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The importance of machine learning in the computer application

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ABSTRACT

Machine learning is about extracting knowledge from data. It is a research field at the intersection of statistics, artificial intelligence, and computer science. It is known as predictive analytics or statistical learning. The application of machine learning methods has in recent years become ubiquitous in everyday life. It is from automatic recommendations of which movies to watch, to what food to order and which products to buy, to personalized radio and recognizing. The many modern websites and devices have machine learning algorithmsat their core.

It is very likely that every part of the site contains multiplemachine learning models. It is outside of commercial applications,machine learning has a tremendous influence on the way data-driven research is done today. The tools introduced in this book have been applied to diverse scientific problems such as understanding stars. The finding distant planets, are discovering new particles, analyzing DNA sequences, and providing personalized cancer treatments. It is large scale or world changing.

Machine learning is programming computers to optimize a performance criterion using example data or past experience. We

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have a model defined up to some parameters, and learning is the execution ofa computer program to optimize the parameters of the model using the training data or past experience. The model may be *predictive* to make predictions in the future, or *descriptive* to gain knowledge from data, orboth.

Keywords : automatic, Machine, Facebook, Amazon, or Netflix.

Machine learning is the term coined to introduce humanlike intelligence in machines to do real-world tasks. In 1997, Tom Mitchell gave a very clear definition with respect to engineering domain: "A computer program which can learn from experience with respect to some task and some performance measure and improves its performance with experience." It is the study of algorithms that improve the performance of humans at some task with experience. The term "experience" refers to a training done prior to getting the results on new data. This means that the algorithm will train itself using the past experience so as to handle new data. The quality of the solution is judged by some criteria which is called fitness function of heuristic function. This function is decided based upon the problem characteristics so as to best represent the fitness of the current solution. For example, in the travelling salesman problem, it will be the distance travelled so far, in the image classification problem, it will be the classification accuracy obtained and so on. Machine learning encompasses a range of techniques such as rough sets, fuzzy sets, etc. Many statistical measures such as regression testing, support vector machines, naive Bayes classifier, etc. are used to train and test the algorithms developed.[i]

Machine learning can be generously applied in the design of recommender systems. In traffic pattern prediction on roads, military enemy base station prediction, and movie recommendation) These algorithms can also be applied very efficiently in natural language processing applications like in text summarization, sentiment analysis, etc. These algorithms are efficiently designed to solve the optimization problem at hand and represent and evaluate the model for inference

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There are several evaluation measures used for testing the performance of machine learning algorithms (eg, statistical tests, Kappa coefficient, error matrix in classification problems, and precision and recall). Machine learning is used when not much human expertise exists to work for every input in hand. For example, navigating on Mars is an example of a problem where no prior expertise exists and there needs to be an inferencing mechanism which will predict the challenges that will be faced and the solutions for the gaps that exist. Here comes the role of machine learning. Another example is the image classification problem. To solve this problem, we will need a prior knowledge base of some representative pixels which tells us that the given pixel in the image belongs to which land cover feature on the ground. This prior knowledge base is called training set in machine learning terminology, and this database will be used henceforth in every machine learning application belonging to supervised category.[ii] To throw light on the term "training set", we would like to mention that there are broadly two types of machine learning supervised and unsupervised.

Supervised learning, as the name suggests, means in the presence of an expert knowledge base. Thus, we require human expertise on some test cases to predict the solutions of the remaining cases in the input database. The training set is a small portion of the total dataset which is meant to train the machine learning algorithm such that it will produce the correct solution over the rest of the database on which it has not been trained. Thus, we call this approach as supervised learning approach.

On the other hand, unsupervised learning is the ability to draw conclusions about the patterns in the database so that the database is grouped together into clusters and the prediction has to be done cluster-wise. We consider each cluster as a separate entity describing some characteristics different from the other clusters. We thus classify the data into corresponding solutions based on the cluster similarity without any training set or intervention of human expertise. This type of learning may not be able to generate final named solutions, however, it will be able to group s solutions. For

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example, in image classification problem, this type of learning cannot classly the pixels as belonging to a specific feature; rather, it can group the similar pixels which belong to a common feature together. This type of learning is not practically used in machine learning approaches

Machine learning is used classically when humans are unable to explain their expertise. Asa example, consider the case of speech recognition. A person can identify the difference in the sound of different individuals. However, quantitative assessment of therify the which he used to judge this is not an easy question for him to answer since this decision remains subjective human perception. These kind of problems can very well be approached by using various ma hon the algorithms. Another case where machine learning sprucharysetul is when the ton changes over time. For example, routing on a computer network in this case, the dec variables which characterize the solution change over time.

Machine learning algorithms can deal with this type of situation by tuning the weights of these variables to incorporate the changed values with every iteration. Thus, the solution which is opti mal is found at the end of the iterative process. They are also useful when the solution needs to be adapted to particular cases, as most machine learning algorithms are dependent on a fitness function or heuristic function which is in turn dependent upon the set of variables which charac venize the solution. This set of variables can be formulated according to the problem domain in the beginning of the iterative process of any machine learning algorithm. Hence, we can adapt the algorithm according to the particular case. For example, for a biometric application, the user's biometrics can form the decision variables based on which the decision about the individual will be made. A more specific example is that of face recognition application, where factors such as the eigenvalues of faces and the Euclidean distance between the face features formulate the decision variables based on which the face is classified into an appropriate category.

