Robotics in Construction

Notes and References

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1 Articles and Videos

- DURUS Brings Human-Like Gait (and Fancy Shoes) to Hyper-Efficient Robots
- Farming robot anyone?
- Boston Dynamics at it again - new robot SpotMini
- Custom Processor Speeds Up Robot Motion Planning by Factor of 1,000
- Motivational posters with a clever robotics twist
- Labor cost savings from industrial robot adoption to reach 21.85% in United States by 2020
- Meet SAM: the Automated Bricklaying Robot
- SoftBank Prepares Humanoid Robot Pepper's U.S. Debut, Releases Android SDK
- Controlling Self Driving Cars (Good explanation of PID)
- How driverless cars will change cities
- How Tunnels Are Made.
- This Technology Wants to Make Wheelchairs Obsolete
- Amazing tricked-out prosthetic bionic leg imitates how a real leg works
- Quadrotors can now braid bridges for people.
- NFPA Wants Input on Emergency Responders' Use of Robotics

2 Other Online References

- Mathew Holloway Innovation Design Engineer

  Robotic insulation of historic homes.

- NASA's 'power' glove will help workers get a better grip

  Exoskeleton glove

- 3D concrete printing market worth $56.4M by 2021

  > Walls made using 3D concrete printers are capable of creating concrete objects with great detail and precision, making it possible to conveniently construct advanced concrete walls with the push of a button. The report breaks down a number of key statistics concerning ready-mix concrete, precast concrete, shotcrete, high-density concrete, and others, all of which can be used for 3D concrete printing.

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  > Although use of 3D concrete printing is not yet widespread, statistics provided show that the technology can benefit construction in a number of ways. The 3D concrete printing process can, for example, save between 30 and 60 percent of construction waste, reduce production time by 50 to 70 percent, and reduce labor costs by 50 to 80 percent. This triple advantage of material, time, and labor efficiency is drawing attention to the growing technology and fueling the demand for 3D concrete printers across several areas of construction.

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  > At a global level, companies such as DUS Architects (the Netherlands), Fosters+Partners (U.K.), and WinSun Global (China) are providing 3D concrete printing services. Large construction players such as LafargeHolcim (France), Balfour Beatty PLC (U.K.), Kier Group PLC (U.K.), and Carillon PLC (U.K.) have scope to enter into 3D concrete printing services.

- Metal 3D printing more potent than ever with soluble metal support structure breakthrough

  Still slow

- Bruil develops high resolution concrete 3D printing technique and white or colored concrete

  > The Ede-based company Bruil has not only managed to 3D print concrete in high resolution with actual architectural value, but can even do so in different colors. If the name Bruil sounds familiar, thats probably because they have been experimenting with concrete 3D printing before. About a year ago, they showcased some interesting construction results developed in collaboration with industrial 3D printing specialists 3Dealise: a 3D printed 1.6 meter tall H-profile column with an aesthetically pleasing twisting section.

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> Since then, they have clearly been perfecting their approach to concrete 3D printing, as Bruil is now ready to showcase three 1.6 meter tall structures at Material Xperience and Gevel 2016 in Rotterdam (both 27 to 29 January), all realized with a new architectural 3D printing technique. All are also colored. Concrete 3D printing is currently largely associated with unfinished grey building frames, such as those that are being developed in China. We want to prove to architects that 3D printing can also be used to change the spatial language of buildings. Eventually, we can even 3D print parametric façade shapes with a high aesthetic value, Theo Voogd, the manager of Market & Innovation at Bruil, says of this new concrete 3D printing technique.
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> Essentially, they have developed a method for 3D printing concrete in high resolution. And because they make their own cement on site, they can easily 3D print it in color or even create color shifting effects. While most concrete 3D printers make single constant layer, the Bruil machine is also capable of realizing different patterns such as waves to give the architect a creative device, rather than solely a production tool. Their ideas can now thus be realized in concrete, both in terms of shape, color and texture. Theo Voogd therefore predicts that this could be revolutionary in the construction industry, as the architectural influences can be strengthened again. To further accommodate architects, Bruil has also developed custom CAD software that easily translates 3D models into print paths for their custom machine. Importantly, this also gives a preview of the final results before the costly 3D printing process begins.

