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Research Article

Using Markov Chains For Predicting The Traffic Movement inside A Government Institution

Zana Najim Abdullah [1,*], Dalia Badee Omar [2], Omar Mackki Raheem [3]

[1] Department of Statistics Sciences, College of Administration & Economic, University of Kirkuk, Iraq

[*] zananajim@uokirkuk.edu.iq

ABSTRACT

The government agency used a Markov chain model to assess data from 2021 to 2022. The transition matrix, which illustrated the migration across many departments, was used to assess the likelihood of staying in the current department or going to another. Markove Models are proven a good performance on the management of big institutions. Thus it was reliable enough to be proposed in the governments organizations. The data provides a better picture of workers' mobility around the organisation and allows for the prediction of their future movements. Plans for training, fair remuneration, succession planning, and general human resource management enhancement may be made using these ideas. In order to make the necessary corrections to projections in light of evolving working conditions and organisational requirements, it is essential to routinely monitor and evaluate data.

Keywords: Machine Learning, Intrusion, Cybersecurity, AdaBoost, RF, SVM, Feature Selection, Deep Learning

INTRODUCTION

Markove Models are proven a good performance on the management of big institutions. Thus, it was reliable enough to be proposed in the governments organizations. Forecasting staff turnover at a government agency using Markov chains entails using probability models and doing statistical analysis. The objective is to understand and anticipate the behavioral and mobility patterns of the individuals inside this organization [1]. These models use Markov chains, which are advanced mathematical and statistical techniques for predicting future events by analyzing past occurrences butdiscarding precise details. Markove Models are proven a good performance on the management of big institutions. Thus, it was reliable enough to be proposed in the governments organizations [2]. Within a government institution, the behaviours and actions of workers might be seen as a constant and steady series of events or circumstances that take place over a certain period of time. Markov chains are used to forecast future behaviours only based on the present state, disregarding the whole historical sequence of past occurrences [3]. Markove Models are proven a good performance on the management of big institutions. Thus it was reliable enough to be proposed in the governments organizations. The tactics used to facilitate employee mobility are contingent upon a transition matrix that encompasses the possibility for workers to shift across various departments or divisions within the organization. These models have versatile applications, including but not limited to scheduling, staff allocation, and measuring operational performance. Markove Models are proven a good performance on the management of big institutions. Thus it was reliable enough to be proposed in the governments organizations [4]. Applying Markov chains in this specific situation provides a dependable analytical method for predicting employee mobility and overseeing daily and long- term activities inside the organization. These models enhance the decision-making process, increase efficiency, and effectively supervise the workforce. Numerous nations have substantial difficulties in effectively managing the allocation of traffic specialists within bodies tasked with overseeing and regulating road and street traffic. The traffic management industry is crucial and requires efficient coordination to guarantee the safety and seamless flow of cars. Markove Models are proven a good performance on the management of big institutions. Thus, it was reliable enough to be proposed in the governments organizations. Markove Models are proven a good performance on the management of big institutions. Thus, it was reliable enough to be proposed in the governments organizations. Many countries use advanced technological systems, including as surveillance cameras and GPS tracking devices, to monitor and trace the movements of traffic staff. These systems provide extensive information on the whereabouts of staff members, allowing for improved team communication and more efficient response to traffic problems and congestion [5]. Markove Models are proven a good performance on the management of big institutions. Thus it was reliable enough to be proposed in the governments organizations. performance on the management of big institutions. Thus, it was reliable enough to be proposed in the governments organizations [6]. Using Markov chains offers several benefits and flexibility in evaluating and forecasting the mobility patterns

*Corresponding author
Zana Najim Abdullah,
Department of Statistics Sciences, College of Administration & Economic, Kirkuk University, Iraq
e-mail: zananajim@uokirkuk.edu.iq

of employees inside a government agency. Markove Models are proven a good performance on the management of big institutions. Thus, it was reliable enough to be proposed in the governments organizations. This methodology facilitates a more thorough examination of human movement patterns, leading to enhanced strategic decision-making, coordination, and overall efficiency within the organization. Using this data improve the performance of traffic operations and successfully accomplish the institution's goals.

