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Institut für
Bau- und Infrastruktur-
management
Circular Engineering for
Architecture

Bachelor Thesis

Automating Scan-to-BIM for Telecom Site Planning

A Comparative Analysis and Case Study

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Declaration of Originality

I hereby declare that the written work I have submitted entitled

Automating Scan-to-BIM for Telecom Site Planning

is original work which I alone have authored and which is written in my own words.[1]

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Preface

This thesis was developed as part of my bachelor's degree in geospatial engineering. Since I enjoy translating scientific findings into practical applications, I sought an industry-related project for my research.
TODO: Finish this paragraph

Jeffrey Leisi
Zurich, 2025

Abstract

- **Introduction to the Topic**
- **Research Objective**
- **Methodology**
- **Results**
- **Conclusion and Impact**

Keywords

BIM, Scan-to-BIM, telecommunications, automation, point cloud processing

Contents

Symbols

Symbols

ϕ, θ, ψ	roll, pitch and yaw angle
b	gyroscope bias
Ω_m	3-axis gyroscope measurement

Indices

x	x axis
y	y axis

Acronyms and Abbreviations

ETH	Eidgenössische Technische Hochschule
D-BAUG	Departement Bau, Umwelt und Geomatik (depatement of ETH)
IBI	Institut für Bau- und Infrastrukturmanagement (institute of D-BAUG)
CEA	Circular Engineering for Architecture (research group at IBI)
BIM	Building Information Modeling

Chapter 1

Introduction

1.1 Background and Motivation

The construction industry is one of the largest economic sectors, yet its productivity has stagnated for decades. In the two decades from 1995 to 2015, its productivity grew by only 1%, far below the global economy's average of 2.8%. One of the reasons cited is the low level of automation [1].

1.1.1 Conventional Planning with CAD

Until the turn of the millennium, construction planning had been largely digitized, primarily through the use of Computer-Aided Design (CAD) for creating construction drawings. This represented an evolutionary innovation, optimizing conventional planning methods. Manual drafting on the drawing board was replaced by manual drafting on the computer, while the individual work steps remained largely the same. In conventional planning, a real object is inductively represented by individual two-dimensional drawings (e.g., floor plan, section, detail). These drawings are often stored as isolated files (e.g., DWG, DXF) and are neither geometrically nor semantically linked. Any changes to the real object must be manually updated in all drawings.

1.1.2 model-based planning with BIM

At the turn of the millennium, Building Information Modeling (BIM) began to gain traction. It represented a disruptive innovation that fundamentally changed previous workflows. In this context, BIM refers to both the technology (software) and the methodology (processes). In model-based planning, a three-dimensional model is created as a digital representation of the real object. The two-dimensional drawings are then deductively derived from the model. The model is stored as a unified file (e.g., IFC) and contains both geometry and semantics. Any changes made to the model are automatically reflected in all drawings.
Scandinavian countries and the United Kingdom have taken leading roles in the implementation of BIM. However, integrating the technology in Switzerland has proven challenging. By 2021, only 20% of Swiss construction companies had adopted BIM, compared to 70% in Germany and 80% in the UK. This places Switzerland slightly above the European average. [2]. Among the factors contributing to this slow adoption are the fragmented nature of the construction industry and high competitive pressure, which led smaller companies, in particular, to shy away from the initially high investment costs. [3].

1.1.3 Telecommunications Planning

The Swiss telecommunications industry has recognized the potential of model-based planning. BIM is increasingly being used for the management of approximately 20000 mobile network sites [4]. While the traditional construction sector typically focuses on large, individual building projects, the telecommunications industry operates with a high volume of smaller projects. This results in different requirements for building models.

Whereas the conventional construction industry demands high-quality, detailed models of entire building structures, the telecommunications sector prioritizes efficiently generated models of exterior structures. While BIM is still primarily applied to new construction projects in the traditional building industry, mobile network installations are usually integrated into existing buildings. The efficient capture of existing buildings has opened up a research field that continues to be actively explored.