- Amorphous metals successfully 3D printed for the first time by Heraeus and Exmet

  Still new - for use on the manufacturing side

- Researchers in Abu Dhabi file patent for 3D printing lightweight architectured foam structures

  Manufacturing side

- 3D printing industry to reach $21 billion by 2020, UPS and CTA report shows

  > The worlds largest package delivery company, UPS, recently teamed up with the Consumer Technology Association (CTA) to release a report detailing how the 3D printing industry is expected to grow over the next four years.

- 3D printed buildings can improve the planet, says Google's Eric Schmidt

  > ...Of course 3D printing as a whole is often listed among breakthrough technologies - Gartner called it one of the ten strategic technology trends of 2016.But of all the possible 3D printing applications, Schmidt argued that 3D printed homes and buildings can have the biggest economic impact.

As the Alphabet CEO told listeners in Beverly Hills, construction represents five percent of the economy, and that entire segment can be made cheaper, more efficient and superior when it begins to integrate 3D printing. Right now, construction is time-consuming, energy-intensive, wasteful and costly, he argued. Through 3D printing, however, construction times could be decreased dramatically, and almost every structure could be made from recycled materials. Whats more, construction would be far more efficient if production took place on site. These innovations would not only decrease construction costs dramatically, but would also significantly decrease the construction industrys carbon footprint. Construction-based 3D printing, it seems, should not be underestimated.

- The metallurgy and processing science of metal additive manufacturing

  Manufacturing Side of Construction

- CONPrint3D, conceptual system for 3D printing concrete structures, recognized at Bauma 2016

  Many construction companies and startups have begun to recognize the potentials and advantages of using additive manufacturing in building processes as it offers a cost saving and materially efficient way of constructing buildings. Companies like WinSun have pioneered 3D printed buildings, having designed and additively manufactured 3D printed villas, and 3D printed Chinese courtyards, and now, many other companies are following suit with the innovative trend. Recently, for instance, a research team from the Dresden University of Technology has conceived of CONPrint3D, a technology that could allow for effectively 3D printing concrete on a large scale.

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Developed by a team of engineers at TU Dresden led by professor Gnter Kunze, the CONPrint3D technology is aimed towards eventually producing 3D printed concrete structures on a large scale using specially controlled robotic arms. Concrete, one of the most used building materials today, can still be very expensive, especially when taking into account the cost of scaffolding and formworks that are currently necessary for securing concrete in its desired shape. Additionally, after being used once, many pieces used for the formwork, such as wooden structures, cannot actually be reused for other buildings.

For these reasons, and wanting to eliminate construction waste and costs, CONPrint3D was conceived of. The technology is designed to be capable of directly applying concrete to the building site without additional formworks through an additive manufacturing, or layer-by-layer system. As the team of researchers explain, a special mix of fast setting concrete will be extruder through print head nozzle, itself “guided with geometric precision by a large scale robotic system.”

The robotic mechanics for the CONPrint3D have been based on more conventionally used machinery, like track-mounted concrete pumps, which extrude concrete mixtures through a pump based system. Of course, the technology is still in its early stages, though institutes are working together to further develop the 3D printed concrete system until it is a viable construction method.

- Autodesk's Project Escher connects multiple 3D printers for faster, scalable large-format 3D printing

  Still plastic

- Amalgamma develops new 3D printing concrete technique for large-scale structures

  Manufacturing with powder bed

- Just 17 days to create worlds first 3D office in Dubai [video]
- Dubai Inaugurates First 3D Printed Office Building, Constructed in 17 Days
- Compact Apis Cor 3D Printer Constructs Buildings in One Day
- Apis Cor: Building walls printing [video 6:53min]
- Wikipedia - 3D printing
- Wikipedia - Continuous Liquid Interface Production
- About Additive Manufacturing

  A discussion about the Powder Bed Fusion process.

- How 3D Printing is Changing Construction

  A rapid prototyping discussion.