Machine learning is not used when the decisions are subjective to human interpretation. That s. when the decisions are dependent upon human perception, different individuals may find different

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solutions for the same problem because they perceive different solutions to be the best as per their expertise In this case, if machine learning is used, it will produce different answers depending upon the dataset which is used for training the algorithm. So, in such cases, it will not produce accurate results. Machine learning is also not advised when the domain knowledge is easily available for large datasets as machine learning will be a waste of computer resources. In such cases, human expertise is sufficient to give best solutions as domain knowledge is available for complete dataset and, therefore, generation of training set is not required. Machine learning algorithms search, they do not discover. This means that machine learning algorithms can search for the best solution amongst the already available solutions and optimize the search to give the best results iteratively. [iii]

However, they cannot generate new solutions. They do not discover any new solution. This means that they can search for an existing solution but cannot find out any new better solution. Machine learning techniques can lead to cost reduction since manpower is expensive and therefore human expertise cannot be available always for large datasets, In this case, we use machine learning to train the algonthm on the small dataset for which human expertise is available and then test on the remaining dataset to get prediction on unknown data. This way human expertise is not required on the complete data and this leads to significant cost reduction using machine learning algorithms

Approaches To machine learning

- **Optimization problem:** Every machine learning problem isangdimication problem, be Optimization of maximization problem. For example, in training artificial neural network (ANNs) with many decision variables or parameters, we try to tune the weights in each ters tion so that we get an optimal fitness function which will make the sum of squared me between actual and desired output as minimum and the accuracy of results is max when viewed on the training sets. Similarly in support vector machines (SVMs), the problem is viewed as a constrained optimization problem to minimize the objective function called hinge loss. The

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learning algorithm is an optimization problem and we use different types of optimization methods, for example, gradient descent in ANNs, quadratic programming in SVMs, Maximum Likelihood Classifier (MLC), Minimum Distance to Mean Classifier (MDMC), rough sets, fuzzy sets, etc. for performing learning.

- **Probabilistic search:** Machine learning problems can be viewed as probabilistic search problems since the probability of the solutions are compared to determine which one is the best solution amongst the existing ones. The training set is used to generate the probabilities of the decision variables. The fitness function which assumes the probabilities of wegtes very near to the generated probabilities is chosen. This fitness function will best represent the training set and will be the most accurate on new inputs. The training algorithm is viewed as performing probabilistic inference to find the maximum likelihood or the maximum pos teriori probability parameter values. Thus, using Maximum Likelihood Estimation (MLE) Maximum Apriori Probability (MAP), the machine learning algorithm will first find the correct weights of the decision variables and formulate a fitness function and then use it to solve the given problem on the test dataset so as to maximize or minimize the error.

- **Parametric programming:** This refers to choosing parameter values in machine learning algorithms so as to formulate the fitness function based on the domain knowledge of the given application. For example, deep neural networks can be viewed as implementing parameterized programs where the learned parameters make a specific program out of a set of candidate programs predefined by the network structure. More complex networks like recurrent neural networks (RNNs) have a greater number of representable programs.

- **Evolutionary search:** In this, learning leads to an improvement in accuracy but it is not clear whether that improvement comes from probabilistic inferencing or from optimization Evolution is a process in which the successor is better but the environment as well as the set of competitors of the successor also change, so the definition of better successor is not crisp.[iv]

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Review of literature

- **According to Nishika Gupta 2017:** The father of Artificial Intelligence, John McCarthy states a definition for AI which says that Artificial Intelligence is the science and engineering of making intelligent machines, especially intelligent computer programs. Artificial Intelligence (AI) is intelligence exhibited by machines. In computer science the field of AI defines itself as the study of intelligent agents. Generally, the term AI is used when a machine simulate functions that humans associate with other human minds such as learning and problem solving.

- **According to Nazmiye Guler, 2024:** Artificial Intelligence (AI) has emerged as a disruptive force, transforming industries, reshaping our lives and work, and significantly impacting businesses, institutions, and societies. Driven by advancements in machine learning and deep learning, as well as the exponential growth of available data, AI technologies have enabled machines to handle complex tasks such as natural language processing, image recognition, and decision-making

- **According to Francisco Bolaños 2024**: A Systematic Literature Review (SLR) is a rigorous and organised methodology that assesses and integrates previous research on a specific topic. Its main goal is to meticulously identify and appraise all the relevant literature related to a specific research question, adhering to strict protocols to minimise biases (Higgins 2011; Moher et al. 2009). This methodology originally emerged within the realm of Evidence-Based Medicine Sackett et al. (1996), and it was subsequently adapted and employed in diverse research disciplines including social sciences Petticrew and Roberts (2008), engineering and technology Keele et al. (2007), education Gough et al. (2017), environmental sciences Pullin and Stewart (2006), and business and management Tranfield et al.

