Guest Editorial

Machine Learning and Pattern Recognition

Learning is needed when there is no human expertise existing or when human beings are unable to explain their expertise. In such a situation, one simply collects all the possible previous information, analyse it and then make a rule for future prediction or taking meaningful decision. When we plan to conclude such a work with the help of a computer by providing it ample amount of data and our past experience with tools and techniques, then the whole process becomes machine learning. Hence, machine learning can be defined as 'programming computers to optimise a performance criterion using example data and past experience'. For example, recognition of spoken speech is being done by human beings seemingly without any difficulty, but cannot explain how they do it. In machine learning, the approach is to collect a large sample of utterances from people having different age, gender, or accent and learn to map these to words. It means to solve a problem which changes with time or depends on the particular environment; we would like to have a general purpose system that can adapt to its circumstances. In robotics, robots may learn to optimise their behaviour to complete a particular mission with limited resources.

Machine learning is an exciting field for many future applications like auto-driven cars under different road and weather conditions, multilingual telephony on real-time basis with translating facility to and from a foreign language, and autonomous robots that can navigate in a new environment on the surface of another planet, etc. Machine learning incorporates methods and tools that have their basis in different fields like pattern recognition, statistical learning theory, artificial neural networks, artificial intelligence, fuzzy logics, signal processing, and data mining.

Pattern recognition is a key to handle all such problems. A pattern is a meaningful regularity or a structure and it forms the basis of recognition for any source, symbol or structure. By the recognition of a pattern, we essentially mean classifying it to its appropriate class. The capability of pattern recognition of the biological system is the ultimate of technology. The human perceptive power seems to be well adapted to such pattern processing task. For example, recognition of individual speech, character of different fonts in a very robust manner, recognising the entire tune by observing just few whistle notes or identifying an old friend with a glimpse of the back of his head in a crowd. To understand the basis for this power in biological system, and consequently making an intelligent machine capable of performing the required recognition task involves the following two steps.

(i) Understanding the pattern recognition capability of living organisms, and
(ii) Developing the theory and techniques for designing devices capable of performing a given recognition task automatically.

Human beings interpret the physical world with the information available to them in the form of some patterns. Mathematically, a pattern is an arrangement of d-real numbers in vector or matrix notation such as $X=[x_1, x_2, x_3, \ldots, x_d]$ where d is the number of features characterising each pattern. In machine pattern recognition, the decision rules based on previous knowledge of the system are developed for each pattern class and these rules are used for deciding class-membership of unknown or new patterns.

Pattern recognition methods and models have attracted the researchers from the varied areas like biomedical and medical diagnosis, handwriting analysis, image processing, speech recognition, signal processing, and character recognition. The technique has got wide applications in the field of remote sensing, weather forecasting, forensic science application, sensor technology, computer science and engineering, information theory, cryptology, military science and many other areas of information retrieval and decision-making. This indicates the importance of the subject and the need for further development.

All methods and models can be classified in two exclusive categories. One is unsupervised pattern recognition or clustering, which uses only the proximity matrix to perform the classification and no category labels denoting *a priori* partition of the objects are used, and the other is supervised pattern recognition, where category labels on both the objects as well as the proximity matrix are required. The problem is then to establish a discriminating surface that separates the objects according to category.

In the present special issue, some of these technologies have been presented in some review papers, research papers, and short communications, a brief outlines of which is as follows.

In the paper 'Temporal pattern classification using kernal methods for speech recognition and speech emotion recognition' Chandra Sekhar and his co-author have proposed two models namely discrete hidden Markov models (DHMMs) and continuous density hidden Markov models (CDHMMs) in the kernel and explicit kernel feature space extracted from temporal data and SVM as classifier for speech recognition and speech emotion recognition problems. For recognition of spoken letters, they have proposed a model using discretised representation and string kernel SVM-based classification and observed that the performance is better than that of the model using continuous valued representation. The score vector-based approach and segment modelling-based approach have been used in a hybrid framework to model the sets of vectors-based representation to obtain a fixed-length pattern representation for a varying-length temporal data and these used these for classification. GMM score vector-based approach and the segment modelling-based approach are found to be much better for the task of speech emotion recognition.

