International Journal of Research in Advent Technology, Vol.7, No.5S, May 2019 E-ISSN: 2321-9637 Available online at www.ijrat.org Hidden Markov Models: A Stepping Stone To Multidisciplinary Research

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Abstract--- Hidden Markov Models (HMM) is an efficient machine learning technique which is designed to model the complex, non-linear and stochastic processes. HMM provides many phases for researchers in the field of pattern recognition, bioinformatics, information retrieval, e-commerce applications etc. This paper reviews the basic concepts behind HMM which can be used as an efficient method to do multidisciplinary researches. **Keywords---** Hidden Markov Models (HMM), Machine Learning, Pattern Recognition.

1. INTRODUCTION

A. Machine Learning

Machine Learning is a study of methods for programming computers to learn. It addresses research questions in the field of statistics, data mining and psychology, with different emphasis. Consider the speech recognition data and it would focus on different emphasis. A machine learning approach may focus on building an accurate and efficient speech recognition system; statistician and psychologists would focus on the hypotheses about the mechanisms underlying speech recognition; A data mining approach would discover patterns in speech data that could be applied to group of speakers according to age, sex etc [2].

B. Pattern Recognition

Humans have developed highly sophisticated skills for sensing their environment and taking actions according to what they observe such as recognizing a face, understanding spoken words, reading handwriting, distinguishing fresh food from its smell. The similar capabilities that human would perceive are applied to machines result in pattern recognition [1].

TABLE 1 APPLICATIONS OF PATTERN RECOGNITION

Problem Domain	Application	Input Pattern	Pattern Classes
Speech Recognitio n	Telephone Directory Assistance	Speech Waveform	Spoken Words
Biometric Recognitio n	Personal Identificatio n	Face, Iris, Fingerprin t	Authorized Users
Medical	Computer Aided Diagnosis	Microscop ic image	Cancerous/ healthy Cell
Military	Automatic target recognition	Infrared images	Target type

2. HIDDEN MARKOV MODEL (HMM) *A. Introduction*

Hidden Markov Models (HMM) is a statistical Markov model which is modeled and assumed to be a Markov process with unobserved (hidden) states and it resembles a simple dynamic Bayesian network.HMM is closely related to optimal non-linear filtering problem such as a stochastic process. In HMM, the state is not directly visible but the output dependent on the state is visible and each state has a probability distribution over the possible output tokens [3].HMM can be considered as a generalization of a mixture model where the hidden variables which control the mixture component to be selected for each observation are related to a Markov process.



Fig.1 A simple HMM Model

B. Example problem for HMM



Fig.2 Weather Forecast Problem

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Suppose a person is locked inside the room for several days. If he wants to predict the weather outside, the only evidence is whether the care taker is carrying an umbrella or not and the following probabilities of carrying an umbrella include:

TABLE 2

PROBABILITY OF CARRYING UMBRELLA		
Weather Type	Probability of Umbrella	
Sunny	0.1	
Rainy	0.8	
Foggy	0.3	

The equation for the weather Markov process before a person locked in the room is given by:

$$P(w1, ..., wn) = \prod_{i=1}^{n} P(wi|wi-1) - (1)$$

Now the actual weather is hidden from the person and by using Bayes' rule:

$$P(w1, ..., wn | u1, ..., un) = \frac{P(u1, ..., un | w1, ..., wn) P(w1, ..., wn)}{P(u1, ..., un)}$$

where ui is true, if the caretaker bought an umbrella for day i, and false if the caretaker didn't. The probability P(w1, ..., wn) is the same as the Markov model and the probability P(u1, ..., un) is the prior probability of seeing umbrella events (eg. {True,False,True}).The probability P(u1, ..., un|w1, ..., wn) can be estimated as $\prod_{i=1}^{n} P(ui|wi)$ and for all i, given wi,ui is independent of all u_j and w_j, for all $i \neq j$.

C. Types of HMM



Fig.3 Illustration of 3-distinct types of HMMs. a) A 4state Ergodic Model b)A 4-state L-R Model c)A 6state Parallel Path L-R Model

Ergodic or fully connected HMMs in which every state of the model could be reached in a single step from every other state of the model. i.e., an ergodic model has the property that every state can be reached from every other state in a finite number of steps. Left-Right or a Bakis model is underlying on the fact that as time increases, the state index increases or stays the same. i.e., the states proceed from left to right [4]. The fundamental property of all left-right HMMs is that no transitions are allowed to states whose indices are lower than the current state. A cross coupled connection of two parallel left-right HMM is a left-right model that has the flexibility over Bakis model is that its re-estimation procedure [4].

D. Matrix representation of HMM

Consider a Markov model with two states and six possible emissions. The model uses: red die, having six sides, labeled 1 through 6. A green die, having twelve sides, five are labeled 2 through 6 and the remaining seven sides are labeled 1. A weighted red coin is tossed where the P(H)=.9 and P(T)=.1 and a weighted green coin where P(H)=.95 and P(T)=.05. It is represented in the Fig.4.



Fig.4. Probability of tossing red and green coins

It would create a sequence of numbers $\{1, 2, 3, 4, 5, 6\}$ with the following rules: Emission- Rolling the red/green die and writing down the number that comes up.

Step 1: Toss the red coin and do any one of the operation:

If it is heads, roll the red die and write down the result.

If it is tails, roll the green die and write down the result.

Step 2: At each subsequent step, flip the coin that has

the same color as the die.

Step 3: If the coin comes up heads, roll the same die

as in the previous step. If the coin comes up tails,

switch to the other die.

E. HMM's role in Social Networks

HMM is used to classify the user generated content during mega events like World Cups; sequence of topics are used to specify an event; combining information from multiple events using SUMMHMM; In Twitter, HMM is used to generate Parts of Speech tagging(POS); segmenting block of text during conversation in FB. Intel introduces Streaming SIMD Extensions 2 (SSE2) technology to evaluate HMM with Viterbi Decoding [5].

F. Applications of HMM

HMM is applied in a variety of fields such as Speech recognition, Language modeling, Information retrieval, Motion video analysis/tracking, Protein sequence and genetic sequence alignment and analysis, financial time series prediction, Modeling growth and the use of cells in biological systems etc [5]. It is quite useful in applying probabilistic models to analyzing discrete sequence data in molecular and computational biology. Lots of interesting applications

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of HMM in Computational Biology include finding whole genome shotgun sequence fragment assembly, multiple alignments of conserved sequences, splice site detection and inferring phylogenetic trees [5].HMM can be applied to other application domains such as E-Commerce to extract product/pricing information from many sites, convert information into structured format and to provide interface to look up product information. Users can consult a single site rather than navigating to and searching many sites [5]. *G: Merits and Demerits*

Merits of using HMM are: It is elegant and easy to understand; easily extended for strong tasks; dynamically assembled according to the class sequence during training; it has embedded reestimation procedure; HMM is very effective in speech recognition.

Demerits of using HMM are: Make very large assumptions about the data; requires more no of parameters; the states and transitions depends on the class being learnt.

3. CONCLUSION

Hidden Markov Model (HMM) is a statistical Markov process usually designed to model complex, non-linear and stochastic processes based on machine learning approach. This paper reviews the basic concepts behind HMM and its matrix representation. Variety of real world applications using HMM are portrayed and it serves as an efficient stone for researchers who want to pursue multidisciplinary research.

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