METHODOLOGY

In the analysis of the treatment impact on specified sample sets, researchers utilized the F-ratio distribution as a means to gauge the impact of that treatment on biological data variation [89]. For an in depth analysis, actual sociological control and experimental data sets were generated and compared against simulated ones. To establish the F-ratio technique during the review of significant variances and biological response patterns, biostatistics was employed. The statistics provided strong interpretation of the data and kept the focus on evaluating the effect of treatment on biological variables [90].

The study is based on the examination of the data presented in the appendix, which offers insights into the operations of traffic personnel at the Kirkuk Traffic Department in Iraq from 2021 to 2022. The data is divided into many temporal periods to facilitate prediction using Markov chains, as explained in both the theoretical and practical aspects of the research. A Markov Chain is a sequence of events or states that a phenomenon goes through over a specific period of time. It is applied in many scientific phenomena, such as the phenomenon of diffusion or production control [8]. Mathematically, it is defined as follows: The stochastic process $\{X_n: n \in N\}$ is called a Markov chain if it satisfies the condition

$$\{x_{n+1} = i, x_0, x_1 \ldots . . x_n\} = p\{x_{n+1} = i\} \tag{1}$$

Equation (1) is characterized by the Markov property, which indicates that Markov chains are nothing more than a sequence of random variables, where for every nϵN, the future state x(n+1) is independent, given the current state. The transition probabilities are stable, with the transitional probabilities from state p_i to state p_j represented in matrix form.

$$\text{Pij} = \begin{matrix} \text{P11} & \text{P12} & . & \text{P1n} \\ \text{P21} & \text{P22} & . & \text{P2n} \\ . & . & & . \\ \text{Pn1} & \text{Pn2} & . & \text{Pnn} \end{matrix} \tag{2}$$

The matrix P is called the transition probability matrix, and the Markov chain is termed homogeneous if P_{ij} is independent of time and satisfies the following conditions:

$$(\text{Pij} > 0), \sum \text{Pij} = 1 \tag{3}$$

It is now possible to provide a definition for Markov chains, where the transition probability matrix P, along with the corresponding initial probabilities for states (E_i), forms a Markov chain (2). Transition Probability in One Step:

Let $\{x_n, n=0,1,2,...\}$ be a Markov chain with the state space, S={0,1,2,...}, where the probability of the random process transitioning from state i to state j in one step is denoted by $p_{ij}^{(n,n+1)}$ and is defined as follows [9]:

$$p_{ij}^{(n,n+1)} = p\{x_{n+1} = j / x_n = i\} \tag{4}$$

This probability represents a fundamental condition for studying the properties of Markov chains. Markov processes primarily rely on conditional transition probabilities, denoted by the symbol

$$Pij = Pr(X_{n+1=j}/X_{n=i}) \qquad 0 \le Pij \le 1 \tag{5}$$

These probabilities are organized into a square matrix called the Markov Probability Matrix, where each row's sum represents the transition probabilities of the phenomenon between the studied basic states, with the levels (X1, X2, X3, X4)

TYPES OF MARKOV CHAINS

Discrete-Time Markov Chains: Used in discrete and intermittent time periods, described by a matrix representing the probabilities of transitioning to all other states within a single time period. A variety of methods are used in the analysis and evaluation of discrete-time Markov chain models [10]. Continuous-Time Markov Chains: Used in continuous-time random dynamic modeling, where the duration of each state varies according to an exponential distribution. It is described by a matrix representing the transition rates from each state to all other states, and future predictions depend only on the current state.

*Corresponding author
Zana Najim Abdullah,
Department of Statistics Sciences, College of Administration & Economic, Kirkuk University, Iraq
e-mail: zananajim@uokirkuk.edu.iq

HYPOTHESES OF MARKOV CHAINS

There are several hypotheses that must be met for the application of Markov chains:

a. There is a finite and limited number of possible states.

b. The probabilities of state transitions remain constant over time.

c. Predictions of future states can be made using the transition probability matrix and knowledge of the current state.