- **According to Muhammad Yasir Mustafa:** The roots of Artificial Intelligence (AI) go back

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to the 1950s when John McCarthy organized a workshop at Dartmouth College aiming at defining AI (Russel & Norvig, 2010). The concept of AI was then widely and broadly discussed and investigated in many fields and domains, especially education. The growing usage of AI is reshaping the educational environment extensively in the last five years (Allam et al., 2023; Chu & Yang, 2022), as Artificial intelligence in education (AIED) has changed the education system, knowledge-sharing approaches to learning, cognition and development of civilization (Kaur, 2021). Bojorquez and Vega (2023) highlight that AIED could advance learning practices, support teachers, and create more personalized learning opportunities for learners.

Building Efficient Machine Learning Systems

- We might need to make additional assumptions about the dataset beyond the training sets based on our domain knowledge since no system can get 100% accuracy on unseen datasets. This because the machine learning system cannot learn based on the input training set. All the classification rules for each output category depend upon the completeness of the training set. This is also called "no free lunch" theorem.

- There are always some error in the fitness function learned by machine learning systems These errors are of bias, variance, and natural error. Bias error comes when the system faidh to consider equally each possible function that can be defined over the input. This is because the system search space may be insufficient to represent every function that can be labeled over the input. Variance in the training data can also be a source of error.[v] If we consider training data obtained from a set of random examples, then statistical variations in this set of random samples can lead to unrepresentative training sets, thus leading to error. The error can be reduced by increasing the number of training sets samples. The other error is unavoid able error which might happen due to learning non-deterministic functions which happens in most of the cases since the output is the probability of being correct. For example, if the correct output of

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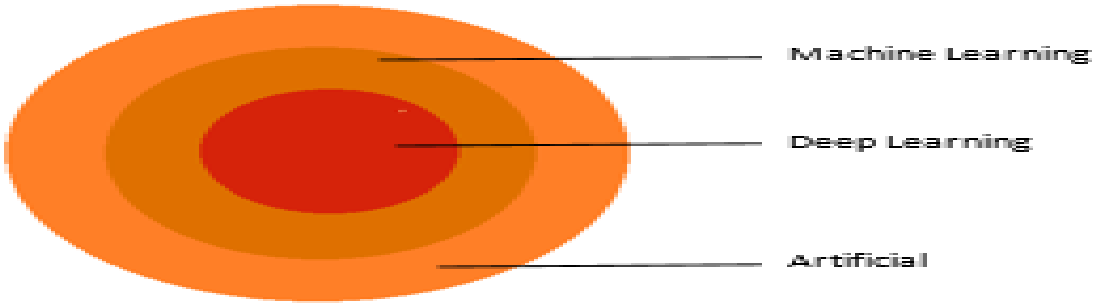
the classifier has 0.6 probability then this will mean that output will be wrong in remaining of the cases. If the correct output has probability 0.4, then the output will be correct in 40% of the cases.



Artificial intelligence versus Machine learning.

- We should consider overfitting in the training samples when designing machine learning algorithms. Overfitting is the case when the error rate shown over the training data is less than that over the actual data. This problem comes when the size of training samples is small or the search space is huge. In both the cases, multiple solutions may perform equally well over the training data and the decision about which will perform best over future test data cannot be made. Solution is to use cross validation and regularization. Cross validation is a means of choosing the size of the search space based on its performance on training data and regularization is adding a tolerance limit so as to adjust for future errors beforehand. This means adding a penalty to the learning objective that reduces the value of parameters, thus providing a bias. This increase in bias decreases the sensitivity of the machine learning algorithm to variance in the training sample

- We can use Bayesian networks for joint probability distributions over a set of decision variables. These networks are directed acyche graphs in which each node represents a variable,

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edges represent probabilistic dependencies, and conditional probabilities are associated with each variable which define the joint probability distribution over the entire set of variables. The structure of this network represents assumptions about the conditional independence among variables and represents how a factorization of the joint probability of "e" variables can be mapped to "n" terms. The joint distribution obtained by the chain rule of probability can be compared with the joint probability in this network to see the restrictions in the graphical structure that Bayesian network allows.

- We can build efficient machine learning systems by the use of two types of learning models generative and discriminative models. Naive Bayes method and logistic regression are based on both types of models since logistic regression uses a function for which the input comes from Bayesian method. For sequential data. Hidden Markov Models and Conditional Random Fields are examples. The discrimination part does not make any assumptions while training and generative part constrains the search space.

Conclusion

We can use deep neural networks to perform larger computations, where learning involves training the parameters of all units in the network. This training can be done using gradient descent methods with specialized hardware such as nonlinear rectilinear units and long- short term memory (LSTM) units. There are specific architectures available such as sequence-to-sequence architectures used for machine translation and other types of sequential data, convolutional network architectures for image classification, and speech recognitions. An important characteristic of the architecture is that it gives constant cut put in case of multiple translations of input representing same data, for example, different positions of the same image or same speech at different time. Deep neural networks can learn reopent tiems of input data at different hidden layers in the network. The ability to leate such representations has led to networks capable of assigning tags to multimedia hased on their metadata.

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