

AI, Deep Learning and Deep Fuzzy Network

Abstract: We are living in an era where Artificial Intelligence (AI) has started to scratch the surface of its true potential. Not only does AI create the possibility of disrupting industries and transforming the workplace, but it can also address some of society's biggest challenges. In many contexts, notions of AI, machine learning, and deep learning are used interchangeably, but machine learning and deep learning are a subset of AI. AI is the branch of computer science focused on building machines capable of intelligent behaviour, while machine learning and deep learning are the practice of algorithms, where a machine can learn by experience and make predictions or take autonomous actions without any human involvement. Therefore, instead of programming specific constraints for an algorithm to follow, the algorithm is trained using a large amount of data to give it the ability to learn, reason, and perform a specific task independently.

Even with the advances and success of deep learning algorithms in various applications like speech recognition, image classification, handwriting recognition, fraud detection, etc., the deep learning model has still some limitations. As the number of hidden layers and nodes increases, the number of parameters also increases, which in turn increases the computational complexity of the model. Along with that, a large amount of labeled training data is required for training the deep network from scratch. In addition, parameter optimization and hyperparameter tuning greatly affect the performance of deep networks. However, in the era of big data, a large chunk of data available from various sources generates data that can be used to train the deep models easily. Also, to deal with computational complexity, graphical processing units have garnered popularity in the deep learning community for their ability to handle a high degree of parallel operations and efficiently perform matrix multiplications. Machine learning algorithms based on different architectures built using artificial neurons have become state-of-the-art algorithms. Of them, multi-layered feed-forward Artificial Neural Networks (ANN) have been the most successful. Typically, the data used for machine learning algorithms can be categorized in (a) Numerical and (b) Linguistic forms. However, both have certain limitations. Extracting relevant information using only the numerical data is not sufficient because the dataset may have some missing points which may not be able to provide accurate information about the system. On the other hand, relying only on linguistic data, derived from human supervisory operators, is useless for training various algorithms because human experts aren't always able to describe the complete relevant information of a system. Fuzzy sets and Fuzzy Inference Systems (FIS) prove to be capable of incorporating both the above forms of data in the underlying system. Even in the absence of sufficient learning examples, fuzzy set-based systems can be trained using linguistic data. Both ANNs and FISs are used to mimic a system whose model is unknown since both have the universal function approximation capability. Due to advancements in fuzzy logic and systems in the past decades, handling such complex data has become easy. In effect, the addition of fuzziness into the model of a neuron makes it better to adapt the behaviour of underlying systems that are imprecisely defined through their high degree of complexity. The linguistic and numeric forms of data can be handled together by a Deep Fuzzy Network (DFN). There is a wide scope to develop very effective machine learning architectures based on DFNs with high abstraction quality, high robustness towards uncertainty due to vagueness,

ambiguity, and imprecision as well as uncertainty due to randomness and intuitively intelligible to human beings in terms of design and working. DFN allows machines to solve complex problems even when using a dataset that is very diverse, unstructured, and inter-connected. The more deep learning algorithms learn, the better they perform.

Brief CV: Dr. Nishchal K Verma is a Professor in the Department of Electrical Engineering at the Indian Institute of Technology Kanpur, India. He obtained his Ph.D. in Electrical Engineering from the Indian Institute of Technology Delhi, India. He is an awardee of Devendra Shukla Young Faculty Research Fellowship by Indian Institute of Technology Kanpur, India, for 2013-16.

Dr. Verma's research expertise falls under Artificial Intelligence (AI) related theories and its practical applications to many inter-disciplinary domains but not limited to machine learning, deep learning, computer vision, prognosis and health management, bioinformatics, cyber-physical systems, complex and highly non-linear systems modeling, clustering, and classifications, etc. He has published more than 250 research papers and 4 Books (edited/ co-authored) in the field of AI. He has completed 23 projects from various funding agencies such as The BOEING Company, USA, DST, DRDO, JCBCAT, MHRD, SERB, CSIR, IIT Kanpur, MCIT, SFTIG, VTOL, etc. He has 15+ years of experience in the field of AI. He has been serving as Associate Editor/ Editorial Board Member of various reputed journals and conferences, including IEEE Transactions on Artificial Intelligence, IEEE Transactions on Neural Networks and Learning Systems, IEEE Computational Intelligence Magazine, Editor, IEEE Access, and many more. He has also developed several AI-related key technologies for The BOEING Company, USA, and organized AI-related workshops, conferences, seminars, short-term courses, etc.