Impacts of Artificial Intelligence on Management of Large Complex Projects[1]

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The management of large complex projects is entering an era of unprecedented challenge and one which warrants further attention and examination. While this paper is written from the perspective of large complex engineering and construction projects the key points and challenges are broader.

The specific challenge this paper focuses on arises from the increased incorporation of artificial intelligence (AI) of all forms (AI, machine learning, natural language processing, etc.) into the various elements of project execution as well as the broader corporate frameworks in which these projects reside. This article in no way intends to suggest that we should avoid the incorporation of AI into our day to day project activities. Rather it is intended to highlight the extent and breadth of its development in the engineering and construction field and to highlight the challenges to the industry and profession which must be addressed.

This paper is not intended to be a primer on AI and the project management profession would benefit from education on the opportunities and risks that AI will create.

Short Background on AI

AI makes it possible for machines to learn from experience, adjust to new inputs and perform human-like tasks. Examples are computers learning to play chess or Jeopardy using AI, for intelligent assistants (Siri; Alexa) or for self-driving cars.

Big Data and AI are interlinked. Data is being generated at an exponential rate. Analyzing these large sets of structured and unstructured data requires self-learning computers to recognize patterns using concepts like 'deep-learning', 'machine-learning' and 'neural networks'. Big data and AI go hand-in-hand, one will not be useful without the other and the two reinforce each other.

Although most think AI is driven by Big Data analytics, the scope of the technology under the umbrella term that is AI falls into three distinct categories: Big Data, vision, and language. In essence, vision and language are related to machines being able to imitate and enhance human perception capabilities, while Big Data is related to how machines

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can analyze large amounts of data much quicker and more accurately than humans, find correlations, and even make predictions of how systems will behave in the future.

AI encompasses a wide range of core technologies but this paper is focused primarily on:

- **Machine learning** (ML) type of AI that involves using computerized mathematical algorithms that can learn from data and can depart from strictly following rule-based, pre-programmed logic. ML algorithms build a probabilistic model and then use it to make assumptions and predictions about similar sets of data.

- **Deep learning (DL)** is a form of ML that uses the model of human neural nets to make its predictions about new data sets.

- **Natural language processing (NLP)** enables computers to understand human language as it is spoken and written, and to produce human-like speech and writing.

- **Computer vision (CV)** attempts to identify images of objects that can be seen. It can also include attempts to use the same technology to identify patterns in data, such as seismographic readings, that humans cannot readily see.

- **Machine reasoning (MR)** attempts to simulate human thought processes by using a computerized model of language to acquire knowledge, and then make decisions. Instead of being programmable in the traditional sense, expert systems are designed to build the model's own understanding of the world based on the relationships between words and concepts.

- **Strong AI** also referred to as artificial generalized intelligence (AGI) attempts to simulate general human thought processes by using a computerized model of concepts to organize knowledge and then act on it. Instead of being programmable in the traditional sense, strong AI seeks to make sense of the world by relying on human language's inherent model of reality buttressed by the discipline of logic.

Extent and Breadth of Potential AI Use Cases

The rate of technology adoption is accelerating and soon AI will be leading the way. This will have a broad impact on both the projects that we do and how we do them. The Artificial Intelligence (AI) market will reach $36bn in 2020, and then almost quadruple to $127bn by 2025. AI is projected to be the single largest driver of tech spending over the next 5 to 10 years. We are only at early stages of Big Data monetization where only 1% of data is stored and analyzed, and only 8% of companies have deployed machine learning beyond the initial testing phases.

This will have a range of medium and longer term implication for industry with a sampling of those that the engineering and construction industry will face shown in Table 1.

