Extended Reality Application Development Framework for a digital twin based smart crane

Aalto-yliopisto
Aalto-universitetet
Aalto University

Slides: Chao Yang

07/04/2022

TABLE OF CONTENTS

01

Research Introduction

Digital Twin, Extended Reality

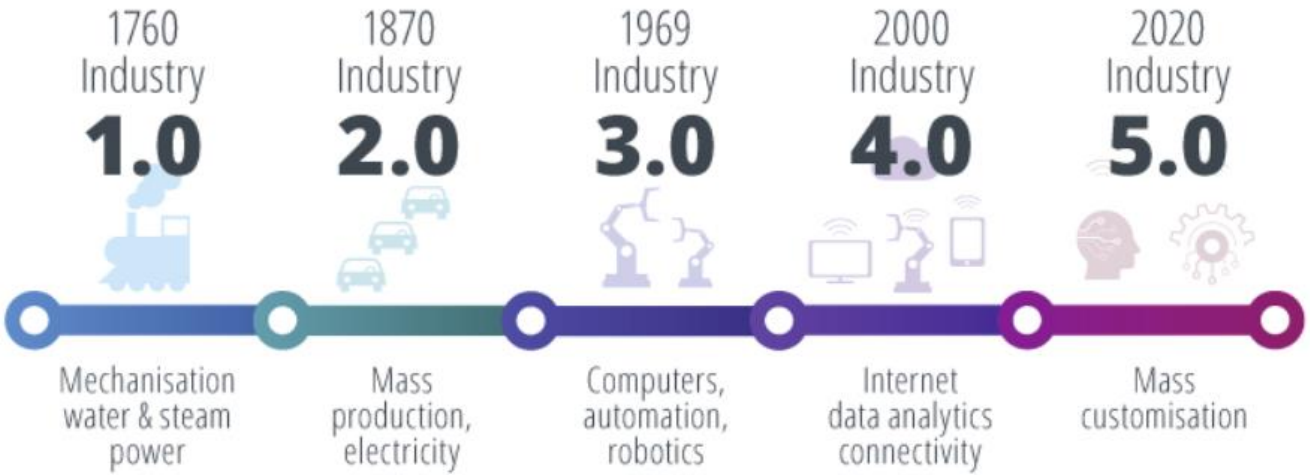
Research Introduction

Industry 4.0

The connection of people, things, and machines with IoT to realize intelligent of machine.

Industry 5.0

Return the human back to the “centre of Universe”.

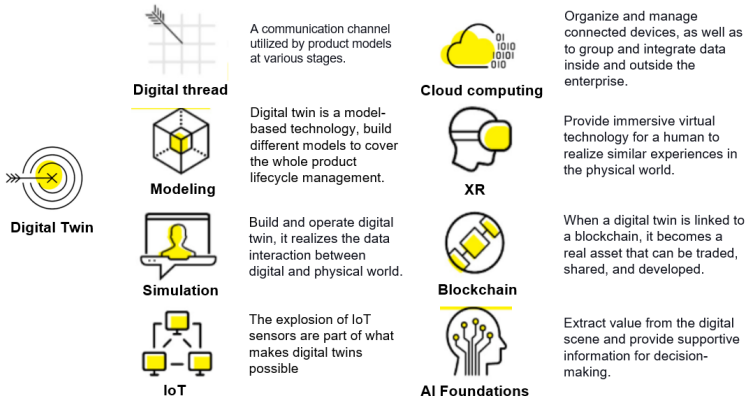


https://nickelinstitute.org/en/blog/2020/november/customising-the-future-the-next-industrial-revolution/

