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Research Article

An Analysis on the Markovian Model for Production Management and Establishment of New Pharmacies Using Hyper Graph

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Stochastic models are mainly used to rectify the real-life problems in different areas of the busy world such as marketing, trading, networking, communicating media, and challenging biomedical inventions, for the survival of mankind. Any business which runs on the basis of getting more profit with less investment includes all the resources for production and the man power too, during the current century. To bring the equality in business gain and man power, many stochastic models have been introduced since the 1940s. The different states and the steady state probabilities are discussed by the Markov models to overcome the insufficiency of man power. An Iterative Hidden Markov Model has been introduced for effective production by considering the observable states depend on hidden states under the circumstances of real-world probabilities are known and unknown. This paper mainly deals with the various machines, pharmacies, and different methods, namely, Nonadjacency Search Method and Adjacency Search Method applied through the Hyper graph. Comparison made between Nonadjacency Search Method and Adjacency Search Method through hyper assignments using cliques helps us to obtain tremendous profit through effective production and to start new pharmacies, instead of predictions through computational methods. Results were discussed based on the information obtained from Apollo pharmacies.

1. Introduction

Markov models are always act as an effective medium among the inventions of various areas such as inventory control, Marketing, customer classification, Economics, Finance, Risk analysis, and Bio-Informatics. Probabilistic Markov models are widely applied in inventories to burnish control over the business. Customer's demand, available product, production management, and the manpower are the resources involved in the business. The Iterative Hidden Markov Model has been applied in man power and machine power for the effective production management involves the real-world parameters which are estimated by using the minimization problem [1]. Hidden Markov Models (HMMs) are used to identify the threats involved in national security, diseases involved in the human body, and the data sequence analysis in human cell movement. Though the diseases can be arrested and treated by the variety of medicines given by the doctors, paying the bills raised by the hospitals are very big challenges to the patients. The economic evaluation and also the effective cost management are discussed in[2, 3]. During the COVID-19 pandemic situation, people are seeking for the medicines to be delivered to their home and searching for the better services provided by pharmacies. The nonadjacency search method has been applied in bipartite hyper graph to find the route map for purchasing the better medicines in better medicals in minimum cost and to maximize the profit in the production field too [4, 5]. The trend has changed to the new modern society which includes the levels of people and the different

methodologies used for the better survival. As the population increases, the production of manufacturing also increases with greater competitions [6]. These healthy competitions make the business world to fight for the survival of their concerns. The workers are always shifted from one place to another place based on the atmospheric conditions, salary, and other benefits. Because of frequent transformations, only concerns remain but not the workers [7, 8].

To avoid the shortage of workers, Markov models and many algorithms, namely, the Viterbi algorithm, Maximum likelihood estimators have been applied [9, 10]. Applications of man power in various stages of business are discussed and solution were obtained by using eight point scale and ten point scale of stochastic models. A group of people lying under the same initial point of different diseases are categorized and treated them with an appropriate therapy and the patients of each state are also estimated by simulated Markov models [11, 12]. Monte Carlo methods have been used for data sequence analysis [13, 14]. Beyond the mathematical models and calculations, graphical representations are always the supreme power for validating the Markov models and giving the quick and exact judgments of the models [15]. Hyper graphs are constructed in different methods on the basis of (1) Visual features and (2) View clustering. Samples selected for an experiment are denoted by vertices and the relationships between the samples are represented by the edges of a graph in general. Preferably graphs might be determined by directed or undirected in which the relationships between samples are commensurate or not. The hyper graph has been explored innumerable data mining and information recuperation assignments, as it has the potential for assimilating an interrelationship between samples in higher order [16, 17]. The survey has been conducted among the different pharmacies, whether the proposed models through hypergraph are effective to open more pharmacies of the respective type. Outcomes were discussed in later sections and the solutions arrived at using cliques were shown graphically.

2. Basic Definitions

The following are the definitions which are related to the hyper graph that exists in [18–20].

Definition 1. A graph in which each edge is associated with any number of vertices is called hyper graph [21].

(i.e.) A hyper graph χ contains (X, C), where X denotes the vertex set and C denotes the set of hyper edges. Each hyper edge can accommodate any number of vertices from the vertex set X and the set is not empty. Therefore, each hyper edge is a nonempty subset of the vertex set X.

Definition 2. A hyper graph χ (X, C) is bipartite if X is disassociated into two subsets A and B of X whose intersection is null and $X = A \cup B$.

The bipartite hyper graph is represented as $\chi = (A, B, C)$, A and B are the set of vertices whose intersection is null and C contains all the hyper edges of a given graph. The disassociated vertex sets are equal in number as assumptions made and all hyper edge $c \in C$ has the same number $|c \cap A| = |c \cap A| > 0$ of vertices in A and B.

