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As a globally recognized project analytics thought leader and software entrepreneur, Dan has over 20 years of experience building project management software companies, including Pertmaster and Acumen.
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Title

How Artificial Intelligence and the Digitization of Knowledge is Driving Contractor Efficiency

Abstract

This paper discusses how a large U.S. construction contractor is embracing Artificial Intelligence and knowledge digitization to improve the efficiency and accuracy of project cost and schedule forecasting.

Introduction

Capital expenditure (CAPEX) projects are, by their very nature, extremely complex, lengthy and highly involved endeavors. Not only do they carry potentially competing project objectives – optimal time versus minimal cost – they also involve multiple stakeholders, who themselves have objectives that may or may not align with those of the project.

For a contractor, the risk and reward for a project of this magnitude can be huge. Yet, with contractor margins typically in the single digits, the swing between project success and failure is highly volatile. The contractor's challenge is to create a sound and achievable forecast and then track to that forecast. Despite this being the premise for construction project management, achieving it is still quite difficult.

To help with this, project controls advancements over the past 20 years have driven up the volume of project information. Today, there is so much data, but still surprisingly little insight truly being gleaned from it. That's because the interpretation of the data is still a very manual process limited to the human expert. The results are huge inefficiencies for a contractor organization during both the planning and execution phase of a project. It's a huge limitation to

not being able to satisfactorily leverage past historical data when bidding on a project. Likewise, it's a bottleneck to remediation to not be able to accurately extrapolate out future timelines, cash flow curves, etc., based on execution performance to date.

Contractor organizations that recognize there is a big difference between data and knowledge are the ones who will solve this challenge. They are turning to data technology such as Artificial Intelligence (AI) and machine learning to help **capture**, **digitize** and **classify** organizational and project domain human expertise in a way that then provides fast and easy **interpretation** of this stored knowledge. The result is the holy grail – better planned and executed projects.

This paper highlights the journey underway at Kiewit to make digital knowledge part of its daily project controls process.

The Need for, and Challenge of, Knowledge Digitization

The science of capital project planning isn't so different from the art and wizardry of a fortune teller using a crystal ball. In both cases, the future is being predicted even though there are so many unknowns that it would be impossible to repeatedly get it right. Getting the future right is dependent on the amount of context the planner and fortune teller have. The more context and understanding, the more accurate the prediction will be. Context is used to help draw inferences.

Where project planning differs from fortune telling is that project planning is bolstered by the experience and expertise of the planner. Their lessons learned and knowledge of past outcomes are what contractors rely on today to predict the future, thereby creating the project plan itself. Where this becomes problematic, though, is when a junior planner simply lacks real-world experience – or an experienced planner retires or leaves.

The solution is to capture and effectively reuse historical project knowledge of the experienced planner.

Capturing historical information is not very difficult. For a long time now, databases have been designed to capture highly structured data, e.g., CPM schedule data. More recently, databases have evolved to better capture less structured data. Technologies such as NoSQL (a database that doesn't require a schema or tables to be defined prior to storing data) reliably store data, drawings and other unstructured project knowledge sources.

The real challenge, though, is the effective **reuse** of this historical knowledge. To overcome this challenge, Kiewit is embracing the power of AI and machine learning to help mine this stored digital knowledge in a meaningful manner.

How AI and Machine Learning Are Realizing the Digitization Challenge

If we consider the definition of AI as something along the lines of "*the ability for a computer to perform tasks that normally require human intelligence,*" then we can start to see how this can

satisfy the challenge of intelligently mining historical information so as to provide insight and guidance to the planner when developing project cost and schedule forecasts. Instead of Kiewit planners having to carry this expertise themselves, the organization can now pull a lot of this knowledge from its digital asset-based approach.

Kiewit sees its use of AI for planning and scheduling as a pivot in the interaction between a human and a computer. Prior to using AI to help mine historical digital knowledge, Kiewit planners would, for the most part, tell the computer information (e.g., here is my suggested sequence of work and durations). With AI, that interaction is now bidirectional. For the first time, the computer is now pushing knowledge back to Kiewit planners in the form of suggestions and real-time critiques on a given plan. This interaction is driving the quality and realism of the plans that Kiewit puts forward in its bid packages.