Research Environment

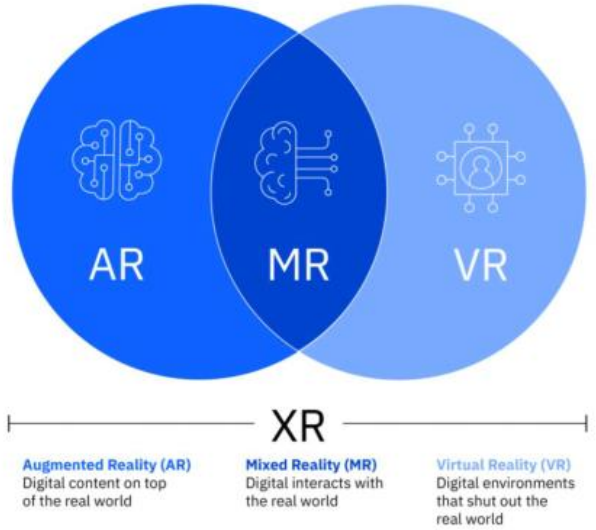
Digital Twin

“A digital twin is a virtual model designed to accurately reflect a physical object.”
The digital twin is a digital representation of a physical object, building a bridge between the virtual world and the real world.



Extended Reality

An umbrella term of AR, VR, MR.
AR: Impose Virtual information on the real environment.
MR: Develop a virtual space the same as real space for interaction.



Research Environment

Aalto Industrial Internet Campus

Aalto University Industrial Internet Campus (AIIC) is a platform for students, researchers, and companies to innovate and co-create smart, connected products and services.

Ilmatar Open Innovation Environment

Ilmatar OIE is an open physical and digital development environment targeted for different third parties, who want to develop new devices and applications that are connected to Konecranes overhead cranes.

Machinaide Project

Machinaide is a project that defines how the industrial ecosystems work together in the future.

Ilmatar

Ilmatar is the nickname of the crane installed to Aalto Industrial Internet Campus premises in late 2016.

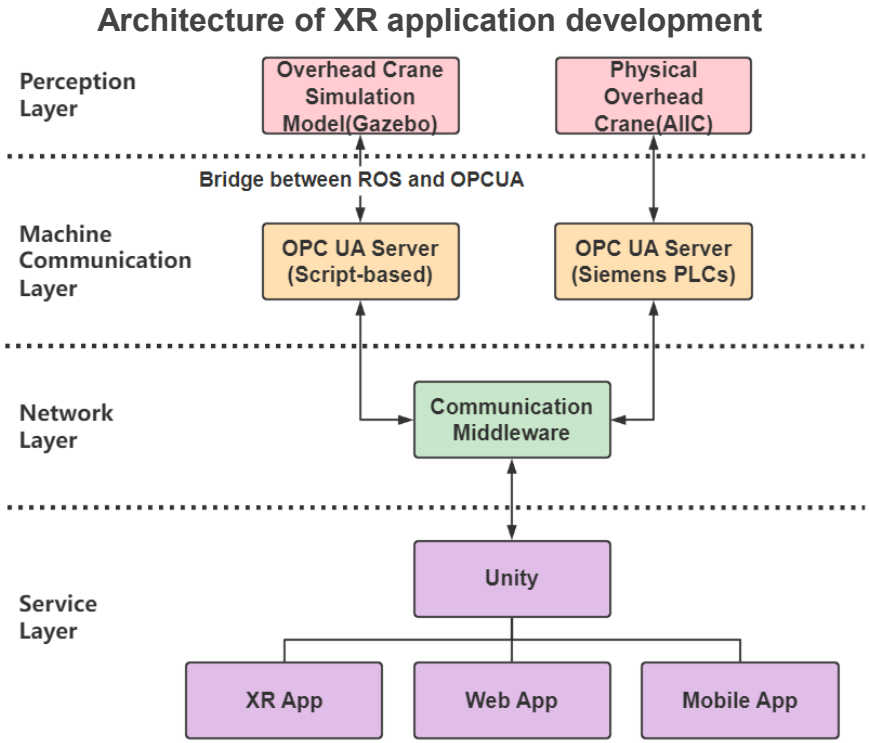
Aalto-yliopisto
Aalto-universitetet
Aalto University