Jha and his co-author in the paper 'Development of surface acoustic wave electronic nose using pattern recognition system' have modelled 11-element SAW sensor-based electronic nose to detect trinitrotoluene and dinitrotoluene explosive vapours in the presence of toluene, benzene, dimethylphosphonate (DMMP) and humidity as interferents. They have very wisely used several denoising techniques, principal component analysis (PCA) for feature extraction and artificial neural network (ANN), K- nearest neighbour, Naïve Bayes, and SVM as classifier. The electronic nose systems are very effective in detecting the hidden explosives and can play an important role in homeland security and forensics. The life of soldiers can be saved in case of chemical warfare. Developing pattern recognition system for each application with actual data is a costly affair, and hence, the proposed development of PR system for electronic nose with synthesised data is practical viability to search for appropriate sensors and effective data processing capability that will reduce the cost and time of development.

Singh and Yadav have proposed a new method for transient feature extraction, which uses approximation coefficients of discrete wavelet transform as input for PCA-based feature creation and selection in the paper 'Features extraction by wavelet decomposition of SAW sensor array transients'. The above tools have been used for recognition of seven volatile organic compounds (VOCs) vapours: chloroform, chlorobenzene, *O*-dichlorobenzene, *n*-heptanes, toluene, *n*-hexane and *n*-octane. Synthetic transient response data have been generated by a prototype 3-element polyisobutylene (PIB)-coated SAW sensor array. The analytical approach presented in the paper could be a new method for design and development of odour-sensing system based on SAW sensor array and pattern recognition.

Gireesh Kumar, Poornaselvan, and Sethumadhavan in the paper 'Fuzzy support vector machine-based multi-agent optimal path planning approach to robot environment' have dealt with the real-time navigation of a mobile robot. Fuzzy logic-based SVM have been proposed to achieve a collision-free path for the robot. The proposal has been validated in different unknown environments cluttered with static and dynamic obstacles and the robots have reached safely the target.

In the paper 'Boosting principal component analysis by genetic algorithm' Somvanshi and Yadav have combined PCA with GA to have a effective feature extraction method. PCA provides alternate feature spaces for data representation. All these features are fused and given a chromosome representation. The genetic evolution of fused feature vector provides significant feature components (genes) as survivours. The neural network classifier has been used with these features and UCI repository data have been analysed. The performance of the proposed method has been found to be better than the results reported in the literatures for most of the data analysed. The research work shows that the performance of PCA got boosted by GA.

Manju Bala and Agrawal in the paper 'Statistical measures to determine optimal structure decision tree-based one versus one support vector machine' have proposed to solve multi-class problems, where optimal structure of decision tree is determined with the help of information gain, gini index and chi-square. The performance of (OVO-ODT SVM) has been compared with (OVO SVM) in terms of classification accuracy and computation time. It has been observed that the proposed one is either comparable or better on various UCI repository data sets.

In the paper 'Influence of terrain on modern tactical combat : Trust-based recommender system' Bedi, *et al*. have designed and developed a prototype of trust-based recommender system for recommending to use a specific type of weapon or a set of weapons that best suit in a given type of terrain. They have used intuitionistic fuzzy set, from trustworthy pears and produced aggregated order of recommendations taking degree of trust on recommenders into consideration.

In the paper 'Payload estimation in universal steganalysis' the authors have attempted to compute the embedded payload in the image by any of the six popular steganographic algorithms, viz., JP Hides and Seek, PVD, LSB flipping, Outguess, S-Tool, and F5. Universal steganalysis can easily recognise the image with or without cover, but estimation of payload is an open problem. They have used PCA along with support vector regression to estimates the payload and support vector machine for classification of six algorithms. The detection accuracy and the quantitative steganalysis are found to be better than that of universal steganalysis.

Saxena, *et al.* in their paper 'Index for garbledness for automatic recognition of plain English texts' have studied the characteristic of plain English language and extracted 10 fuzzy features, based on which they have defined Index of Garbledness to identify the plain English text even from the running character stream. It also provides the information, that to the extent the text is random. This tool can be used effectively to identify the plain English text from cipher text.

Asthana and Verma in their paper 'Classification of encrypted text and encrypted speech' present the identification of encrypted text and encrypted text bit stream from mixture of cipher bit stream. This work is of much importance from cryptanalysis point of view. They have taken various block length data for feature extraction and used well known minimum distance classifier and maximum likelihood classifier for identification.

There is fair representation of tools and techniques used in machine learning and pattern recognition in the present special issue. I am very grateful to all the authors who have contributed research papers covering many aspects of this widely used technology.

I am indeed grateful to the reviewers for their time and providing expert comments for the improvements and revisions of these papers by the authors. I am also grateful to Editor-in-Chief for prompt approval of my proposal to bring out a special issue on state-of-the-art topics on machine learning and pattern recognition for defence science problem.

Finally, I would like to thank Director, DESIDOC and his team for their untiring efforts in bringing out this special issue.

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