Report for the Construction & Robotics Lecture Series II

Construction Project Application Cases:

A. Al Bahar Towers - AEDAS Architecture
   - Smartgeometry 2013 -- Constructing Data: Realizing Algorithm
   - https://www.youtube.com/watch?v=Y7CwSA6TSIo
B. Leadenhall Building - Rogers Stirk Harbour + Partners
   - https://theleadenhallbuilding.com/
   - https://www.youtube.com/watch?v=xrRprzvPxmg
C. 425 Park - Foster and Partners
   - https://www.fosterandpartners.com/projects/425-park-avenue
   - https://www.youtube.com/watch?v=NxcQTnb1WVk
D. Barclays center - Shop Architects
   - https://www.shoparc.com/projects/barclays-center/
   - https://www.youtube.com/watch?v=paBmRJbLt20
E. SF Moma - Kreysler & Associates
   - https://www.kreysler.com/projects/all/architecture/sf-moma
   - https://www.youtube.com/watch?v=dhsjktCyeNo

Choose a **very specific** on-site assembly process (such as the curtain wall installation process or the steel beam assembly process) within a phase of construction for **one** of these given application cases and write the following chapters according to description.

The goal is a very detailed analysis of the automation potential within the process and the creation of a short pitch meeting like document. Therefore, it is necessary to go through a detailed on-site process based on individual assembly steps that need to be taken and shorten your report to focus on the important and unique aspects that are relevant for your specific analysis and not general or generic information.

(*as a rule of thumb* a paragraph is typically between 10-100 words about 1-4 sentences)

1. Introduction

Short description of on-site assembly process you will focus on in your construction application case. This should contain a joining process such as welding, riveting, screwing, nailing gluing, or similar *(1-2 short paragraphs for description)*. Put specific focus on modular design elements in contrast to customized parts. Focus on repeatable task based on a modular design of the applied construction system. If the elements are individualized and a non-modular system is applied, consider the repeatability within the assembly steps (*1-2 short paragraphs on modularity*).

Analyze the process steps by creating a **process flow diagram** for each construction part (beams, nodes, plates, screws, etc.) consider using subassemblies and employ the following types of process steps for describing your process flow:

- storage (sorted, unsorted)
- separation (or singularization)
- clamping (temporary fastening, temporary hooking, temporary attachment, etc.)
- moving/transport/positioning (rough, fine positioning, fine orientation, adjustment)
- joining (fitting, welding, screwing, gluing, rebar tying, bolting etc.)
- unclamping (unfastening, unhooking, detaching, etc.)
- checking (location, color, quality, etc.)

Associate each of your process steps with the product (construction part, material, etc.) and other resources (people, machines, tools, etc.) that are used (*1 image flow diagram, no additional text than clear labels necessary, a full page can be used for the diagram, use different color for process, resource and product/material in your flow diagram, the website draw.io is a helpful tool in creating diagrams, inkscape is a helpful software to create vector graphics, e.g. if you want to add icons to your exported .svg from draw.io*)

2. Environmental Factors

Consider the location and sustainability of the overall construction project. Execute a SWOT analysis. The SWOT analysis should focus on factors of Urban Planning and therefore reflect on the construction/building as a whole, such as:

- Influences of important landmarks
- Environmental factors of brownfield construction
- Infrastructure integration and compatibility with mobility concepts
- Social inclusion and or application of urban industry concepts (integration of production industries in urban/city environments)

(*1 SWOT Table/diagram, 1-2 paragraphs discussion of the main strength and weakness according to these factors*)

3. Joining processes & ergonomics

Analyze an on-site joining process within the application case, such as: welding, gluing, rebar tying, bolting or screwing, based on your flow diagram of part *1 Introduction*. Rate each step that requires human assistance for its ergonomical strain. Create a list of strain factor such as: overhead work, heaviness of part, location and position of the worker and assign a value for each step. (*1 table with values for each step and its strain factors, as well as the overall result, your table should be based on a weighted sum model*).

Discuss your rating system, how did you try to achieve comparability and consistency between factors how important or rather which weight did you assign to each factor, give one example of why a certain step was rated more strenuous than another (*1-2 short paragraphs for this discussion*). Based on this analysis identify potentials for machine assistance (such as crane lifting, tool extension for better reach, redesign of joining process, etc.) in highly strenuous activities. (*2-3 short paragraphs for machine potential analysis and an additional step analysis based on your suggested changes*).

4. Construction machines, kinematics and navigation

Describe the kinematics chain of an employed construction machine (excavator, lifting-crane, etc.) (**No:** simple tower cranes or industrial robots) by creating a diagram of rotary and linear axis, specifically highlight and note elements that are either parallel, flexibly linked or cable connected and specifically effected by external factors such as weather etc. (*1 diagram of the kinematic*)

Describe which parts need to be added to allow for an (semi-)automated control of the construction machine? **Specifically reference each axes** and describe what sensor, encoder or other needs to be added to determine axis position and how control of the axis might be added (is the actuator an electric motor or part of a hydraulic system?) (*1-2 short paragraphs*)

Why are other sensors than GPS necessary to accurately determine the location of the machine? For this please consider the machine applied as an automated robot for the **execution of on-site tasks**, so think about what you learned in the lecture series (e.g. L9). (*1-2 short paragraphs discussion*)

For what other purposes than a pure determination of location can these sensors be applied in the automation of the construction machine. (*1-2 short paragraphs discussion*)

5. Innovation Potentials

Given the analyzed construction and joining processes, determine the biggest technological gap for the on-site construction that could be solved through automation technologies. (*1-2 short paragraphs discussion*)

Try to determine the necessary degree of automation/autonomy and the machines that could be automated for this process. Create a **Decision Matrix/***weighted sum model* to compare different solutions and try to determine the effort of automation, the cost associated and the potential strain reduction. It's recommended to compare solutions with different degrees of automation for the same process step (*1 decision matrix*).

Consider the dissemination process of the new technology, the necessary leap of innovation with the associated cost, the mixed human-machine work environment and the flexibilities towards deviations in location, material and construction-parts. (*1-2 short paragraphs to discuss your decision matrix results and consider the dissemination of your preferred solution)*

6. Sustainability Factors

Create a SWOT analysis focusing on your specific assembly process, this analysis should focus on factors of Sustainability & Cycle Oriented Construction, such as:

- Use of local resources or extensive use of modular prefabrication with high transportation cost
- Waste reduction concepts: less formwork, use of lightweight material, easy fitting on site, etc.
- Reuse concepts for maintenance, refurbishment and deconstruction
- Recycling concepts for single-sort material filtering in demolition work

(*1 SWOT Table/diagram, 1-2 paragraphs discussion of the main strength and weakness according to these factors*)
Discuss the changes to these results if your solution from part *5 Innovation Potentials* would be implemented (*1-2 paragraphs discussion*)

7. Synopsis

Give a quick final summary of your results. This part should not contain any new information that is not given by the previous chapters. This part rather gives you the chance to give your own opinion, position on the overall results you came to. Similar to a quick pitch of your idea, however this can be both positive or negative, e.g. if you come to the conclusion that current technology does not allow for the automation of your assembly phase just yet.

(*1-2 paragraphs discussion*)