02

Research method

Framework

Research method



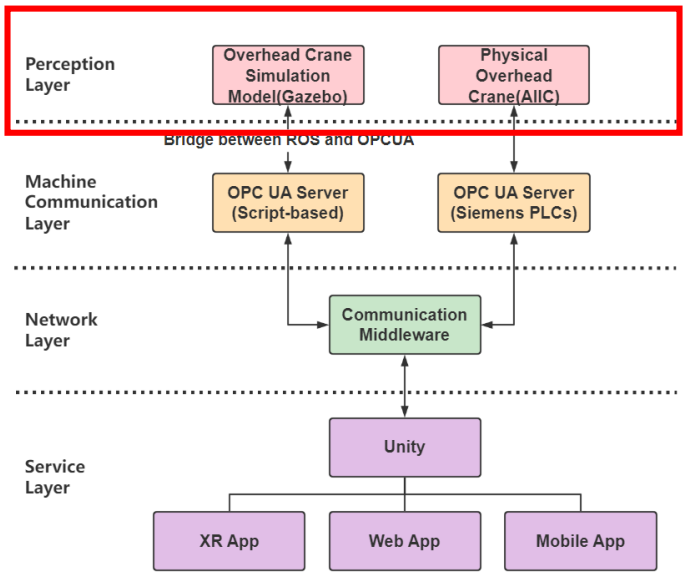
The simulation model of the physical crane are developed.

The Bridge between ROS and OPC UA are built by Joel to presents the PLCs-OPC UA structure for the real machine.

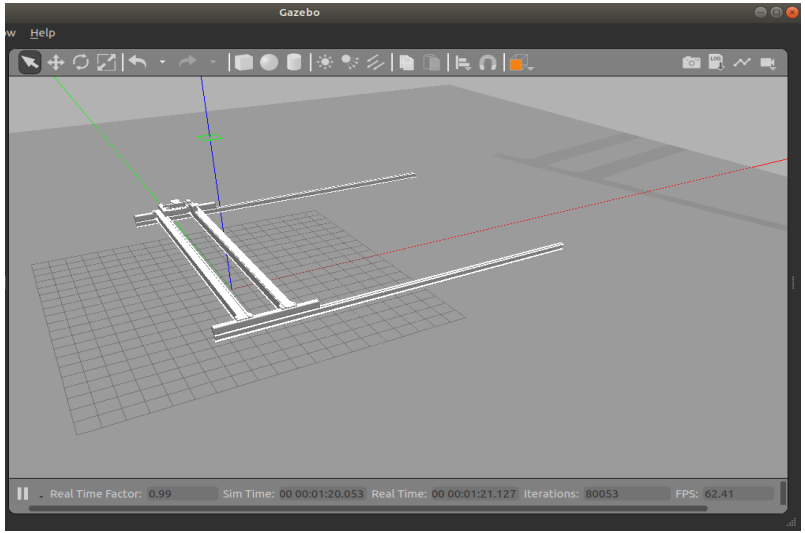
OPC UA-GraphQL Wrapper, OPC UA-MQTT Gateway, and OPC UA-Unity Client are built.

Unity used as the physical engine for the development of various applications.

