Construction robotics 2030
Motivation
Start from reviewing ISARC papers

• What are people concerning in the field of construction robotics field?
• ISARC
  - International Symposium for Automation and Robotics in Construction
  - Held by IAARC (International Association for Automation and Robotics in Construction)
  - From 1984; 2012 in Eindhoven
  - 3000+ papers in 30 years
Problem and objectives

- Lack of an overview of the whole picture of the technical innovations in construction robotics
- Lack of an exploration of the possible future of construction robotic technologies

- **state of the art** of the technical innovations' application
- **future landscapes** of technologies in construction robotics.

Main research question:
In the Dutch construction industry, **what technologies are available to enhance the robotics level** and **what are the possible futures of technical innovations in construction robotics in 2030?**
Research question

• In the Dutch construction industry, what technologies are available to enhance the robotics level and what are the possible futures of technical innovations in construction robotics in 2030?
Limitation

• Tasks:
  - limited time
  - select two tasks to study in detail

• Technologies:
Research process

Step 1: Identification of technologies and tasks in construction robotics

Step 2: Current technologies applied in the selected tasks

Step 3: Future of the current application
Step 1:
Identify the tasks and technologies in construction robotics
Method

- Systematic literature review;
- ISARC papers as the main resource;
- 572 papers from 2012 to 2016;
- 255 papers are about specific technologies' application
- Groups of the papers according to the tasks they contribute to and technologies they use:

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<tr>
<th>Task</th>
<th>CPS/IoT</th>
<th>RFID</th>
<th>A&amp;R</th>
<th>MD</th>
<th>AM</th>
<th>PLM</th>
<th>HCI</th>
<th>S&amp;A</th>
<th>BIM</th>
<th>VR</th>
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Identified tasks

16 construction tasks

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<td>First type: directly related to the physical production</td>
<td>Earthwork, Reinforcement, Paving, Concrete distribution, Concrete finishing, Welding, Coating, Assembly, Interior finishing, Masonry</td>
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<tr>
<td>Second type: related to the construction process</td>
<td>Surveying and monitoring, Logistics, Site planning and management, Safety, Quality control, Process management</td>
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# Identified technologies

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Step 2: Current technologies
## Current technologies: construction assembly

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- **Not employed**
- **Under research**
- **Limitedly employed**
- **Employed**
- **Widely employed**
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<th>Techs</th>
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Step 3:
Future study
Sub questions and Research methods

• Sub question 3: What are the possible landscapes of construction robotic technologies in the Netherlands in 2030?
  - scenario planning based method
Future studies - factors identifying
Future studies—scenario planning

- Political
  - Labor rights

- Social
  - Availability of employees
  - Regional growth
  - Industry integration and globalization
  - Monopolization

- Economic

- Technical
  - Artificial intelligence
  - Additive manufacturing
  - Energy supply & carbon emission

- Environmental
Future studies—scenario planning

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<td>Monopolization (MO)</td>
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![Graph showing predictability and impact of various scenarios](image)
Future studies – scenario planning

• Artificial Intelligence

• Integration of the construction industry
  - construction industry: highly fragmented;
  - product level: uniqueness of each project;
  - process level: process of each product is different;
  - market level: thousands of contractors on market;
  - the manufacturing industry: standard product > standard process > fewer suppliers;
  - integration of the construction industry: working more like the manufacturing industry.
Scenario planning – Matrix

- **INTRODUCTION**
  - **LOW INTEGRATION**
    - **SMART TIMES**
      - Scenario 2
    - **STATE OF THE ART**
  - **LOW AI**
  - **HIGH INTEGRATION**
    - **PARADISE**
      - Scenario 3
    - **LEGEND**
      - Scenario 1
  - **WHERE WE ARE**
  - **WHERE we WERE**

- **HIGH AI**
  - **SMART TIMES**
    - Scenario 2
  - **PARADISE**
    - Scenario 3
  - **STATE OF THE ART**
  - **LEGEND**
    - Scenario 1
Scenario 1

- Brandization and standardization in small and simple buildings;
- Large buildings: higher level of prefabrication;
- Market and process integration: fewer and bigger players;
- Most of the works have been moved into factories, but human workers still dominant the onsite works;
- Globally-distributed massive production is introduced into the construction industry.
Scenario 2

- AI-supported highly automatic onsite construction process;
- Wide application of robots and the reduced demands for labors;
- Information technologies dominate the construction;
- Many small companies survive;
- Construction robotics is applied in maintenance and renovation projects.
Scenario 3

- Highly automatic building process, high standard level of the construction industry;
- Customization as a popular business model;
- Medium monopolization;
- Localized production.
Evolvement of technologies

Drivers
Efficiency enhancement, demands, ...

A specific technology

Barriers
Technically not fully developed, Not ideal financial feasibility, ...

Scenarios
Scenario 1
**Scenario 2**

**Laser Scanning and Photogrammetry**
Laser scanning and photogrammetry are employed to build a digital model in short time, assisting inspection works. They are also employed to monitor the assembly process.

**Proximity Detection**
IoT helps to monitor and locate the on-site objects in real time, detecting the possible collisions between them.

**Big Data**
Big data is used to analyze the pattern of accidents, helping to improve the safety performance of future projects.

**Cloud Computing**
Cloud computing assists the information sharing in the construction process.

**Simulation**
Using the information from BIM, the construction activities could be simulated before they actually start, to identify the hazards in the process.

**Internet of Things**
By scanning the tags attached to the on-site objects, they could be included into the IoT, which could be employed to locate and track them.

**Bottom-Up System**
Bottom-up system enables the assembly works to be executed on the ground level, then lifted by jacks, avoiding aloft works. No heavy equipment is needed.

**Swarm Robots**
Swarm robots have replaced the single-task robots, handling the on-site construction assignments, under AI’s control.
Scenario 3

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Cloud computing assists to share information for the construction process.

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**Swarm Robots**
Swarm robots replace the single-task robots, handling the on-site construction assignments, under AI's control.

**Construction Factory**
On-site Construction Factory provides an indoor environment for the construction activities, enabling more robotic technologies to be applied.
Overlap

- Scenario 1 vs Scenario 2&3
- Technologies related to human intervention decrease;
- CF most used in Scenario 1 and Bottom-up system most used in Scenario 2.
- Cloud computing is applied in Scenario 2 and 3.
- Overlap: wireless sensing, BIM, robots, laser scanning
- In scenario 2&3: evolve to the direction of swarm robots.
- Similar with the situation in assembly;
- Technologies related to human intervention decrease;
- Cloud computing is applied in Scenario 2 and 3.
- Overlap: wireless sensing, BIM, Virtual prototyping
Thanks and questions