Table 1

Implications for Engineering & Construction from Growth in Use of AI

Medium Term	**Longer Term**
With the rapid evolution of technology, there will be an increased need for engineers to research, create and test AI systems.	History has shown that technological advances in the past have helped create new jobs. This will be especially relevant for those in the engineering community.
Engineers have an enormous opportunity to showcase their creativity in response to advances in AI.	AI literacy/proficiency a prerequisite for survival
New types of experts will increasingly be in demand in response to the new types of work created by AI technology.	Existing business model replaced by value added business model. (In part)
New developments in AI will enable engineers to complete their work more efficiently and solve a wide range of problems	Risk of new entrants to business grows.
Exemplar AI use cases become mainstream. First movers accrue competitive advantage in winning work and executing work	Technology partnerships important but also increasingly transitory (techceleration hollows out then current technology advantages at an increasing rate)
Existing labor time business model put under stress	Continuous innovation and process improvement are prerequisite for survival

The extent and breadth of AI use cases in just the engineering and construction industry is shown in the following table. It is likely that this table is not complete but is indicative of the breadth of the impacts. Project management will be challenged with ensuring the veracity and quality of results derived from AI enabled activities. How will we approach this?

Table 2 Potential AI Use Cases in Engineering & Construction	
Use Area	**Potential Use Case**
Business Development	
Marketing	
	Marketing Analytics
	Marketing Personalization
	Neuromarketing for pre-testing (test content in private for desired effect)
	Context aware marketing
	Static image recognition, classification and tagging to improve discovery
	Social media optimization (channel, audience, message, timing)
	Social analytics and automation (Stakeholder applications also)
	Website personalization
	Visual search
	3rd party data analytics to understand existing and target clients (including sentiment analysis)
	Content generation
	Crowd Sourced Market Research
Sales	
	Pricing optimization
	Sales forecasting
	Sales data input automation
	Predictive sales/lead scoring
	Sales content personalization
	Sales contact analytics
	Intelligent CRM Systems
Data (to support AI)	
	Data preparation platforms (extract, transform, load (ETL) platforms)
	Converting Paperwork into Digital Data
	Data cleaning and validation platforms
	Data integration and transformation
	Data management and monitoring

Analytics	
	Employee empowering analytics platforms (problem and insight identification)
	Client supporting analytics services
	Geo-analytics platforms
	Business analytics platforms
	Data visualization
	Real time analytics
	Image recognition and visual analytics (inspection; safety)
Financial	
	Fraud detection
	Financial analytics (project performance and spend; overhead spend)
	Credit scoring (client; subcontractors and vendors)
	Expense reporting and management
	Billing and accounts receivable automation
	Tax filing and processing
	Agent-Based Simulations for Decision Making
Legal	
	Legal and regulatory compliance
	Contract Lifecycle Management (CLM)
Project Health	
	Project Manager selection
	Project data analytics
	Project risk modeling, mitigation and management
	Project mitigation and recovery plans
	Project execution discovery and modeling
	Real time predictive analytics
	Automated report generation
Human Resources	
	Candidate identification and screening
	Performance management
	Retention management
	HR analytics
	HR services

Information Technology	
	Cybersecurity prediction and analytics
	Autonomous cybersecurity systems (prevention against cybersecurity threats)
	Autonomous code development
	Knowledge management
	Design recognition library
	Innovation support and prioritization
Engineering & Design	
	Planning
	Stakeholder Management
	Estimating
	Design automation and optimization
	Generative design
	Project staffing
	Design compliance (contract; specifications; codes and standards)
	Design checking; validation; verification
	RFI automation
	Resident engineer/construction inspection
	Continuous improvement
	Evolving skills
Operations	
	Back office automation
	Facilities management
	Predictive maintenance
	Operating project analytics
Supply Chain	
	Supply Chain
Logistics	
	Automated Logistical Truck Services
	Object Detection and Classification – Avoidance and Navigation
Construction	
	Construction management
	Construction safety

	Construction Quality
	AI Assisted Construction
	AI Robot Assisted Construction
	Automated Report Generation
	Post-Disaster Assessment

Barriers, Threats, Risks

Barriers

Several barriers to AI adoption exist within the engineering and construction industry and analogs will exist for other industry segments. These include:

- A lack of understanding.
    - Engineers don't fully understand how AI predicted outcomes were derived. This not only raises trust issues but also creates potential legal and liability issues.
    - Data analytics are developing at a rapid pace, making it difficult to keep up with technology advancements and the benefits associated with them.
- A lack of resources.
    - Many companies simply do not have the in-house IT infrastructure and expertise to successfully harness big data.
- A lack of willingness to change.
    - Having already invested heavily in legacy software systems, many executives may be hesitant to invest in new software solutions.