Research method – Perception layer



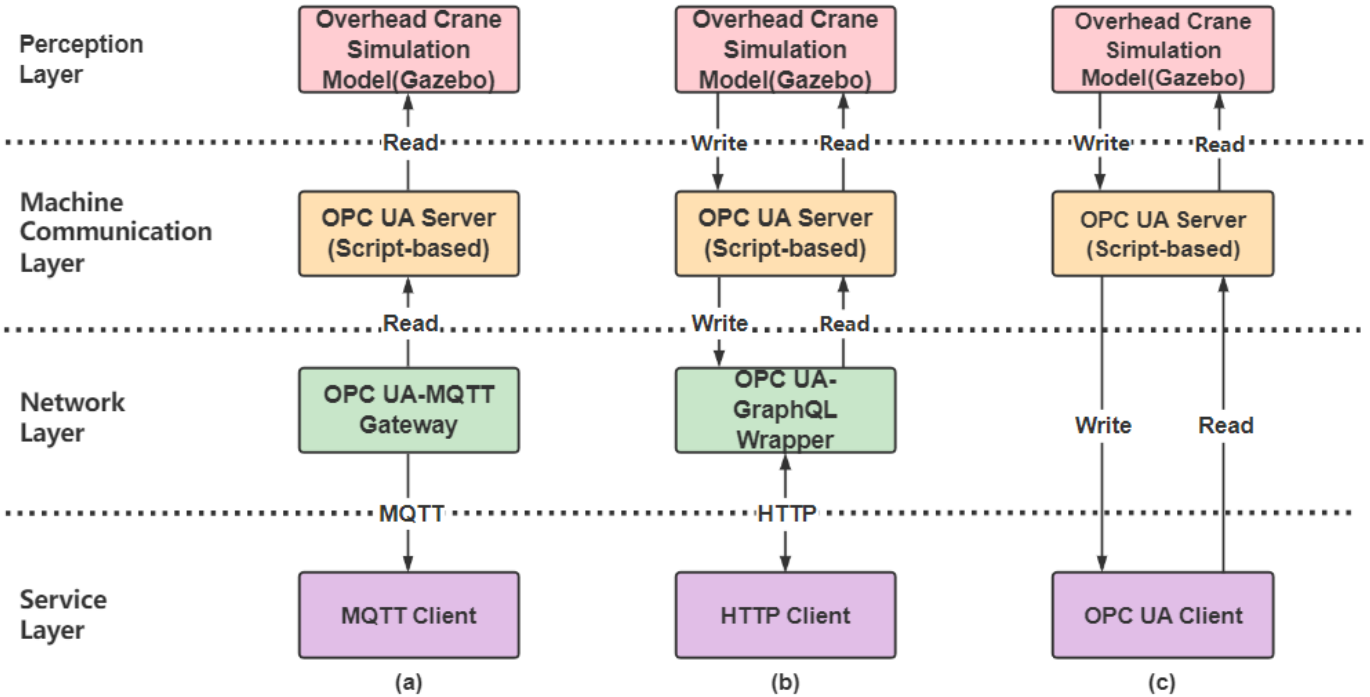
The simplified 3D model are imported to the ROS gazebo simulation platform based on the URDF format, which integrated with the same sensors as the physical crane.
ROS is widely used for the robot and autonomous robot control; the development of ROS simulation environment is the fundament for the further research on the collaborative control.



