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The Rise of the AI: Impact of AI and Machine Learning in Construction

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Learning Objectives

- Understand the impact and applications of AI and machine learning in the field of construction
- Learn steps that can be incorporated to take advantage of this wave of data-centered products
- Understand from industry leaders and early adopters the applications and value of machine learning in construction
- Learn best practices about data capture, standards, and tools that will help you maximize your advantage from machine learning and AI today

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Description

The field of construction is well placed to benefit from the advent of machine learning and artificial intelligence. As part of the BIM 360 Project IQ Team at Autodesk, I've had the privilege of being a part of Autodesk's foray into machine learning for construction. This talk will focus on summarizing the developments in this space, and we'll cover some ways in which one can prepare to maximize value from this technology. The class has 2 sections. The first part provides a broad survey of some of the applications of AI and machine learning in construction, and the potential impact. These processes are making changes across various areas, including risk management, schedule management, subcontractor management, construction site environment monitoring, and safety, to name a few. In the second part, the focus will be on construction industry leaders who will talk about their experiences with smarter tools in their daily jobs, and their views of the impact that these tools might have in the short and long terms.

Speaker(s)

Anand Rajagopal is currently a Data Scientist at Autodesk where he is part of the product team for BIM 360. In his current role, he works closely with customers to build, test and deploy machine learning models that are specific to construction. He previously worked as a software developer for Philips Healthcare. Anand has earned a BE in Computer Science from PES University, India and a MS in Information Management and Systems from UC Berkeley. He is also a part time photographer, with an interest in outdoor and wildlife photography.

Christina is a Regional Quality Manager with Swinerton Builders. She began her career in construction as a field engineer where she gained hands-on understanding of basic project controls through surveying and layout responsibilities. As she progressed through the project engineer role, her exposure to design details developed through writing and processing RFIs and submittals. Her experience as a project manager brought together these elements and added to her proficiency of financial and subcontractor management. Christina currently oversees the divisional quality control managers and their project's quality control plans which addresses quality control and assurance processes and procedures used throughout a project including architectural, structural, mechanical and electrical work.

Josh Lannen's current position with BOND Brothers is a quality assurance / quality control (QA/QC) manager, and he oversees BIM 360 software deployment. Has worked on projects for clients such as Liberty Mutual, Blue Cross Blue Shield Association, and Harvard Business School. Over the last 17 years, he has held the positions of field engineer, assistant superintendent, superintendent, and project manager. In his current role as Corporate QA/QC manager for BOND, he oversees the quality program and BIM 360 software database for the entire company. He is continually improving best practices and keeping the company current on industry advances and trends. Josh earned a BS in civil engineering from Northeastern University and is a member in good standing with American Society of Civil Engineers.

Josh Kanner is Founder & CEO of Smartvid.io, a cloud platform for the intelligent management, collaboration and analytics of industrial video and photos. Most recently he was co-founder of Vela Systems, a pioneer in the use of web and tablet workflows for construction and capital projects. Vela Systems grew from bootstrapped beginnings to include over 50% of the ENR Top Contractors as customers and deployments all over the globe. The company was successfully acquired by Autodesk in 2012 and has been rebranded as BIM 360 Field. Prior to founding Vela Systems, Josh was responsible for product management and strategy at Emptoris (now part of IBM), a web-based strategic sourcing software company with customers including Motorola, GlaxoSmithKline, Bank of America, and American Express. Kanner graduated from Brown University and earned an MBA from MIT's Sloan School of Management. He still gets excited to put on a hard hat and walk a job.

What do we mean by A.I.?

Definitions

The public perception of artificial intelligence (or A.I.), usually ranges between the two extremes of having it rule the world to it being dismissed as fantasy with no place in a serious conversation. In reality, the truth lies somewhere in the middle where A.I. is very far from being a form of super-intelligence but a branch of study that has found tremendous application and is a big driving factor of applications in today's technology.

Traditionally, defining A.I. has always been a challenge. "Artificial" is the easier part of the definition where it can simply mean "not naturally occurring". "Intelligence" on the other hand has led researchers down several rabbit holes. **In general, A.I. refers to a broad field of science encompassing a range of subjects from computer science, psychology, philosophy to linguistics. It is primarily concerned with getting computers to do tasks that would normally require human intelligence.**

This series of articles provide deeper reading into understanding the definition and history of artificial intelligence.

