TEST Engineering & Management

November-December 2019
ISSN: 0193-4120 Page No. 3074- 3080

Machine Learning: Tasks, Modern Day Applications and Challenges

Lamyaa Zaed Aljuaid[1], Koh Tieng Wei[2], Khaironi Yatim Sharif[3]
aljuaid.lamiaa@gmail.com[1], twkoh@upm.edu.my[2], khaironi@upm.edu.my[3]
Department of Software Engineering and Information System, Faculty of Computer Science and Information Technology, University Putra Malaysia, 43400 UPM Serdang, Selangor.

Article Info
Volume 81
Page Number: 3074- 3080
Publication Issue:
November-December 2019

Abstract:
During the last decade, we have witnessed significant development in artificial intelligence (AI) capabilities and its application areas such as healthcare, self-driving cars, eLearning, military, smart cities, industry, etc. Machine learning algorithms learned from available data. Further, this learning laid the foundation to develop AI for the various systems around us. These machine learning algorithms are a collection of complex mathematical models and human intuitions. Over the last decade, we are able to develop algorithms which can produce better accuracies so better decision making can be achieved. Particularly in today's scenarios, deep learning algorithms are breaking all records. These algorithms mimic the neural system of humans and successfully breaking several barriers in image classification, NLP, and robotics, etc. The contributions of this paper are in three folds. Firstly, we reviewed current state-of-the-art research and development work in the area of machine learning. Secondly, we identified a machine learning task and reviewed them. Thirdly, we related these developments with how they are affecting human societies with respect to their applications such as image classification, autonomous driving, and data fusion. This paper provides reader with the direction of what has been done and what can be done in machine learning to exploit open problems in this area.

Keywords— *Artificial Intelligence, Machine Learning, Deep Learning, Data Fusion, Smart Cities.*

Article History
Article Received: *5 March 2019*
Revised: *18 May 2019*
Accepted: *24 September 2019*
Publication: *14 December 2019*

I. INTRODUCTION

Machine learning is one of the most important tools that we use to develop artificial intelligence in machines.Alan Turing famous experiment put the initial seeds of how we can make a machine learn and act like humans. In 1950, he proposed the Turing test to test the ability of the machine to exhibit intelligence like humans[1]. However, theoretically, Bayes' Theorem, Markov Chains, Least Squares played an important role in the development of machine learning methods. Other significant developments which were critical for artificial intelligence domain in early times were the introduction of first artificial neural networks by Marvin Minsky and Dean Edmonds in 1951[2]. In Fig 1, we depicted some of the major historical developments in the area of machine learning with their years. Most significant initial developments are in the area of mathematics where Bayes' theorem in 1763, Least Squares in 1805 and Markov Chains in 1913. This development made still the core machine learning. However, with time a lot of advances happened and happening. First, we feed data and train the algorithms. After training algorithm can predict data instance using some kind of inference. Later this prediction is used to make decisions. For example, temperature prediction algorithm can predict tomorrow temperature by learning from historical temperature data, etc.

Machine learning algorithms are very complex in their design. However, the core idea of these algorithms is still taken from classical machine algorithms like neural networks, K-nearest neighbor, Support Vector Machine, etc. In the past, due to hardware limitations, several machine learning development was never been explored much. However, today we have fast and parallel processors, and memory capacities exponentially increased. Overall computing capabilities of our machines increased greatly. In addition, the cost of manufacturing hardware goes down too. For example, the cost of 0.00098 KB was$392.00 in 1958, to 64 MB for $57.59 in 2000 and today we can get 16GB for just $60. Similarly, processors were single core previously today we have multicore process through we can do parallel processing.

