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Hidden Markov Model

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I. Acknowledgement

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II. Declaration

We declare that the Submitted Report is our original work and no values and context of it have been copy-pasted from anywhere else. We take full responsibility, that if in future, the report is found invalid or copied, the last decision will be of the Faculty concerned. Any form of plagiarism will lead to the disqualification of the report.

III. Abstract

Hidden Markov Model (HMM) is a statistical model in which the system will be modeled and assumed to be a Markov process. In a hidden Markov model, the state X is unobservable however there will be an outcome Y based on the which state the we are in at a time t. Credit Card fraud detection technique using HMM is a process which trains the Hidden Markov Model using the sequence of transactions of the cardholder. Whenever there is an incoming transaction, if that incoming transaction is not accepted by trained HMM with sufficiently high probability then we consider the transaction to be fraudulent

IV. Introduction

Credit cards are used to buy products and services in everyday life, either as a virtual card for online transactions or as a physical card for offline transactions. Credit cards are inserted into payment machines at merchant shops to purchase products in a physical transaction. In this case, tracing fraudulent transactions may be impossible because the attacker has already stolen the credit card. In the case of online payments, attackers simply use only a small amount of information to carry out a fraudulent transaction (secure code, card number, expiration date etc.). The majority of transactions in this buying method will take place over the internet or over the phone. Smaller transactions are often subjected to less scrutiny and are less likely to be scrutinized by the card issuer or the retailer. Issuers of credit cards must take greater precautions against fraud. fraud detection and financial losses. Credit card fraud cases are increasing every year. Hidden Markov Model will be helpful to find out the fraudulent transaction by using the spending profiles of users. It works on the user spending profiles which can be divided into major three types such as 1) Lower profile; 2) Middle profile; and 3) Higher profile.

V. Markov Models

A Markov model is a stochastic method for randomly changing systems that possess the Markov property. This means that, at any given time, the next state is only dependent on the current state and is independent of anything in the past. Two commonly applied types of Markov model are used when the system being represented is autonomous – that is, when the system isn't influenced by an external agent. These are as follows.Markov chains. These are the simplest type of Markov model and are used to represent systems where all states are observable. Markov chains show all possible states, and between states, they show the transition rate, which is the probability of moving from one state to another per unit of time. Applications of this type of model include prediction of market crashes, speech recognition and search engine algorithms.Hidden Markov models. These are used to represent systems with some unobservable states. In addition to showing states and transition rates, hidden Markov models also represent observations and observation likelihoods for each state. Hidden Markov models are used for a range of applications, including thermodynamics, finance and pattern recognitionMarkov decision processes. These are used to model decision-making in discrete, stochastic, sequential environments. In these processes, an agent makes decisions based on reliable information. These models are applied to problems in artificial intelligence (AI), economics and behavioral sciences.Partially observable Markov decision processes. These are used in cases like Markov decision processes but with the assumption that the agent doesn't always have reliable information. Applications of these models include robotics, where it isn't always possible to know the location. Another application is machine maintenance, where reliable information on machine parts can't be obtained because it's too costly to shut down the machine to get the information.

VI. Three observations related to HMM

a) T: here are three fundamental problems that we can solve using HMMs. Here, we briefly describe these three problems, and in the next section we give efficient algorithms for their Solution. 1.Given a Hidden Markov Model and an observation sequence What is the probability of the Model producing that particular sequence. 2. Given a Hidden Markov Model and an observation sequence Which state sequence maximizes the probability of given observation sequence. 3. Given an observation sequence, how to train the model to get such parameters of HMM to maximize the probability of the observation sequence.

VII. Algorithms

a) Forward Algorithm: The Forward Algorithm is used to calculate the forward probability of the sequence given our parameters and the observation sequence. The forward probability is also known as "Belief state".We have observed three observation symbols which may come from the either sunny state or rainy state. We need to find the probability of the corresponding observation sequence given our Hidden Markov Model. Here the initial probability is considered as stationary distribution Viterbi Algorithm The Viterbi Algorithm is similar to the forward algorithm. This algorithm helps us to find a state sequence which maximizes the probability of the given observation sequence. We will take the node with the maximum probability Now let's understand the algorithm Intuitively: Consider the above diagram explained in HMM. Now we know how to calculate the initial probabilities. Baum Welch Algorithm In this algorithm we will train our HMM according to the given observation so that the probability produced for that observation would be maximum. In this algorithm we use Maximum Likelihood Estimation. Steps: 1. We will start with the initial set of values of A and B. That may be either random or can be equal probabilities 2. Now we will compute the expectation of how often each transition/emission has been used. We will estimate latent variables [,]. 3. Now we will re-estimate the probabilities [A,B] based on the latent variables , . 4. We will repeat this process until values of A and B converg:

VIII. Credit Card Fraud Detection

a) In credit card fraud detection we take the spending profile of the card holder and divide that into 3 types low, medium and high using KMeans clustering. The values of low, medium and high depends on the spending profile of the card holder. With those labels (which are predicted my the kmeans algorithm) we will train a HMM using Baum-Welch Algorithm and get the values of A and B. Whenever there is an incoming transaction 1st we will take last 10 transaction and calculate the forward probability of those last 10 transactions and denote them as 1 . Now we will take last 9 transactions and append the incoming transaction to that last 9 transaction and calculate the forward probability of these 10 transactions and denote them as 2 . When 1 2 > 0 which means that the new transaction is accepted by the HMM with less probability and this transaction could be a fraud transaction. From the experimental values we set the threshold value to be 0.6. When 1 2 1 then we consider the incoming transaction to be fraud. This system is implemented in code part as FDS which is Fraud Detection System. Applications:

IX. Some wide applications related to HMM

a) Sequence Alignment in Biology Widely Used in NLP Inference from Time Series Molecular Evolutionary models Phylogenitcs:

X. Conclusion

a) We took the real-world data i.e. transactions of a credit card and trained our model with some of the data and then tested it, which resulted in greater than 90exploring this concept of HMM made us walk through some other concepts like ContinuousTime Markov Models, other methods of expectation-maximization, etc.: