estimate the costs for a machine configuration and prepare an initial bid. Rapid preparation of bids can increase the likelihood of sales and thus increase revenues. Other advantages include simplification of the tendering process and reduced scope for errors.

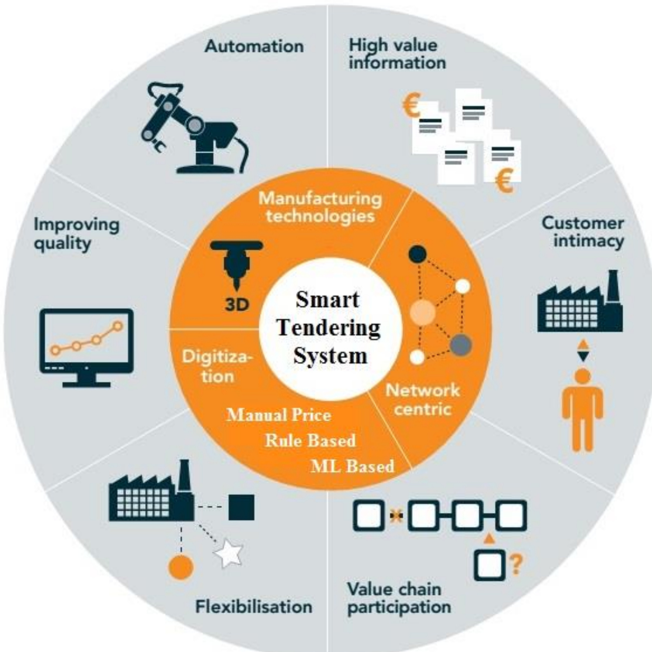

Fig. 5 Smart Tendering System

4. Data is a raw material

Data are becoming the most important currency of the 21st century and are the foundation of ML. More data were generated in the last two years than in all of human history. Data are increasingly becoming a factor in production along with land, capital, and labor. They enable cost reductions and new business models. The increasing importance of data is causing a change in the sequence from algorithms, data; decisions to data; algorithms; decisions, a factor that represents the revolution is shown in Fig. 6. Since the first programmable chip, the Intel 4004 was launched in 1971 software development have always followed the same pattern: First the problem is defined, then objectives and work steps are specified, and finally the application is programmed as a sequence of algorithms. In practice, these algorithms are supplied with data, and users reach decisions based on the results. This approach is currently undergoing a structural change; the data are now gathered in advance and analyzed with generally valid algorithms in the second step. This results in causalities, upon which decisions are made, for example, to optimize production, and these decisions are increasingly often being made autonomously.

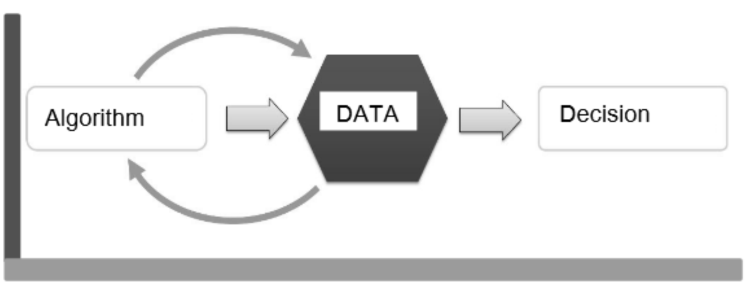

Fig. 6 Rule-based data-driven

5. Conclusion

Machine Learning (ML) is a powerful tool, at the beginning of an initial stage, it is necessary to consider the opportunities and risks and to gauge and quantify the costs and benefits always with a clearly defined objective. In industry, we mainly rely on quantitative instead of qualitative statements when working with conventional systems. Along with data formats and the required connectivity with uniform standards, data content and the issue of its links to individuals are important criteria for further processing and handling. The processes need to be verified and validated, and experience has to be gained. This paper reviews the implementation of machine learning (ML) in mechanical engineering application using artificial intelligence (AI), the industry concern should expertise in three areas as mentioned,

- Developing algorithms, and developing solutions based on existing algorithms
- Use of the algorithms by operating staff and managers
- On the market, with customers, and along the entire supply chain

6. Reference

[1] Catherine Elsen, JeanNoël Demaret, Maria C. Yang and Pierre Leclercq (2012). Sketchbased interfaces for modeling and users' needs: Redefining connections. Artificial Intelligence for Engineering Design, Analysis, and Manufacturing,26, pp 281301 DOI:10.1017/S0890060412000157

[2] Das, Sumit & Dey, Aritra & Pal, Akash & Roy, Nabamita. (2015). Applications of Artificial Intelligence in Machine Learning: Review and Prospect. International Journal of Computer Applications. 115. 31-41. 10.5120/20182-2402.

[3] Dennis M. Dimiduk, et al, Perspectives on the Impact of Machine Learning, Deep Learning, and Artificial Intelligence on Materials, Processes, and Structures Engineering, Integrating Materials and Manufacturing Innovation September 2018, Volume 7, Issue 3, pp 157–172

[4] Honey, “Role of Artificial Intelligence in Mechanical Engineering”, International Journal of Technology & Engineering, Vol 1 No. 1 May 2016) IJTE

[5] Li L, Ota K, Dong M (2018) Human-like driving: empirical decision-making system for autonomous vehicles. IEEE Transactions on Vehicular Technology

[6] Komal Shaonak, et al, Impact of Artificial Intelligence in the Mechanical Engineering, International Journal of Mechanical And Production Engineering, Volume-5, Issue-7, Jul.-2017

[7] Machine Learning - the future for mechanical engineering, https://www.thenewsmarket.com/global/vdma/ machine-learning---the-future-for-mechanical-engineering/s/160ca3a5-791d-4a69-acbc-96e980ebac8c, Feb - 2019, Source: VDMA

[8] Redding JD, Johnson LB, Levihn M, Meuleau NF, Brechtel S (2018) Decision making for autonomous vehicle motion control. US Patent App 15:713,326

[9] Rudy SH, Brunton SL, Proctor JL, Kutz JN (2017) Data-driven discovery of partial differential equations. Science Advances 3(4):e1602,614

[10] Qi Huang, Application of Artificial Intelligence in Mechanical Engineering, 2nd International Conference on Computer Engineering, Information Science & Application Technology (ICCIA 2017), *Advances in Computer Science Research, volume 7*