Technische Universität München

esri Deutschland

Procedural 3D modeling and visualization of geotypical Bavarian rural buildings in Esri CityEngine software

Master‘s Thesis

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1. Introduction

1. Motivation

Created 3D city models can be widely used in different areas

2. Purpose

Is the software CityEngine appropriate for creating the 3D content of rural areas?

3. Objectives

- Literature review
- Data collection and preparation
- 3D model creation
- Publication of the results

2. Theoretical Background

1. Related work
2. 3D modeling
3. Procedural 3D modeling
4. Esri CityEngine as a tool for procedural 3D modeling

2.1. Related work

- “Research and Development of 3D Modeling” by Luan et al. (2008)
  - ✓ overview of the 3D modeling process
  - ✓ application possibilities of a 3D modeling
- “Procedural Modeling of Cities” by Parish and Müller (2001)
  - ✓ introduction of “CityEngine”
  - ✓ Description of L-Systems
- “Procedural Modeling of Buildings” by Müller et al. (2006)
  - ✓ description of CGA shape
  - ✓ comparison between CGA and L-Systems
- “Procedural Urban Modeling in Practice” by Watson et al. (2008)
  - ✓ Description of a typical workflow and applications of CityEngine
  - ✓ Suggestions for creating a more realistic 3D urban content

2.2. 3D modeling

*„The **process** of creating a 3D model in the **computer**“* (Govil-Pai 2004, p.83)

Consists of 3 main steps:

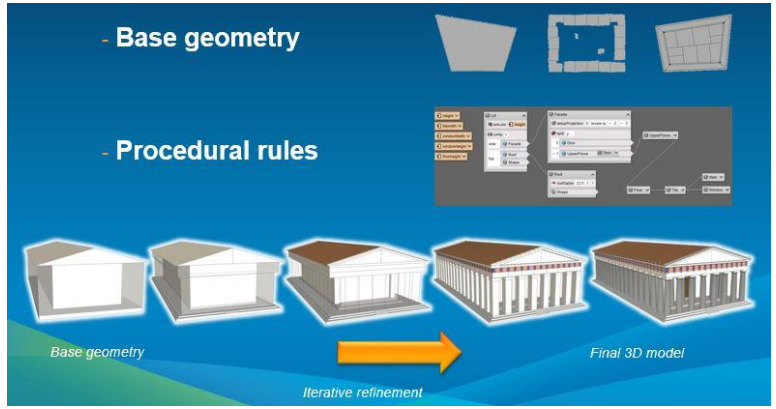
- 3D data acquisition
- Modeling
- Rendering

(Luan et al. 2008)

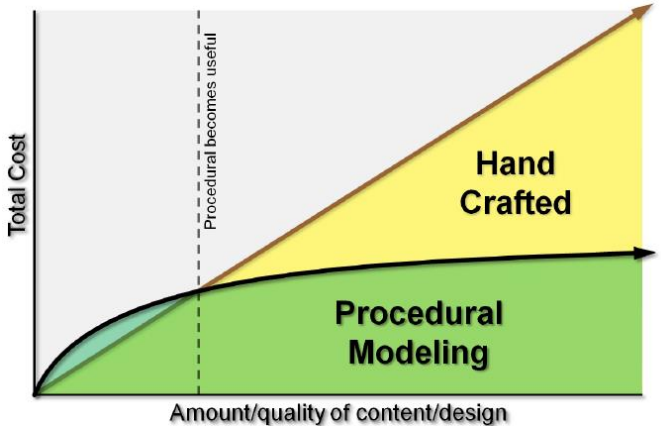
A wide range of **applications:** Architecture, Animation, Decision Making

2.3. Procedural 3D modeling

- A 3D model creation process using **rules** and **algorithms**
- Consists of a **base geometry** and **procedural rules**
- Saves **time** and **costs** when a lot 3D modeling iterations are needed



Principles of the procedural modeling
Source: Schubiger (2012)



Comparison of efficiency between manual and procedural modeling
Source: Schubiger (2012)