Threats

AI does not come without some risks. Algorithms are being designed to emulate as closely as possible what a human would do. Hence algorithms can introduce human biases. While AI is useful for unstructured datasets, automatic classification, and forecasting and prediction, it is not ideal in understanding the 'why,' especially when many external factors are involved.

AI could help rejuvenate overall productivity, but the technology has to become a whole lot easier to use

AI has to overcome many ethical issues; it mandates thorough due diligence and impact assessment.

Some specific AI threats might include:

- Highly believable fake videos that impersonate prominent figures to manipulate public opinion
- Automated hacking
- Finely-targeted spam emails using information scraped from social media

- Exploiting the vulnerabilities of AI systems through adversarial examples and data poisoning.
- Crashing fleets of autonomous vehicles
- Turning commercial drones into face-targeting missiles
- Holding critical infrastructure to ransom

Risks

AI creates three specific risks.

First, intelligent machines often have hidden biases, not necessarily derived from any intent on the part of the designer but from the data provided to train the system. For instance, if a system learns which job applicants to accept for an interview by using a data set of decisions made by human recruiters in the past, it may inadvertently learn to perpetuate racial, gender, ethnic or other biases. Moreover, these biases may not appear as an explicit rule but, rather, be embedded in subtle interactions among the thousands of factors considered.

A second risk is that, unlike traditional systems built on explicit rules of logic, neural networks deal with statistical truths rather than literal truths. That can make it difficult, if not impossible, to prove with complete certainty that a system will work in all cases, particularly in situations that were not represented in training data. Lack of verifiability can be a concern in mission-critical applications (such as controlling a nuclear power plant or aircraft) or when life-or-death decisions are involved.

A third risk is that, when machine learning systems make errors, diagnosing and correcting the precise nature of the problem can be difficult. What led to the solution set may be unimaginably complex, and the solution may be far from optimal, if the conditions under which the system was trained happen to change. Given all this, the appropriate benchmark is not the pursuit of perfection, but rather, the best available alternative.

Impacts on Engineering & Construction Companies

Artificial Intelligence will become a factor at all stages of the project lifecycle impacting not only how companies do business but also the business they do, the services they deliver and the mix of skills they will require.

Planning

Planning transformation can be thought of in two dimensions. The first revolves around the changed planning process on the public sector side and the second is in the execution of planning activities themselves.

The public sector planning system is ripe for machine-learning, and initiatives include:

- AI customer-facing interface to answer general planning inquiries, from the status of applications to various other queries. It will retrieve and present any information that people are likely to need, via computer or phone.
- A validation process with AI validating applications and then saving and checking all documents before placing them in the planning database.
- Public consultations are also set to be transformed through AI that will allow passers-by with smart phones to take a virtual look at design proposals for a vacant lot as they stand at the site itself.

In executing traditional planning activities we tend to limit the number of scenarios considered given their complexity and often non-deterministic nature. AI enables seeing deeper correlations and hidden constraints and couplings, suggesting solutions outside of what otherwise may have been considered.

Design

A search of ASCE[2] papers shows the industry is not standing still on AI. A number of potential use cases have been described and researched. These discrete and very specific use cases represent the immediate future of AI in the civil engineering profession while the medium and longer term aspects covered in this white paper are accelerating towards us.

The use cases to date stop short of addressing the broader issues on how the design process needs to change and how maximum industry leverage can be obtained. The importance of performance-based standards must be called out as an enabler of innovation broadly but the enablement of broad AI adoption specifically.

AI aids the design process but also modifies it[3]. Research into AI has produced:

- Software systems that design artifacts
- Software systems that provide assistance to designers (for example by critiquing design choices or suggesting other alternatives)
- Theories about how designers reason
- Studies and analyses of actual design activities
- Models and descriptions of natural categories of design activity (for example, routine parametric design)
- Guidance about how to apply existing AI techniques to design problems

The field has progressed to functional reasoning and creative design, and from solo designers to teams.