November-December 2019
ISSN: 0193-4120 Page No. 3074- 3080

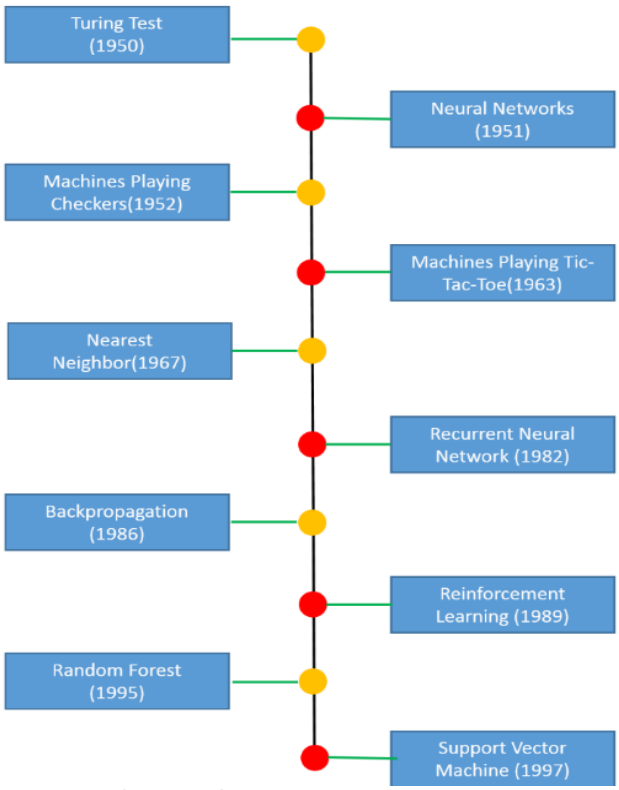

Figure 1. A brief history of major machine learning developments

We are also witnessing today that data will be too critical for future human societies as this data will be used by a machine learning algorithm for learning purpose. This further leads to developing intelligence for predicting and forecasting purposes. Some of the sources of the famous datasets are Kaggle, UCI data Repository[3], Stanford datasets[4], Amazon public datasets[5], KITTI [6], and Berkeley Open datasets[7]. Conventional data was used in a structured manner like tables which have rows and columns. But today we have data in an unstructured format such as documents, social media, etc. This gives rise to unstructured datasets and a completely different machine learning domain know as natural language processing (NLP) which uses machine learning algorithms to develop AI and further this AI will be used in our systems. Some example of unstructured data areemails, word, PowerPoint and pdf documents, multimedia files like videos, photos, audios, social media and etc. We need special non-SQL databases to store them such as MongoDB, HBase, RavenDB, Radis, HyperGraphDB, Cassandra, and Db4objects. In this paper, we will critically examine the past and current machine learning developments.

II. Paper Structure

This paper is divided into seven sections. In Section III, we stated the contributions of our work. In Section IV, we divided machine learning into the tasks it performs. Whereas in Section V, we critically discussed the application area with modern day perspective and in Section VI we stated the challenges in this area. Finally, we concluded in Section VII. In Fig 2, we depicted a hierarchical block diagram of this review paper.

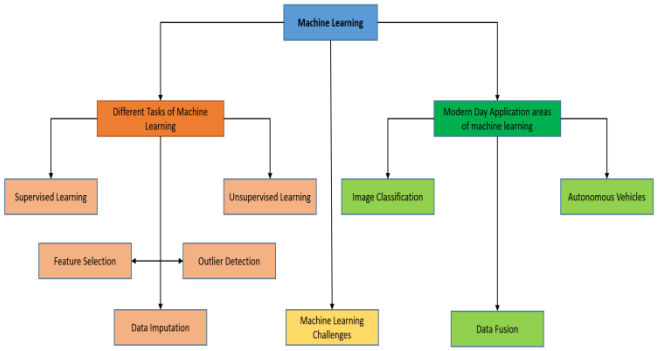

Figure 2. Block diagram of the structure of this review paper

III. Contributions

In this review paper, our aim is to study machine learning from various perspectives. The contributions of this work are in four-fold:

- We analyzed how machine learning evolved in the last few decades.
- We reviewed current state-of-the-art research and development work in the area of machine learning.
- We identified different task machine learning can perform.
- We discussedmodern-day applications of machine learning.
- In the end, we compared some of the most widely used machine learning algorithms.
- This work will act as a foundation for readers who want to know and explore machine learning.

IV. Machine Learning Tasks

Machine learning is a form of classification in which machine learning algorithm learn with the data with labels (class) which is a categorical variable (hot, cold, day night), etc. Where as in regression machine learning algorithm learn with the data with numerical or continuous variables which is a categorical variable (hot, cold, day night) etc. In this section, we are going to discuss different categories of machine learning tasks [8].

A. Supervised Learning

In supervised learning, machine learning algorithms are trained with labeled data (continuous or categorical) and aftertraining it can take unlabeled data to predict the class of data (continuous or categorical)[9]. Major application areas of supervised learning are image classification, disease prediction, weather prediction, natural language processing, activity recognition, and many more. Supervised learning algorithms are used a lot in image classification tasks, when you have to recognize an image correctly to its respective class, the same critically discussed in [10] from various perspectives. Authors also suggested how image classification be improved. With the inception of the Internet of Things (IoT), we have a class of sensory data now. One of this type of problem is activity recognition where we identify human activity such as lying, standing, sitting, walking, playing, talking, eating,etc, through the sensors data which is a classification problem [11]. The source of the

November-December 2019
ISSN: 0193-4120 Page No. 3074- 3080

data can be smartphone, video or images from which machine learning algorithm gets trained to predict human activities [12]. Some of the popular classification algorithms are K-NN, Support Vector Machine (SVM), Random Forest, and Neural networks.