Definition 3. $\chi = (A, B, C)$ is a bipartite hyper graph. The subset C_1 of C in the hyper graph χ is called an assignment if any two hyper edges in C_1 are nonadjacent.

Definition 4. $\chi = (A, B, C)$ is a bipartite hyper graph. An assignment H in χ is said to be a hyper assignment in χ if every vertex belongs to its union (i.e) $v \in A \cup B$ is contained in exactly one hyper edge $c \in H$.

Definition 5. Let $\chi = (A, B, C)$ be bipartite hyper graph. A clique of a hyper graph is defined as for every two different vertices of vertex set, there is an edge of hyper graph which includes both the vertices.

3. Algorithm for Nonadjacency Search Method

The hyper assignments of a bipartite graph are identified using a Nonadjacency Search Method (NASM).

Stage 1: group all the edges which are not adjacent to each edge in the given graph and are denoted by C_i (set of all edges which are not adjacent to each of c_i, $i = 1, 2, \ldots, n$).

Stage 2: erect the edge set $C^* = \{m \in \{C_1, C_2, \ldots C_n\}: \bigcup_{c \in m} c = A \cup B\}$.

Stage 3: if C^* is empty, then there is no hyper assignment. If C^* is nonempty then go to stage 4.

Stage 4: take $C^* = \{C_1^*, C_2^*, \ldots C_m^*\}$, $1 \le m \le n$. Consider C_1^*.

Stage 5: enumerate the complete edge set which are adjacent to each edge of C_1^* with respect to C_1^*.

Stage 6: enumerate the complete edge set whose intersection is null w.r.t C_1^* by applying the set obtained from stage 5. Consider this set as $D^* = \{D_1, D_2, \ldots D_p\}$: $1 \le p \le n$.

Stage 7: if D^* is empty then the graph has no hyper assignment related to C_1^* and proceed to stage 9. If D^* is nonempty then proceed to stage 8.

Step 8: for each $1 \le i \le p$, $\bigcup_{c \in D_i} c = A \cup B$, then D_i is a hyper assignment in χ, or else it is an assignment in χ.

Stage 9: apply stage 5 to stage 8 for $C_2^*, C_3^*, \ldots, C_m^*$ and eject the enumeration.

Stage 10: get the hyper assignments from Stage 8.

4. Hyper Graphical Structure for Effective Production

Let us consider the man power with High, Moderate, and Low levels are denoted as set of vertices a_1, a_2, and a_3, and the machines used to manufacture the products with High, Moderate, and Low levels are denoted as a set of vertices b_1, b_2, and b_3. The production companies are denoted as a set of edges c_1, c_2, c_3, c_4, c_5, and c_6. The production companies

which are related to the different levels of man power and machines are defined as follows: the production companies c_1 and c_2 avail high man power $a_1$and highly production rate machine b_1. The production companies' c_2, c_3, and c_4 avail moderate man power a_2 and moderate production rate machine b_2. The production companies' c_2 and c_5 avail high man power $a_1$and moderate production rate machine b_2. The production companies' c_5 and c_6 avail low man power a_3 and low production rate machine b_3. The edge set which contains the collection of vertices are represented as follows: $c_1 = \{a_1, b_1\}, c_2 = \{a_1, a_2, b_1, b_2\}$, $c_3 = \{a_2, b_2\}, c_4 = \{a_2, b_2\}, c_5 = \{a_1, a_3, b_2, b_3\}, c_6 = \{a_3, b_3\}$. The relation among the vertices and edges are shown in Figure 1.

Let C_1, C_2, C_3, C_4, C_5, and C_6 be the set of all edges which are not adjacent to each of c_i, $i = 1, 2, 3, 4, 5, 6$.

$$C_1 = \{c_1, c_3, c_6\}, C_2 = \{c_2, c_6\}, C_3 = \{c_3, c_1, c_6\},$$
$$C_4 = \{c_4, c_1, c_6\}, C_5 = \{c_5\}, C_6 = \{c_6, c_1, c_3\}, \quad (1)$$

and $\bigcup_{c \in C_i} c = A \cup B, i = 1, 2, 3, 4, 6$.

To apply stage 5 to stage 8 in C_1, $\{c_1, c_3, c_6\}$ is the hyper assignment. To apply stage 5 to stage 8 in C_2, $\{c_2, c_6\}$ is the hyper assignment. To apply stage 5 to stage 8 in C_4, $\{c_4, c_1, c_6\}$ is the hyper assignment.