2.4. Esri CityEngine as a tool for procedural 3D modeling

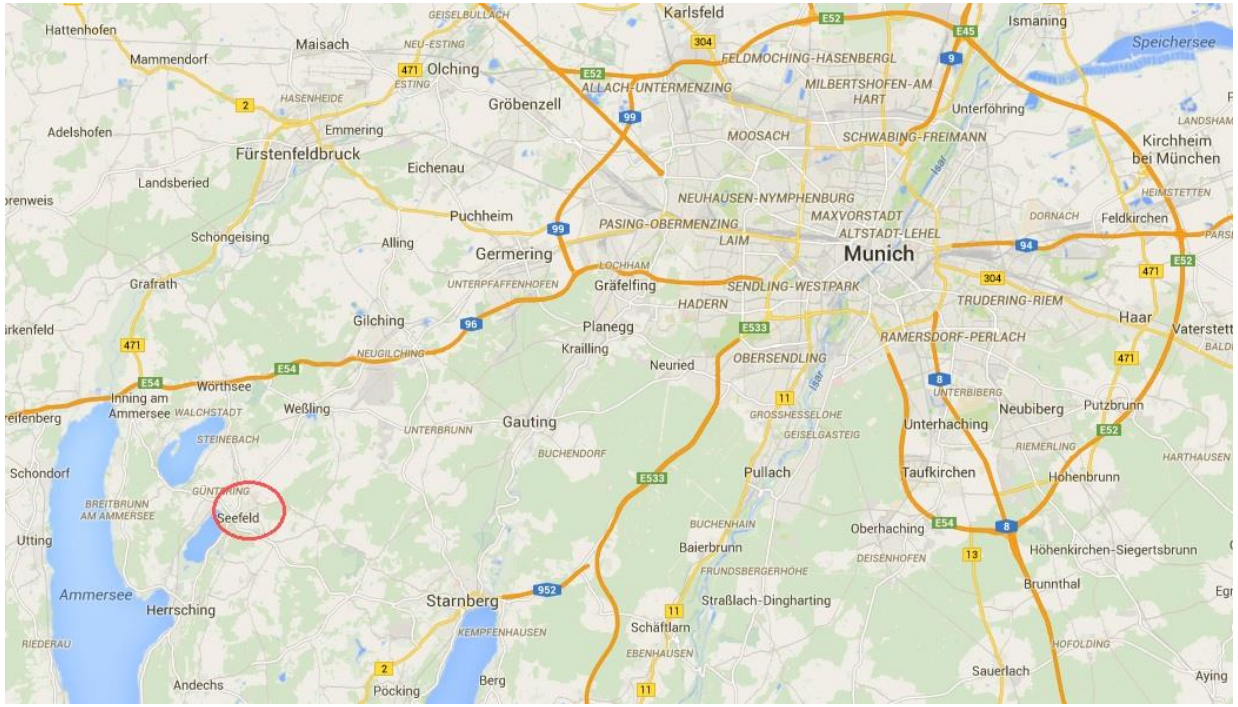
- A stand-alone software which transforms 2D GIS data into smart 3D City models
- Combines procedural modeling methods with shape and split grammars

Creation steps of a 3D city model in the CityEngine software
Source: Esri (n.d.)

3. Case Study Area

Seefeld

- a municipality in the district of Starnberg
- located southwest of Munich
- lies on the northern coast of the Pilsen Lake



Location of Seefeld
Source: www.maps.google.de

3. Case Study Area

Why Seefeld Village?

- Scattered (nucleated) village
- Data availability
- Typical target buildings

Case study area

3. Case Study Area

Typical building **parameters**:

- 1-6 floors (mainly 1 or 2 floors)
- gable and flat roofs
- building facades are light colored
- windows with shutters
- flowers in front of windows

Typical buildings in Seefeld

4. Data Processing

1. Data preparation
2. Data import
3. Procedural modeling using Esri CityEngine
4. Overview of modeling problems

4.1. Data preparation

Data preparation in the software Esri ArcGIS 10.2.2

- Selection of the **coordinate system**

  WGS 1984 Web Mercator

- Calculation of the **necessary building parameters**
- **Simplification** of building footprints
- Creation of locations for **vegetation objects**