An emerging secondary benefit is the ability for the Kiewit knowledge library to not only get constantly updated, but also for it to actually become more accurate. The Kiewit AI engine, the inference engine that mines the knowledge through an understanding of context, gets smarter. It self-adjusts based on the degree of acceptance and uptake from Kiewit planners. The more the AI suggestions are adopted, the more weighting that particular knowledge segment is given the next time around. This machine learning capability is a massive differentiator for Kiewit – as market conditions change, as execution techniques evolve, its digitized knowledge adjusts accordingly.

One of the biggest challenges for Kiewit so far in this knowledge digitization process has been the “decorating” of these large quantities of non-structured data (e.g., project schedules or drawings with a sufficient number of meaningful touch points or attributes for the AI Inference engine to understand that elusive context). To overcome this, the company has adopted a process known as knowledge tagging – a simple means of adding knowledge classifiers such as location, weather conditions, sub-contractors and project year to the data sources to create context for the AI engine. This is proving to be a highly effective means of improving the computer’s ability to pinpoint context and subsequently offer Kiewit planners intelligent suggestions and benchmarks that relate to what is being forecasted and planned.

Quantity Growth Is the Biggest Project Threat

One project characteristic that Kiewit takes very seriously is the recognition that project plans and cost estimates should all be tied back to the quantities of deliverables and components being built. This is quite different to the philosophy behind traditional CPM scheduling, for example, where activity durations are driven by the planner’s expertise and not derived from the likes of quantities and productivity rates.

With the emergence of project data digitization and the ability for quantities to be captured from automated takeoff processes that pull from 3D models or 2D drawings, project schedule activities can be automatically generated and tied back to these quantities. Where this linkage becomes even more valuable is the automatic updating of activity durations during the project

life cycle as the quantities change – changes not just as design becomes more and more detailed (e.g., 30%, 60%, 90% evolution), but changes during execution too.

Tying this back to the use of AI, Kiewit sees an opportunity to track historical quantity growth during a project life cycle to help better predict what quantities will be required for future projects.

Today, just over 50% of Kiewit's total project work value is being managed through this digitization transformation with a goal of 100% by 2022.

The Advent of Truly Integrated Project Controls

Looking forward to the future of project controls and considering some of the characteristics of software needed to support the likes of knowledge digitization, we can confidently make several predictions:

- The days of multiple point solutions appear limited. As a result of the need for a continuous flow of knowledge (and its enrichment) from concept through planning through execution to closeout, there is a requirement for more of a platform-type environment. Platforms offer the ability to more easily pass knowledge from phase to phase as well as for various stakeholders to enrich it as the project phases pass.
- Starting with deliverables and building work plans, schedules and estimates against those deliverables is a better way to plan. In other words, plan more in context of what we are building. In a CPM schedule, for example, start with deliverables and then determine the work needed to satisfy the delivery and handover of those deliverables.
- Planning during execution shouldn't be forgotten. Too much focus is given to building a plan during the pre-execution or pre-construction phase of a project. When it comes to execution, the planning process falls apart and is often done in spreadsheets, or worse, with pen and paper. This short-term field execution planning is just as important as CAPEX CPM planning – so much so that the two processes should be tied together. Project controls should support the ability for the likes of two- to three-week short-term lookahead plans to be developed against the bigger picture CPM CAPEX plan. Even better, if the short-term field execution is then captured as status against this plan, why not feed that information back into the organizational knowledge library to help recalibrate productivity rates for the next go-around?

Conclusion

Kiewit is taking bold and innovative steps to digitize its organizational project controls expertise. The company recognizes that capturing and reusing large quantities of historical facts from complex projects is a much more effective means of more accurately planning and forecasting its projects.

By adopting the likes of AI to help critique its bid plans, as well as using a single source of truth in the form of continually enriching project knowledge throughout the entire project life cycle,

Kiewit's forecasting ability is stronger, as is its ability to quickly pinpoint root causes of project concerns for faster remediation during execution.

While certainly at the cutting edge, Kiewit is not alone in embracing this AI revolution. The construction industry as a whole is slowly but surely moving toward widespread adoption because the benefits are undisputable. While still a buzzword today, fast-forward five years and an organization that doesn't use AI as part of its planning and controls process will surely be the exception and not the norm.

Disclaimer

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Acronyms (in order of appearance)

PMP – Project management professional
CAPEX – Capital expenditure
AI – Artificial intelligence
CPM – Critical path method
3D – Three-dimensional
2D – Two-dimensional

Bibliography

n/a

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