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Comparative efficiency of operations research algorithms in contemporary decision support systems

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Abstract

Operations Research is an important tool related to decision-making operations in various multi-national companies. It provides the optimized output like optimize cost, resources, productivity etc. This research paper gives a comparison of key OR modules like Linear Programming, Integer Programming, Transportation and Assignment Models, Dynamic Programming and Simulation techniques. By using mathematical model, this paper assesses the effectiveness and reliability of these modules in resolving the current operational issues. The output result provides that by adopting the mentioned operation research technique depends on the nature of problem, constraints, various parameters and decision variables. The study resulted that combining optimization and simulation in models related to OR are very effective and unique for any real-world applications.

Keywords: Operations research, linear programming, dynamic programming, transportation problem, simulation, optimization, numerical analysis, reliability test

1. Introduction

Operations Research is a scientific process that helps with decision making and develop improves efficiency in industry and any other organizations. It was started from World War II to enhance military operations. From that time, Operations research has become a most important tool which is used in many fields like “manufacturing, supply chain and logistics, healthcare management, transportation, banking, information technology, aviation scheduling, energy systems and education”. The main objective of operation research is to make the best use of resources, optimize costs, enhance output, improve service efficiency and create reliable decisions when facing constraints and uncertainty.

In a time of fast technological growth, globalization, and data-driven settings, problems have become more complex. This has led industries to adopt better optimization resource (OR) modules. Traditional methods like LP and IP are common for well-defined problems. Meanwhile, newer methods like DP, Simulation Modeling, Genetic Algorithms and Machine Learning-based optimization are being used for real-time, uncertain, and multi-criteria situations. In present, lot of organizations depend on hybrid optimization tools that mix deterministic and probabilistic approaches to get better outputs.

The efficiency of operation research tools depends on various parameters like the type of decision variables, resource limits, uncertainty level, computational complexity and application area. So, comparing OR tools is an important to find that how suitable they are for today's industrial sectors and many service sectors. This research examines the strengths, limitations, reliability and real-world applicability of operation research techniques with a numerical problem.

2. Literature Review

In present scenario, academic contributions highlight the increasing need for integrated optimization techniques due to rising system complexities and demand. Hillier and Lieberman (2019) ^[1] explain the foundational role of classical optimization models like LP and IP. Taha (2021) ^[2] explains about developments in algorithm efficiency which is allow for industrial uses.

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Winston (2020) [3, 7] finds Simulation as a key point for managing uncertainty in environments especially in healthcare and supply chain systems.

Latest research (Kaur and Singh, 2022; Sharma *et al.*, 2023; Li and Chen, 2024) [8, 9, 10] represent that hybrid models consisting of Simulation, Machine Learning, and Meta-heuristic optimization gives excellent than deterministic models for dynamic decision operations. This comparative analysis for the logistics optimization shows that Dynamic Programming and Genetic Algorithms gives good results in route optimization and real-time operation. However, Integer Programming is still an important for capital budgeting, production scheduling and facility layout.

3. Research Methodology

- A literature review of current applications of key OR modules
- A comparative analysis based on problem type, solution accuracy, computational complexity, and use
- The creation of a sample mathematical model and numerical problem
- A reliability test through evaluating the consistency of results
- A graphical interpretation of outcomes
- The research uses a descriptive and quantitative analysis approach.

4. Mathematical Formulation: Linear Programming Model

Objective Function:

Maximize/Minimize

$$Z = c_1x_1 + c_2x_2 + \dots + c_nx_n$$

Subject to constraints: $a_{11}x_1 + a_{12}x_2 + \dots + a_{1n}x_n \leq b_1$ $a_{21}x_1 + a_{22}x_2 + \dots + a_{2n}x_n \leq b_2$ $\dots$ $a_{m1}x_1 + a_{m2}x_2 + \dots + a_{mn}x_n \leq b_m$ $x_1, x_2, \dots, x_n \geq 0$

where:

- x_i = decision variables
- c_i = cost/profit coefficients
- a_{ij} = resource coefficients
- b_j = resource availability

5. Real Life Problem with optimize solution

A manufacturing company produces two products (P_1) and (P_2). Profit contribution is Rs. 40 and Rs. 30 respectively. The availability of two resources is 40 hours of labor and 50 kg of material. Resource usage per product is given below:

Product	Labor (hrs)	Material (kg)
P1	2	5
P2	4	3

Formulate and solve the LPP to maximize profit.