4.2. Data import

Data import into the software Esri CityEngine

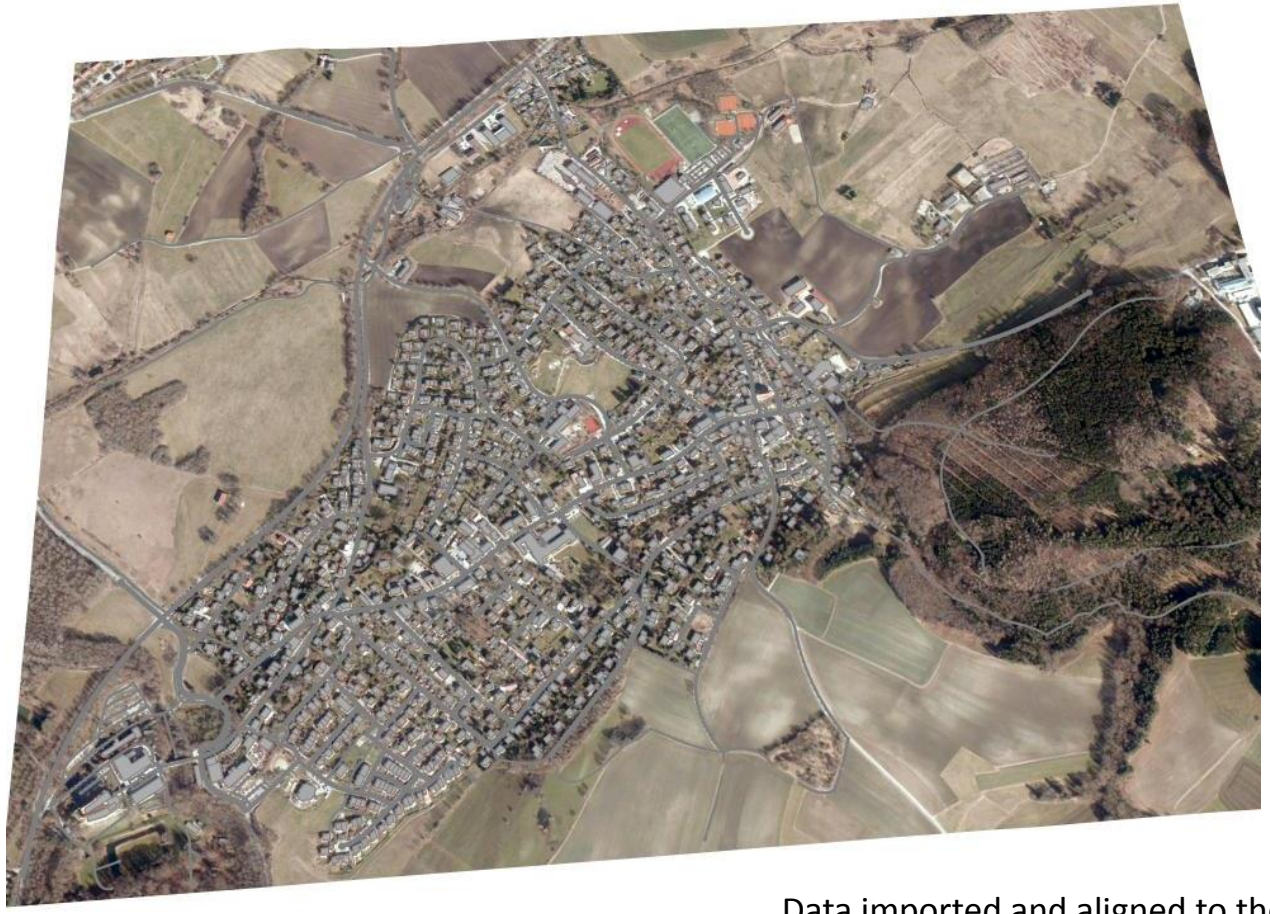
Data Types:

- Shape files
- OSM data
- Object data
- Raster (TIFF, JPEG)
- KMZ

Data	Type	Source
Building footprints	SHP	Esri Deutschland GmbH
Street network	OSM	OpenStreetMap
Locations of vegetation	SHP	Assigned according to imagery base map (ArcGIS base map collection)
Vegetation elements	OBJ	Esri 3D Vegetation Library
Imagery base map	JPEG	ArcGIS base map collection
Height map	TIFF	Generated from the DTM25 provided by the Bavarian State Office for Survey and Geoinformation
3D model of the Bavarian Church	KMZ	3D Warehouse
3D model of a car	KMZ	3D Warehouse
3D models of people	KMZ	3D Warehouse

