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Architectural Surveying, from Point Cloud to CAD/BIM: Towards Automation of Data Processing for Large-Scale Projects

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Abstract

As part of a project to digitize the infrastructure of the Université Libre de Bruxelles, a semi-automated digital acquisition methodology was developed to create a 3D inventory of the buildings on the Solbosch Campus. The objective is to build an up-to-date graphical database to facilitate the daily maintenance of the sites and support future renovation projects. A systematic workflow was therefore established: one that is both tailored to the constraints, challenges, and goals specific to each building, and that incorporates automated data processing methods to ensure efficiency, consistency, and scientific accuracy throughout the acquisition process. The ultimate aim is to produce coherent datasets that are aligned with one another, streamlining procedures for projects of similar nature and scale. The long-term value of this approach lies in the potential to fully automate certain stages of the workflow, thereby improving efficiency while maintaining high standards of data accuracy.

CCS Concepts

· ***Computing methodologies** → **Computer graphics**→ **Shape modeling** → **Point-based models***

1. Introduction

As part of a comprehensive digitization project of the *Université Libre de Bruxelles* campuses, a point cloud acquisition strategy and methodology were established to inventory several buildings. Spread over about ten hectares on the site of the 1910 World's Fair, the campus includes libraries, forums, restaurants, former student housing, auditoriums, and classrooms in various architectural styles—from industrial to Art Deco and modernism. Built over roughly a century from the early 20th to the early 21st century, many buildings are now heavily deteriorated and few still match the original plans held by the university. Many have been transformed over time, while others underwent numerous plan modifications even before construction.

The project therefore focuses on the inventory of campus buildings through their digitization into 3D models and their faithful transcription into architectural graphic documents—plans, sections, elevations, etc. The objective is twofold: firstly, to establish a realistic and up-to-date record of the buildings, facilitating effective daily site maintenance. Secondly, it provides (future) architects with the most recent plans possible, enabling them to successfully carry out various renovation and repurposing projects planned by the university authorities.

Depending on the requirements, the methodology and scope of the acquisition project are adjusted to best suit the intended use: renovation, interior redesign or site surroundings, technical building management, etc. This tailored approach nonetheless allows for the establishment of a series of templates which, in the long run, enable faster data processing and smoother reading of the produced documents. Thus, the best digital acquisition methods can be defined based on in situ conditions (building state, accessibility, weather), the most appropriate acquisition techniques per case (laser scanning or photogrammetry), the use of the most relevant CAD and BIM software for the studied case, as well as a standardized graphic charter [FL22] [KAY22].

To successfully carry out this project, particular attention has therefore been given to automating as many steps as possible in the data processing workflow.

2. General Methodology

From the very inception of the project, it is crucial to follow a logical strategic approach to achieve the best results and ensure the consistency of the collected information. While the working methodology broadly aligns with conventional practices for this type of acquisition, our focus here lies on the systematized steps. These primarily concern the processing of raw data, rather than the acquisition process itself or the final conversion into a CAD/BIM model (see the red points in Figure 1).

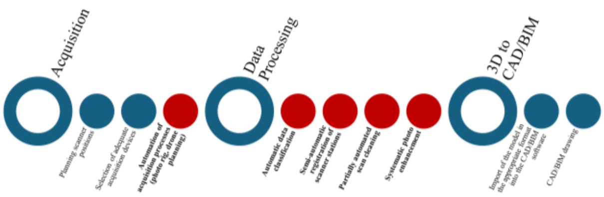

Figure 1: *Simplified diagram of the acquisition methodology within the "Infrastructures" project. The steps highlighted in red include partial automation of data processing procedures.*

3. Focus on the partially automated steps

In general, the points in the workflow that we aimed to automate as much as possible often correspond to stages in the project where multiple constraints arise. The goal is to find the most suitable solutions to address these recurring issues, knowing that they occur intermittently or even systematically in projects focused on building acquisition. These constraints range from managing large-scale acquisitions, which can sometimes be very lengthy, to the tedious manual cleaning of areas heavily frequented by the public, as well as recurring problems with reflections and transparency often found in windows that distort the raw data, for example.

