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Review Article

Study of Sequencing Model Application and Solution of LPP Formulation

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ABSTRACT: Sequencing models, which are a type of machine learning model, are designed to process and generate sequences of data. They have found numerous applications across various domains due to their ability to understand patterns and relationships within sequential data. A sequencing model refers to tasks where you need to determine the optimal order or arrangement of items or events according to certain criteria. Linear programming can be used to solve optimization problems, and it's possible to frame some sequencing problems as linear programming problems. Sequencing models deal with arranging items or events in a specific order to optimize certain objectives. They find applications in various fields. Both sequencing models and linear programming are powerful tools that require a solid understanding of mathematical concepts, problem formulation, and appropriate solution techniques to effectively address complex real-world challenges. To solve an LPP, you'll need to translate the real-world problem into a mathematical model, apply the appropriate solution method, and then interpret the results in the context of the problem.

KEYWORDS: Sequencing models, Linear Programming, Arrangement, Events, Maximum, Minimum, and Objective.

INTRODUCTION

A sequencing model as a Linear Programming Problem (LPP) involves representing the task of arranging items or events in a particular order as an optimization problem. Linear programming provides a framework to find the optimal sequence that meets specific objectives while satisfying various constraints. Sequencing models deal with determining the best arrangement or order of items, tasks, or events to optimize a certain objective. This can involve minimizing completion times, maximizing efficiency, or adhering to specific constraints. Linear programming, on the other hand, is an optimization technique used to find the best solution for linear problems under certain constraints. Sequencing problems involves arranging a set of items, tasks, or activities in a specific order to achieve certain objectives while considering various constraints. These problems are common in fields such as manufacturing, scheduling, operations research, and more. Linear Programming is a powerful optimization technique used to solve problems where the goal is to maximize or minimize a linear objective function subject to linear constraints. Sequencing problems involves arranging tasks, items, or events in a specific order to achieve desired objectives while considering various constraints. Linear Programming provides a mathematical framework to solve optimization problems where the goal is to maximize or minimize a linear objective function subject to linear constraints.

Sequencing problems are concerned with an appropriate order (sequence) for a series of jobs to be done on a finite number of service facilities (like machines) in some well–defined technological order so as to optimize some efficiency measure such as total elapsed time or overall cost etc. In such cases, the effectiveness is a function of the order or sequence in which the tasks are performed. The effectiveness may be measured in terms of cost, time or mileage, etc., A sequencing problem could involve jobs in a manufacturing plant, aircraft waiting for landing and clearance, maintenance scheduling in a factory, programmers to run on a computer center, customers in a bank, and so forth.

In sequencing, we are concerned with a situation where the effectiveness measure is a function of the order or sequence in which a series of tasks or jobs are performed. Suppose we have n jobs $(1, 2, ..., n)$ of which has to be processed or performed one at the time on each of m machines A, B, C ... The order (sequence) of processing each job through the machines as well as the actual or expected time required by the jobs on each of the machine is also given. The effectiveness in terms of cost, times or mileage etc., can be measured for any given sequence of jobs at each machine and our aim is to select the most suitable sequence (which optimizes the effectiveness measure) among all theoretical possible sequences whose number will be $(n!)^m$. Although theoretically it is always possible to select the best sequence by testing each one but it is practically impossible due to large number of computations. Hence, we have to compute effectiveness for each of $(n!)^m$ sequences before selecting the most suitable one.

Suppose there are n jobs $(1, 2, 3 \dots n)$ each of which has to be processed one at a time at each of m machines $A, B, C, \dots$ The order of processing each job through the machines is given (for ex. Job 1 is processed through machines A, C, B- in that order). The time required for each job at each machine is also given. The problem is to find among $(n!)^m$ number of all possible sequences (or combinations) that sequence (or order) for processing the jobs so that the total elapsed time for all the jobs will be minimum. Mathematically we define

$$A_i = Time\ for\ i^{th}\ job\ on\ machine\ A\ \forall\ i$$

$$B_i = Time\ for\ i^{th}\ job\ on\ machine\ B\ \forall\ i$$

$$T = Time\ from\ start\ of\ the\ first\ job\ to\ completion\ of\ the\ last\ job$$

We wish to determine for ach machine a sequence $(i_1, i_2, \dots, i_n)$ where $(i_1, i_2, \dots, i_n)$ is a permutation of the integers $(1,2 \dots, n)$ which will minimize total elapsed time T.

Solution of A Sequencing Problem: When a number of jobs are given to be done and they require processing on two or more machines, the main concern of a manager is to find the order or sequence to perform these jobs. We shall consider the sequencing problems in respect of the jobs to be performed in a factory and study the method of their solution. Such sequencing problems can be broadly divided in two groups. In the first one, there are n jobs to be done, each of which requires processing on some or all of the k different machines. We can determine the effectiveness of each of the sequences that the technology feasible (that is to say, those satisfying the restrictions on the order in which each job must be processed through the machines) and choose a sequence which optimizes the effectiveness. To illustrate, the timings of processing of each of the n jobs on each of the K machines, in a certain give order, may be given and the time for performing the jobs may be the measure of effectiveness. We shall select the sequences for which the total time taken in processing all the jobs on the machines would be minimum.

