Industrial Control System Based On Machine Learning SVM Algorithm

Hanane Zermane, Hayet Mouss, and Djamel Touahar

Laboratory of Automation and Manufacturing, Industrial Engineering Department, Batna 2 University, Batna 05000, Algeria
h.zermane@univ-batna2.dz

Abstract. Machine learning is one of the most prominent signs of evolution and a mark of the marks of civilization in this century, as the latter immersed in many areas of life, it contributes to the improvement in smarter and faster ways. The idea of this work is based on use of machine learning to create an industrial supervision system that controls automatically a factory on real time mode as an alternative for the operators as possible as it is available. This work comes to highlight the importance of this learning in the field of industry as the main nerve of the economy of many countries. It depends on the use of one of the tools of machine learning, which is SVM technique in an attempt to create an automatic control program for industrial systems of SCIMAT Company for cement production.

Keywords: Industrial process, Supervision system, Machine Learning, Support Vector Machine, Classification, Regression.

1 Introduction

Since the first of the last century until now the volume of human being knowledge has begun raise up unprecedentedly year after year and day after day, until scientists have said that in these last years the human being knowledge renewed every eighteen hours, which means every eighteen hours we get new information, researches, discovers, data and others, in any field, such as, economy, industry, medicine, politic, education, etc. This huge capacity of knowledge our brain can't estimate it all as fast as it should be, and for that human being brain thought in another way alternatives it in this service, which should be intelligent, fast and precise at the same time. Then in the middle of the last century it products and developed a new meaning called Artificial Intelligence (AI), it presents in another brain or memory can do our brain missions, learning, thinking, and resulting. Artificial intelligence mission has been presented in many forms or branches; one of them is making the machine learns or thinks instead of our brain in such time and situation our own brain cannot work with. Thus, when AI got by scientists another meaning, or branch called machine learning (ML).

Driving machines to learn and think is a huge idea makes us able to do many things in a short time with a big precise, thus we can develop our knowledge too more and faster. Learning things needs an important tool, it is the information which is called in AI by the data, the information puts the brain inside its field it very well, where the brain can get knowledge about this field as much as information it has about it, thus how our brain works. With the same way machine can learn too, but it needs a line connect between the data and the machine to learn about it. Here when scientists developed this line or way, it is called training. It means driving the machine to train the data and fit it each other together, then it can learn or predict the result that data drives into.

ML developers developed many techniques to apply this way with the machine; the most popular one is SVM technique, it is developed to classify the data to groups and classes according to their type and their field, or making a regression for them. All this to get ability for our machine to predict the position that new data should be on. This work comes through this science (machine learning), to drive it into a very import field specially in these years; it is the industry, where ML with SVM has no many experience comparing with many other fields ML has developed them very well.

The idea is to create a program controlling and regulating an industrial supervision system instead of the operator. By using SVM technique with Python programming language, and the automatic

programming language Simatic Step7, that it brings the data from the real industrial system at a real time to Python, which uses SVM to analyze and treat this data to get at the end the automatic controller program. We talked in the first section about machine learning and artificial intelligence. However, we focused on ML because it is the main for this work, we get on what machine learning means, and how it works, as well as its missions and services that can help us in this work, addition to the field that it is up with.

The second section is about "SVM" technique. We talked about it as a fundamental definitions and history with some explanations. We concerned by its two main services: classification and regression that will help us in building the work program. We presented at the end the role that this technique will do in this work. The third section presents our application. We explained how the application got out to be applied. It comes through the training period that we took for achieving the application, contains a definition to the industrial society SCIMAT and the service we focused on as a reference to the program data, and then illustrated too, the program, the main base, steps of building the code and the way for connecting with Simatic Step7. Finally, we showed the results that are the options and orders that the program is up to do.

2 Related Works

Scientists have proposed many new theories and algorithms of human-inspired computing, which have been applied widely in many fields, such as artificial intelligence, machine learning and data mining. Human-inspired computing is becoming a significant force to promote science and technology progress [1]. First, ML is briefly introduced in more detail with respect to the manufacturing domain [2]. Machine learning is about extracting knowledge from data. It is a research field at the intersection of statistics, artificial intelligence and computer science. Another technique is SVM, which is selected as a machine learning algorithm applied in classification problem. SVM is a supervised machine learning algorithm proposed by Vapnik [3], [4]. It has a strong theoretical foundation and achieved excellent empirical success. It has been widely used in a variety of pattern recognition applications [5] and classification problems.