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3.1. Automation in acquisition

Before processing the raw data, the step most suitable for automation is the preliminary preparation of the equipment. For example, in the photogrammetric survey of a façade, this can involve setting up a rig with multiple cameras, including various lenses—standard or wide-angle depending on the desired shot. This method, for instance, allowed us to reduce the acquisition time of a university building's exterior by a factor of four. Once the system is installed, it can be reused for capturing numerous façades while maintaining proven settings from previous projects (lenses, focus, orientations, etc.).

3.2. Automation in data processing

Regarding data processing, it offers a broader field of experimentation concerning the automation of workflow steps.

- **Automatic data classification**

Thanks to the development of customized code, the raw data imported onto the laboratory's computers are directly named, sorted, classified, and catalogued systematically according to conventions recognized by institutions active in heritage preservation. Besides facilitating exchanges with these institutions and enabling collaboration opportunities, this approach also ensures a linear organization across all projects, making them more accessible.

- **Semi-automatic registration of different scans**

In laser scanning acquisition, the initial focus is placed on automatic alignment tools that optimize the superposition of data collected during acquisition. In most cases, this suffices to register the entire dataset, provided acquisition requirements have been met.

- **Scan cleaning and geometric corrections**

To retain only useful data and effectively eliminate extraneous elements from acquisitions without compromising the project's integrity, the raw data cleaning phase is essential [SHS12]. Besides using auto-classification tools that intelligently detect categories of point clusters (vegetation, buildings, ground, etc.), another challenge lies in handling duplicated data caused by reflections in windows or mirrors, or data extended by transparency. This regularly occurs during laser scanning acquisitions on built structures. We therefore aimed to develop our own internal automatic point classification system to differentiate erroneous data from accurate data, thereby facilitating intelligent scan cleaning (Figures 2 & 3) [BSD23].

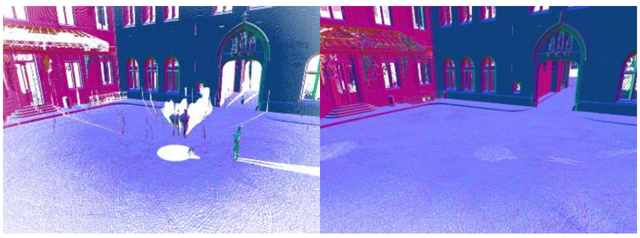

Figure 2: *Geometric corrections (here, removal of people present)*

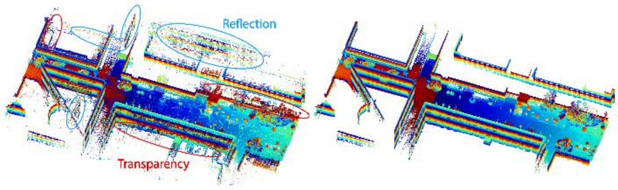

Figure 3: *Automatic detection and cleaning of reflection or transparency areas caused by windows*

- **Improvement of color processing**

Whether in photogrammetry or laser scanning, particular attention is given to color processing. This involves the use of color charts, as well as the development of correction tools that ensure consistent rendering when applying textures to point cloud models (Figure 4).

Figure 4: *Color corrections (here, uniformization of colors within the same texture)*

4. Conclusion

In general, it is rare at this stage to speak of full automation for certain steps in data processing. Often, the system must be supplemented by human intervention, as it is not always entirely reliable and remains under continuous development. However, this gradual automation allows for producing results with greater efficiency and provides increased confidence in the scientific accuracy of the collected data. We therefore hope to continue developing these systematic methodologies in the future to facilitate large-scale architectural projects, but also to apply them to other types of digital acquisitions with specific technical requirements, notably in the context of heritage preservation and analysis projects—archaeological sites (excavations) or diverse artifact collections.

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