

Survey of Machine Learning Algorithms For Dynamic Resource Pricing In Cloud

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ABSTRACT

The paper provides insights of various machine learning algorithms that could be helpful in deriving the dynamic pricing of resources in cloud. Currently machine learning has impact on many IT and non IT sectors. At the same time because of great change in computing from on premise to cloud computing many big companies have opted cloud computing in which resources are provided on demand basis via internet. On the basis of resource usage machine learning algorithms help to predict the future demand and also help in deciding the price of resource at the time of request (spot request).

Keywords: Cloud Computing, Cloud Pricing, Machine Learning Algorithms

I. INTRODUCTION

One of the aims of machine learning algorithms is prediction. Like linear regression, multiple regression algorithms help various sectors to increase profitable opportunities by forecasting demand. Forecasting can be based on the past data sets. As cloud services are delivered on demand basis the future demand of resources can be forecast by using these machine learning algorithms and new pricing models can be derived.

The paper has started with cloud computing and its pricing policies(1.1), brief about machine learning algorithms and its

categories(1.2), literature surveyed on machine learning algorithms is represented under heading(2), conclusion(3).

1.1 Cloud Computing and pricing policies: cloud computing are the services provided over the internet, like other utility consumer needs to pay the bills as per the consumption. There are various layers of services provided by cloud like software as a service (SaaS), platform as a service (PaaS), infrastructure as a service (IaaS) etc are presented in Table-1.

The major reasons for the companies opting cloud is security, scalability, fast data recovery etc. Big cloud providers are Amazon (AWS), Google (Google cloud), Microsoft, IBM etc.

Table 1. Service model

Service Model Name	Description	Providers	Services
Software as a Service (SaaS)	Cloud provider delivers its software as a service to be used by the customer on demand.	Google	Google doc
		Microsoft	Microsoft Office
		Salesforce	CRM
		in	LinkedIn
Platform as a service (PaaS)	Provider's delivers application development tools in addition to services for testing, deploying, hosting and maintaining applications.	Google	AppEngine
		Microsoft	Azure
		Salesforce	Heroku
		Amazon web services	Elastic Beanstalk
		IBM	Bluemix
		RedHat	OpenShift

Infrastructure as a Service (IaaS)	Providers provides users with physical and virtual resources that satisfies the requirement of the user applications in terms of CPU, memory, operating systems and storage	Amazon	EC2,S3
		Google	Google compute engine
		Microsoft	Windows Azure
		IBM	IBM SmartCloud Enterprise

The cloud providers have their own policies to charge for the services like Amazon has on demand pricing, reserved pricing and auction based.

With On-Demand instances, user pays for compute capacity by the hour with no long-term commitments or upfront payments. User can increase or decrease their compute capacity depending on the demands of the application and only pay the specified hourly rate for the instances they use. [1]

Reserved Instances provide you with a significant discount (up to 75%) compared to On-Demand instance pricing. In addition, when Reserved Instances are assigned to a specific Availability Zone, they provide a capacity reservation, giving you additional confidence in your ability to launch instances when you need them. [2]

Auction pricing was proposed by Amazon EC2 which whether or not a subscriber obtains the VM depends on the price it offers. It is also known as dynamic pricing. Auction based pricing is fair for both customer and service provider because the price is set as per the level of demand and supply [3]. In auction pricing there are two terms first spot price and second bid price.

For using spot instance the customer can request for instance (spot request). Request contains the bid price also. If the bid price is greater than the spot price the resource will be allocated to the customer immediately otherwise it will be allocated when price of spot become less than the bid price.

Table 2. Cloud Resources

Sr#	Name of family	Instance Name	Description
1	General purpose	M4,M3,T2	Memory to CPU ratio suitable for most general purpose applications.
2	Compute Optimized	C4,C3	More CPU than RAM for compute sensitive applications.
3	Memory Optimized	R3,R4	Larger size for memory intensive applications.
4	GPU	P2	Parallel processing for 3D graphic capability using OPENGL.
5	Storage	L3,L2	For data warehousing

Above Table 2 represents some example of resources provided by AWS.

1.2 Machine Learning-Machine learning is the branch of computer science that concerned with generating such algorithms that takes input from the historic data(training data set) and make prediction based on it. One of the examples is Amazon's algorithms that

recommend item based on items you have purchased before

There are mainly three types of machine learning algorithm as shown in Fig-1. Supervised machine learning, unsupervised learning, reinforcement learning. Supervised learning is algorithm in which there are training data labelled data is given.

Currently most industry uses the supervised learning to achieve the work well known algorithm in this category

are artificial neural network (ANN), linear regression, support vector machine (SVM), deep learning based CNN (convolutional neural network) and RNN(Recurrent neural network) architectures .Unsupervised is same without labelled data. K-means clustering is an example of unsupervised algorithm still most of the unsupervised algorithms are under the area of research. Reinforcement learning is the algorithm in which machines are forced to learn and take appropriate action contextually. It is mostly used in area of AI.

In recent years a London based start up which is later acquired by the Google, Deepmind achieve the major breakthrough in the area of AI by using the reinforcement learning algorithm. The company developed the algorithm which beats the highest score by human in 50 plus games. The summary of various machine algorithms is presented in Table: 3 (Machine learning algorithms).

These algorithms help the cloud provider to predict the price of the resources at the time of bidding.