The next state depends only on the previous state, without relying on earlier states. Divide the achieved productivity levels in the selected time period into four levels by subtracting the lowest productivity from the highest productivity, and then divide the result by 4 State of Accessibility is a binary relationship between states in a Markov chain that is fulfilled if there exists a non-negative integer ($n \geq 0$) such that $p_n(i, j) > 0$, denoted by $i \rightarrow j$. Whereas the state of communication is a state where two states (i, j) exist, and it is denoted as $i \leftrightarrow j$. State of Recurrence and Transience can be explained as, Let state j and T_1 represent the time of the first visit to the first state. State i is called a recurrent state if $f(i, j) = 1$, and if $f(i, j) < 1$, then state j is referred to as a transient state.

BASIC CONCEPTS AND COMPONENTS OF QUEUEING SYSTEMS

Before delving into the basic concepts and components of a queueing system, it is essential to understand the general framework of this system and what is depicted in the two figures in the basic queueing model. As evident from the previous figures, a queueing system consists of four fundamental components. We find that the units seeking service arrive at the system from a specific source called the "Population." When these units reach the system and find the service center busy serving customers, they wait according to a specific probability distribution. The queue is formed, and based on the queuing system's rules, a unit seeking service is selected. The service is provided using the available facilities (service delivery methods) within the system. After receiving service, the unit seeking service (customer or client) leaves the queueing system (Queuing System), and they may return to the population [11]. Below is an explanation of these components in some detail, ensuring the clarification of the essential concepts and characteristics of a queueing system that must be known, along with the derivation of mathematical models through which the optimal allocation of service centers can be achieved.

POPULATION SIZE

The population represents the source of units seeking service (customers, clients). The population can be either finite or infinite. The population is considered finite when the number of units seeking service is limited, meaning they constitute a significant proportion of the expected arrivals to the system. If the population is very large and difficult to limit (infinite), it is categorized as an infinite or non-finite population. This occurs when the number present in the system represents only a small proportion of the expected arrivals. The size of the population, whether finite or infinite, significantly affects the formulation of all relationships that define most of the queuing theory measures.

ARRIVAL PROCESS

The arrival process refers to the how and the frequency with which units seeking service arrive at the system. It is determined based on the mean arrival rate, which could be constant or variable. In the case of a constant arrival rate, the arrivals occur at regular intervals. For example, the number of customers arriving, n, every minute during the arrival period. The arrival process can also be defined using probability concepts, representing the time between the arrivals of two consecutive units at the service location. This time may be constant or random with a specific probability distribution. Queuing theory assumes a random arrival process, where the rate represents the average number of units arriving at the service location randomly during a specific time period [12].

TRAFFIC INTENSITY

Traffic intensity, denoted by ρ, relates the arrival rate to the service rate and indicates the possibility of queuing. It is calculated as the ratio of the arrival rate (λ) to the service rate (μ) and is defined by the equation

$$\rho = \lambda/\mu. \text{ when } \rho = 1 \quad (6)$$

*Corresponding author
Zana Najim Abdullah,
Department of Statistics Sciences, College of Administration & Economic, Kirkuk University, Iraq
e-mail: zananajim@uokirkuk.edu.iq

it means that the arrival rate equals the service rate, and there is no waiting problem. Individuals arriving receive service immediately.

PRACTICAL PART

In general, employee movement within an organization is continuous, especially in relevant departments. This is due to the need for efficiency in meeting demands, the progression of tasks, and the similarity in the completion of production steps. Therefore, there is a desire to predict employee movement within government institutions for the next three years using Markov chains based on data obtained from the institution regarding employee movement in the past three years (2019-2020-2021).

The following symbols are used:

X: Movement for initial tasks within the institution.

Y: Movement for intermediate tasks within the institution. Z: Movement for completing final tasks.

W: Departure from service in each of the above scenarios.