Overview of the data imported

4.2. Data import

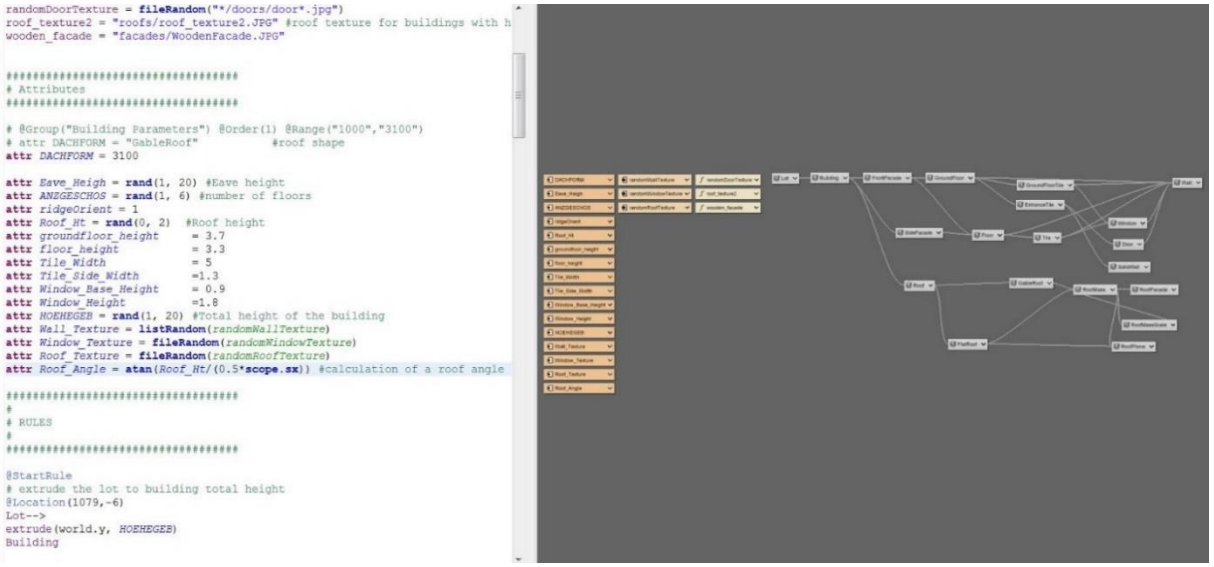


Data imported and aligned to the terrain

4.3. Procedural modeling using Esri CityEngine

„A rule file – a collection of attributes, functions and rules“

(Esri 2014)



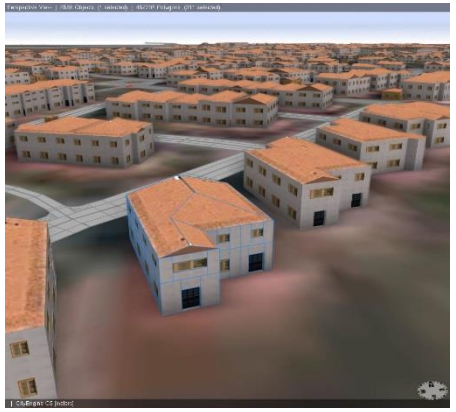
```
randomDoorTexture = fileRandom("*/doors/door*.jpg")
roof_texture2 = "roofs/roof_texture2.JPG" #roof texture for buildings with h
wooden_facade = "facades/WoodenFacade.JPG"


##################################
# Attributes
##################################

# @Group("Building Parameters") @Order(1) @Range("1000","3100")
# attr DACHFORM = "GableRoof"            #roof shape
attr DACHFORM = 3100

attr Eave_Heigh = rand(1, 20) #Eave height
attr ANZGESCHOS = rand(1, 6) #number of floors
attr ridgeOrient = 1
attr Roof_Ht = rand(0, 2)  #Roof height
attr groundfloor_height     = 3.7
attr floor_height           = 3.3
attr Tile_Width             = 5
attr Tile_Side_Width        =1.3
attr Window_Base_Height     = 0.9
attr Window_Height          =1.8
attr HOEHEGES = rand(1, 20) #Total height of the building
attr Wall_Texture = listRandom(randomWallTexture)
attr Window_Texture = fileRandom(randomWindowTexture)
attr Roof_Texture = fileRandom(randomRoofTexture)
attr Roof_Angle = atan(Roof_Ht/(0.5*scope.sx)) #calculation of a roof angle

##################################
#
# RULES
#
##################################

@StartRule
# extrude the lot to building total height
@Location(1079,-6)
Lot-->
extrude(world.y, HOEHEGES)
Building
```

Representation of rule file

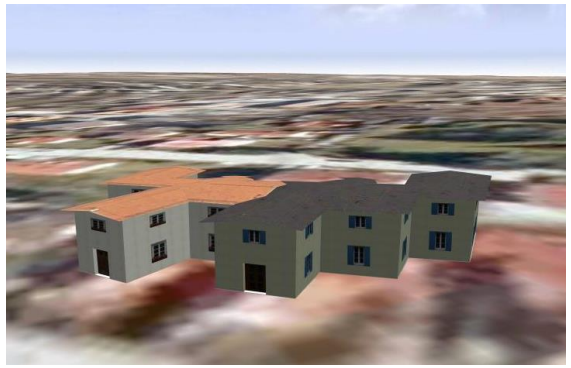
Standard CityEngine workflow
Source: Viinikka (2014)