SVM has been shown to provide higher performance than traditional learning machines and has been introduced as a powerful tool for solving classification problems. However, there are some limitations, including outlier-handling, long learning times, and an increased number of support vectors [6]. This limitation can make necessary a combination of SVM with other artificial intelligence techniques. Different works improved the powerful of this idea. We can observe its application with fuzzy logic in order to classify the arrhythmia patterns of an electrocardiograph [7] and with Genetic Algorithm for genetic outlier's detection for a robust SVM [8]. So, SVM is one of strong machine learning algorithms [9]. SVM has good generalization ability and can obtain best compromise between complexity of model and learning capability when solving small samples and the nonlinear problem [10]. To learn an industrial supervision system how to supervise the factory, this machine learning algorithm needs examples of when things are going right as well as examples of when things are going wrong.

3 Cement Industrial Process

The way that cement is created by is similar for all Cement fabrication societies; SCIMAT society accredits in general the next steps or production lines:

1. Career equipment: assemblage and transport of raw material (limestone and clay).
2. Raw mill: crushing raw material into first powder.
3. Oven supply: rotary and cooler for creation clinker.
4. Cement crushed: fabrication cement (final product) using the clinker.
5. Storage and distribution the final product out there.

In this work, we choose the workshop of raw mill. This workshop has a specific production line, within this line the product moves across a group of electric, mechanic, automatic equipment and many others, for processing this operation and keep it on functionality mode as long as system needs. Figure 1 presents the process of raw mill.

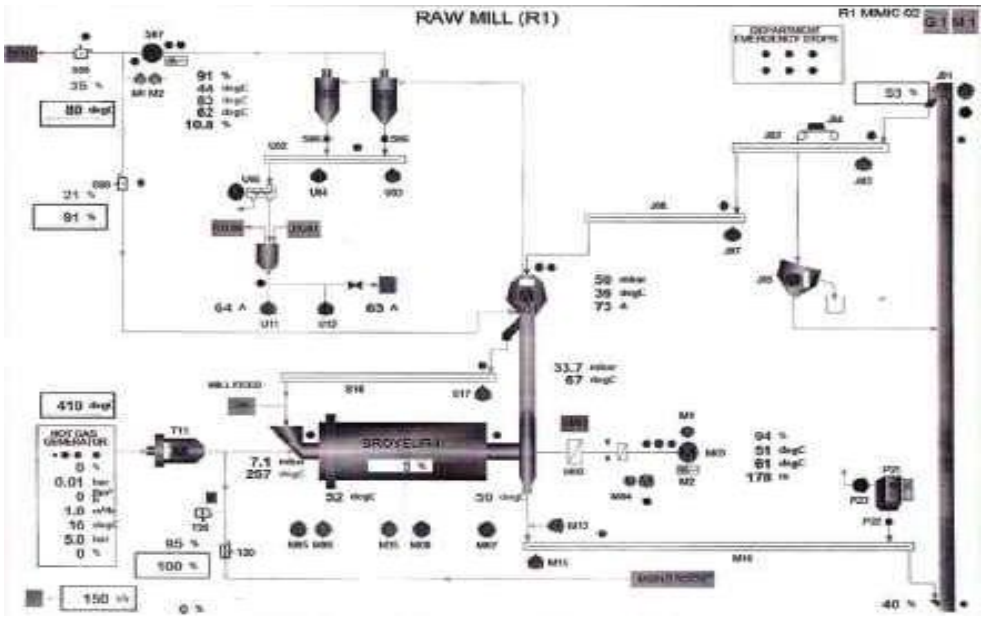

Fig. 1. The raw mill workshop.

Any equipment has a couple of parameters that the industrial system needs to run, stop and control everything about this one for driving it into the good issue. Table 1 gives a good look at these parameters and their characteristics.