While AI affects the design process indirectly in a myriad of ways including categorization of types of knowledge, new tools and new processes, it can also affect the design process directly. Some examples of direct impact include:

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[2] American Society of Civil Engineers

[3] Chapter 6 Artificial Intelligence foe Design Process Improvement; David C. Brown; Worcester Polytechnic Institute

- Agent learning
- Methodology generation
- Planning

There are many examples of task based uses of artificial intelligence in civil engineering design.[4]

AI can help guide the design process. As a result what we design will be different than what we might otherwise have done. Similarly, new tools allow some of what we previously have designed, investing engineering time and talent in, to be adequately handled by artificial intelligence.

Procurement/Supply Chain

Digital transformation is poised to change the supply chain more profoundly than any other functional area and more dramatically than at any point in its history in terms of driving efficiency and resiliency to disruption. In the context of the challenges facing supply chains it becomes clear that the old ways of working will not suffice and that even best-in-class performance today is unlikely to be good enough in the future. The supply chain must become a "thinking" supply chain, one that is intimately connected to all data sources, enabled with comprehensive and fast analytics, openly collaborative through cloud-based commerce networks, conscious of cyberthreats, and cognitively interwoven.

If we broadly assess the typical supply chain, two major "gaps" emerge. The first gap is an analytics gap whereby available analytics and even AI capabilities are not keeping up with the growth and diversification of data and data sources. If a supply chain is to be best in class, or even above average, available data must be fully leveraged — whether it is traditional structured data that is easily searchable by basic algorithms or unstructured data more akin to human language. Unstructured data doesn't fit nicely into relational databases, and searching it based on traditional algorithms ranges from difficult to impossible. Then there is also dark data, broadly defined as data that is not visible, or not yet visible, to an organization. Regardless of the nature of data, however, the thinking supply chain must have access to the data, and be able to analyze it for value, in real time.

The second gap is one of attention and knowledge. Supply chain organizations have pursued cost reduction and traditional lean practices to the point that there are fewer people in the organization than at any time in the past, and as baby boomers retire, they take with them knowledge and practical experience that is not replaced by the millennials who succeed them. While this may be productive in the short term, as data analytics capabilities invariably grow in the supply chain, there likely won't be enough "eyeballs" available to act upon the resulting insights. Thus, the role of AI and machine learning becomes critical.

[4] Artificial Intelligence in Civil Engineering; Pengzhen Lu, Shengyong Chen, and Yujun Zheng; Hindawi Publishing Corporation; Mathematical Problems in Engineering; Volume 2012, Article ID 145974, 22 pages doi:10.1155/2012/145974

The imperative exists, therefore, for a digitally enabled, thinking supply chain that can manage, in real time, massive amounts of structured and unstructured data from both internal and external sources, including data sets that might previously have been elusive. Imagine a thinking supply chain that could aggregate data across regions to both anticipate future demand accurately and manage current replenishment or that could manage asset, inventory, and shipments through real-time tracking and optimization and then configure and change orders even in the middle of production — all done automatically without direct human intervention. This supply chain would not replace people necessarily — they would have oversight, of course; rather, it would enhance and augment the decision-making process. A thinking supply chain could iterate decisions far faster than any human could.

How does the project manager's role and oversight responsibilities change?

Construction

From automotive robots that can "see" what to weld**,** AI is extending into construction.

Business Implications

AI has direct impacts on the business models driving both companies that do projects as well as the business of projects. AI impacts the skills we need and the tools we use.

Business Model

AI has the potential to unlock new business models for companies. These business models can be described as "AI First" business models. The "AI-First" business model is about using data and algorithms for three main things, all of which contribute to category leadership:

- Create better products/services, thereby becoming leaders in product/service adoption
- Optimize processes by augmenting humans, thereby becoming leaders in product/service pricing
- Reduce costs by replacing humans, thereby becoming leaders in workforce efficiency

It is important to note that the value added created by AI does not lend itself to value capture through charging for man-hours. New pricing models will be required in the industry. In developing these new models it is important to recognize that along certain dimensions the firm, and by extension its projects, are becoming an AI supplier and thus needs to understand the predominant strategies and business models for AI firms.

Three potential business models include:

- Bolt-on
- Enhanced process

- Letting the machine stand alone

In the third AI business model, the AI technology changes an entire workflow by introducing an AI-infused, better-way-to-complete-a-business-process. AI "owns" the experience end-to-end, with very little human-required assistance, giving algorithms the full control over the experience. What is the role of the project manager?