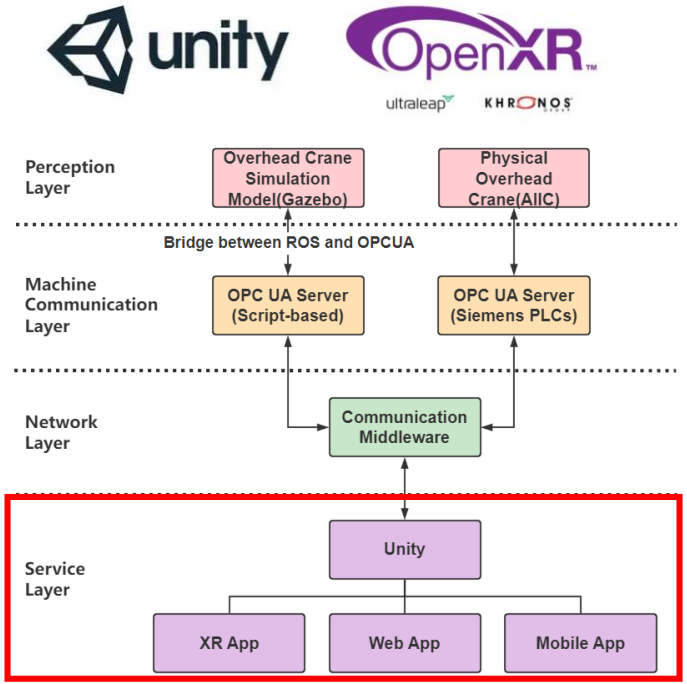
Gazebo Simulation Environment

Research method – Network layer

Architecture of the Network Layer



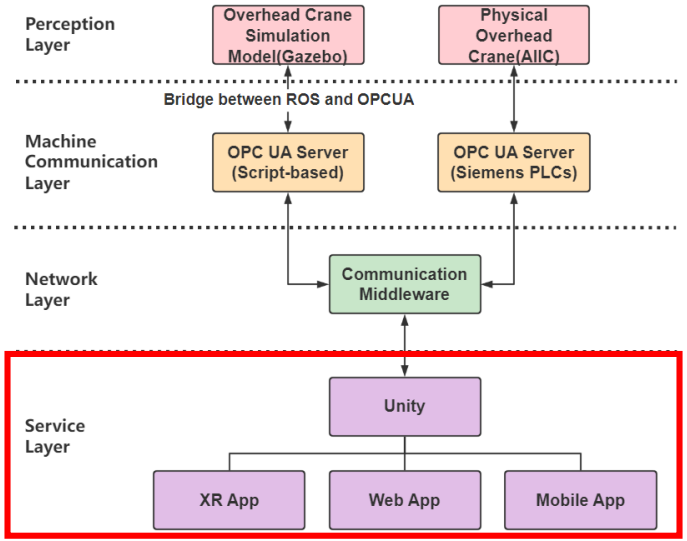
Research method – Service layer



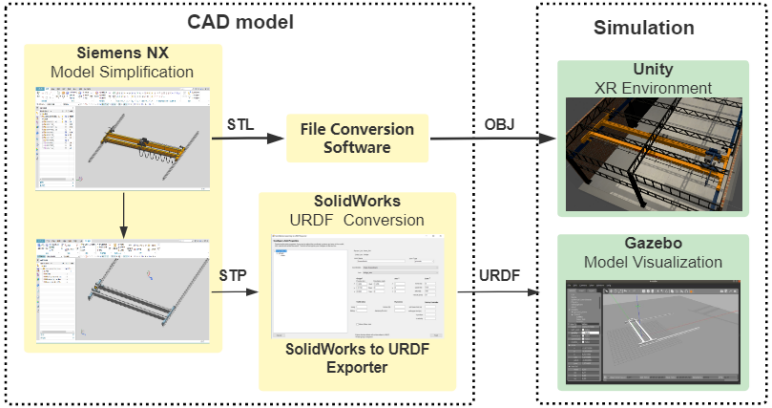
Unity advantages:

1. Friendly programming language and comprehensive documentation.
2. Free for the non-profit developer.
3. Support for XR applications.
4. OpenXR is a royalty-free, open standard that provides high-performance access to Augmented Reality (AR) and Virtual Reality (VR)—collectively known as XR—platforms and devices.
5. Toolkit for Microsoft HoloLens 2 (MRTK) .
6. Better cross-platform support, Unity supports at least 21 platforms.

