JÖNKÖPING UNIVERSITY

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A case study from Småland, Sweden

EXPLORING THE UTILITY OF AR FOR QUALITY INSPECTIONS IN TIMBER-FRAME HOUSE PRODUCTION

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AGENDA

- Research problem and idea
- Design Science Research Method
- Timber-frame house production
- Augmented reality in quality inspection
- Evaluation

Fig. 1 Timber frame element quality inspection using Hololens2 device

RESEARCH PROBLEM AND IDEA

Problem

- Prefabricated timber elements in 90% of Sweden's new single-family homes (Kitek-Kuzman and Sandberg 2017)
- 20% of the new residential buildings highly prefabricated (Steinhardt et al. 2020)
- Timber-frame building industry has witnessed heavy investment in automation (Schauerte 2010)
- Compared to other industries still high levels of manual labor (Vestin et al. 2019, Manley and Widen 2019)
- Quality challenges, rework and variations cause substantial cost and time escalations (Josephson et al. 2002)
- Augmented reality (AR) technology supports quality assurance in manufacturing (Kohn and Harborth 2018)

Idea

How can augmented reality (AR) be successfully applied to support quality assurance practice in the wood-based building industry?

- Use DSR (Design Science Research) to (1) understand the industrial context, (2) provide a practical AR method for quality assessment, and (3) evaluate the method in its industrial context conducting a quasi experiment

METHOD: DESIGN SCIENCE RESEARCH

- Design science research (DSR) is useful to develop new solutions to known problems (Gregor and Hevner 2013)
- Important research method in information systems
- Focus on developing a knowledge contribution

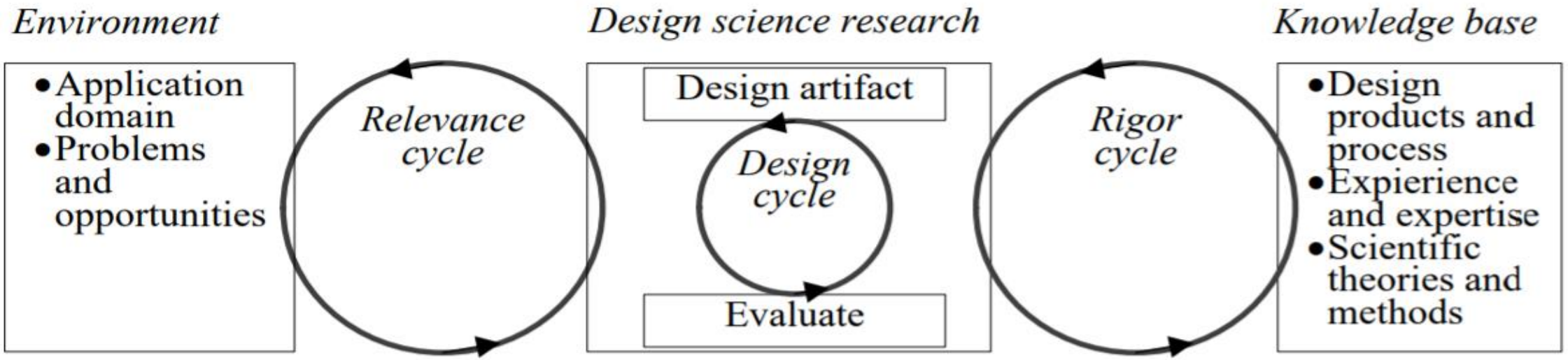

Fig.2 Design Science Research Cycles [p. 88, Hevner 2007]

Table 1. Overview of the interviewees in the relevance and design cycles

Professional role	Age	Experience	Duration	Interview type	Date
▶ Relevance cycle					
Production technician	32	-na-	49:21 min	Semi-structured interview (Microsoft teams)	210224
HSE and quality manager	32	-na-	78:51 min	Semi-structured interview (Microsoft teams)	210316
Innovation engineer 1	29	2,5 years	28:55 min	Semi-structured group-interview (Microsoft	210330
Innovation engineer 2	27	2,5 years		teams)	
▶ Design cycle					
Evaluator 1 worker	27	10 years	07:05 min	Structured interview (face to face)	210428
Evaluator 2 worker	40	6 years	07:06 min	Structured interview (face to face)	210428
Evaluator 3 worker	51	6 years	09:54 min	Structured interview (face to face)	210428
Evaluator 4 worker	30	6 years	08:11 min	Structured interview (face to face)	210428
Evaluator 5 superintendent	53	17 years	07:07 min	Structured interview (face to face)	210428

