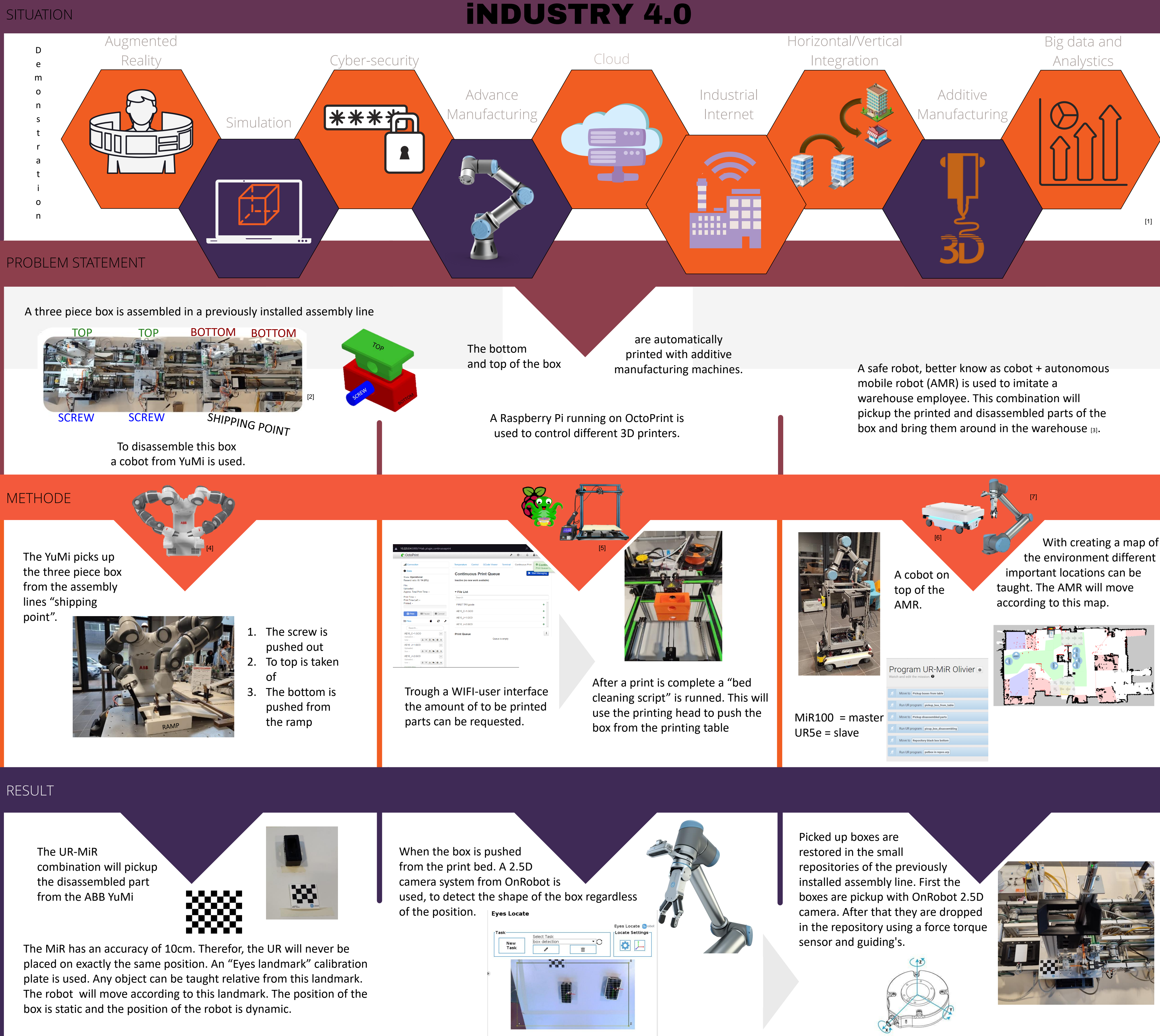# Master's Thesis Engineering Technology

2021-2022

Implementing of supply chain 4.0 with cobots, AMR and AM

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Master of Energy Engineering Technology – Automation Engineering Technology

SITUATION

iNDUSTRY 4.0

Demonstration

Augmented Reality

Simulation

Cyber-security

Advance Manufacturing

Cloud

Industrial Internet

Horizontal/Vertical Integration

Additive Manufacturing

3D

Big data and Analytics

[1]

PROBLEM STATEMENT

A three piece box is assembled in a previously installed assembly line

TOP   TOP   BOTTOM   BOTTOM

SCREW   SCREW   SHIPPING POINT   [2]

To disassemble this box a cobot from YuMi is used.