II. METHODS AND MATERIAL

Table 3. Machine learning algorithms

Sr No.	Name of Algorithm	Description	Mathematical model	Applications	Advantages	Limitations
1.	Linear Regression [5]	Supervised learning technique to predict the outcomes in quantitative way. Its work on the basis of error minimization technique to fit the linear model.	$h_{\theta}(x) = \theta_0 + \theta_1 x$ θ_0, θ_1 are parameters Cost function $J(\theta_0, \theta_1) = \frac{1}{2m} \sum_{i=1}^m (h_{\theta}(x^{(i)}) - y^{(i)})^2$	Evaluate the trend in the business and help in forecasting future demand.	It is useful when there is a linear relationship between dependent and independent variable.	It is limited to linear relationship only. It is predicting numeric output only.
2.	Multiple Regression [6]	It is extended version of linear regression model to predict the outcomes of more than one variables	$h_{\theta}(x) = \theta_0 + \theta_1 x$ θ_0, θ_1 are parameters Cost function $J(\theta_0, \theta_1) = \frac{1}{2m} \sum_{i=1}^m (h_{\theta}(x^{(i)}) - y^{(i)})^2$	Predict the multivariable outcomes/multi classification problems. Used in market research.	It is useful when there is a linear relationship between dependent and independent variable.	It is limited to linear relationship only. It is predicting numeric output only.

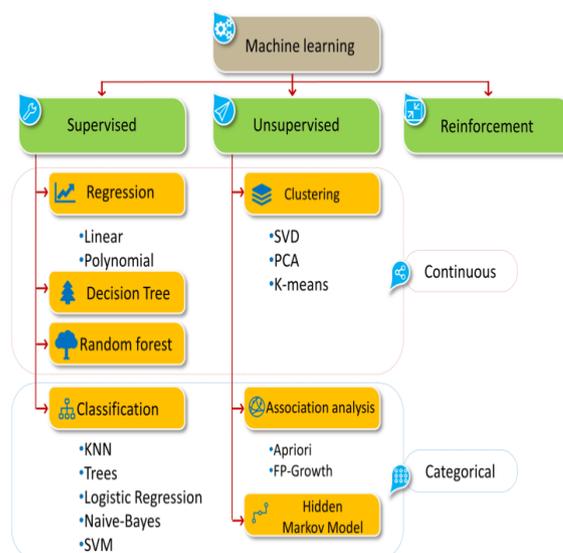


Figure 1. Categories of Machine learning algorithm [4]

3.	Decision Tree[7]	In decision tree outcome is based on the combination of conditions.	$Entropy = -p \log_2 p - q \log_2 q$ Entropy for each branch is calculated to get the gain or decrease in entropy. $Gain(T, X) = Entropy(T) - Entropy(T, X)$	Used in bank for loan processing, in finance for option pricing	It finds the most important feature in data sets, easy to understand.	Complex for the large data set.
4.	Naive Bayes classifier [8]	Naive Bayes classifier works on the basis of bayes theorem to predict the outcome of posterior probability from the prior probability.	$P(c x) = P(x c)P(c) / P(x)$	Sentiment analysis, document categorization-mail spam filtering	It is well when the input variables are categorical, converges faster, requiring relatively little training data than logistic regression	It works under the assumption of Markov chain that means the current outcome depends on only the previous outcome. y(t) outcome depends on y(t-1)
5.	Artificial Neural Network (ANN) [9]	ANN is method which has input unit hidden units and output unit's weights to predict the outcomes. Mainly work on the basis of back propagation algorithm and gradient decent optimizer.	derivative = output * (1.0 - output) error = (weight_k * error_j) * transfer_derivative(output) weight = weight + learning_rate * error * input	Very good to solve the classification problem and pattern analysis	Easy to understand and produces good classification results.	-
6.	K-means clustering [10]	It is well known unsupervised learning algorithm to make the cluster/label from the data. It's a generative algorithm which works iteratively.	-	It is used by the most of the search engine like Google to cluster WebPages by similarities of their content.	It does not required labelled data.	Missing variate values cannot be handled by this algorithm.
7.	Support vector machine (SVM) [11]	It is a supervised algorithm, it can be helpful in analysing the data for regression as well as for classification	Depends on the selection of kernel.	Recognition of hand written characters, image classification.	It represents the data in latent space. It performs well for image data.	Computationally complex as compare to ANN.
8.	Hidden Markov Model (HMM) [12]	Hidden Markov model work on the basis of Markov chain assumption, state transition probability and emission transition probability.	θ =sequence of state o =sequence of observation $q_0 q_1$ =(start, final) A=state transition probability B=emission probability C=initial state probability compute probability model (A,B,C)	Language translation, pattern recognition, language modelling	It reveals the hidden features of given sequential data set.	Complex to understand

9.	Deep learning [13]	Deep learning algorithms are deep neural networks which work on the raw data sets. DNN automatically select the best suited features to perform the task.	There are different architectures to deal with different types of problems.	Classification Problems, Pattern recognitions, Speech recognition, Natural language processing, Object detection, etc.	No need of manual feature engineering. It selects the feature automatically from data sets and performs the task.	It is computationally very expensive and need lot of training data set as well.
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III. CONCLUSION

As there are different cloud service provider in the market and the boom of the cloud, IT companies has opted cloud. According to the behaviour of the company adoption of cloud the above machine learning algorithm can predict the future demand of cloud resources and help the provider to drive the new pricing policies. Each algorithm has its advantage and limitations; it can be found which will give the best result by implementing WEKA (Waikato Environment for Knowledge Analysis) [14] and other tools. Authors [15] compared various supervised learning algorithms.

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