- The Plan to 3D Print a Steel Bridge in Mid-Air

  MX3D

- ASTM International Proposes New 3D Printing Guidelines for Powder Bed Fusion Machines
- America Makes Enters into a MOU Agreement with ASTM International

  ASTM 3D printing standard discussion

- Contour Crafting to 3D Print Entire Homes in Under 24 Hours On-Site

Web Resource: `http://www.3ders.org/3d-print-technology.html`

3 Scholarly Articles

- Key challenges in automation of earth-moving machines

  Best for mining operations as of now

- Two-way integration of 3D visualization and discrete event simulation for modeling mobile crane movement under dynamically changing site layout

  > ... It is a difficult task to ascertain the shortest and obstacle-free mobilization route for each of these cranes in a changing dynamic site layout as well as estimate the mobili- zation duration required for each of the module's lifting activity.

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  > The proposed distributed Simulation Visualization framework is based on the High Level Architecture (HLA) standards ...
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  > This work presents enhancements for simulation-driven visualization. It proposed a solution to model mobile crane movements under tempo-spatial changes of construction site layout that result from either project progression or relocation of temporary facilities. The enhancement integrates discrete simulation capabilities with a 3D visualization component; exploiting their capabilities for time and resource representation and analysis. Two-way communication and integration between the two technologies are done through distributed simulation protocols.
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  > The application involves an implementation of a path finding algorithm that integrates mesh generation and A* algorithm to model movements of mobile cranes. The path finding algorithm assesses feasible paths for each mobilization event, determines the shortest obstacle-free path and calculates its associated duration to complete the event. The durations provided through path finding analysis provide a more accurate representation of time required to move the cranes and are then used by the discrete event simulation model. Demonstration of the framework capabilities was also presented through a prototype used on a real world industrial construction project. Limitations associated with the proposed framework are also discussed, for example, the mesh generation mechanism disregard to change in terrain during its operation as well as not enabling real-time integration of the simulation model with jobsite. Future research should introduce methods to overcome this limitation and advance the current state of art, importantly, by enabling real-time interaction between the simulation model and jobsite. The proposed framework will contribute towards the construction industry by integrating time related site space management with simulation capabilities.

- Decision support for tower crane selection with building information models and genetic algorithms

Tower cranes are major construction equipment that is highly demanded in construction projects. The planning process for tower cranes utilization starts in early stages of the construction projects. Poor selection could incur extra costs on the construction projects or cause delays in project duration. The planning procedures for tower cranes include selection, allocation and operation. This paper presents a framework for the selection of tower cranes types and locations at construction sites. The framework considers three main models: 1) decision making model to select the tower crane type, 2) optimization model for the selection of the ideal number and location of tower cranes, and 3) 4D simulation model to simulate tower crane operations. Several clash detection scenarios are presented to assure the safety operation of the tower crane group. A case study is shown herein to demonstrate the capabilities of the developed framework.

- Robotic timber construction – Expanding additive fabrication to new dimensions

  Despite strong advancements in timber prefabrication using CNC systems, the timber construction sector is still characterised by a relatively high proportion of (manual) assembly tasks. Together with the inherently limited flexibility and working areas of conventional CNC machinery, this handicaps the sector when trying to take advantage of the rapidly spreading trend to use complex digital designs directly as input for comprehensively automated construction processes. Here, robotic systems are extremely useful – not only can their use lead to significant time savings, but their ability to transfer digital design data directly to 1:1 assembly operations enables the fully automated construction of non-standard timber structures. As a result, their use opens up entirely new possibilities for future timber construction that is not limited by the same constraints - such as, for example, work - intensive joinery and/or additional scaffolding - as manual assembly processes of pre-machined components; its most evident and radical consequences are therefore the ability to digitally oversee and control a large number of aspects of the design and construction (for instance the sequencing of the single elements and their assembly) and the ability to freely position building components in space.

  Considering full-scale applications, Robotic Timber Construction (RTC) research is still in its infancy, and presents many theoretical, practical and methodological challenges to architecture. Obvious examples are wide-ranging and include, for example, the need for advanced computational design tools and novel constructive systems for automated construction processes, and the integration of robust and adaptive robotic fabrication technology. ...

  Researcher's website

- Autonomous Repositioning and Localization of an In situ Fabricator