Scan-to-BIM
An interdisciplinary workshop on the present and the potential of scan-to-BIM in industry

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Research Problem Statement & Purpose

The application of digital technologies has the potential to overcome large construction sites exceeding planned construction time by 20% and cost frame by 80%. By now, 3D scanners and Building Information Models (BIM) have become a standard digital ecosystem in architecture, engineering, and construction (AEC). Through steady enhancements of 3D measurement technology, such as 3D scanners, the resulting 3D point clouds are high resolution and ever more accurate. However, an automated transformation of several hundred million 3D points into BIM is an area of interest still to be addressed. Therefore, enhanced workflow regarding automation, flexibility, and accuracy is expected to save up to 30% of time and costs. The research project “Large Clouds to BIM” (LC2BIM) aims to develop a new efficient workflow for automated transformation of 3D point clouds to BIM. Algorithms and data structures for real-time visualization are to be developed to allow users to work on massive point clouds without time-consuming pre-processing actions. Also, combining various 3D recordings and necessary manual steps that are not just error-intensive but also waste time and economic resources pose unresolved issues. Optimization methods and minimal user input are intended to reconstruct BIM objects from 3D point clouds.
Within the research project, a workshop was conducted to merge research findings with expertise and practitioner from the industry. Feedback and input from potential users were obtained and assessed.

Research Methodology & Approach

Workshops are an essential tool in human-centered design of a proposed workflow. They represent a possible approach to supply research with expertise from potential users. The workshop's approach was to aim for technology acceptance within the industry. The research methodology can be structured into three steps: (1) identifying relevant information to gather, (2) conducting a workshop with potential users, and (3) evaluating acquired data.
The research project "LargeClouds2BIM" aimed to conduct an interdisciplinary workshop, merging insights from researchers and potential users from architecture, engineering, and construction (AEC). The findings through the workshop's participants shall (a) provide early feedback for the project work, (b) assess the subjective quality of the project results and (c) include final users in the human-centered design loop throughout the project. On one hand, three buildings were scanned with terrestrial laser scanners and assessed by existing 2D plans. Several workflows were evaluated for the obtained point clouds regarding implementing the data sets into BIM-able software solutions to generate BIM models automatically. As a reference, BIM models were manually generated from 2D plans. Several challenges were located throughout the evaluated as-automatic-as-possible workflows from 3D point clouds to BIM models. The most frequent ones are accuracy, time- and cost-efficiency, compared to benefits and challenges regarding available software solutions. For those issues identified, it was necessary to connect to practitioners to obtain information about the exploitation and utilization of acquired data through scan-to-BIM approaches in practice. Throughout bi-weekly meetings of the consortium, ideas, suggestions, and questions were collected concerning recording digital building stock through laser scanning, photogrammetry, and other methods. Eventually, those were concretized for the workshop with stakeholders from the AEC industry on questions concerning (A) motivation and efficiency of scan-to-BIM-solutions, (B) mode of operation using scan-to-BIM-solutions, and (C) potentials and obstacles using scan-to-BIM-solutions.

Twenty-two people from the industry attended the workshop: 2 business developers, four architects, two research engineers, one technician, six BIM managers, one surveyor, one VR expert, two students, two project managers, and one managing director. The participants were first asked to introduce themselves and further answered three question-and-answer sessions (Q&As), whereas after each main question block ((A), (B), (C)), there was time for a round of open discussion. Afterward, the present results of the research project LC2BIM were briefly presented, and the participants then gave feedback on those results.
Each Q&A round, as well as the open discussion rounds, were audio-recorded and transcribed. Photographs were also taken of the participants' noted responses. These recordings made it possible to summarise the results described in the next chapter. Within the research project, a workshop was conducted to merge research findings with expertise and practitioner from the industry. Feedback and input from potential users were obtained and assessed.

Key Findings

In this chapter, the results obtained throughout the workshop are described. Therefore, the quantitative, as well as qualitative results are presented separately. Finally, the current findings of the research project LC2BIM are briefly presented as an approach to implement scan-to-BIM methods into practice.