There are now many fields of work within the broader scope of A.I, but to define two of the more popular areas – Machine Learning and Deep Learning. **Machine Learning** is one such subset that deals with writing algorithms that allows computers to learn from data without being explicitly programmed. If, for example, you want to write an algorithm to identify spam in e-mails, you will have to train the algorithm by exposing it to many examples of e-mails that are manually tagged as being spam or not-spam. The algorithm "learns" to identify patterns, like occurrence of certain words or combinations of words, that determine the chance of an e-mail being spam. **Deep Learning** can be considered a set of specialized techniques within that the umbrella of machine learning that have really developed more recently. They are based on neural networks, a type of machine learning algorithm that simulates the neurons in the human brain. Deep Learning allowed several breakthroughs to be made in the fields of image and language processing allowing the possibility of advanced applications such as the home assistants and self-driving cars.

Contributing Factors

A.I., as an academic field, has been around for a long time, the first conference on A.I. was held in 1956, but has been more in the spotlight over the last decade. This can be attributed to several factors that have themselves improved over a lot recently. All of A.I. requires a lot of data to be present to power the insights that can be derived from it and there has been a tremendous increase in the amount of data generated over the last few years. According to an IBM blog, a few years ago, 90% of the data was then created in the last two years. I guess that can be stretched to about 95% today. Along with data, the computing power available to analyze this data has increased exponentially every year while the cost of the computing power reduced. Today, almost all the data resides in the cloud, and given the availability of resources

to process this data, we have seen an outburst of applications that are focusing on making better decisions based on insights received from this analysis.

Applications of A.I.

A good way to begin to understand the range of applications A.I. is examining how ubiquitous it has become. We get several emails every day and most of us spend more time on it that we would like. However, have you noticed how few the number of outrageous spam emails have become? Five years ago, you would have a received at least one email each week claiming that you have won the lottery. Spam detection is one of the older and more well-known applications of machine learning. By looking at thousands of emails, computer programs have been able to "learn" what a spam email usually look like. It can understand that the sender is not someone likely to email you, or from the text of the email that the content is most likely fraudulent. This is just one example of text processing.

Another area of development is the analysis of images. Problems in this space can be reduces to two broad classes, identifying what the image represents and then identifying where exactly an object is there in an image. For example, given a photo, is there a cat in the photo? The second challenge would be whether you can detect where exactly is the cat in the image?
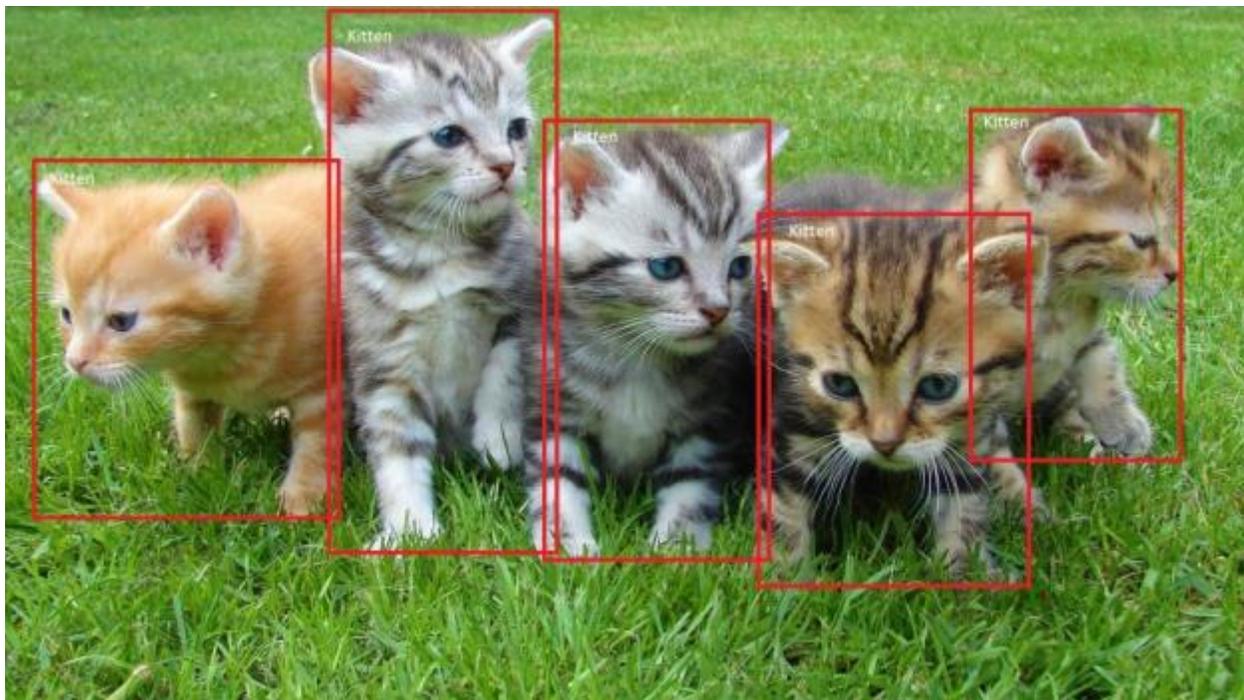
With the development of deep learning, there have been several breakthroughs in this space. Moving from the detection of cats, the new IPhones come with face detection based locking functionality. The algorithms are able to distinguish the finer details of a photo and do it quick enough that they can be used to make real-time decisions. The algorithms were detecting if photos had a cat in them but now they can actually tell you if it is the same cat in every photo.

When these image recognition and detection algorithms are combined with other forms of A.I., you get fascinating applications like self-driving cars. They are able to sense their surrounding

and use that to navigate the environment. It is a complex task of understanding different objects in the environment, understanding the differences in how they behave or operate, the rules they imply in the environment. The image below is the example of a view that a self-driving car would use to navigate. The system is able to distinguish between people, cars, stationary objects. It has to understand the meaning of a red light and a one-way sign. It is able to estimate the distance between the objects and use this to make decisions. This article provides for a more in-depth and interactive reading on how they are made and the technology behind them.
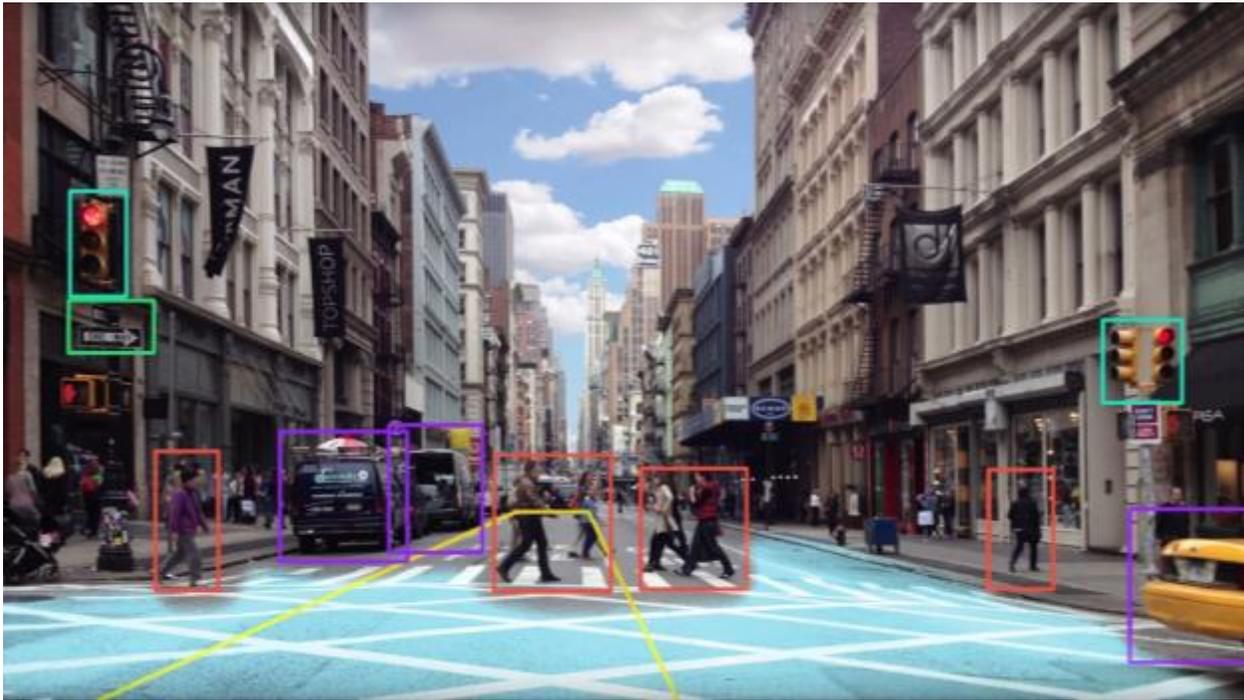
Human minds are capable of dealing with about three to four different data points when making a decision. This is another area that artificial intelligence has made headway. While human minds are only capable of dealing with three to four dimensions, AI algorithms don't have a limit. When you are binge watching a show that Netflix recommended, their recommendation engine probably considered a lot of different things; what's your age, gender, what do other people of this profile like to see, what kind of shows have you been watching, the reviews for the show, the engagement of other users with this show and many such other attributes.

The common requirement across all of these examples is that these algorithms need a lot of data to learn from. A.I. provides a recommendation or a solution based on the data it is provided with and therefore is only as good as the quality of that data. In order to be able to really utilize what this technology offers, we have to put thought into organizing what data we collect and managing it across all products. A common saying in A.I. circles, "Garbage in, garbage out".

What are the changes A.I. is bringing to Construction?

Technology for construction has seen a lot of investment over the last few years. Huge portion of that investment has gone towards digitization of different parts of the construction workflow. BIM models have changed the way that buildings are designed, the project management and issue management processes have moved to the cloud, operations management is also becoming more "sensorized" and automated. With the availability of data, artificial intelligence based applications have been finding more utility in construction.

Generative Design

Generative design is a form-finding process that can mimic nature's evolutionary approach to design. Computer scientists have found ways to aid the building design process. It usually starts with clearly specifying the design goals and then explore innumerable possible permutations of a solution to find the best option. It becomes clearer with an example.

An Autodesk team in Toronto has moved into a new building which was designed using a new design process and this also makes for a good story. Researchers used generative design to assist them in finding the ideal design for the building that met all their needs. The process began with understanding all the parameters that would important to the residents of the office building - adjacency preference, work style preference, buzz, productivity, daylight, and views to outside.
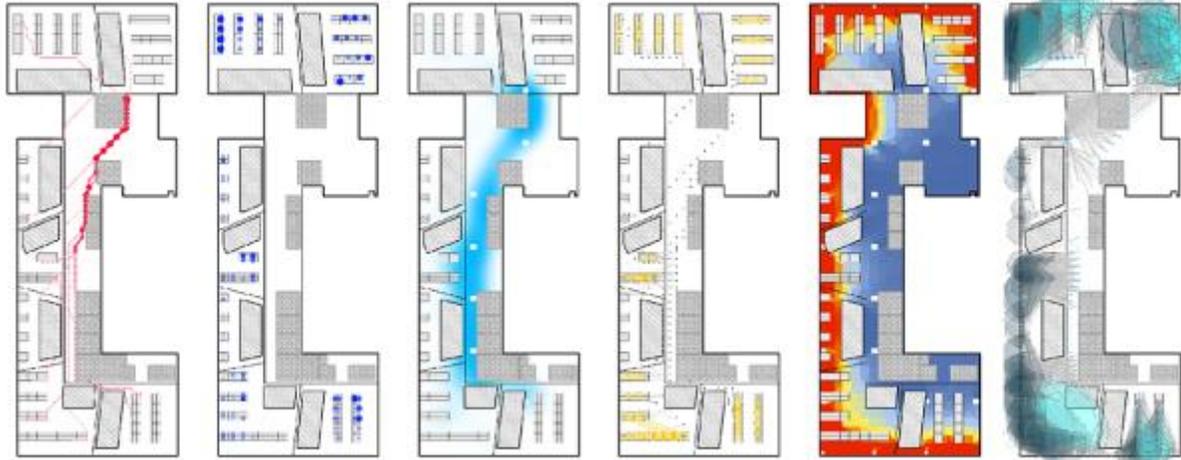
Caption: From left to right, each plan is overlaid with a simulation of the following parameters, adjacency preference, work style preference, buzz, productivity, daylight, and views to outside.