B. Unsupervised learning

In unsupervised learning, machine learning algorithms are trained without labeled data and after training it can take data to predict group (cluster) the data belong to. Unsupervised learning is also known as clustering [13]. Saxena et al performed a detailed survey of various unsupervised machine learning algorithms in [14], which can be referred for further details. Clustering is useful when we have data and we do not know which group it belongs to. Some of the most common and popular clustering algorithms are K-mean, hierarchical clustering, and density-based clustering.

C. Forecasting

In forecasting is basically a form of classification. But it is based on some time series data. Forecasting can also be seen as an extrapolation of past to future[15]. For example what will be the earth temperature in 2030? We need to forecast it. Over the last decade, we saw that machine learning now actively used for forecasting purpose. These days machine learning algorithms like neural networks are widely used for the purpose of the weather forecast.

D. Feature Selection

In feature selection, first, we find out which feature is more important or in other words which feature hold maximum information [16]. Feature selection is done for two reasons which are (1) to reduce computation by selecting most important features only and (2) it is well known, have more features does not mean better results, selecting features which contain maximum information can enhance results. Machine learning methods are widely used for selecting the best features [17]. For example random Forest, Navie Bayes, neural networks and K-nearest neighbor.

E. Outlier/Anomaly Detection

Outliers are the extreme values in datasets which tend to be incorrect. Outliers can arise due to a number of reasons such as mechanical failure, a faulty sensor, network error, wrong data entry, electronic inference during sending and receiving data and human biases [18]. Sometimes these outliers are also be known as anomalies, specifically, anomaly word is used with suspicious behavior such as fraud, crime, unauthorized access, intruding enemy. Machine learning is on the forefront in this area as highlighted in the survey by Escalante[19]. Some fields were machine learning based outlier detection algorithm used is biomedical [20], petroleum industry [21], robotics [22], manufacturing industry [23], surveys [24], etc. It is well-proven fact that predicting of outlier increases the accuracy rather than just deleting the outlier observation.

F. Data Imputation

Missing values are common in real life datasets due to human error, a faulty sensor, network error, electronic inference during sending and receiving data. Prediction these missing values is known as data imputation [25]. There can be two types of value we need to predict. One data value which is completely missing and other is deleted as it is identified as an outlier. Some of the popular choice for data imputation algorithms are SVM [26] proposed by Yang et al, KNN where we select candidate best replacements for the missing data items [27], Random Forest [28], etc. As today we are on verse of technological revolution due to the inception of paradigms like IoT, Smart cities, Self-driving cars, and Edge computing, which means there will be enormous use sensors. This is well-known sensors tend to produce outliers and missing values. Therefore we must develop a method which is robust and can produce higher accuracies.

V. Application Areas of Machine Learning

Machine learning today is used in almost every domain, maybe it's military, medical, industry, IoT, aviation, social media. In this section, we will discuss various application areas of machine learning.

A. Image Recognition

Image recognition is one of the oldest application domain where machine learning has been used. Today image recognition such as face recognition is a hot topic of research due to its numerous advantage such as person identification, tracking, security, authentication, etc. A visual sensor such as a camera which capture faces of people got trained can tell a lot about a person. Like his appearance, time to time changes in his appearance, etc. These days much facial recognition toolsare every coming in market which can predict a face with great precision. this technology is so effective that now countries are using it in catching criminal, tracking them, tracking various suspicious objects such car, people in the city and report the same to the security agencies in real time. However, some latest face recognition technologies are creating serious concerns for the people and their privacy. For example at Google, the employees got upset that Google is working with the US military in image recognition so the military can track people around the globe from using satellites[29].

What is an image? Basically, an image is a collection of pixels (RGB) color values. The image can contain several other attributes such as hue, saturation, entropy, intensity, etc. Every pixel has a label which is the name of the object it belongs to such as is it cat or dog or cow. For example in Fig 3, we depicted a pixel of the eye of a cat and a dog with their respective class labels. We trained a supervised machine learning algorithm using these labeled pixel values. Then for practical, use when the image without the label is fed to the algorithm it uses some sort of mathematical inference to map the class that specific image belongs to. Image classification can be of two types which are (1) we can classify the whole image as a single class and (2) we can classify segments in the image such as driving scene which contains various objects such as cars, people, traffic lights, etc.