Therefore, $H_1 = \{c_1, c_3, c_6\}, H_2 = \{c_4, c_1, c_6\}, H_3 = \{c_2, c_6\}$ are the hyper assignments which shows that the manpower is more whenever the machines are more, manpower is moderate when the machines are moderate and the manpower is low whenever the machines are low.

The production companies can follow any one of these hyper assignments for effective production of products to get maximum profit.

5. Algorithm for Adjacency Search Method Using Cliques

The hyper assignments of a bipartite graph are identified using a new model called Adjacency Search Method (ASM) using maximal cliques.

Stage 1: collect the set of all cliques of each edges c_i, $i = 1, 2, \ldots, n$ of a hypergraph

Stage 2: identify the edge which contains the clique of maximum order is called the maximal clique represented by $c_i^*, i = 1, 2, \ldots n$

Stage 3: group all the edges which are adjacent to each edge in the given hypergraph. Let it be C_i, $i = 1, 2, \ldots, n$

Stage 4: identify the C_i, $i = 1$ in which the maximal clique exists is called the hyper assignment otherwise called an assignment. If the hyper assignment does not exist then go to stage 5

Stage 5: proceed stage 4 for each C_i, $i = 2, 3, \ldots, n$. to get the hyper assignments

6. Structure of Hyper Graph for Opening Maximum of New Pharmacies

Reasons for opening a new pharmacy are listed as follows:

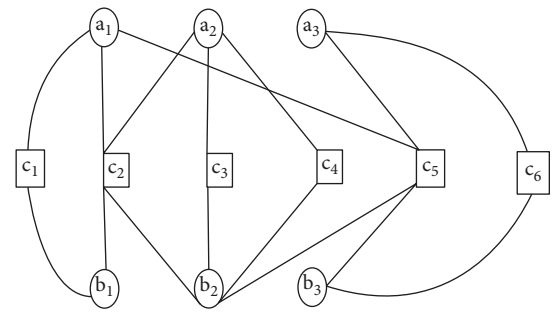

Figure 1: Hyper graph (manpower, machines, production companies).

(1) More sales ⇒ More discount

(2) Less rent for shops ⇒ Flexibility to pay medicine bill

(3) More residential area ⇒ Expect home delivery

(4) More parking area in shops ⇒ Customer's convenient to park their vehicle

(5) Common transport facility for the customers to reach the branch ⇒ Customers do not have own vehicle

(6) Located in visible region ⇒ An advertisement to the people passing by

(7) Availability of medicines for customers' satisfaction ⇒ Prescribed by different doctors for various diseases

The production and sales of a particular product depends on the demand and best service from customers and shop keepers. The manufacturers are always working for customers' satisfaction. The following are the key points for opening a greater number of Apollo pharmacies in Tamil Nadu. For example, different types of medicines are prepared for different diseases by different manufacturers. Customers avail the medicine from the manufacturers is quite difficult. The numbers of medical shops in different names have been opened to serve the customers. Some shops are getting developed by opening more branches and some shops are tending to close. The following model analyzes the reason for opening/closing medical shops using hyper graph.

Let a_i, $i = 1$ to 7 be the vertices which represents the strength of manufacturers in view of shop keepers of a hyper graph. Let b_i, $i = 1$ to 7 be the vertices which represents the strength of manufacturers in view of customers of a hyper graph. Let c_i, $i = 1$ to 6 be the edges which represents the medical shops on different names of a hyper graph. The vertices of a hyper graph in view of shop keepers and customers are defined as follows:

a_1- More sales

a_2- Less rent for shops

a_3- More residential area

a_4- More parking area in shops

a_5- Common transport facility for the customers to reach the branch

a_6- Located in visible region

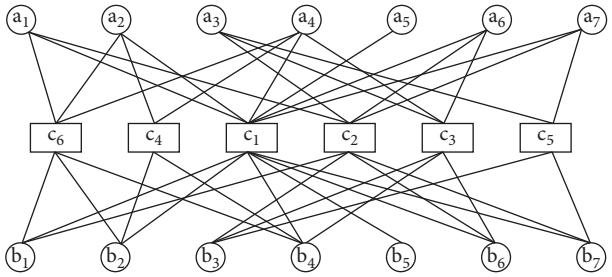

Figure 2: Hyper graph (strength of manufacturers in view of shop keepers, customers, pharmacies).