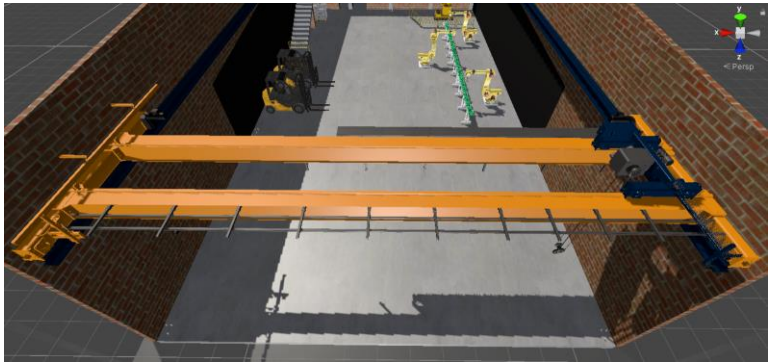
Research method – Service layer



Model Conversion Process



XR Environment in Unity



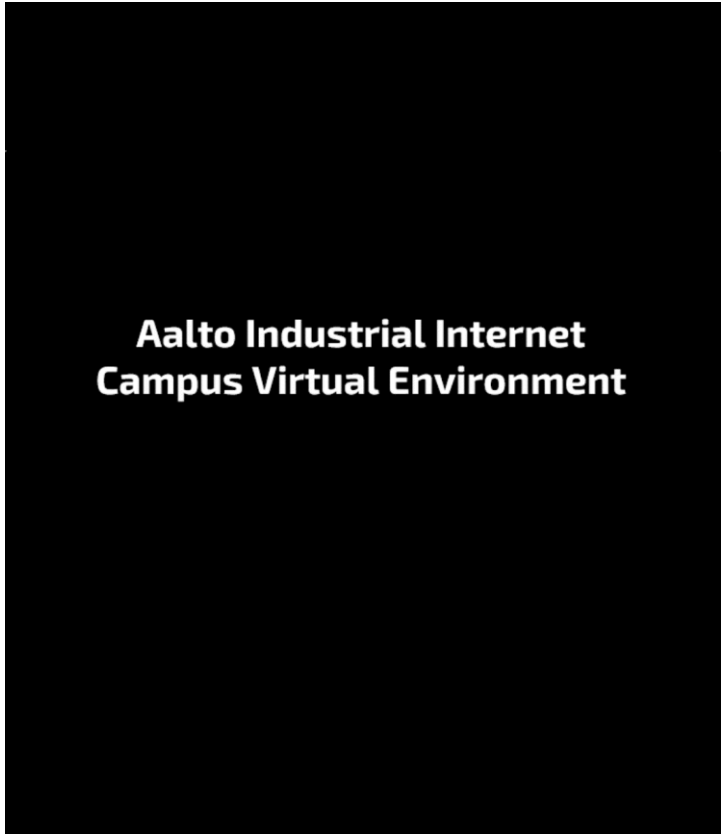
Aalto-yliopisto
Aalto-universitetet
Aalto University

03

Use cases

Research display

Use cases – VR training



Features

Physical VR hand model

Multi-Interactor

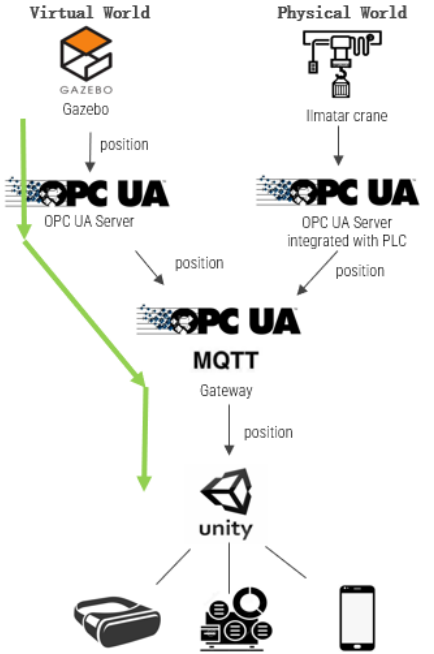
Multi-modal interaction capabilities

Multi-scene

Data parameter synchronization

Use cases – Remote monitor

Technical architecture



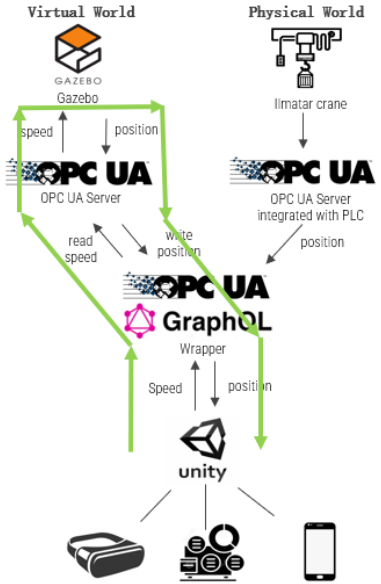
Prototyping Application

Use cases – Remote monitor

Remote monitor

Use cases – Remote control

Technical Architecture



OPC UA-GraphQL Wrapper

OPC UA GraphQL Wrapper GitHub

OPC UA Node browser

Node arguments for GraphQL queries

server:

nodeId:

craneRos
grindingMachineRos
grindingMachine

GraphQL queries are POST in JSON format to URL:

http://86.50.143.154:7777/graphql

Queries can be tested and more documentation can be found at the same URL.

