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CNNs And GenAI Aren't The Only Games In Town For Supply Chain Planning

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If I were a Martian descending on Earth and hanging out in a Palo Alto cafe today, I would listen to the conversation and assume that the only technology on planet Earth is a large language model (LLM).

This is not surprising, given that every enterprise and venture capitalist worth their salt is investing billions in ChatGPT and generative AI. Many will fail because the technology is still in its infancy and, more importantly, because the fit between the LLM technology and the problem being solved is often lost in the melee. To a hammer, everything looks like a nail!

Optimization: The Problem At The Heart Of Everything From Natural Evolution To Supply Chain

Optimization, which is at the heart of most business problems—from finding the cheapest airfare to determining the optimal staff required in a restaurant—is defined as simply finding the best, most effective use of the existing resources in a given situation.

The complexity of the optimization process depends entirely on the complexity of the problem being solved. In manufacturing, for example, the constraints are on both the demand (including the personalization that buyers seek and product variants) and supply (including production line topology and capacity) sides—which make for a complex and intricate problem.

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Consider the famous traveling salesman problem ("TSP" for short) that would, in today's world, be called the Amazon delivery truck problem: *"Given a list of n cities (a.k.a. stops) and their distances, what is the shortest route that ensures that the salesman (a.k.a. the Amazon truck driver) visits each city (stop) once and returns to the original city (stop)?"* While apparently simple, optimizing is hard as the number of paths to choose from scales exponentially with *n*. So, while a 5-city path has just 12 choices, a 20-city path has ~6e^16!

This combinatorial behavior makes the TSP problem extremely hard to solve. In mathematical language, it is "NP-hard" because it neither has an exact solution nor a guarantee of finding a (near-)optimal solution in a finite time. When one overlays the additional realities of life—delivery priority, traffic and vehicle maintenance—as constraints, an already hard problem becomes nearly impossible to solve with precision.

Can Neural Networks And Generative AI Be Used To Solve The Traveling Salesman Problem?

Neural networks are used to recognize patterns in data (e.g., images) and to classify the output (e.g., the animal is a cat). Generative AI uses large language models to probabilistically create new content from existing data (e.g., compose an essay). Thus, while neural networks and generative AI are exciting, powerful problem-solving technologies, they are unfortunately not relevant to quantitative problems like TSP.

Applying Local Search To Solve NP-Hard Supply Chain Problems

Since most supply chain problems, such as the TSP, are combinatorial in nature and typically lack closed-form (or "exact") solutions, the best approach is to use heuristics and find near-optimal solutions.

Local search is a class of these heuristic AI techniques that, by mimicking processes from the natural world like particle energy and evolution, enable the search process to jump across spaces, avoid local optima and converge on the globally optimal solution. Like a subatomic particle increasingly energized with heat randomly jumping across more energy bands.

Local Search-Based Optimization In The Automotive Industry

An example of a real-world challenge in the automotive industry is determining the optimal sequence in which to build cars while adhering to business constraints.

This, at first, doesn't sound anything like the TSP. After all, there are no cities to travel between! But mathematically, it is very similar. Instead of the shortest travel path between cities, we look to sequence the cars while minimizing materials, time and business rule violations. One business rule, for example, forbids painting a light-colored car after a dark-colored car. This avoids the need to flush the paint lines and thus saves time, money and the environment. Often, there are hundreds of important business rules that must be considered.

When solving this sequencing challenge, we are looking for a combination of variables that simultaneously satisfy the constraints and ensure near-optimality, just like in the TSP.

The most common industry solutions to the constrained factory optimization problem use spreadsheets and manual optimization. They often relax constraints (i.e., delete business rules) or use weak heuristics (like sorting or greedy algorithms) to deliver suboptimal plans. In fact, these suboptimal plans and schedules generated by these approaches often create new issues—bottlenecked stations that lead to downtime and operators working at an unsustainable pace that produces a higher percentage of product defects.

But, when manufacturers apply local search-based optimization, the gains are anything but trivial: Tens of percentage points increases in throughput and on-time delivery times as well as tens of percentage points decreases in the number of changeovers, inventory and delivery lead times adding up to millions of dollars

in upside.

Selecting The Right AI Technology

While one might be tempted to start with the solution *du jour*, you will be better served by starting with your business problem and then identifying an appropriate solution.

• For optimization problems, select from a list like this or this.

• For data-based learning problems (classification, regression, etc.), select from a list like this; for neural networks, select from a list like this.

• For engaging with or generating human-like outputs, consider large language models from a list like this.

Quite likely, these solutions will need to be carefully selected for your problem to deliver high-quality results. For example, at Drishti, we have pioneered new neural network architectures to accurately extract information from video streams, while at Optessa, we have developed a very general purpose and robust local search solver for supply-side planning. Yet, both companies are in manufacturing, with AI solutions running on the plant floor!

If there is a takeaway, it is that the fit between the problem and the solution is absolutely critical to your success. Don't lose sight of this!

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