Table 1. Description of system parameters.

Sub_system	Parameters	Set point range	Designation
Crusher	R1M01I01	[100-150]	Total feed rate (t/h)
	R1M01_P1	[1-2.1]	Pressure input, crusher (mbar)
	R1M01_T1	[220-400]	Temperature input, crusher (°C)
	R1M01_P3	[17-24]	Pressure output, crusher (mbar)
	R1M01_T3	[70,120]	Temperature output, crusher (°C)
	R1M01_X1	[0,50]	Crusher, folaphone (%)
	R1M03_J1	[0-92]	Engine crusher, power (%)
	R1J01_J1	[0-60]	Elevator, power (%)
	R1S07_J1	[0-94]	Fan, power (%)
Separator	R1S03_P1	[0-60]	Separator, pressure (mbar)
	R1S01M1I01	[0-120]	Separator, current (%)
	R1S08_Z01	[0-95]	Butterfly register, position (%)
	R1S09_Z01	[0-50]	Butterfly register, position (%)
Feeders	QCX_R1_H2O	[0.8-15.8]	Operator sp03 (%)
	QCX_R1_R90	[0.9-18]	Operator sp02 (%)
	R1B02_F1	[100-150]	Transp. Tape, flow (R1M01I01-Sum(R1(A02,D02, E02))) (t/h)
	R1A02_F1	[0-24]	Transp. Tape, flow (t/h)
	R1D02_F1	[0-3]	Transp. Tape, flow (t/h)
	R1E02_F1	[0-5]	Transp. Tape, flow (t/h)

These are global parameters that system works by them, we decided to choose from all these ones the most important parameters, which have the big power and effect on the system, and they are R1M01I01, R1M01_P1, R1M01_T1, R1M01_P3, R1M01_T3, R1M01_X1, 1R1J01_J1, R1S01M1I01. The industrial application that our program adopts is about classifying these parameters into specific classes according to their set point interval, and they are 3 classes, such as:

- High range: value more than the interval,
- Normal range: value inside the interval,
- Low range: value less than the interval.

4 Application of the Approach in Industry

4.1 The Process Learning using SVM

As known SVM is a supervised learning method. The supervision system can learn how to deal with all situations, either in a good, or in a case of bad functioning, it means when an alarm is occurred. In classification problem, the goal is to predict a class label, which is a choice from a predefined list of possibilities. SVM classifiers attempt to find the optimal hyperplane separating two different classes of data that will generate the best model for future data [11]. These classes of data in our case are, there is an alarm or there is not. The training set consists of dataset extracted from the process during its running. We have a record of all the sensor settings that can be used as training for the machine learning system. The types of kernel functions include splines, polynomials, hyperbolic tangents, sigmoid functions, and radial basis functions (RBFs) [12]. However, in this study, we used a RBF kernel, which is generally known to have an excellent performance capability. SVM is a high-performance classification technology that has attracted much attention in various fields.

SVM includes mapping of learning patterns into a high-dimensional feature space and finding an optimal hyperplane that maximizes the margin between two classes [13]. Intuitively, the gamma parameter (in our case gamma='auto') defines how far the influence of a single training example reaches, with low values meaning ‘far’ and high values meaning 'close'. The gamma parameters can be seen as the inverse of the radius of influence of samples selected by the model as support vectors. The C parameter (in our case c='1.0') trades off misclassification of training examples against simplicity of the decision surface. A low C makes the decision surface smooth, while a high C aims at classifying all training examples correctly by giving the model freedom to select more samples as support vectors. We applied as a library, scikit-learn. The scikit-learn project is constantly being developed and improved, and it has a very active user community. It contains a number of state-of-the-art machine learning algorithms.

After we caught our datasets, SVM takes its place to analyze these later using the two algorithms we mentioned before classification SVC and regression SVR. Actually the most using of these two is coming separating, each one is for a different type of datasets according to the form that this data are showed by. In this work, we decide to collect them together using the benefit of each one of them that can help us analyzing the datasets. SVS is for classifying our data to different specific classes, as we need in the program. SVR is for good prediction. SVM technique analyses the datasets by training each other together, testing this training motivation, than make validation. After training and testing the datasets, SVM classify them according to our order, and then gives us ability to predict and put each new data into its special and fitted class.