4.4. Overview of modeling problems

Problems with doors

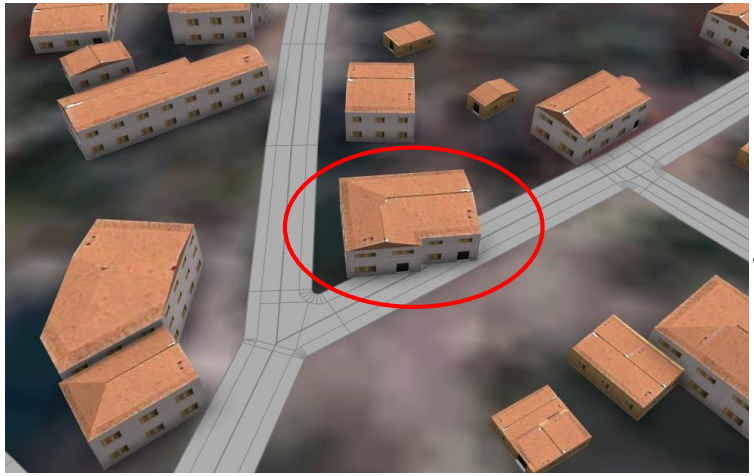


```
Building-->
comp(f) {bottom : X.
         |2: FrontFacade
         |top : Roof
         |all:SideFacad}
```

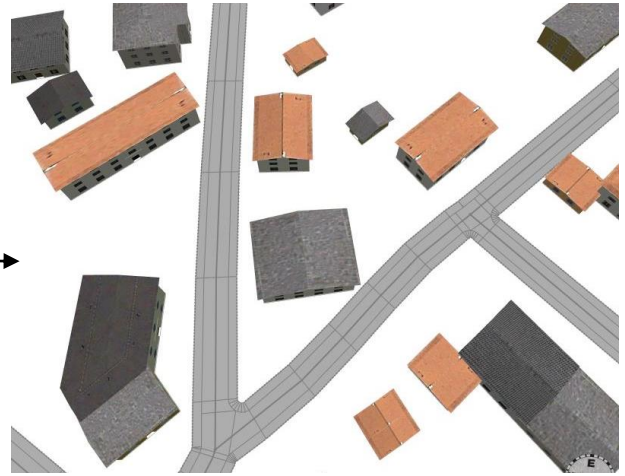


4.4. Overview of modeling problems

Mismatch of the layers

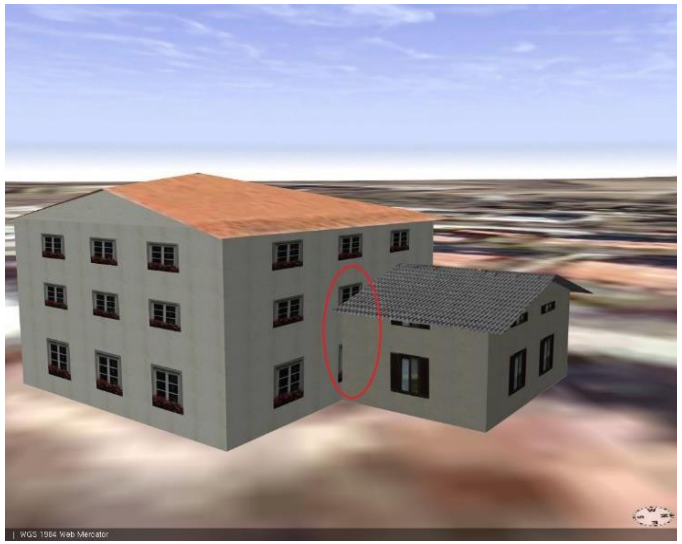


Move streets according to the base map and avoid crossing with the buildings



4.4. Overview of modeling problems

Building elements at intersections




```
Window -->
case touches () :
Wall
```

```
Door -->
case touches () :
Wall
```

4.4. Overview of modeling problems

Roof overhangs

```
attr Roof_Angle =
atan(Roof_Ht/(0.5*scope.sx))
```

```
t(0,0.01,0.01)
```

5. Results

1. Procedurally generated 3D model of Seefeld represents:

- buildings, street network, vegetation, satellite image and DTM
- typical Bavarian rural buildings in Seefeld

2. Dealing with modeling problems in rural area

3. The final results published as CityEngine WebScene

3D model of the case study area

5. Results

3D model output samples from CityEngine

Final result of the 3D model of the case study area

5. Results

Additional 3D objects

A car model added to the final result

Models of people added to the final result

6. Summary

- **Procedural modeling** is one of the most appropriate solutions for creating **large size 3D city models**
- Created **rules** can be **re-used** for further projects
- The software **CityEngine** can be applied for modeling **rural areas**
- Procedurally created model of Seefeld can be used for **further analysis** and **planning purposes**
- In the future the model can be improved with different **LoD (Levels of Details)**

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Thank you!

Questions?