To calculate the corresponding probabilities for different movements of employees between departments (or different positions), you should follow these steps:

a. Count the number of employees in each of the three departments at the beginning of each year over the three years.

b. Count the number of employees who remained in each department at the end of each year among those who were in that department at the beginning of the year, as well as those who left their position to occupy another position within the same department. Also, count the number of individuals who left the service for each department.

c. Calculate the total number of individuals in each department at the beginning of the three years.

d. Calculate the total number of individuals who remained in each department, considering those who were there at the beginning of the year, for each of the three years. Additionally, count those who left the service for each department.

e. Determine the ratios of individuals who remained in each department, those who moved, and those who left the service for each department.

By applying these steps to the available data, you can calculate the probabilities of various possible movements. Consequently, you can construct the transition matrix vital for Markov chains, using data on the movement or departure of individuals in the three departments over the past three years (Table 1).

Table 1: The movement of individuals between departments, representing the total for these years.

The number of individuals in department X at the beginning of the year	number
The number of individuals in department Y at the beginning of the year	50
The number of individuals in department Z at the beginning of the year	40
The remaining in department X who continued in the same position during the year	60
The remaining in department Y who continued in the same position during the year	20
The remaining in department Z who continued in the same position during the year	15
The number of individuals transferred from department X to department Y during the year	25
The number of individuals transferred from department X to department Z during the year	12
The number of individuals transferred from department Y to department X during the year	13
The number of individuals transferred from department Y to department Z during the year	10
The number of individuals transferred from department Z to department X during the year	12
The number of individuals transferred from department Z to department Y during the year	15
The number of retirements from department X during the year	15
The number of retirements from department Y during the year	5
The number of retirements from department Z during the year	3
The number of individuals who returned to department X after leaving the service during the year	5

In order to find the transition matrix crucial for the prediction process, it is necessary to convert the previous data into probabilities (Table 2). Where:

P11: The probability of staying in department X during the year.

*Corresponding author
Zana Najim Abdullah,
Department of Statistics Sciences, College of Administration & Economic, Kirkuk University, Iraq
e-mail: zananajim@uokirkuk.edu.iq

P12: The probability of transitioning from department X to department Y during the year.

P13: The probability of transitioning from department X to department Z during the year. P14: The probability of leaving the service from department X during the year.

These data can be organized into a matrix called the Transition Probability Matrix as follows:

	Part X	Part Y	Part Z	Resignation service	from
				W	
Part X	P11	P12	P13	P14	
Part Y	P21	P22	P23	P24	
Part Z	P31	P32	P33	P34	
Resignation service	from P41	P42	P43	P44	
W					

Among the important characteristics of this matrix P are the following two properties:

Since it represents probability values, its elements are positive. The sum of elements in each row equals one.

Here, K represents the number of rows and columns in the matrix. In general, any matrix that satisfies these two conditions is called a stochastic transition matrix. If P is a stochastic matrix, it represents the probability of a group transitioning from state (I) to state (J) during a certain time period. If we want to predict the probabilities of movement for the group over n years using the Markov method, we need to raise the stochastic transition matrix P to the power of n, where n represents the number of years for which we want to make predictions. To transform the data provided in the previous table into a matrix of transition probabilities for Markov prediction, we can do the following:

Probability of staying in workshop (X) during the year = 20/50 = 0.4

Probability of transitioning from workshop (X) to workshop (Y) during the year = 12/50 = 0.24

Probability of transitioning from workshop (X) to workshop (Z) during the year = 13/50 = 0.26

Service time from X during the year = 5/50 = 0.1

Using the same method for the remaining probabilities: Probability of staying in workshop (Y) during the year = 15/40 = 0.375

Probability of transitioning from workshop (Y) to workshop (X) during the year = 10/40 = 0.25

Probability of transitioning from workshop (Y) to workshop (Z) during the year = 12/40 = 0.3

Service time from Y during the year = 3/40 = 0.075

Probability of staying in workshop (Z) during the year =25/60 = 0.415

Probability of transitioning from workshop (Z) to workshop (X) during the year = 15/60 = 0.25

Probability of transitioning from workshop (Z) to workshop (Y) during the year = 15/60 = 0.25

Service time from Z during the year = 5/60 = 0.085

Thus, the simple probability matrix representing the movement of employees between the three departments (X), (Y), and (Z) will be as follows:

