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Application of Markov Chain in Forecasting Demand of Trading Company

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Abstract

Markov chain is one of the techniques used in operations research with possibilities view that managers in organizational decision making (industrial and commercial) use it. Markov processes arise in probability and statistics in one of two ways. Markov process is a tool to predict that it can be make logical and accurate decisions about various aspects of management in the future. A stochastic process, defined via a separate argument, may be shown mathematically to have the Markov property, and as a consequence to have the properties that can be deduced from this for all Markov processes.
Keywords: Markov Chain,Forecasting Demand,Trading Company

1. Introduction

Managementis defined decisionsina simple form and the most important factor for decision making is forecasting future. Atpresent erathose organizations have highcomplexity and much information is available, so their arrangement and refine can help to managementina logicaland accuratedecisions.The use of various aspects of operations research is easier to deal with complex issues for managers. Markov chain isone of the techniques used in operations research with possibilities view that managers in organizational decision making (industrial and commercial) use it.Successful decision is a picture of the future that this will not be achieved only from the prediction, based on scientific principles. Markov process is a chain of random events that by having information about the current location can be predicted next period and in fact Markov chain is a tool that used for forecasting of situation organization in future periods.

2. Definition ofStochastic ProcessesandMarkov Chains

Arandomprocessis definedasaset ofrandom variables [x_t] that defects of T is often referred to time, there is around a specific set of T (hakimipour,1998).If random process $\{x(t), t \in T\}$ be such that withidentify the value of x (s) values of x (t) for t> s depends on the values x (u) make for u <s, then its process is called Markov process that such a process is defined by the following expression:

If for $t_1 < t_2 < \ldots < t_n < t$

$$P_r\{a \le x(t) \le b | x(t_1) = x_1, \ldots, x(t_n) = x_n\} =$$

$$= P_r\{a \le x(t) \le b | x(t_n) = x_n\}$$

It is result that process $\{x(t), t \in T\}$ is Markov process (soldo, 2012).

Markovanalysisbegan withtheresearch. A.Markov, Russian theoristin years(1907 - 1906)in the field of probabilityscience. However, a comprehensive theory processes and analysis of Markov by. A.n.gorov- w.dublin-p loe-j.l.dub& others were completed it in 1930 (Hakimipour, 1998).

Markovchain is certainmodelsfrommore generalpotential model that these models are famous random processes and in them current state of a system depends on all previous states. Markov process is a random process. With this feature that current state of system is dependent just prior final state of the system. In other words in prediction of state of a system at the future times according to the information related to current state of system will be analyzed (Wang, 2004). In fact Markov analysis, it will establish a way to the current analyze for certain variables because is possible to predict the future movement same as variables because Markov process is chain of a random events that by having the current success can be predicted the next phase (Lee, Tong, 2011).

The field of Markov chains has been widely used in management science that these can include:

1. Human resources planning model
2. Pyramid Maslow's model on human needs
3. Model to predict price changes.
4. Changes in brand by customer product
5. Behavior of customer receivables

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6. Maintenance model

7. Inventory control

8. Describing a particular type of storage issues

9. Analysis and replacement human resources

10. Prediction of system reliability

11. ......

3. Basic Concepts of Markov Processes

For analysis of system from Markov model should determine the two basic elements of the system and the possibilities of movement between them. System state is the status of the system at a moment in time like a car works or does not work at a moment in time. Probability of movement among the states call transition Probabilities that representing the system moves from one state to another state during a specified period $(i \rightarrow j)$ Probability of some change from one state to another state in the next period is called transition Probabilities of the Markov model P{Xt+1=jXt=i}
If thenumber ofpossible statesin Markov chain isalimited,transition probabilities can show to form a matrix that this matrix in Markov process will be always square (m * m). In thismatrixPijshowtransition probabilities fromstateto stateinnext time period (Deng, 1990).

$$
\begin{array}{cc}
 & \begin{array}{ccccccccc} 1 & 2 & & & j & & & m \end{array} \\
P = \begin{array}{c} 1 \\ 2 \\ \vdots \\ \vdots \\ i \\ \vdots \\ \vdots \\ \vdots \\ m \end{array} &
\begin{bmatrix}
P_{11} & P_{12} & \cdots & \cdots & P_{1j} & \cdots & \cdots & P_{1m} \\
P_{21} & P_{22} & \cdots & \cdots & P_{2j} & \cdots & \cdots & P_{2m} \\
\vdots & & & & & & & \\
\vdots & & & & & & & \\
P_{il} & P_{i2} & \cdots & \cdots & P_{ij} & \cdots & \cdots & P_{im} \\
\vdots & & & & & & & \\
\vdots & & & & & & & \\
\vdots & & & & & & & \\
P_{m_1} & P_{m2} & \cdots & \cdots & P_{mj} & \cdots & \cdots & P_{mm}
\end{bmatrix}
\end{array}
$$

Also transition probabilities can show in form of graph.