This input then was fed into a computer system that understood these design parameters along with the requirements of the physical location. The algorithm then produced several designs which fit all these needs that the architect can pick from to match the style and other needs. Since this process was very quick, it was easy to make the design experience iterative and work and reform the final design based on several conversations. As this article explains in more depth, in addition to solving vexing practical challenges, generative design could also raise the efficiency and economy of the overall development process by producing designs that improve scheduling and coordination between multiple stakeholders.

Risk Mitigation

Risk evaluation and mitigation happens everyday on a construction site. There are hundreds of subcontractors working on different trades simultaneously; there's thousands issues which get created and manged and everything is changing constantly. The BIM 360 IQ project focused on understanding the challenges that construction managers, project managers and superintendents, deal with on a daily basis to manage these issues and the ways that the process might be improved with A.I. After talking to several construction superintendents, visiting their jobsites and then looking at the data that they were generating, we identified that prioritization of issues by risk would provide an actionable way to improve efficiency.

Using A.I., especially construction language analysis, it is possible to automatically assign priority to issues. The algorithms are able to understand and predict complex things like whether an issues would cause a potential water inflitration if not addressed. The system makes use of the descriptions that many quality managers across projects have observed when they monitor their projects.

Caption: BIM 360 IQ provides a prioritized set of issues for the superintendent's attention

For example, if a quality manager observes an issue about the flashing outside a window being incomplete and records it BIM 360 Field, as is usually the practice, then when the A.I. algorithms runs through this data and automatically flags it as a potential water issue. This can then brought to the superintendent's attention when they review all the issues on the dashboard. This system is currently available on pilot and available to anyone using BIM 360 products.

The system also goes one step further where it encapsulates all the risk from the issues into the subcontractors who are responsible for it. It considers various factors about the subcontractors such as their past behavior of issue management, current workload, the importance of the issues for which they are responsible for. The algorithm is then able to assign a "risk score" to each subcontractor in the project, a metric to indicate the amount of risk that they are currently exposing the project to, so that the construction managers can better prioritize their time to work closer with these teams.

Safety

Construction safety is the number one priority across all jobsites. The BIM 360 IQ focused on understanding the behavior and context around safety issues and then bringing it to the attention of safety managers. The IQ application automatically scans all safety issues on a jobsite and attaches a tag to them indicating whether it could lead to a potential fatality. OSHA shows that about 67% of all construction related fatalities in 2015 were due to issues related to the "fatal four"– Fall, Struck By, Caught Between and Electrocution. The IQ algorithms classifies safety issues that are precursors to the fatal four.

Subcontractor Safety Risk

Name	Total ▾	Fall	Caught Between	Electrocution	Struck By	Fire	Other
⚠ Nesting Paving Co...	367	215	43	123	16	43	123
⚠ Reliant Rebar, LLC	355	16	43	16	38		64
⚠ ProAm Services, Inc.	272	64	14	123		42	38
Gateway Window...	261	42	42	42	42	14	43
Alied Contracting...	236	14	123		42	6	123
Utility General Com...	121	42		14	38	9	42
O'Bay Interiors	120	123	38	9	14	3	14
⚠ Lewis & Clark Ser...	99	14	3	14	9	1	14
Tarlton Construction	96	14	3	38	1	14	1
⚠ AMY Ventilation, Inc.	87	1	6	16	6	16	38

Risks

Caption: The IQ application shows a list of subcontractors on a project and a breakdown on their safety issues by the "fatal four" categories

The application also provides insight into what the hazard causing the potential incident actually was and shows a distribution across 39 different hazards.