Changing Skills

Part of the AI mindset is a shift in the way we approach problem-solving. AI must learn through mistake-making and in various iterations of a task over time while gathering information from a larger data set. Shepherding this process requires visionary talent with a relatively high tolerance for both risk and failure. This will challenge project managers and their need to reliably deliver project outcomes.

AI professionals need the creativity to imagine how the technology can be applied, paired with the analytical acumen to measure results and determine success over time. They must be willing to take risks and perform experiments while being resilient enough to fail fast and move on faster. Talent like this can only succeed within the right organizational culture. Projects and project management practices may be seen as a drag on AI adoption. This must be recognized and reconciled.

Agility is a skill in hot demand.

Tools We Use

Much can be written about individual tools but this is not the focus of this paper. Tools that the project manager will increasingly use include AI but also a set of inter-related tools:

- Cloud Computing
- Data analytics
- Data mining
- Artificial Intelligence
- Augmented Reality (AR)

Impacts on the Profession

Three broad sets of challenges exist for the profession. These include:

- **Resources**
    - Access to quality training data
    - Access to limited pool of talent
    - Re-skilling workforces

- **Big Data**
  - Significant time required for data cleaning and processing, ensuring data integrity
  - Lack of interoperability across protocol, device types, data types, and data sets
- **Standards and Regulations**
  - Lack of algorithmic standards
  - Unclear ethical standards
  - Unchartered legal/liability and regulatory questions or standards
  - Uncertainty around compliance with existing regulations
  - Risks of algorithmic explainability and compliance in highly regulated industries
  - Lack of industry-specific best practices

Skills Requirements

The demands of a techceleration environment, especially in Artificial Intelligence (AI), will require an educational system which provides industry with talent that is immediately ready to add relevant value. The education system must then keep engineers on the cutting edge of being able to gainfully deploy, use and manage the technology it further advances. Advancements will arrive from all directions and in all disciplines. Improvements in collecting, storing and processing big data will continue to enable the expansion of AI and other technological advancements' which will have significant effects upon the engineering and project management professions.

Effective delivery teams will be essential to succeed in an environment of techceleration and expanding Artificial Intelligence. Teams will need to have access to a wide variety of skills and experiences. They will need to be collaborative, seamlessly synchronized and able to fully leverage the advantage of their collective intelligence and capabilities … both human and artificial. They will need to be able to efficiently share information through a widely distributed communications system. The teams and the team composition will need to grow and adapt to a rapidly changing working environment. Project managers will have a leadership role.

Artificial Intelligence will present unique opportunities for the profession but for those opportunities to be fully realized we will have to carefully understand and appreciate AI applications' strengths and limitations. The AI environment will not be static by any means. Existing AI applications will evolve and new applications will rapidly merge both from commercial, "off the shelf" and internally developed sources. Project managers and engineers will need to not only effectively use existing AI applications but also actively seek applications to address specific engineering and management challenges.

Adaptability will be a key characteristic as the obsolescence of past practices will take on an accelerating pace to match techceleration advancements.

We must also be leaders and managers. Effective use of technology can provide an advantage within a very competitive industry. Leadership and management skills will take on a more important role to ensure the effective deployment of technology is not only efficient but also reliable and safe. AI systems must be continuously improved and evaluated to achieve quality results. Leadership and management skills will be essential to ensure the delivery teams are integrating technological advances to ensure operations at fullest potential and peak performance.

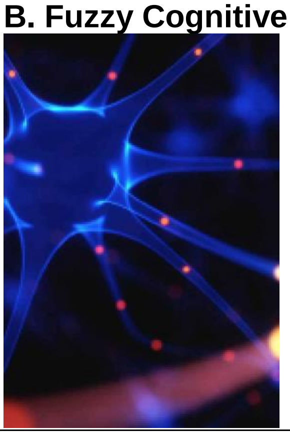
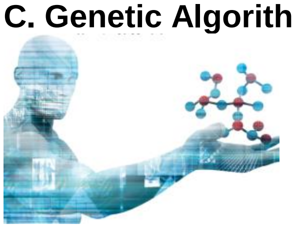
Future needs will require project teams to:

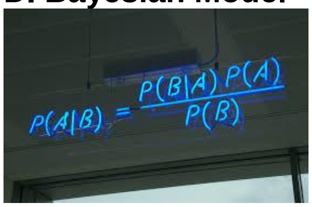
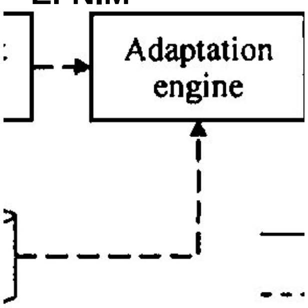
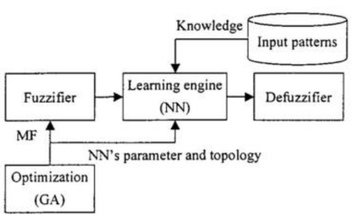
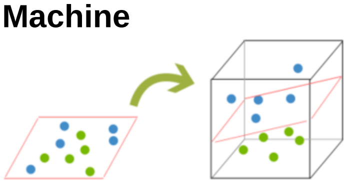
- Understand neural networks and multi-layer data abstraction, empowering analysis and utilization of data
- Comprehend and differentiate between theoretical concepts and practical aspects of machine learning,
- Master and comprehend advanced topics such as convolutional neural networks, recurrent neural networks, training deep networks and high-level interfaces
- Understand major applications of Artificial Intelligence across various use cases including analogous use cases in various fields
- Implement classical Artificial Intelligence techniques, such as search algorithms, minimax algorithm, neural networks, tracking, robot localization
- Apply Artificial Intelligence techniques for problem-solving and explain the limitations of current Artificial Intelligence techniques
- Formalize a given problem in the language/framework of different AI methods (e.g., as a search problem, as a constraint satisfaction problem, as a planning problem, etc.)

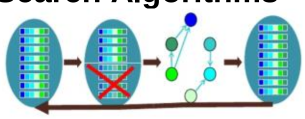
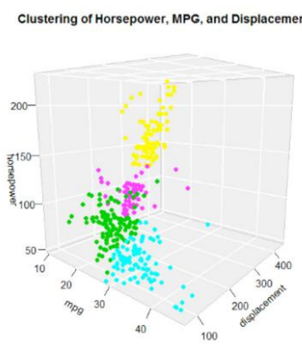
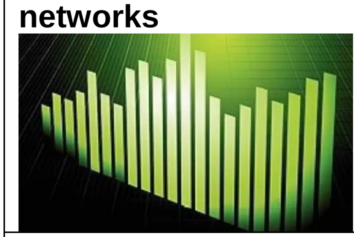
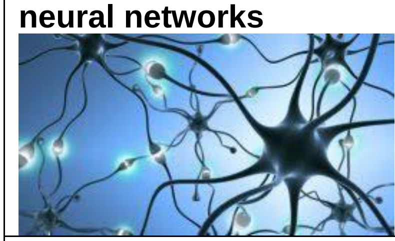
AI tools

Algorithms based on artificial intelligence, and applied to project success are reflected in Table 2 and represent a select list of the new AI tools that the project industry, especially as it relates to engineering and construction, is likely to require increased familiarity with in the years ahead.

Table 2
AI Tools in the Engineering & Construction Industry

A. Neural Networks 	Neural Networks attempt to simulate, to a degree, human way of thinking, and are used, nowadays, for multiple purposes, from credit approval, fraud detection, surveillance systems and other kinds of prediction purposes. One of the main parts of neural networks consists of learner training so neural network adjust to data patterns and give better results. This training is done comparing neural network results with real and known data and is repeated so it adjusts until results of a very low error rate are achieved. Neural networks, because of their characteristics, are more accurate than linear models, based on regression models, which have been frequently used in project management.
B. Fuzzy Cognitive Maps 	Fuzzy Cognitive Maps are fuzzy graphical structures that allow the representation of causal reasoning. This graphical representation is made of nodes where the most relevant nodes are specifically identified for a decision-making system. Fuzzy cognitive maps have their origin in a fuse of fuzzy logic and neural networks.
C. Genetic Algorithms 	Genetic Algorithms (GAs) try to simulate the evolutionary natural process as originally proposed. They are easy to apply so they can be fused with other heuristic methods creating ad-hoc solutions. However it is difficult to apply them to large, complex, difficult-to-solve problems. Different variants of GAs are in use including messy GA and fast messy GA. The Fast Messy Genetic Algorithm can identify optimal solutions in an efficient way to problems with a large number of permutations. It is known because of its flexibility and because it can be fused with other methodologies to get better results.