1.1.4 Scan-to-BIM

The reverse engineering process of converting a physical object into a BIM model (as-is BIM) using terrestrial laser scanning or photogrammetry is commonly referred to in the literature as Scan-to-BIM. While the data acquisition process is relatively fast, the post-processing of point clouds can become time-consuming when performed manually. To enhance efficiency, automated methods are required.

1.2 Research Objectives and Questions

Both BIM and Scan-to-BIM have been extensively researched in recent years [5]. Surface modeling has also been a major research focus in the fields of computer vision and computer graphics, specifically in the general reconstruction of object surfaces from point clouds [6].

There are numerous existing algorithms that could be suitable for modeling point cloud data. Some of these algorithms are available as open-source code, while others have already been implemented as plugins for BIM software. Each algorithm has a different focus and is suited for specific applications, making it challenging to maintain an overview of the available options. So far, no dominant algorithm has been identified that consistently delivers the best results across all use cases.

As part of this study, the first phase will involve comparing various algorithms. In the second phase, the most promising approach will be implemented in a practical setting, and concrete recommendations for its application will be provided.

The following research questions are derived from this approach:

- **Research Question 1:** Which algorithm is the most promising for a practical implementation of a Scan-to-BIM workflow?

- **Research Question 2:** How can the most promising algorithm improve the efficiency of an existing Scan-to-BIM workflow?

1.3 Scope and Limitations

TODO: Define the boundaries of the study.

1.4 Methodology Overview

To address the research questions, the study is divided into two parts. The first part answers the first research question through a comparative study. The second part addresses the second research question through a practical implementation.

1.4.1 Part 1: Comparative Analysis

In the first step, various algorithms for processing point clouds will be analyzed regarding their suitability for automating BIM modeling. The evaluation will be based on the following criteria:
TODO: Add more details on algorithm TODO: Add more details on the criteria.

1.4.2 Part 2: Case Study

After the analysis phase, the most efficient algorithm will be implemented in a real-world project.
TODO: Add more details on the implementation steps.

1.5 Thesis Structure

An effort was made to reflect the two-part structure of the study in its overall organization. Since the implementation builds upon the analysis, a linear structure was chosen. This approach offers the advantage that no distinction needs to be made between the different parts within individual chapters. As a result, the reader clearly understands their current position in the document and knows what to expect next.

1.5.1 Part 1: Comparative Analysis

First, in Chapter 2, a literature review is conducted to neutrally identify and describe the relevant algorithms. Subsequently, in Chapter 3, these algorithms are compared and evaluated. Their respective areas of application are determined, identifying which use cases they are particularly suited for. This serves as the foundation for the second part of the study.

1.5.2 Part 2: Case Study

The second part focuses on a practical case study, developed in collaboration with Axians Schweiz AG, a leading provider of turnkey mobile network installations in Switzerland. This section presents the scientifically relevant aspects of this collaboration.
In Chapter 4, the initial problem of the case study is identified. Chapter 5 then discusses the results of the implementation. The detailed process leading to these results is documented on GitHub. This section provides only a brief overview of how the most promising algorithm was applied in practice and what results were achieved.
Finally, in Chapter 6, the findings are summarized, and an outlook on future research directions is provided.

Chapter 2

Literature Review

2.1 Introduction

TODO: Introduce the purpose of the literature review.

2.2 BIM

TODO: Introduction BIM. Explain most relevant concepts and applications.

2.3 Telecom Site Planning

TODO: Introduction Telecom Site Planning

2.4 Scan-to-BIM

TODO: Introduction Scan-to-BIM. State-of-the-art technologies and applications.

2.5 Automating Algorithms

TODO: Overview of existing algorithms for Scan-to-BIM.

Chapter 3

Methodology

3.1 Introduction

TODO: Provide an overview of the methodology.

Chapter 4

Problem Description

4.1 Introduction

TODO: Provide a brief introduction to the chapter.

4.2 Initial Situation

4.3 Chosen Approach

Chapter 5

Results

5.1 Introduction

TODO: Provide a brief introduction to the chapter.

Chapter 6

Discussion

6.1 Introduction

TODO: Provide a brief introduction to the chapter.

Chapter 7

Conclusion

7.1 Introduction

TODO: Provide a brief introduction to the chapter.

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