Autofilled example queries

Read:

```
query {
  node(server: , nodeId: ) {
    name
    variable {
        value
        dataType
    }
  }
}
```

Write:

```
mutation {
  setValue(server: , nodeId: , value: value, dataType: "dataType") {
    ok
  }
}
```

Prototyping Application

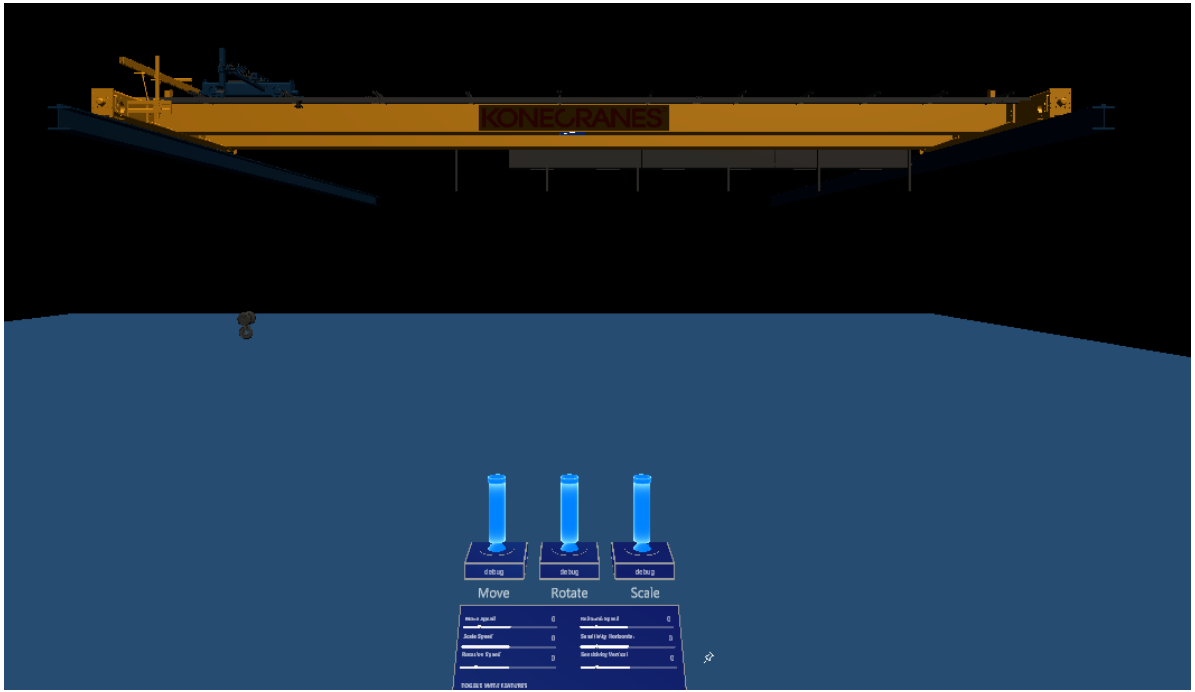
Aalto-yliopisto
Aalto-universitetet
Aalto University

Use cases – Remote control

Remote control

Use cases – AR control

HoloLens 2 AR



04

Future direction

Prospect

Research Introduction

Data Driven Digital Twin Simulation Model
- Information model
- Data flow

Collaborative Control
- AGVs
- Autonomous vehicles
- Arm robots

Wireless communication research
- 5G, B5G
- edge cloud/center cloud

Security
- Network Layer, local network, VPN, edge server
- Service Layer, authority management

Thank you

Chao.1.yang@aalto.fi

aalto.fi

Aalto-yliopisto
Aalto-universitetet
Aalto University

Backup

XR devices