APPLICATION DOMAIN: TIMBER-FRAME HOUSE PRODUCTION

- “The frame station is fairly automated, but you still have to stand by the machine and help. Then the plaster portal is fully automated where it nails everything. Similarly, when the element enters the panel stations, they are fully automated. […] In the frame station, for example, insulation is cut and falls down so that the fitter can put it in place in the frame.” (production technician).
- “The production manager produces the drawings because we still use ordinary drawings. We can use digital drawings, but we currently do not have access to such equipment in production. The production manager instead keeps track of production via the business system and prints all the drawings that then follow from the first station.” (production technician).
- “My experience tells me that if you look at the mistakes we make, then I do not exaggerate if I say at least 95 % of them are, so-called careless mistakes, so this is something, if only you had a 100 percent focus that would never have happened.” (HSE and quality manager)
- “Then you can say that technologically, the wooden house industry is pretty much behind. I myself have worked in the metal industry before where there are more technical solutions to minimize errors. You have more simulations of things, etc.” (innovation manager)

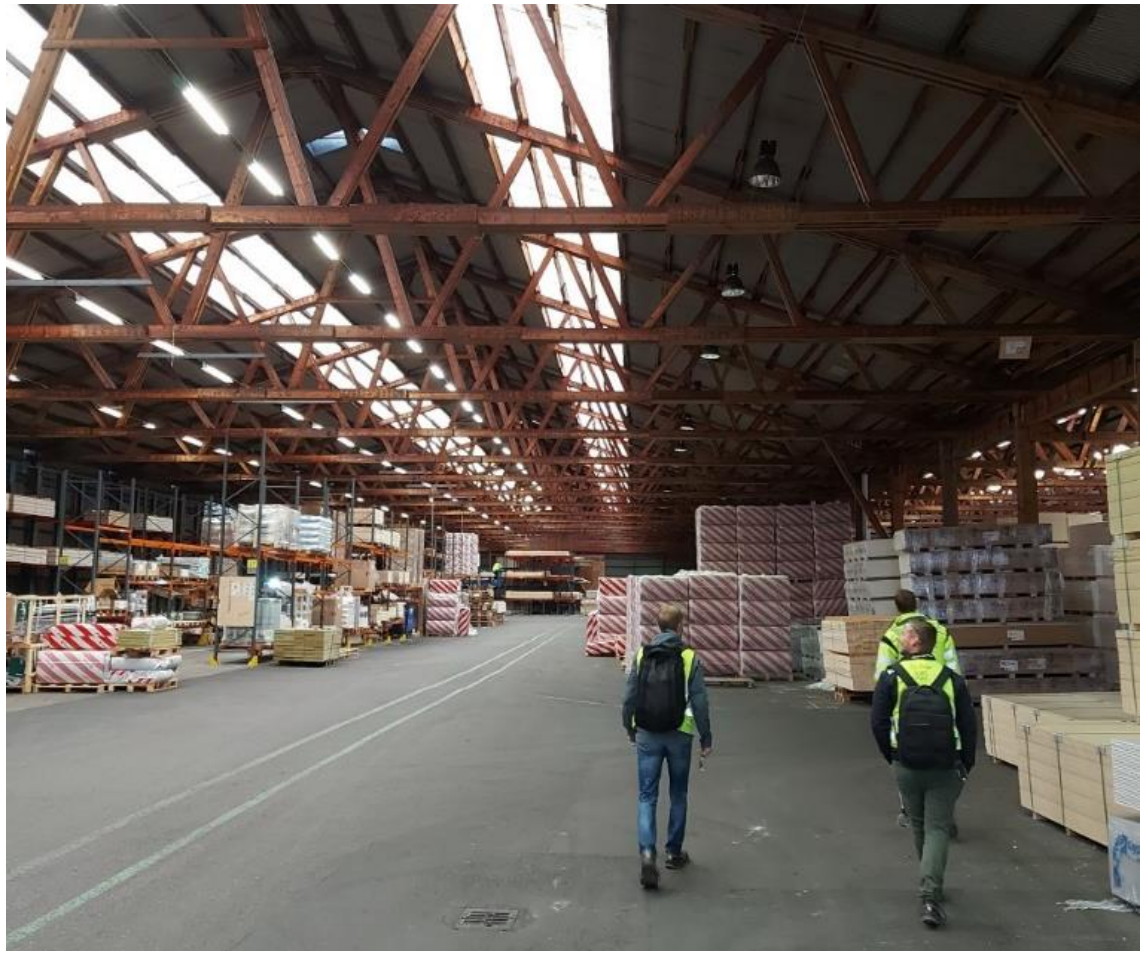

Fig.3 Case company: storage facility

- Large producer of turn-key timber frame homes (95000 homes produced since 1920ies)
- Serial production of timber frame homes applying standardization and modulization
- Automated frame, plaster and panel stations
- Paper workshop drawings used in quality assessment
- Few simulations, systems, and technical solutions to minimize production errors

