# Simplification & Visualization of BIM models through Hololens

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# About Me

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- Thesis (Nov Now)
- Tensing



# Outline

- Introduction
- Motivation / Problem Statement
- Literature Review
- Methodology
- Implementation Results
- Conclusion
- Future Work



# Improving & Modernizing Construction

#### □ Construction projects [1]:

- □ **40%** are late
- □ **50%** over budget
- □ **30%** fail to meet expectations

Rework [2] (construction errors - design discrepancies):
 costs 5% to 20% of the contract value
 contributes to 52% of the cost growth
 increases the schedule overrun by 22%

#### **50%** due to design changes



# Demand for Visualization of the Final Outcome





Cost Reduction

Customer Satisfaction









# Building Information Modelling (BIM)

#### **Benefits:**

- Improved coordination
- Clarity in task requirements
- Reduction in inconsistencies







# Augmented Reality (AR)



Benefits for Architecture :

- Improved collaboration among the actors of a design project
- Natural interaction with the design
- Reduction of cognitive load to evaluate design solutions

![](_page_7_Picture_0.jpeg)

# Microsoft Hololens

- Head-Mounted Display (HMD) unit or a Wearable Windows 10 computer
- The user can interact with holograms using gestures or voice commands
- Creates a 3D model of the surrounding environment

![](_page_8_Picture_0.jpeg)

![](_page_8_Picture_1.jpeg)

# Motivation

## Problem Statement

• Exterior envelope

• Isolation of every floor

• Creation of Holograms

![](_page_9_Picture_4.jpeg)

# Use Case (AMC)

• 127 MB

- 778.000 faces
- Extensive U shape

![](_page_10_Picture_4.jpeg)

# Related work: Simplification of IFC

• Benner et al. (2005)

• Nagel et al. (2007)

• El-Mekawy et al. (2011)

![](_page_11_Figure_4.jpeg)

Simplification steps (Nagel et al., 2007)

![](_page_11_Picture_6.jpeg)

# Related work: Simplification of IFC

• Diakite' et al. (2014)

![](_page_12_Picture_2.jpeg)

• **Donkers et al.** (2016)

![](_page_12_Picture_4.jpeg)

# Related work: AR Visualization

• Kopsida and Brilakis (2016)

• Fonnet et al. (2017)

![](_page_13_Figure_3.jpeg)

• Cardoso et al. (2017)

![](_page_13_Picture_5.jpeg)

![](_page_13_Picture_6.jpeg)

# Methodology

![](_page_14_Figure_1.jpeg)

![](_page_14_Picture_2.jpeg)

# Conversion of proprietary format to an open standard

- NOT human readable
- NOT script adjustable

![](_page_15_Picture_3.jpeg)

# Semantic Isolation of Every Floor

- Iterative process
- Identification of relationship among entities
- Grouping of them
- Writing in a new .ifc file

![](_page_16_Picture_5.jpeg)

## **Object Creation for Each Element**

- New file for every element
- File's name as metadata

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![](_page_17_Picture_4.jpeg)

# Extraction of the Exterior Envelope

![](_page_18_Figure_1.jpeg)

# Exterior Part: Bounding Box & 3D Points

![](_page_19_Picture_1.jpeg)

## Exterior Part: Raycasting

![](_page_20_Figure_1.jpeg)

![](_page_21_Picture_0.jpeg)

# Exterior Part: Inclination Raycasting

## Exterior Part: Inclination Raycasting

![](_page_22_Picture_1.jpeg)

![](_page_22_Picture_2.jpeg)

# Exterior Part: Split of the Model

![](_page_23_Picture_1.jpeg)

![](_page_23_Picture_2.jpeg)

![](_page_23_Picture_3.jpeg)

### Exterior Part: Semantical Enrichment

![](_page_24_Picture_1.jpeg)

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![](_page_24_Picture_4.jpeg)

![](_page_24_Picture_5.jpeg)

# Configuration of the Holographic scene

• Project Settings

• Apply Augmented Reality Scene Settings

 Spatial Perception Capability Settings

![](_page_25_Picture_4.jpeg)

# Hologram Manipulation: Material Creation & Assignment

Materials:

- Different material for every group of object
- Holographic textures
- As simple as possible (no reflections, hover light, etc)

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![](_page_26_Picture_6.jpeg)

# Hologram Interaction: Color Highlighting on Focus

![](_page_27_Figure_1.jpeg)

![](_page_27_Figure_2.jpeg)

TUDelft Delft Tubelft Delft University of Technology

# Hologram Interaction: Metadata Visualization

![](_page_28_Figure_1.jpeg)

![](_page_28_Picture_2.jpeg)

# Hologram Interaction: Grow-Shrink-Rotate

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![](_page_29_Picture_2.jpeg)

# Hologram Interaction: Model Positioning

![](_page_30_Figure_1.jpeg)

![](_page_30_Picture_2.jpeg)

# Hologram Interaction: Menu Creation

![](_page_31_Picture_1.jpeg)

# Deployment

- Deployment to the AR device
- Deployment to a simulation environment

![](_page_32_Picture_3.jpeg)

![](_page_32_Picture_4.jpeg)

# Implementation Tools

**File Conversion** 

![](_page_33_Picture_2.jpeg)

B

#### IFC Visualization

**Semantic Isolation** 

![](_page_33_Picture_6.jpeg)

# Implementation Tools

**Exterior Extraction** 

![](_page_34_Picture_2.jpeg)

#

Scene Configuration Hologram Manipulation

![](_page_34_Picture_4.jpeg)

![](_page_34_Picture_5.jpeg)

![](_page_34_Picture_6.jpeg)

![](_page_35_Picture_1.jpeg)

![](_page_35_Picture_2.jpeg)

![](_page_36_Picture_1.jpeg)

![](_page_36_Picture_2.jpeg)

![](_page_37_Picture_1.jpeg)

![](_page_37_Picture_2.jpeg)

![](_page_38_Picture_1.jpeg)

![](_page_38_Picture_2.jpeg)

![](_page_39_Picture_1.jpeg)

![](_page_39_Picture_2.jpeg)

![](_page_40_Picture_1.jpeg)

![](_page_40_Picture_2.jpeg)

![](_page_41_Picture_1.jpeg)

![](_page_41_Picture_2.jpeg)

![](_page_41_Picture_3.jpeg)

![](_page_42_Picture_1.jpeg)

![](_page_42_Picture_2.jpeg)

# Conclusions

- Intuitive perception of the design
- Precision of the exterior shell depends on the number of points, rays & cores and complexity of the model
- Inclination raycasting facilitates the exterior extraction
- Dynamic interaction with holograms is possible (resizing, rotating and positioning the model)
- Hololens still has certain limitations

![](_page_43_Picture_6.jpeg)

# Recommendations / Future Work

- Use of the interior / exterior attribute
- Use of PyCuda for the extraction of the exterior
- Dynamic occlusion of geometry (prepared caches)

![](_page_44_Picture_4.jpeg)

![](_page_45_Picture_0.jpeg)

# Thank You

![](_page_45_Picture_2.jpeg)