4.2 Data treatment in the PLC

At this point means we trained our datasets and got the classes prediction. Now we need to connect this program to the Simatic Step7 code, which allows us to import the data inside Python to predict and classify them from a real data, or from the industrial system, we work on. This how we can make the program accessible to these system parameters, then it can control them automatically instead of the operator. This operation has a special library, which is snap7. Connecting python to Simatic Step7 needs another tool as a line connects between these two, which is NetToPlcsim. This

tool can get accessibility to the IP Address of PC and the IP Address of Simatic Plcsim. We run the tool to get accessibility to stop any automatic program. That allows this tool to access to any new running for the stopped automatic program. We configure the network IP address of the PC and Simatic Plcsim IP addresses and Rack/Slot, and then we start the Server to connect into Step7 (see Fig. 2).

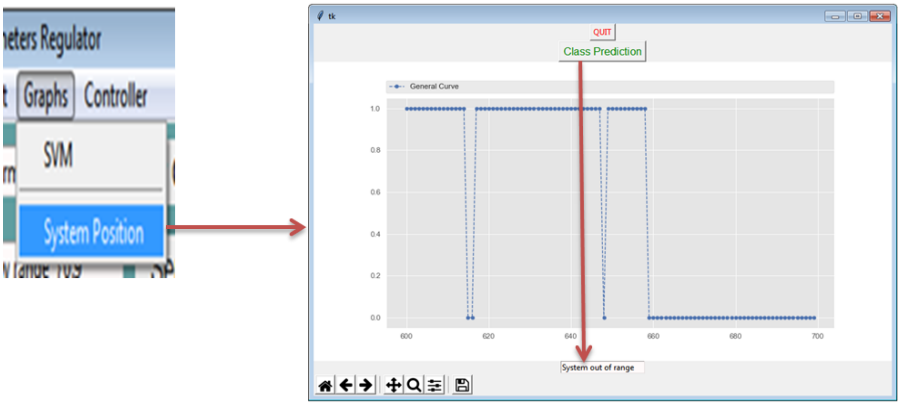

Fig. 2. Parameter's prediction.

When it gets any new value from the system within real time work, we will see the curve moves and class changes according to this value amount. Actually, we add this option to let operator knows that when the system is out of range means there is one parameter or more out of range. That drives him to check out this issue. The "Graphs" option in the menu allows too operators get accessing to SVM graphs for each one of the parameters. We chose "input temperature (R1M01_T1)" that has a set point range [220-400] °C, as an example here and in the next operation. Figure 3 illustrates how program shows the SVM curve for this parameter.