a_7- Availability of medicines for customers' satisfaction

b_1- More discount

b_2- Flexibility to pay medicine bill

b_3- Expect home delivery

b_4- Customer's convenient to park their vehicle

b_5- Customers do not have own vehicle

b_6- An advertisement to the people passing by

b_7- Prescribed by different doctors for various diseases

The edges of a hyper graph are the famous group of pharmacies which are located in Tamil Nadu are defined as follows:

c_1- Apollo Pharmacy

c_2- Med Plus

c_3- Green Pharmacy

c_4- Muthu Medicals

c_5- Bawa Medicals

c_6- Thulasi Medicals

The edge set which contains the collection of vertices are represented as follows: $c_1 = \{a_1, a_2, a_4, a_5, a_6, a_7, b_1, b_2, b_4, b_5, b_6, b_7\}, c_2 = \{a_1, a_3, a_6, a_7, b_1, b_3, b_6, b_7\}$, $c_3 = \{a_3, a_4, a_6, b_3, b_4, b_6\}, c_4 = \{a_2, a_4, b_2, b_4\}, c_5 = \{a_3, a_7, b_3, b_7\}$, $c_6 = \{a_1, a_2, a_4, b_1, b_2, b_4\}$. The relation among the vertices and edges are shown in Figure 2.

From stage 1, let the cliques of each edge c_i, $i = 1, 2, \ldots, 6$ be.

c_1 contains the clique of order 12

c_2 contains the clique of order 8

c_3 contains the clique of order 6

c_4 contains the clique of order 4

c_5 contains the clique of order 4

c_6 contains the clique of order 6

From stage 2, since c_1 contains the clique of maximum order 12, c_1 has a maximal clique and is denoted by c_1^*.

From stage 3, let the set of all adjacent edges of c_i, $i = 1, 2, \ldots, 6$ be.

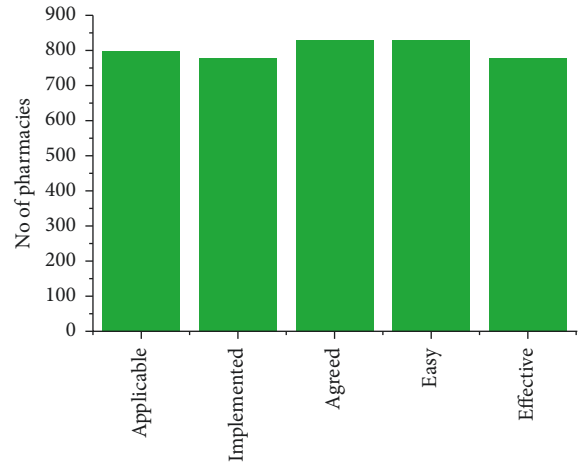

Figure 3: Bar chart representation of number of pharmacies accepting different criteria for starting new pharmacies.

$$C_1 = \{c_1^*, c_2, c_3, c_4, c_5, c_6\},\ C_2 = \{c_2, c_1^*, c_3, c_5, c_6\},$$
$$C_3 = \{c_3, c_1^* c_2, c_4, c_5, c_6\},\ C_4 = \{c_4, c_1^*, c_3, c_6\}, \quad (2)$$
$$C_5 = \{c_5, c_1^*, c_2, c_3\},\ C_6 = \{c_6, c_1^*, c_2, c_3, c_4\}.$$

From stage 4, all C_i's, $i = 1, 2, \ldots, 6$ contains a maximal clique c_1^*. Hence C_i's, $i = 1, 2, \ldots, 6$ are the hyper assignments.

Since the maximal clique c_1^* exists in all hyper assignments and the corresponding edge c_1 is adjacent to all other edges of a given hypergraph, every clique of a hyper assignment is connected to each other. Therefore, the hypergraph corresponding to the given model representing the Markov chain is irreducible [22]. Hyper assignments are identified using cliques rather than the nonadjacency search method is reliable and adapted to different circumstances.

Hence, it is concluded that the edge c_1 which represents the Apollo pharmacy meets the maximum number of conditions on customers view and the shopkeepers view and it is being opened in large numbers in recent years compared to other pharmacies.

7. Results and Discussion

Based on the survey conducted among the production machines and the pharmacies around 850 numbers, the following queries were put forth whether the proposed modified model ASM in terms of cliques would be (1) Applicable, (2) Implemented, (3) Agreed, (4) Easy, and (5) Effective? It has been answered by the people that the model is applicable by 800 numbers, implemented by 780 numbers, agreed by 830 numbers, easy by 830 numbers, and effective by 780 numbers. Figure 3 and Table 1 show the data sheet of the sample analyzed in the study.

From the bar chart, it is very clear that the production machines and the pharmacies which agreed and easy to manipulate the ASM have the high production rate, and also the number of Apollo pharmacies has been started in more

Table 1: Data for the pharmacies to adopt ASM.