November-December 2019
ISSN: 0193-4120 Page No. 3074- 3080

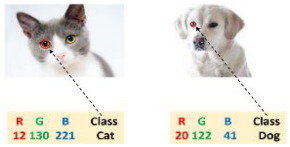

Figure 3. Elements of an Image.

A number of machine learning algorithms are in used for the image classification task. Some of the popular algorithms are SVM [30]. SVM is a very powerful algorithm for binary image classification problems [31]. Random forest is another power algorithm which uses decision trees to conclude the final class of the image, is used widely for satellite images, traffic image, multi-object classification problems [32] and another decision-based classifier C5.0 which is highly fast and uses memory very efficiently is also used in this area [33]. KNN remains most well-known, a simple algorithm to classify an image, though the accuracy is generally lower than other classifiers like SVM, Random forest, C5.0.

The above state algorithms are pretty good but during the last 5 years, a lot of technological leaps have been achieved in the area of deep learning with respect to image classification. We depicted the classical architecture of the deep learning algorithm. It consists of an input layer where basically we give the input data and the hidden layer where weights are assigned and computation is performed and the output layer is where the classification output lies. Some common problem deep learning algorithm can solve very efficiently are image classification, object detection, object tracking, image segmentation, colorization, image Reconstruction [34]. Deep learning is indeed breaking all barriers in terms of prediction accuracies. A classical deep learning architecture consists of an input layer which is basically data items, the hidden layer is where a weight is assigned to these data items. Further, an activation function is used to construct the output layer by the hidden layer. A comprehensive survey of different deep learning algorithms and architectures has been done by Alom et al [35], where they critically discussed Convolutional Neural Network, Feed Forward Neural Network, Recurrent Neural Network (RNN), Deep Belief Network, Deep Reinforcement algorithm, and Autoencoder.Also, this survey critically analyzed recent developments in deep learning and its ever-increasing application domain. Another survey by Pouyanfar et al [36], discussed deep learning algorithm and its applications in our world.Deep learning is taking AI to completely new levels, things which were not possible 5 years back are possible now. However deep learning has two major drawbacks which are (1) they are resource exhausted algorithms and (2) they follow black box approach that means, we do not know how they reach to the conclusion.

B. Autonomous Driving

Autonomous vehicles (AVs) are vehicles that can drive themselves without any human interference. AVs are now in the final stages of testing. Several industry titans such as Google, Tesla, Apple, Ford, Toyota, Uber all are in a race to bring a first fully autonomous vehicle on road. AVs consist of many sensors such as Lidar, Radar, cameras, GPS, etc. The problem here is to recognize different objects in the driving scene. In Fig 4, Alam et al [37], depicted an autonomous driving environment, which consists of dynamic scenes.Alam et al [37], proposed a multiple object detection algorithm which used multiple machine learning algorithms such as deep learning, C5.0, and SVM, to reach the final conclusion. They used a dataset which consists of five classes.Further, Alam et al[38], did a comparative analysis between C5.0 and feed-forward deep learning classifier for pixel level binary classification problem for AVs.

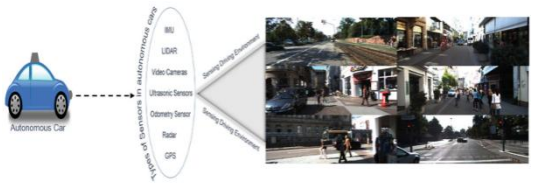

***Figure 4. Autonomous driving environment* [37].**

In the area of AVs, there are multiple problems which are critically needed for driving safely on road. Such as road detection, traffic signal identification, and obstacle detection, etc. Several works exist which uses machine learning to detect driving area which is road surface[39]. Some of them use enhanced versions of the SVM algorithm to predict road surface such as in [40] and Random forest algorithm is also successfully used in [41] for the same purpose. Rezaee et al [42] use high-resolution satellite images to predict road in the city by using a deep neural network. Whereas, Lyu et al[43], usinga combination of convolutional deep neural network and gated recurrent units. The shift from classical machine learning to more complex and advanced deep learning is very much evident in the above literature. Road detection is generally binary or three class problem if we include lane in it. Therefore the complexity level is not too high as compared to multi-class problems.