	The difference between it and other genetic algorithms is based on the possibility of modifying building blocks to better identify partial solutions so as to focus on a global solution faster.
D. Bayesian Model 	Bayesian networks are described as a representation of a joint probability distribution. It is one of the most common methods for data classification in different categories. The Bayesian model allow us to answer questions such as what is the probability of X being in state x1 if Y = y1 and Z=z1. In other words, links the probability of A given B with the probability of B given A.
E. Evolutionary Fuzzy Neural Inference Model – EFNIM 	EFNIM fuses genetic algorithms, fuzzy logic, and neural networks and has been traditionally used for civil engineering problem solving. The combination of these three algorithms makes the strengths of one cover the weaknesses of the other. So genetic algorithms are used for optimization purposes, fuzzy logic deals with uncertainty and neural networks for mapping inputs and outputs.
F. Evolutionary Fuzzy Hybrid Neural Network – EFHNN 	The model EFHNN includes four algorithms of artificial intelligence: 1. Neural Network 2. High Order Neural Network 3. Fuzzy Logic 4. Genetic Algorithm Neural Networks and High Order Neural Networks, named together as Hybrid Neural Network (HNN), manage the inference engine while Fuzzy Logic deals with the fuzzy layer. Genetic algorithms optimize the final model. The difference with EFNIM is that this model is able to manage problems more deeply thanks to the large number of HNN models.
G. Support Vector Machine 	This is a new way of learning, which is more powerful than traditional learning tools. It is able to solve data categorization problems and regression problems as well. Just as neural networks do, SVM requires training and testing with a training dataset. SVM's characteristics allow it to deal better with unknown data and, generally

	speaking, they present some advantages over neural networks. They are being applied successfully to cost estimation in the construction industry.
H. Other Stochastic Search Algorithms 	Other nature-inspired popular meta-heuristic optimization algorithms include Particle Swarm Optimization (PSO), Artificial Ant Colony Optimization Algorithms (ACO), Artificial Fish Swarm Algorithms (AFSA), Artificial Bees Colony Algorithms (ABC), Firefly Algorithms (FA), Bat Algorithms (BA), and Shuffled Frog-Leaping Algorithm (SFLA). They have gained popularity because of their ability of dealing with nonlinear global optimization problems
I. K-Means Clustering 	K-Means is an easy approach for creating data cluster from random data. It is commonly used for image pattern detection as well as for many other applications. Its main problem is that it cannot ensure an optimal convergence, but is widely used due to its simplicity.
J. Bootstrap aggregating neural networks 	Bootstrap aggregating neural networks are a combination of multiple artificial neural network classifiers. They use more than one classifier based on ANNs so the final decision is taken from each classifier by a voting system.
K. Adaptive boosting neural networks 	The main difference with Bootstrap aggregating neural networks is that adaptive boosting neural networks use weights that are readjusted on every iteration giving less importance to those solutions that have not been classified correctly. As a result, classifiers focus on more complex samples obtaining a faster solution each time.
Artificial Intelligence applied to project success: a literature review; International Journal of Artificial Intelligence and Interactive Multimedia, Vol. 3, Nº5 with comments from ILC Workgroup incorporated.	

How the Project Manager's Role May Change

In the near term AI will likely replace tasks rather than jobs. It will also create new, higher value tasks to be undertaken given the power of the new tools. The union of AI and engineering, for example, should create AI Engineering dealing with invention, innovating, designing, building, maintaining, research, and improving structures, machines, tools, systems, manufacturing processes, components, materials, processes, solutions and organizations. The project manager's role will evolve to reflect these changed execution capabilities and approaches.