TOP

SCREW

The bottom and top of the box

are automatically printed with additive manufacturing machines.

A Raspberry Pi running on OctoPrint is used to control different 3D printers.

A safe robot, better know as cobot + autonomous mobile robot (AMR) is used to imitate a warehouse employee. This combination will pickup the printed and disassembled parts of the box and bring them around in the warehouse [3].

METHODE

The YuMi picks up the three piece box from the assembly lines "shipping point".

RAMP   [4]

1. The screw is pushed out
2. To top is taken of
3. The bottom is pushed from the ramp

Continuous Print Queue

Trough a WIFI-user interface the amount of to be printed parts can be requested.

[5]

After a print is complete a "bed cleaning script" is runned. This will use the printing head to push the box from the printing table

A cobot on top of the AMR.

[6]

MiR100 = master
UR5e = slave

Program UR-MiR Olivier

[7]

With creating a map of the environment different important locations can be taught. The AMR will move according to this map.

RESULT

The UR-MiR combination will pickup the disassembled part from the ABB YuMi

The MiR has an accuracy of 10cm. Therefor, the UR will never be placed on exactly the same position. An "Eyes landmark" calibration plate is used. Any object can be taught relative from this landmark. The robot will move according to this landmark. The position of the box is static and the position of the robot is dynamic.

When the box is pushed from the print bed. A 2.5D camera system from OnRobot is used, to detect the shape of the box regardless of the position.

Eyes Locate

Picked up boxes are restored in the small repositories of the previously installed assembly line. First the boxes are pickup with OnRobot 2.5D camera. After that they are dropped in the repository using a force torque sensor and guiding's.

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[1] Andrea Ciffolilli and Alessandro Muscio. "Industry 4.0: national and regional com-parative advantages in key enabling technologies". In: European Planning Studies 26.12 (Dec. 2018). Publisher: Routledge eprint: https://doi.org/10.1080/09654313.2018.1529145,pp. 2323–2343. issn: 0965-4313. doi: 10.1080/09654313.2018.1529145. url:https://doi.org/10.1080/09654313.2018.1529145 (visited on 01/20/2022).
[2] JUNIA. Le d'émonstrateur usine du futur. Type: Journal article. 2021.
[3] Astrid Weiss, Ann-Kathrin Wortmeier, and Bettina Kubicek. "Cobots in Industry 4.0: A Roadmap for Future Practice Studies on Human–Robot Collaboration". 73 In: IEEE Transactions on Human-Machine Systems 51.4 (Aug. 2021). Conference Name: IEEE Transactions on Human-Machine Systems, pp. 335–345. issn: 2168-2305. doi: 10.1109/THMS.2021.3092684.
[4] Product specification - IRB 14000. url: https://search.abb.com/library/Download.aspx?DocumentID=3HAC052982-001&LanguageCode=en&DocumentPartId=&Action=Launch (visited on 11/26/2021).
[5] Rafal Wrobel and Barrie Mecrow. "A Comprehensive Review of Additive Manufacturing in Construction of Electrical Machines". In: IEEE Transactions on Energy Conversion, pp. 1054–1064. issn: 1558-0059. doi: 10.1109/TEC.2020.2964942. Name: IEEE Transactions on Energy Conversion 35.2 (June 2020). Conference
[6] MiR user guide. url: https://supportportal.mobile-industrial-robots.com/support-files/manuals/html/en/mir100_user_guide_3.1/content/manuals/product_presentation/product_presentation_root.htm (visited on11/26/2021).
[7] User Manual UR5e. url: http://help.universal-robots.com/SW_5_11/URSe/Content/Landingpages/LandingpageUR5e.htm (visited on 11/26/2021).

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