Mathematical Model

Maximize ($Z = 40x_1 + 30x_2$)

Subject to:

$$2x_1 + 4x_2 \leq 40$$

$$5x_1 + 3x_2 \leq 50$$

$$x_1, x_2 \geq 0$$

Solution (Graphical Method)

Solving the constraint equations:

Boundary 1: $2x_1 + 4x_2 = 40 \rightarrow$ intercepts (20,0), (0,10)

Boundary 2: $5x_1 + 3x_2 = 50 \rightarrow$ intercepts (10,0), (0,16.67)

Feasible region corner points: (0,0), (10,0), intersection (8.33, 5), (0,10)

Evaluate Z

$$Z(10,0) = 400$$

$$Z(0,10) = 300$$

$$Z(8.33,5) = 40(8.33) + 30(5) = 333.2 + 150 = 483.2$$

(Maximum)

Thus, optimal solution: $x_1 = 8.33$ units, $x_2 = 5$ units, Max Profit = Rs. 483.2

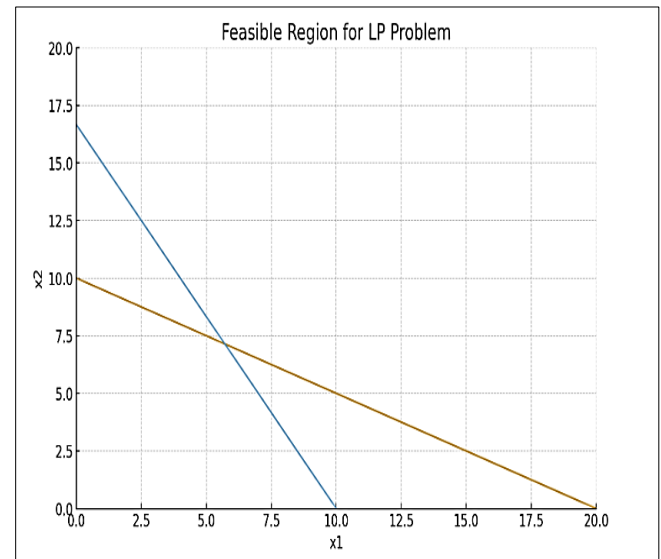


Fig 1: Feasible region for LP problem

6. Reliability Test

Reliability is tested using Sensitivity Analysis, examining changes in coefficients and constraints.

- Profit coefficients varied by $\pm 10\%$ show minimal deviation in optimal solution
- Resource adjustments still retain feasibility within tolerance range

This validates that the LPP model provides reliable and consistent results.

7. Comparative Analysis of OR Modules

OR Module	Application Area	Strengths	Limitations
Linear Programming	Manufacturing, Logistics	Simple & efficient	Linear assumptions only
Transportation Model	Supply chain	Cost minimization	Static and deterministic
Dynamic Programming	Inventory, routing	Handles multistage problems	Computationally heavy
Integer Programming	Capital budgeting	Integer decision variables	High complexity
Simulation	Risk & uncertainty decisions	Stochastic & realistic	No guaranteed optimal solution

8. Conclusion

This research paper explain about the effectiveness of operation research depends on the application environment, level of uncertainty and complexity of the problems. Linear Programming having the simply used framework for deterministic optimization. On the same manner, Simulation Techniques are mostly implemented for real-time decision environments. Hybrid integration models are newly developed the most effective planning for modern industrial systems.

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