Here the solutions of the following cases are seen:

a. n jobs and two machines A and B, all jobs processed in the order AB.
b. n jobs and three machines A, B and C all jobs processed in the order ABC.

GENERAL SEQUENCE MODEL APPLICATION

Some common applications of sequencing models.

- Natural Language Processing (NLP): Language Generation: Sequencing models can generate coherent and contextually relevant text, making them useful for tasks like text generation, story writing, and poetry creation.
- Machine Translation: Models like sequence-to-sequence models can be used for translating text from one language to another.
- Text Summarization: These models can be employed to summarize longer texts into shorter, concise versions.
- Dialogue Systems: Sequencing models are used in chatbots and virtual assistants to generate human-like responses in conversations.
- Speech Recognition and Synthesis: Automatic Speech Recognition (ASR): Sequencing models can convert spoken language into written text, powering applications like voice assistants and transcription services.
- Text-to-Speech (TTS): Models can convert written text into natural-sounding speech, enhancing accessibility and user experience in various applications.
- Music Generation: Sequencing models can compose new pieces of music or generate variations on existing musical themes, catering to various genres and styles.
- Genomics and Bioinformatics: Sequencing models play a crucial role in DNA sequence analysis, aiding in tasks like genome assembly, variant calling, and predicting protein structures.
- Time Series Analysis: Sequencing models are applied to predict future values in time series data, useful in fields like finance for stock price prediction, energy demand forecasting, and more.
- Video Analysis: For tasks like video captioning, action recognition, and video generation, sequencing models are used to understand and generate sequences of images or frames.
- Fraud Detection: In finance and cybersecurity, sequencing models can detect unusual patterns in transactions or behaviors, helping identify potential fraud.
- Healthcare: In medical applications, sequencing models are used for tasks like predicting disease progression, patient monitoring, and analyzing medical records.
- Autonomous Vehicles: In the context of self-driving cars, sequencing models are used to process data from sensors and cameras, helping the vehicle understand and navigate its environment.
- Protein Structure Prediction: In bioinformatics, sequencing models can predict the 3D structure of proteins based on their amino acid sequences, aiding drug discovery and disease understanding.
- Weather Forecasting: Sequencing models are used to model and predict weather patterns based on historical data, satellite imagery, and sensor data.

- Handwriting Recognition: Sequencing models can convert handwritten text into machine-readable text, useful in digitizing handwritten documents.

APPLICATION OF SEQUENCING MODEL AS LINEAR PROGRAMMING PROBLEM

Sequencing models deal with arranging items or events in a specific order to optimize certain objectives. They find applications in various fields, including:

- Manufacturing and Production: Job scheduling to minimize completion times or maximize machine utilization.
- Flow shop scheduling to optimize sequences of operations on multiple machines.
- Supply Chain Management: Vehicle routing problems to optimize delivery routes. Inventory management to determine reorder points and quantities.
- Project Management: Project scheduling to optimize task order and durations. Resource allocation to ensure efficient utilization of resources.
- Genomics and Bioinformatics: DNA sequence assembly to reconstruct complete genomes from fragmentary data.
- Protein structure prediction to determine the 3D structure of proteins.
- Text and Speech Processing: Speech recognition to convert spoken language into text. Machine translation to translate text between languages.
- Finance and Investment: Portfolio optimization to select the best mix of investments. Option pricing to determine the value of financial derivatives.
- Healthcare: Patient scheduling in hospitals to optimize resource allocation. DNA sequencing for personalized medicine and disease diagnostics.

DESIGN OF SEQUENCING MODEL IN MS EXCEL SOLVER TOOL

Processing of n jobs through two machines:

1. For the set of data given below determine the sequence that minimize the total elapsed time for the five jobs.

JOBS	A	B	C	D	E
M1	5	4	8	7	6
M2	3	9	2	4	10

Solution:

STEP 1							
JOBS	A	B	C	D	E		
M1	5	4	8	7	6		
M2	3	9	2	4	10		
MINIMUM	3	4	2	4	6		
OPTIMAL JOB SEQUENCE	B	E	D	A	C		
STEP 2							
JOBS	M1		M2				
	IN	OUT	IN	OUT		IDEAL 1	IDEAL 2
B	0	4	4	13		0	4
E	4	10	13	23		0	0
D	10	17	23	27		0	0
A	17	22	27	30		0	0
C	22	30	30	32		2	0
	TOTAL ELLAPSED TIME			32			
STEP 3							
IDEAL TIME							
M1	2						
M2	4						

2. There are five jobs, each of which must go through the two machines A and B in the order A-B. Processing time are given below:

JOBS	1	2	3	4	5
MAC A	10	2	18	6	20
MAC B	4	12	14	16	8

Solution:

STEP 1								
	JOBS	1	2	3	4	5		
	MAC A	10	2	18	6	20		
	MAC B	4	12	14	16	8		
	MINIMUM	4	2	14	6	8		
	OPTIMAL JOB SEQUENCE	J2	J4	J3	J5	J1		
STEP 2								
	JOBS	MAC A		MAC B				
		IN	OUT	IN	OUT		IDEAL A	IDEAL B
	J2	0	2	2	14		0	2
	J4	2	8	14	30		0	0
	J3	8	26	30	44		0	0
	J5	26	46	46	54		0	2
	J1	46	56	56	60		4	2
		TOTAL ELLAPSED TIME		60				
STEP 3								
	IDEAL TIME							
	MAC A	4						
	MAC B	6						

3. Find the optimum sequence for the following sequencing problem.

JOBS	A	B	C	D	E	F	G	H
MAC A	14	26	17	11	9	26	18	15
MAC B	21	15	16	21	22	12	13	25

Solution:

STEP 1									
	JOBS	A	B	C	D	E	F	G	H
	MAC A	14	26	17	11	9	26	18	15
	MAC B	21	15	16	21	22	12	13	25
	MINIMUM	14	15	16	11	9	12	13	15
	OPTIMAL JOB SEQUENCE	E	D	A	H	C	B	G	F
STEP 2									
	MAC A		MAC B						
JOBS	IN	OUT	IN	OUT		IDEAL A	IDEAL B		
E	0	9	9	31		0	9		
D	9	20	31	52		0	0		
A	20	34	52	73		0	0		
H	34	49	73	98		0	0		
C	49	66	98	114		0	0		
B	66	92	114	129		0	0		
G	92	110	129	142		0	0		
F	110	136	142	154		18	0		
TOTAL ELLAPSED TIME		154							
STEP 3									
	IDEAL TIME								
	MAC A	18							
	MAC B	9							

Processing of n jobs through three machines

1. Find the optimal job sequence, minimize the total elapsed time and idle time on machines G, H, F in the order GFH

JOBS	1	2	3	4	5	6
MAC G	12	8	7	11	10	5
MAC H	7	10	9	6	10	4
MAC F	3	4	2	5	5	4

Solution:

STEP 1						
JOBS	1	2	3	4	5	6
MAC G	12	8	7	11	10	5
MAC H	7	10	9	6	10	4
MAC F	3	4	2	5	5	4
SOLUTION SET						
MINIMUM OF G	5					
MAXIMUM OF H	10					
MINIMUM OF F	2					
JOBS	1	2	3	4	5	6
MAC A	15	12	9	16	15	9
MAC B	10	14	11	11	15	8
MINIMUM	10	12	9	11	15	8
OPTIMAL JOB SEQUENCE	3	2	4	5	1	6

JOBS	MAC G		MAC F		MAC H					
	IN	OUT	IN	OUT	IN	OUT		IDEAL G	IDEAL F	IDEAL H
1	0	12	12	15	15	18		0	5	6
2	12	20	20	24	24	28		0	3	1
3	20	27	27	29	29	31		0	9	12
4	27	38	38	43	43	48		0	5	5
5	38	48	48	53	53	58		0	0	0
6	48	53	53	57	58	62		9	5	4

IDEAL TIME	
MAC G	9
MAC F	27
MAC H	28

2. Find the sequence the minimizes the total elapsed time required to complete the following jobs.

JOBS	1	2	3	4	5
MAC A	5	7	6	9	5
MAC B	2	1	4	5	3
MAC C	3	7	5	6	7

Solution:

STEP 1					
JOBS	1	2	3	4	5
MAC A	5	7	6	9	5
MAC B	2	1	4	5	3
MAC C	3	7	5	6	7
SOLUTION SET					
MINIMUM OF A		5			
MAXIMUM OF B		5			
MINIMUM OF C		3			
STEP 2					
JOBS	1	2	3	4	5
MAC D	7	8	10	14	8
MAC E	5	8	9	11	10
MINIMUM	5	8	9	11	8
OPTIMAL JOB SEQUENCE	2	5	4	3	1

STEP 3										
JOBS	MAC A		MAC B		MAC C					
	IN	OUT	IN	OUT	IN	OUT		IDEAL A	IDEAL B	IDEAL C
1	0	5	5	7	7	10		0	5	3
2	5	12	12	13	13	20		0	5	2
3	12	18	18	22	22	27		0	5	5
4	18	27	27	32	32	38		0	0	0
5	27	32	32	35	38	45		13	10	7
IDEAL TIME										
IDEAL A	13									
IDEAL B	25									
IDEAL C	17									

CONCLUSION

The real-world application based on linear programming problem is considered and one of its models is solved based on open-source software. Some of the models such as transportation, assignment, and traveling salesman are discussed in detail with its existing algorithms. The sequencing model is considered the main part and the existing algorithm to find optimal sequence and total elapsed time are studied in detail. The sequencing algorithm is incorporated using open-source software in Microsoft Excel which helps to solve the sequencing model. Using the open-source software "solver add-in" in Microsoft Excel, the sequencing model is solved within a short span of time. The advantage of using a solver add-in helps in time consumption to solve big problems.

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