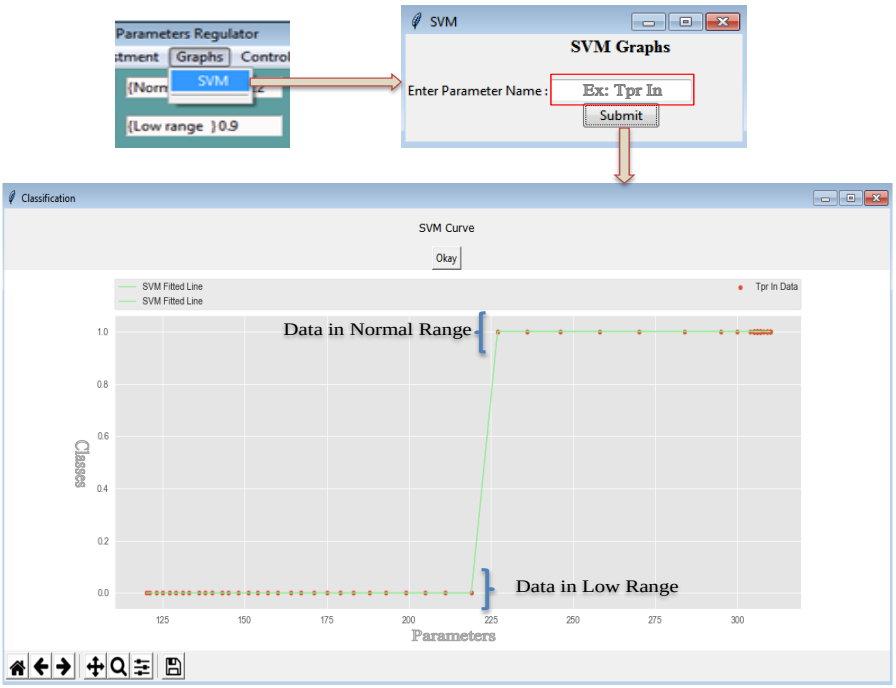

Fig. 3. Parameter's classification.

5 Conclusion

The idea of this work, that it has come for pushing machine learning up into industry and applies this idea to a real industrial project. We picked SVM algorithm as a base to the program, and SCIMAT society as the industrial real project. We applied SVM by using Python as a base of the code. We connected it to Simatic Step7 to get connecting between the industrial supervision system and the program. Thus, we could create the automatic controller program. We built the code depending on a view aims to take it to be the operator instead of human being. One of the most important points in this aim is the interactivity of the program. This can help the operator to get accessibility to control the system as much as he needs.

Machine Learning can pass missing in industrial supervision systems and gets a better production system. This means we need to push up and insert ML inside industry, where it can do better and drives the industry to the top, especially in our country where we miss this propriety very much. For this reason, we applied it in this work, where we applied SVM technique. That proves us that it can does more than just classifying data and plot them, this technique can do very well in industrial field too. It can be the alternative for the human being missions in this issue. This gives us chance to control the industrial system faster and more precise, and get accessing to all system parameters without getting back to human being hands. This costs much money and takes longtime as well as an insufficient controlling.

References

1. Qiao, H. Zhang, H. Rohrbein, F.: Editorial for Special Issue on Human-inspired Computing, International Journal of Automation and Computing, 14(5), 501-502 (2017).
2. Shi, J. Liu, X. G.: Product quality prediction by a neural soft-sensor based on MSA and PCA, International Journal of Automation and Computing, 3(1), 17-22 (2006).
3. Cortes, C. Vapnik, V.: Support-vector networks, Mach. Learn. 20, 273-297 (1995).
4. Vapnik, V.: Statistical Learning Theory, Wiley (1998).
5. Kim, J. S. Jeong, J. S.: Pattern Recognition of Ship Navigational Data Using Support Vector Machine, International Journal of Fuzzy Logic and Intelligent Systems, 15(4), 268-276 (2015).
6. Lee, S. Y. Urtnasan, E. Lee, K. J.: Design of a Fast Learning Classifier for Sleep Apnea Database based on Fuzzy SVM," International Journal of Fuzzy Logic and Intelligent Systems, 17(3), 187-193 (2017).
7. Yong, L. S. Yong, A. D. Hae, S. M. Joung, L. K.: The Classification of Electrocardiograph Arrhythmia Patterns using Fuzzy Support Vector Machines, International Journal of Fuzzy Logic and Intelligent Systems, 11(3), 204-210 (2011).
8. H. Lee, E. Kim, "Genetic Outlier Detection for a Robust Support Vector Machine," International Journal of Fuzzy Logic and Intelligent Systems, 15(2), 96-101 (2015).
9. Hulten, G.: Building Intelligent Systems: A Guide to Machine Learning Engineer-Ing. Apress, Washington (2018).
10. Lei, L. Feng, Y. Peng, Z. Jing-Yi, W. Liang, H.: SVM-based Ontology Matching Approach, International Journal of Automation and Computing, 9(3), 306-314 (2012).
11. Goudjil, M. Mouloud, K. Mouldi, B. Ghoggali, N. A Novel Active Learning Method Using SVM for Text Classification, International Journal of Automation and Computing, 13(3), 1-9 (2016).
12. Hsu, C. W. Chang, C. C. Lin, C. J.: A practical guide to support vector classification, Department of Computer Science, National Taiwan University, Taipei, Taiwan (2003).
13. Cristianini, N. Shawe-Taylor, J.: An Introduction to Support Vector Machines, Cambridge University Press, Cambridge (2000).