ARTIFACT: AR IN QUALITY INSPECTION

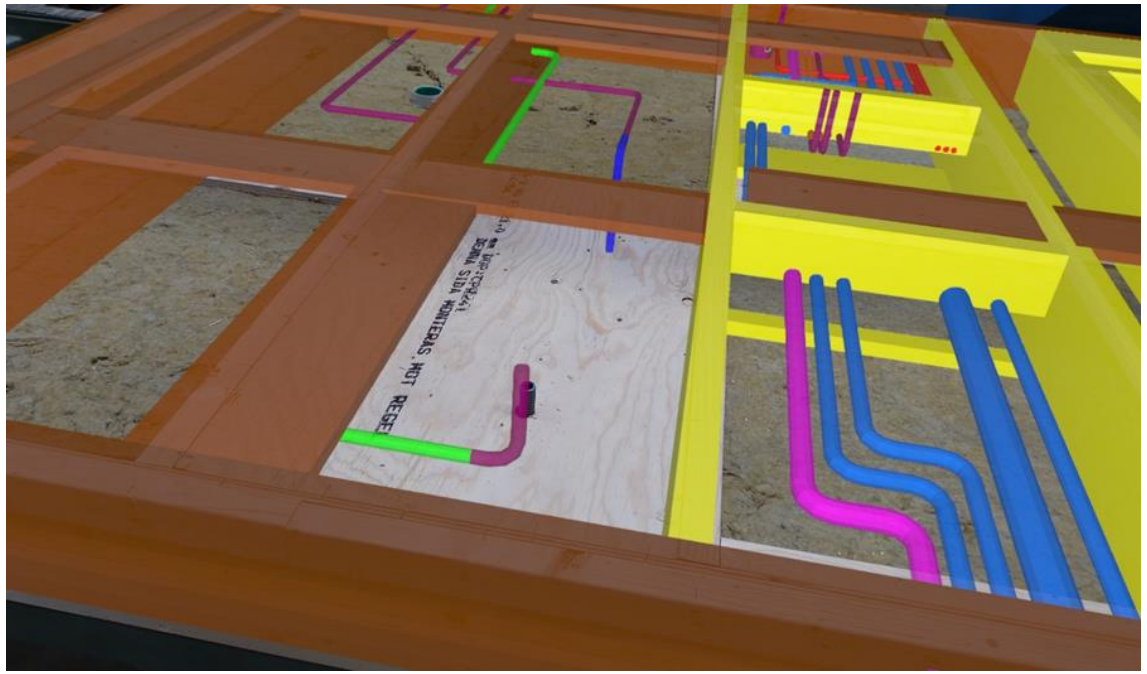

Fig.4 Overlay of the digital model and the physical timber frame element using AR

Fig.5 Quality inspection of a timber frame element using HoloLens2

- Head mounted display Microsoft HoloLens2
- Trimble Connect for HoloLens
- Model was prepared by the factories engineering design team using HSBCad
- Manually geo-located at the inspection site

EVALUATION

Table 2. Main findings from the debriefing interviews

Strengths	Weaknesses
▶ Easier to understand the pipe installations.	▶ Limited field of vision in the glasses
▶ Color-scheme of pipes effective	▶ Reduces attention to the wider work environment
▶ MH2 is comfortable to wear	▶ Requires getting used to and learning
▶ Easy to spot the differences between the 3D model and reality	▶ Geolocation not very precise
▶ Easy to spot deviations and mistakes	▶ An exact model can never correspond to the imperfection of reality
▶ Quick geolocation	▶ The data loaded up to the MH2 needs to be correct
▶ Makes quality inspections more interesting	
▶ MH2 is easy to use	

CONCLUSION

How can augmented reality (AR) be successfully applied to support quality assurance practice in the wood-based building industry?

- Hardware would need to be protected from possible physical impacts of a factory environment which could be done by using lockers, protection shields or AR hardhats
- Geolocation of the virtual models in the real environment would need to be supported by placing QR codes on the timber frame elements
- Users would need to be trained and acceptance for the technology would need to be created
- Evaluators in this case study found the new AR based method intuitive and better than their old way of working
- AR could help eradicating production errors in timber-frame house construction

THANK YOU!

Q&A?

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