Traffic signal and signs identification is also an important problem. Kiran et al [44] proposed a linear SVM and Kumaraswamy et al [45], proposed an optimized SVM for real-time traffic signal predictions. Whereas Greenhalgh et al[46], proposed a method which is the combination of Random forest and Maximally Stable Extremal Regions. One of the toughest problem in autonomous driving as per the words of UC Berkeley research engineer Steven Shladover who said that "*Bicycles are probably the most difficult detection problem that autonomous vehicle systems face*". This is due to small size, fast speed, heterogeneous nature of cyclist and is a multifaceted problem [47].Espinosa [48], proposed pedestrian and cyclist detection method which uses fast deep R-convolutional neural networks.

We can clearly see in this section that machine learning and particularly deep learning is the main pillar for AVs environment perception technologies. They are achieving remarkable prediction accuracies which are not ever possible with other traditional machine learning algorithms. Despite this, there are still gaps which were very much

November-December 2019
ISSN: 0193-4120 Page No. 3074- 3080

evident in recent deadly crashes of Google [49] and Tesla [50] AVs where the driver lost their lives. This show there is a huge window to improve, which should be taken as an opportunity to make a better machine learning algorithm that can perceive our environment better and better and ultimately take us near to human intelligence. In Table

C. Data Fusion

Data fusion is where we combine data sensed from multiple sensors together to reach to the final outcome. It is well known that when we combine data from multiple sensors together it tends to produce better prediction accuracy. Data fusion gained more important now due to the inception of modern day technological paradigms like IoT, smart cities, edge computing and AVs where we have multiple sensors sensing the same environment [51]. Data fusion is an old and well-studied field. Previously it studied from a statistical point of view. However, in the last decade, we witness a shift in this approach. Now data fusion methods are using machine concepts and algorithms to fuse data and achieving better results. Alam et al [51], studied mathematical techniques in data fusion, Pires et al [52], whereas Nowak et al [85], studied the use of machine learning for data fusion purposes. Another important usage of data fusion is to make information precise and to the point. Data fusion can be divided into three categories which are (1) data level fusion, (2) feature level fusion, and (3) decision level fusion.IoT infrastructure is used by Smart cities, thus these future cities need to use data fusion.

VI. Machine Learning Challenges

In the last decade, we witnessed a significant development in the area of machine learning. Today machine learning is used in almost every field. Such as healthcare [53], social media [54], networking [55], eLearning [56], biomedical , robotics [57], physics [58], and climate research [59]. Even though we have achieved a lot in the last decade, still there are some critical and fundamental challenges for machine learning which are:

- It is a prediction, uncertainty always there.
- To have a lot of real data to train is always an issue [60].
- Deep learning algorithms are following black box approach where we cannot know how actually they are predicting.
- Lack of quality data is a huge issue [61].
- Prediction is based on what data machine-learning algorithms are trained, anything that is unknown is problematic.
- Human biases in data and parameter tuning can affect the outcome Madhu[62].
- Machine learning used to build AI can result in job loss [63].

Above stated are some critical challenges that machine learning faces today. However, there is a lot of research and development work going on this issue and we believe slow and steadily we will start solving them.

VII. Comparison

In this section, we will compare and summarized some of the best know machine learning techniques analyzed in [64]–[66]. Such as KNN, SVM, Random Forest, C5.0, Naïve Bayes and Deep learning as given in Table 1.

Table 1: Comparison of machine learning techniques

Technique	Advantages	Disadvantages
K-Nearest Neighbors	• Simple, Easy to implement • Used for Classification and regression	• Low accuracy, slow, cannot handle imbalanced and outlier data • Poor memory utilization
Support Vector Machine	• High accuracy • Handle unstructured and semi-structured data • Scale-up well	• Training time is large • Parameters tuning is hard, can result is poor output
Random Forest	• High accuracy • Scales well and flexible with feature scaling Handle outliers and missing values	• High complexity, Slow • Computationally expensive
C5.0	• Very fast, High accurate • Efficient memory utilization	• Get slower as number of features increase
Naïve Bayes	• Very simple, fast and easy to implement	• Low accuracy • Cannot handle complex data
Deep Learning	• Fast, distributed and parallel handle complex • Used for structured & unstructured data	• Complex design • Need computational resources • Parameter tuning is hard

VIII. Conclusion

Machine learning will greatly affect our lives in the near future. The way we think, eat, likes, dislikes, health, and travel, etc. In this paper, we touched two topics in machine learning which are different types of the machine learning task and modernday applications of machine learning such as image classification, AVs, and data fusion. The review shows that machine learning oriented solution will be more dominant in the future and none of the machine learning techniques can be termed as the best. The selection of technique should be based on the type of data, the problem that one is addressing, performance requirements and computational cost. Though we need to be careful in handling the various challenges that machine learning adds to our lives.

References

[1] A. Turing, “The Turing Test, 1950,” Alan Turing Internet Scrapb., 1950.
[2] Marvin Minsky and Daniel, AI: The Tumultuous Search for Artificial Intelligence. 1993.
[3] UCI, “UC Irvine Machine Learning Repository,” 2019. [Online]. Available: https://archive.ics.uci.edu/ml/index.php.
[4] Standford, “Stanford datasets,” 2019. [Online]. Available: https://snap.stanford.edu/data/.

November-December 2019
ISSN: 0193-4120 Page No. 3074- 3080

[5] Amazon, "Amazon public datasets," 2019. [Online]. Available: https://aws.amazon.com/opendata/public-datasets/.

[6] A. Geiger and P. Lenz, "Vision meets Robotics: The KITTI Dataset," Int. J. Rob. Res., 2013.

[7] E. Dutcher, "Berkeley Open datasets," 2019. [Online]. Available: https://datascience.berkeley.edu/open-data-sets/.

[8] H. Wang, C. Ma, and L. Zhou, "A Brief Review of Machine Learning and Its Application," 2009 Int. Conf. Inf. Eng. Comput. Sci., 2009.

[9] U. Narayanan, A. Unnikrishnan, V. Paul, and S. Joseph, "A survey on various supervised classification algorithms," 2017 Int. Conf. Energy, Commun. Data Anal. Soft Comput., 2017.

[10] P. Kamavisdar, S. Saluja, and S. Agrawal, "A Survey on Image Classification Approaches and Techniques," Int. J. Adv. Res. Comput. Commun. Eng., vol. 2, no. 1, 2013.

[11] Y. Kong and Y. Fu, "Human Action Recognition and Prediction: A Survey," Cornell Univ. Libr., 2018.

[12] H.-B. Zhang et al., "A Comprehensive Survey of Vision-Based Human Action Recognition Methods," Sensors, 2019.

[13] D. X. Tian, "A Comprehensive Survey of Clustering Algorithms," Ann. Data Sci., vol. 2, no. 2, 2015.

[14] A. Kumar, S. Mukesh, P. Mukesh, P. Akshansh, and C.-T. Lin, "A Review of Clustering Techniques and Developments," Neurocomputing, 2017.

[15] R. Hyndman and G. Athanasopoulos, Forecasting: Principles and Practice. OTexts.

[16] J. Miaoa and L. Niu, "A Survey on Feature Selection," Procedia Comput. Sci., vol. 91, pp. 919–926, 2016.

[17] C. Jie, L. Jiawei, W. Shulin, and Y. Sheng, "Feature selection in machine learning: A new perspective," Neurocomputing, vol. 300, 2017.

[18] V. J. Hodge and J. Austin, "A Survey of Outlier Detection Methodologies," Artif. Intell. Rev., vol. 22, no. 2, 2004.

[19] H. J. Escalante, "A Comparison of Outlier Detection Algorithms for Machine Learning," Semant. Sch., 2005.

[20] J. Thongkam, G. Xu, Y. Zhang, and F. Huang, "Support Vector Machine for Outlier Detection in Breast Cancer Survivability Prediction," in Advanced Web and Network Technologies, and Applications, 2008, pp. 99–109.

[21] L. Martí, N. Sanchez-Pi, J. M. Molina, and A. C. B. Garcia, "Anomaly Detection Based on Sensor Data in Petroleum Industry Applications," Sensors, vol. 15, no. 2, pp. 2774–2797, 2015.

[22] R. Hornung, H. Urbanek, J. Klodmann, C. Osendorfer, and P. van der Smagt, "Model-free robot anomaly detection," in 2014 IEEE/RSJ International Conference on Intelligent Robots and Systems, 2014, pp. 3676–3683.

[23] Xiaoqi Peng, Jun Chen, and Hongyuan Shen, "Outlier detection method based on SVM and its application in copper-matte converting," in 2010 Chinese Control and Decision Conference, 2010, pp. 628–631.

[24] H. C. Mandhare and S. R. Idate, "A comparative study of cluster based outlier detection, distance based outlier detection and density based outlier detection techniques," in 2017 International Conference on Intelligent Computing and Control Systems (ICICCS), 2017, pp. 931–935.

[25] B. Suthar, H. Patel, and A. Goswami, "A Survey: Classification of Imputation Methods in Data Mining," Int. J. Emerg. Technol. Adv. Eng., 2012.