Scaffold	Ladder	Lift and Hoist	Holes & Ledges	Housekeeping	N/A	Fire Protection	Materials	Electrical	Missed Inspection	Environmental	Equipment	P.P.E.	Access & Egress	Falling Objects	Sharp Edges
66	54	24	33	24	24	66	9	33	3	54	24	3	33		
32	33	8	16	24	5	3	54	16	33	5	33	8		54	2
12	11	24	8	32	24	33	9		3	54	12	3	3		5
33	9	32	16	24	24	3	54	16	33	9	6	3		54	32
12	33	12		11	3	3	4		3	54	3			8	12
66	9		16	24	5	66	11	16		2	3	8	3	54	
24	54	12		12	2	3	9	16	3	9	24				
5	33	24	12	2	1	5	4	12	3		6	3		2	9
24		66	3	5	11	3	9	16	3	54	24	3			24
5	11	11		11	24	3	4	2			6	3	3		

Hazards

Caption : A subset of the hazards that the IQ application can detect in a safet issue

This allows Safety Managers to understand where exactly they should focus their planning and training efforts and to be more observant for specific problems when they do their safety walk.

Today, there are plenty of photos and videos taken daily on a jobsite. Every construction worker has a phone with a camera and it is almost standard practice to take a photo for every issue they create. Drones have become more common and they are often used for aerial shoots, and for more advanced activities like measuring progress. Go-pros and smart helmets are becoming more common as well. Given the plethora of photos, most technology applications have yet to catch up and there hadn't been a good solution for managing the photos or utilizing them for better insight.