S. no	Criteria	No. of pharmacies
1	Applicable	800
2	Implemented	780
3	Agreed	830
4	Easy	830
5	Effective	780

Table 2: Data for the growth of different pharmacies in Chennai from 2000 to 2021.

S. no	Years	Apollo pharmacy	Med plus	Green pharmacy	Muthu medicals	Bawa medicals	Thulasi medicals
1	2000	165	152	0	1	4	0
2	2005	200	210	0	2	3	1
3	2010	265	270	2	4	4	2
4	2015	280	290	16	8	3	2
5	2020	300	325	18	10	4	5
6	2021	322	325	19	12	4	7

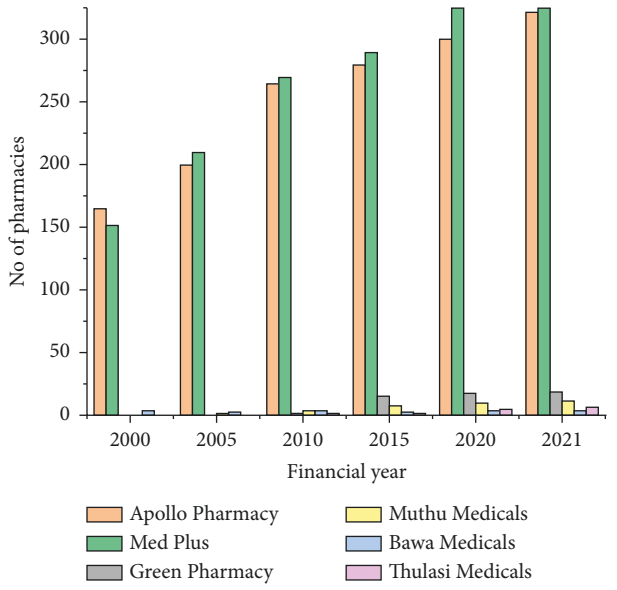

Figure 4: Trend line for the growth of pharmacies in Chennai.

numbers than the other pharmacies discussed in earlier sections 4, 6. Though the Apollo hospitals originated in Andhra Pradesh, their branches have started deliberately in Chennai in the year 2000 with less than 5 hospitals. But thereafter the Apollo pharmacies were started gradually in and around Chennai along with the tough competitors like Med plus, Green pharmacy, Muthu Medicals, Bawa medicals, and Thulasi medicals. The growth of these pharmacies is analyzed in the years 2000, 2005, 2010, 2015, 2020, and 2021 and shown in the following Table 2.

The growth of different pharmacies in the years 2000, 2005, 2010, 2015, 2020, and 2021 are represented as numbers 1 to 6 in the X-axis of Figure 4. From the trend lines, it is very clear that the growth of Apollo Pharmacy increased gradually than the other pharmacies. Though the Apollo pharmacies and Med plus have equally good in the growth till 2020, and the year 2021 shows more advancement of Apollo pharmacies. The growth of Apollo pharmacies is highly effective and started new pharmacies in different corners of cities and out of cities. The Markovian model applied in Hyper graph is discussed in terms of cliques. Hyper assignments were identified using cliques and the pharmacy which has been started in larger numbers is highlighted. The ASM is adequate to the Apollo pharmacies and the reasons for opening new pharmacies in view of customers and shopkeepers are interrelated. Therefore, the relation between the customers and the shopkeepers is very strong and shows the ASM is suitable for Apollo pharmacies. The pandemic situation due to COVID-19 is also being organized by the Apollo pharmacies in 24×7 and the medicines are delivered to the door step of customers [23]. The result and discussion conclude that the pharmacies in different names which adopt ASM have started more new branches.

8. Conclusion

In this paper, the nonadjacency search method (NASM) has been applied in the bipartite hyper graph and the hyper assignments are identified to analyze the better combinations of machines and manpower for effective production management. The modified method called adjacency search method (ASM) has been applied in the bipartite hyper graph and the hyper assignments are identified to analyze the reasons for opening new pharmacies using maximal clique. It is concluded that the hyper assignments of the given hypergraph preserve an irreducible Markov chain which gives strengths to the model construction and a greater number of Apollo Pharmacies are opened in recent years compared to the other pharmacies. In comparison with the NASM and ASM, it is observed that the adjacency search method plays an important role to determine the Apollo pharmacy has strong reasons to open in more numbers than the other pharmacies and is easily adaptable. ASM emphasize the role of graphical representation of HMMs in

terms of hyper graph. Hyper assignments obtained from ASM using maximal clique is more efficient and time limited than the NASM.

Data Availability

All the data in this manuscript are available with the corresponding author upon formal request.

Conflicts of Interest

The authors declare that there are no conflicts of interest regarding the publication of this paper.

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