[26] B. Yang, D. Janssens, D. RuanMario, C. Bellemans, and G. Wets, "A Data Imputation Method with Support Vector Machines for Activity-Based Transportation Models," Found. Intell. Syst., pp. 249–257, 2011.

[27] L. Beretta and A. Santaniello, "Nearest neighbor imputation algorithms: a critical evaluation," BMC Med Inf. Decis Mak, vol. 16, no. 3, 2016.

[28] A. Pantanowitz and T. Marwala, "Missing Data Imputation Through the Use of the Random Forest Algorithm," in Advances in Computational Intelligence, 2009, pp. 53–62.

[29] M, "Facial Recognition Is Getting Incredibly Powerfuland Ever More Controversial," MIT Technol. Rev., 2017.

[30] M. K. S. Varma, N. K. K. Rao, and K. K. Raju, "Pixel-Based Classification Using Support Vector Machine Classifier," 2016 IEEE 6th Int. Conf. Adv. Comput., 2016.

[31] G. Cavallaro, M. Riedel, M. Richerzhagen, J. A. Benediktsson, and A. Plaza, "On Understanding Big Data Impacts in Remotely Sensed Image Classification Using Support Vector Machine Methods," IEEE J. Sel. Top. Appl. Earth Obs. Remote Sens., vol. 8, no. 10, pp. 4634–4646, Oct. 2015.

[32] W. Man, Y. Ji, and Z. Zhang, "Image classification based on improved random forest algorithm," in 2018 IEEE 3rd International Conference on Cloud Computing and Big Data Analysis (ICCCBDA), 2018, pp. 346–350.

[33] R. Shirali, "Classification Trees and Rule-Based Modeling Using the C5.0 Algorithm for Self-Image Across Sex and Race in St. Louis," Washington University, 2016.

[34] A. Abdelfattah, "Image Classification using Deep Neural Networks — A beginner friendly approach using TensorFlow," The Medium, 2017. [Online]. Available: https://medium.com/@tifa2up/image-classification-using-deep-neural-networks-a-beginner-friendly-approach-using-tensorflow-94b0a090ccd4.

[35] M. Z. Alom et al., "A State-of-the-Art Survey on Deep Learning Theory and Architectures," Electronics, vol. 8, no. 3, 2019.

[36] L. Deng, "A tutorial survey of architectures, algorithms, and applications for deep learning," APSIPA Trans. Signal Inf. Process., vol. 3, no. January, p. e2, 2014.

[37] F. Alam, R. Mehmood, and I. Katib, "D2TFRS: An Object Recognition Method for Autonomous Vehicles Based on RGB and Spatial Values of Pixels," Mehmood R., Bhaduri B., Katib I., Chlamtac I. Smart Soc. Infrastructure, Technol. Appl. SCITA 2017. Lect. Notes Inst. Comput. Sci. Soc. Informatics Telecommun. Eng., vol. 224, pp. 155–168, 2018.

[38] F. Alam, R. Mehmood, and I. Katib, "Comparison of Decision Trees and Deep Learning for Object Classification in Autonomous Driving," in Smart Infrastructure and Applications: Foundations for Smarter Cities and Societies, R. Mehmood, S. See, I. Katib, and I. Chlamtac, Eds. Cham: Springer International Publishing, 2020, pp. 135–158.

[39] F. Alam, R. Mehmood, I. Katib, S. Altowaijri, and A. Albeshri, "TAAWUN: A Decision Fusion and Feature Specific Road Detection Approach for Connected Autonomous Vehicles," Mob. Networks Appl., 2019.

[40] L. Jing, T. Wang, M. Zhao, and P. Wang, "An Adaptive Multi-Sensor Data Fusion Method Based on Deep Convolutional Neural Networks for Fault Diagnosis of Planetary Gearbox," Sensors, 2017.

[41] L. Xiao, B. Dai, D. Liu, D. Zhao, and T. Wu, "Monocular Road Detection Using Structured Random Forest," Int. J. Adv. Robot. Syst., 2016.

[42] M. Rezaee and Yun Zhang, "Road detection using Deep Neural Network in high spatial resolution images," in 2017 Joint Urban Remote Sensing Event (JURSE), 2017, pp. 1–4.

November-December 2019
ISSN: 0193-4120 Page No. 3074- 3080

[43] Y. Lyu and X. Huang, "Road Segmentation Using CNN with GRU," Cornell Univ. Libr., vol. abs/1804.0, 2018.

[44] C. . Kiran, P. Lekhesh, R. Abdul, and K. Rajeev, "Traffic Sign Detection and Pattern Recognition Using Support Vector Machine," in 2009 Seventh International Conference on Advances in Pattern Recognition, 2009, pp. 87–90.

[45] R. Kumaraswamy, L. V Prabhu, K. Suchithra, and P. S. S. Pai, "SVM Based Classification of Traffic Signs for Realtime Embedded Platform," in Advances in Computing and Communications, 2011, pp. 339–348.

[46] J. Greenhalgh and M. Mirmehdi, "Traffic sign recognition using MSER and Random Forests," in 2012 Proceedings of the 20th European Signal Processing Conference (EUSIPCO), 2012, pp. 1935–1939.

[47] P. Fairley, "The Self-Driving Car's Bicycle Problem," IEEE Spectr., 2017.

[48] J. E. Espinosa, S. A. Velastin, and J. W. Branch, "Motorcycle detection and classification in urban Scenarios using a model based on Faster {R-CNN}," CoRR, vol. abs/1808.02299, 2018.

[49] A. Marshall and A. Davies, "Waymo's Self-Driving Car Crash in Arizona Revives Tough Questions," The Wired.

[50] J. Stewart, "Tesla's Autopilot was involved in another deadly car cash," The Wired, 2018.

[51] F. Alam, R. Mehmood, I. Katib, N. N. Albogami, and A. Albeshri, "Data Fusion and IoT for Smart Ubiquitous Environments: A Survey," IEEE Access, vol. 3536, no. c, pp. 1–24, 2017.

[52] I. M. Pires, N. M. Garcia, N. Pombo, and F. Flórez-Revuelta, "From Data Acquisition to Data Fusion: A Comprehensive Review and a Roadmap for the Identification of Activities of Daily Living Using Mobile Devices," Sensors, vol. 16, no. 2, 2016.

[53] K.-H. Yu, A. L. Beam, and I. S. Kohane, "Artificial intelligence in healthcare," Nature, 2018.

[54] E. Di Minin, C. Fink, H. Tenkanen, and T. Hiippala, "Machine learning for tracking illegal wildlife trade on social media," Nature, 2018.

[55] F. Alam, V. Thayananthan, and I. Katib, "Analysis of Round-robin Load-balancing Algorithm with Adaptive and Predictive Approaches," 11th Int. Conf. Control, 2016.

[56] R. Mehmood, F. Alam, N. N. Albogami, I. Katib, A. Albeshri, and S. Altowaijri, "UTiLearn: A Personalised Ubiquitous Teaching and Learning System for Smart Societies," IEEE Access, vol. 3536, no. 99, pp. 1–22, 2017.

[57] S. Bhattacharya, S. Dutta, T. K. Maiti, M. Miura-Mattausch, D. Navarro, and H. J. Mattausch, "Machine learning algorithm for autonomous control of walking robot," in 2018 International Symposium on Devices, Circuits and Systems (ISDCS), 2018, pp. 1–4.

[58] D. Guest, K. Cranmer, and D. Whiteson, "Deep Learning and Its Application to LHC Physics," Annu. Rev. Nucl. Part. Sci., vol. 68, no. 1, pp. 161–181, 2018.

[59] B. Kang, J. Jeong, and C. Jeong, "Distributed Parallel Deep Learning for Fast Extraction of Similar Weather Map," in TENCON 2018 - 2018 IEEE Region 10 Conference, 2018, pp. 1426–1429.

[60] M. M. Najafabadi, F. Villanustre, T. M. Khoshgoftaar, N. Seliya, R. Wald, and E. Muharemagic, "Deep learning applications and challenges in big data analytics," J. Big Data, vol. 2, no. 1, p. 21, 2015.

[61] W. Sundblad, "Data Is The Foundation For Artificial Intelligence And Machine Learning," Forbes Tech, 2018.

[62] S. Madhu, "Are Machines Doomed To Inherit Human Biases?," Forbes, 2018.

[63] D. Reisinger, "A.I. Expert Says Automation Could Replace 40% of Jobs in 15 Years," Fortune Tech, 2018.

[64] F. Alam, R. Mehmood, I. Katib, and A. Albeshri, "Analysis of Eight Data Mining Algorithms for Smarter Internet of Things (IoT)," Int. Data Min. IoT Syst. (DaMIS 2016), pp. 437–442, 2016.

[65] X. Wu et al., "Top 10 algorithms in data mining," Knowl. Inf. Syst., vol. 14, pp. 1–37, 2008.

[66] E. Uysal and A. Öztürk, "Comparison of machine learning algorithms on different datasets," in 2018 26th Signal Processing and Communications Applications Conference (SIU), 2018, pp. 1–4.