Every issue to resolve by a Markov process should be having the following three characteristics:
1- Transition probabilities are dependent on only the current state of the system.
2- Transition probabilities are always fixed.
3- Sum of transition probabilities move to other states in the next time period should be equal one.

4. Prediction ofFutureStates

Predictions of future states require that initial states of the system are identified and transition probabilities fixed. There are severalmethodsfor predictingfuturestates that in this paperrefers to as case to the matrix multiplication (Yamaguchi, Nagai, 2006).
Matrix multiplication is a simple method for predicting the state of a Markov system for future periods. By havingthe initial state of matrix multiplication can be used for prediction system at timen.
A) Thestateof the system:

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Firstsystem stateat timenis showed by aone-dimensionalmatrix to name of vector
$P(n)=\{P_1(n),P_2(n)\}$
That in this relation P(n)= value vector (n).P_1
P_1 (n)= the probability that system at time n be in state 1
P_2 (n)= the probability that system at time n be in state 2
If we suppose that system at time n be in state 1Then $P_1(n)=[1,0]$
If we suppose that system at time n be in state 2 Then $P_2(n)=[1,0]$
It is necessary to note here that if there is a system of more than two states, not necessary that the system in the initial state is only one of the states and may be more than one state but in any state vector sum must always be equal to one. For example, the state vector for a system of three cases may be [0/1 and 0/7 and 0/2]
b) Matrix of transition probabilities (p):
Transition probabilitiesmatrixis shownas following

$$P = \begin{array}{c} \\ 1 \\ 2 \end{array} \begin{array}{cc} 1 & 2 \\ p_{11} & p_{12} \\ p_{21} & p_{22} \end{array}$$

In this matrix:
P= Transition probabilities matrix
Pij= Transition probabilities of system from statei to state j
C) Prediction ofthe futurestate:
To calculate theprobability thatsystem at time(n +1) bestatej, we use as follows relationship
P(n+1)=P(n).P
That this relationship: P(n+1)= Stateprobability vectorat timen +1 (one time periodlater)
P(n)= State probability vector at time (n) (current time period)
P = Transition probabilities matrix
According toabove relationshipcanbe calculatedtransition probabilities inseveral periods later in form of simple.
P(n+2)=P(n+1).P
P(n+3)=P(n+2).P
A general relationship is obtained from these relationships that as follow:
$P(n)=P(0).P^n$
That this equation:
P (n) = State probability vector in time period n th
P (0)= probability vector in time period zero (starting point of time that probability of each state is certain)
P^n= power of n th in transition probabilities matrix
n= Number of time periods for which it is predicted.
Therefore it can be done necessary projectionsofthis relationshipforany period of time and used for decision making in planning (Zhang, 2001).

5. Stable State Conditions

In Markovprocess often by more n (in long term) value vector tends tofixing state (Stable state). As to achieve its period multiplying the state vector in transition probabilities matrix is equal to transition probabilities matrix in periods later that this state is called Stable state.
If stable value show by π symbol, instable state, the state vectorwill beinterms ofdecimal values as follow:
$\pi = [\pi_1, \pi_2]$
Inthis relationship:
Π=State probability vector (as relative amounts)
π_1 =amount of state 1
π_2 =amount of state 2
Since in stable state conditions isn't important time period and values are independent of time, multiplicationof state vector in transition matrix avectorin stable statewill be same as state vector. Therefore stable state values can be determined in the following manner algebra:

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$$\pi = \pi.P \Rightarrow \pi = [\pi_1, \pi_2] \times \begin{bmatrix} P_{11} & P_{12} \\ P_{21} & P_{22} \end{bmatrix} \Rightarrow \begin{cases} \pi_1 = \pi_1.P_{11} + \pi_2.P_{21} \\ \pi_2 = \pi_1.P_{12} + \pi_2.P_{22} \end{cases}$$

And on the other hand sumof probability states must be equal to one: $\pi_1 + \pi_2 = 1$

Thereforewe havethree equationsandtwo passive that solving it will obtainedvalue of thestate vectorinperiodn th that it isbeginning ofstable state.A Markov process may not reach always stable state. However, it can be stated thatif there is a value of n that all elements of P^n be greater than zero,in this conditions there will be a Stable state.To calculate the Stable state can be used MicroManager Software that is applicable to in the analysis of Stable state (Ujjwal Kumar, Jain, 2010).

6. Conclusion:

Markov processisatool topredict that it can be make logical and accurate decisions about various aspects of management in the future. Also Markov is random process. With these differencesinMarkovprocessto predictthefuturestateis used information related to the lastperiodthat this is one of the analyzable fundamental principles through Markov chains.

In transition probability matrix that rows and columns should always be equal (it be square shape)sum of rows is equal to one.

In prediction offuturestates based on aMarkovchainifpredictionare calculatedfor several period consecutive of a system.Finally, after some time the results will be the same that is called stable state and thiscaused by interference only data ofone period (zero period) in calculation.

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