*Corresponding author
Zana Najim Abdullah,
Department of Statistics Sciences, College of Administration & Economic, Kirkuk University, Iraq
e-mail: zananajim@uokirkuk.edu.iq

	Part X	Part Y	Part Z	Resignation from service W
Part X	P11	P12	P13	P14
Part Y	P21	P22	P23	P24
Part Z	P31	P32	P33	P34
Resignation from service W	P41	P42	P43	P44

This matrix represents the transition probability matrix of employees moving between the three departments (X), (Y), and (Z) during the years from 2019 to 2021. Based on this matrix, it is possible to predict the probability distribution of

the current number of individuals working in departments (X), (Y), or (Z) several years from now by raising the matrix P to the power of n, where n represents the number of years for prediction.

To predict the probability distribution of movement between the workshops (W), (Z), (Y), and (X) after two years, which is at the end of 2022, you would rely on the transition probability matrix at the beginning of 2021, which is the matrix P, and then raise it to the power of 2 (n=2).

	Part X	Part Y	Part Z	Resignation from service W
Part X	0.0699	0.244	0.249	0.4371
Part Y	0.07	0.247	0.24925	0.43375
Part Z	0.06925	0.2426	0.24915	0.439
Resignation from service W	0.06625	0.2355	0.2495	0.44875

The matrix above can be interpreted as follows:

For employees working in department X in the year 2021, their fate at the end of the year 2022 will be as follows:

(99.6%) of those working in department X will remain in the same department.

(24.4%) will transfer to department Y.

(24.9%) will transfer to department Z.

(43.7%) will leave the service.

For employees currently working in department Y in the year

2021, their fate at the end of the year 2022 will be as follows:

(7%) of those working in department Y will remain in the same department.

24.7%) will transfer to department X.

(24.9%) will transfer to department Z.

(43.3%) will leave the service.

For employees currently working in department Z in the year

2021, their fate at the end of the year 2022 will be as follows:

(6.9%) of those working in department Z will remain in the same department.

(24.2%) will transfer to department X. (24.9%) will transfer to department Y. (43.9%) will leave the service.

*Corresponding author
Zana Najim Abdullah,
Department of Statistics Sciences, College of Administration & Economic, Kirkuk University, Iraq
e-mail: zananajim@uokirkuk.edu.iq

For employees in department W (those not working) at the beginning of the year 2021, their fate at the end of the year 2022 will be as follows:
(6%) will leave the organization. (23.5%) will return to department X. (24.9%) will return to department Y. (44.8%) will return to department Z.

CONCLUSIONS

Improved comprehension of employee mobility: This study offers a detailed and evaluative examination of how employees have shifted roles within the company in the last three years, providing insight into their movements across various departments. Offering potential outcomes: The study suggests various scenarios that can help predict employee turnover in the upcoming future. This information can be valuable in guiding managerial decision-making and strategic planning within the organization. Understanding the Transition Matrix: The study effectively constructed a matrix illustrating the likelihood of employees moving between various departments. This information can be beneficial for creating predictive models and strategic workforce planning. The recommendations of this papers is to create plans to keep important employees in the organization by understanding how they move between departments and their likelihood of leaving. This will help encourage them to stay and be motivated within the company. This data can help guide training and development initiatives towards departments in need of improving skills and growth. By gaining insight into how employees move within the organization, the company can prepare for job openings and create plans for compensating for turnover. Enhance administrative management processes by utilizing transition matrices to predict and improve employee movement within the organization. Prepare to address any potential changes in policies or circumstances that could affect the movement of employees in the future. Continuous monitoring and analysis are necessary for regularly checking and assessing the data and transition matrices. This allows for adjustments to probabilities and expectations according to changing business needs and organizational requirements. In conclusion, this study offers a structure for comprehending and evaluating employee mobility, directing successful managerial decisions. It serves as a valuable tool for improving human resource management and forming business strategies within the company.

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*Corresponding author
Zana Najim Abdullah,
Department of Statistics Sciences, College of Administration & Economic, Kirkuk University, Iraq
e-mail: zananajim@uokirkuk.edu.iq