As AI further enables the various execution activities it will drive changes in traditional roles as well as creating new ones. Traditional roles will increasingly incorporate AI and many steps in the overall work process. The importance of assumptions made including constraints imposed will take on increased importance. The ability to draw a direct line from the assumptions made to the resulting design or analysis may no longer be possible. AI will rely on larger data sets than a discrete engineering or other task would likely consider today. AI will consider many possible optimization scenarios as well as analytical models to employ.

Tomorrow's AI enabled engineer and project manager will require familiarity with how AI is being employed, the veracity and robustness of the assumptions made and importantly any potential biases that may be reflected in the training data used to create the embedded AI algorithms. Sensitivity to assumptions including constraints will also take on increased importance and assumption migration will need to be closely tracked.

Optimization parameters reflected in AI enabled analysis must be closely understood.

Checking of AI enabled designs will present new challenges as will validation and verification of AI derived analyses and designs. Will the resultant outputs be the result of an automated process, a product if you will, produced by a tool or a professional work product. How does project management oversight and capabilities need to change?

In the short to medium term AI enablement will be task focused around valuable use cases. AI aware engineers will be required to identify, define and test prospective high value use cases. Data scientists who understand the existing and prospective big data in this domain will be required to assemble clean and well categorized data sets to train new AI algorithms. They will be supported by data engineers and data analysts. Approaches to validation and verification will be essential especially in any scenario where formal certification that AI tools have been adequately validated and verified is required. Project managers must ensure that the AI employed is applicable for the intended use.

Validation goes beyond traditional model and computational confirmation and must now include assessment of knowledge bases engaged in the AI driven operation as well as the training data efficacy including discovery of both currently known biases as well as currently unknown biases that create the potential for latent risks and insights not well supported by deeper science.

The potential for dangerous suggestions to emerge as data insights (insight without science) is a real challenge we will face and project managers will have a key role to play here.

Should we require AI ethics for project managers?

Summary

This paper has touched upon some of the considerations and implications from accelerating deployment of AI in project industries, especially engineering and construction.

Some of the new considerations for project managers include:

- Veracity and quality of results
- Emerging legal and liability issues
- Thoroughness and quality of due diligence and impact assessment of AI ethical issues
- Hidden biases
- Quality and limits of training data
- Lack of verifiability
- Diagnosis of errors
- Access to sufficient data including relevant dark data
- Access to required AI skills
- Uncertainty around compliance with existing regulations developed pre-AI
- Data integrity
- Adequacy of interoperability
- Assumption tracking and linkage to AI use cases
- Constraint awareness and tracking as it relates to the AI we deploy
- Insight into AI optimization parameters

About the Author

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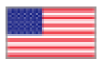

Bob Prieto is a senior executive effective in shaping and executing business strategy and a recognized leader within the infrastructure, engineering and construction industries. Currently Bob heads his own management consulting practice, Strategic Program Management LLC. He previously served as a senior vice president of Fluor, one of the largest engineering and construction companies in the world. He focuses on the development and delivery of large, complex projects worldwide and consults with owners across all market sectors in the development of programmatic delivery strategies. He is author of nine books including “Strategic Program Management”, “The Giga Factor: Program Management in the Engineering and Construction Industry”, “Application of Life Cycle Analysis in the Capital Assets Industry”, “Capital Efficiency: Pull All the Levers” and, most recently, “Theory of Management of Large Complex Projects” published by the Construction Management Association of America (CMAA) as well as over 600 other papers and presentations.

Bob is an Independent Member of the Shareholder Committee of Mott MacDonald. He is a member of the ASCE Industry Leaders Council, National Academy of Construction, a Fellow of the Construction Management Association of America and member of several university departmental and campus advisory boards. Bob served until 2006 as a U.S. presidential appointee to the Asia Pacific Economic Cooperation (APEC) Business Advisory Council (ABAC), working with U.S. and Asia-Pacific business leaders to shape the framework for trade and economic growth. He had previously served as both as Chairman of the Engineering and Construction Governors of the World Economic Forum and co-chair of the infrastructure task force formed after September 11th by the New York City Chamber of Commerce. Previously, he served as Chairman at Parsons Brinckerhoff (PB) and a non-executive director of Cardn0 (ASX)

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