Smartvid.io is a technology start-up addressing exactly this solution. They provide a platform that integrates with different other technology vendors to bring all your images to one place. However they go one step further, they use A.I. to understand what is there in the image. Just as we saw earlier in the example on self driving cars, it is possible to isolate and understand the various objects in an image. Smartvid.io calls them "smart tags" and they allow for a better system to categorize and search your photos.
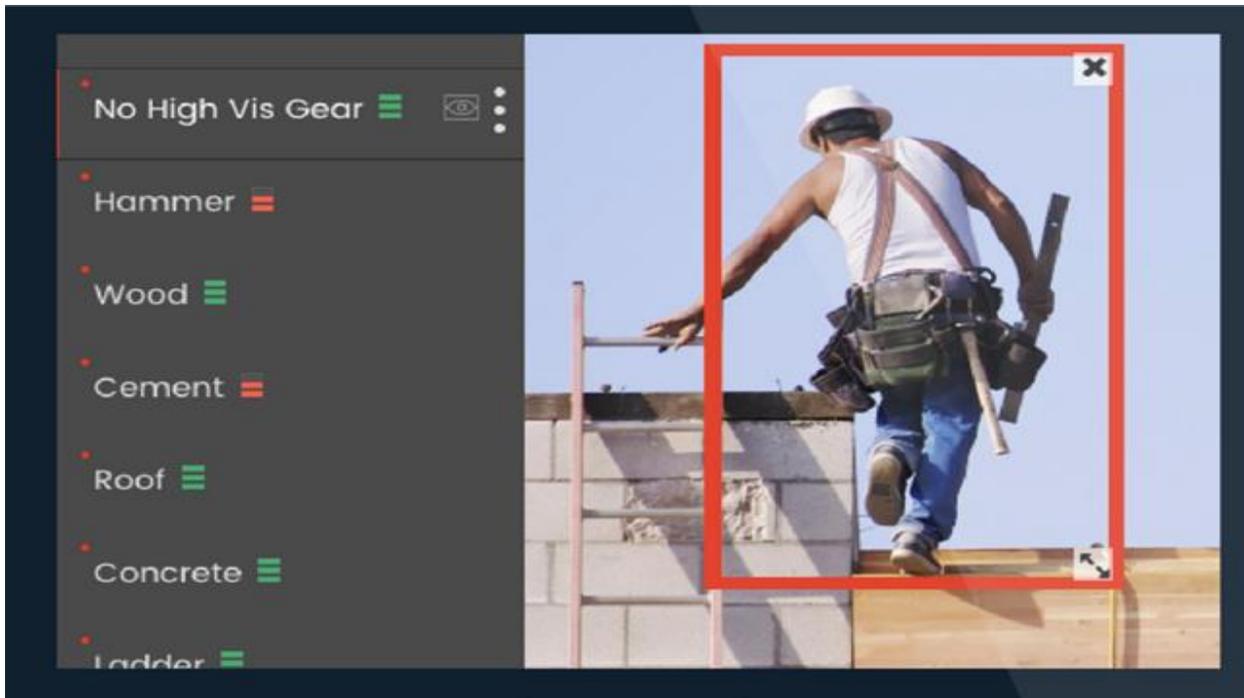
Caption: In this image of a construction worker getting of a ladder, Smartvid.io can automatically add the tags shown on the left to the image.
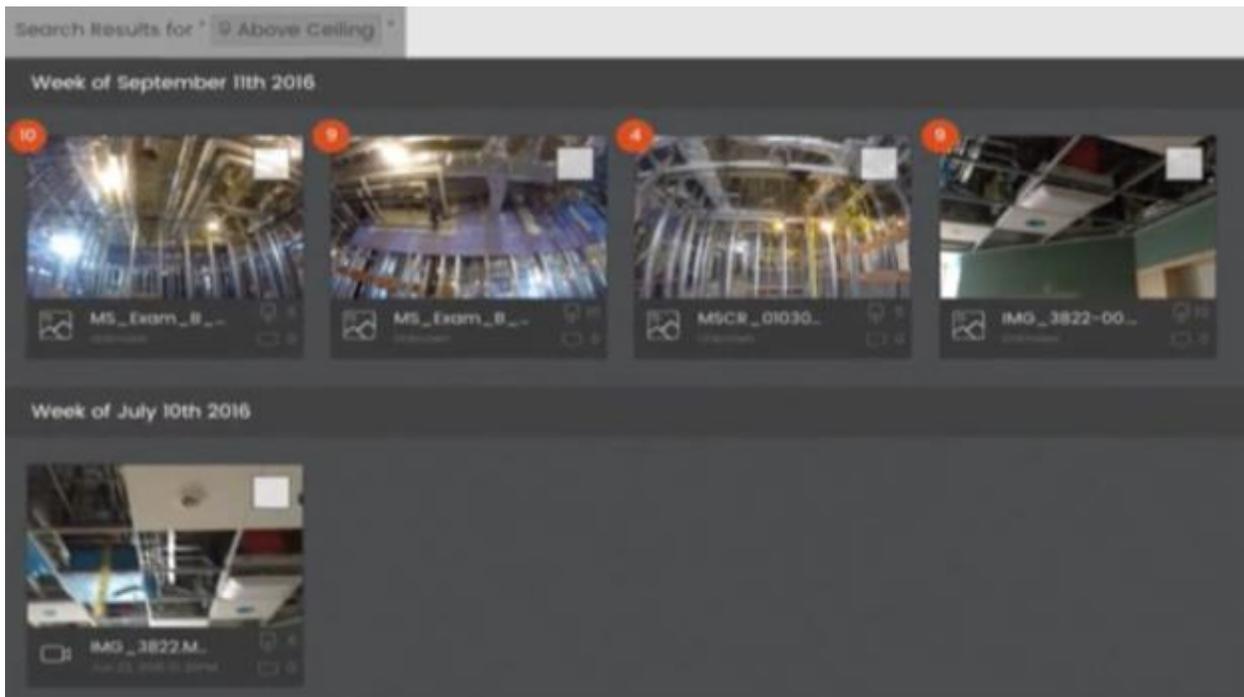
Caption: Since Smartvid.io understands higher level concepts in construction, it provides for smarter searches. The above image shows all the images in a project for the query "above ceiling"

What is Autodesk going to do in the future for A.I. in AEC?

The BIM 360 IQ product for Quality was the first A.I. product for Construction and ever since we've been trying to push the envelope further every year. We've built applications that focus on challenges in both Construction Quality and Safety. Our next effort is to take a similar approach to Project Management and leverage A.I. to enhance the process.

Data Platform

Across the construction industry, there are several technology vendors providing solutions to manage their data but they are often incompatible with each other. The power of AI based solutions can be unlocked best when all data sources can connect to each other. To address this need, Autodesk is also working towards building a data platform that would allow third party integrations. This would enable different construction companies to bring all their data to one platform that would also have the capabilties of a common analytics layer. Autodesk is bringing in other data sources such as ERP data and project management data into this platformas well as partnering with other data companies in Construction such as Smartvid.io, Triax Technologies, SmartBid and others.

Caption: Conceptual architecture of the new BIM360 Data platform