Quantitative Results - Workshop Q&A-Session

The quantitative results of the Q&A of the workshop are presented for each individual question block (see Table 1).

Question Block	Main Questions	Sub Questions
Question Block A – Motivation and Aims	Have you taken actions towards digitalisation (laser scanning, BIM) within your company?	If yes, what was the motivation to do so?
		If no, what has stopped you?
Question Block B - Approaches	Describe your Scan-to-BIM workflow.	Did your expectations come true?
		Were there any additional costs, efficiency gains?
		What were the key findings?
	How is the work distributed in these workflows (internal department or project partnerships)?	
	How does the cooperation work (difficulties, benefits)?	
	How often do you currently use scan-to-BIM workflows within a project?	
	Describe your experience of regular use over the course of a project. How do these differ from single shots?	
	What methods do you use to collect data? What criteria do you take into account?	
	What are the difficulties in extracting information from raw data?	
	How efficient do you consider your scan-to-BIM workflow?	
Question Block C – Potentials and Obstacles	Where do you see the potential of these technologies? What role does your company play in this?	
	Where do you see the biggest hurdles?	
	Under what circumstances (support) would you use Scan-to-BIM more extensively?	

Table 1 Question of Q&A-Session with the Participants

(A) Motivation and Aims

93% of the participants answered the question if they have taken action to implement more digital solutions such as laser scanning and BIM within their business with “yes” (see Figure 1 (l)). On third of them stated the use of laser scanning and point clouds, particularly for “as-built”-models, to compare the models to built geometries or to substitute 2D-as-built plans from construction sites. These scans are also used for documentation during ongoing construction work.

7% of the participants are working with BIM and point clouds but have never used a laser scanner (see Figure 1 (l)). They tried to generate point clouds through available smartphones and further developed them through algorithms.

Figure 1 (r) shows the application of digital tools in practice comparing laser scanning, point clouds, and BIM models.

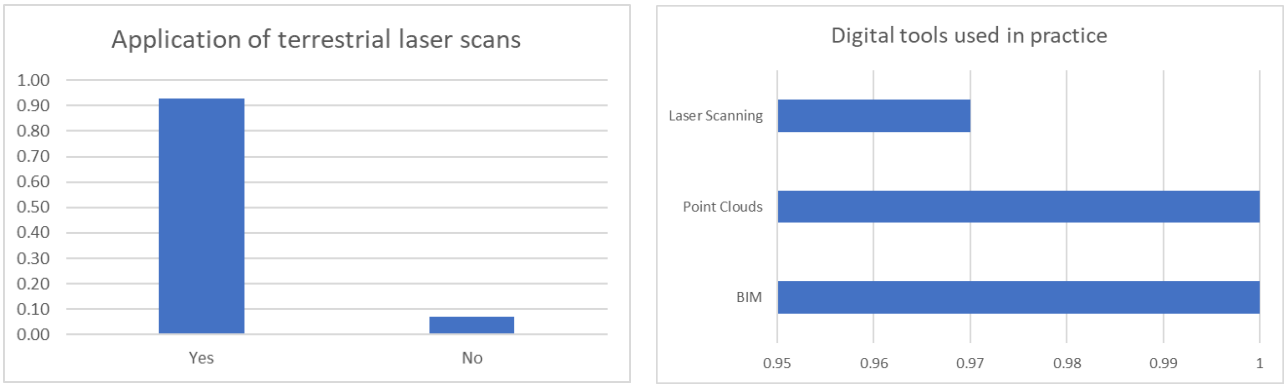

Figure 1 Application of terrestrial laser scans (l) and Usage of digital tools in practice (r)

(B) Approaches

Figure 2 shows that 8% of the participants with laser scanning methods have outsourced the work related to point clouds. While the rest of the participants are divided in half, one half keeps the work of their scan-to-BIM method without exception, while the other half outsources steps along the workflow. Concerning the frequency of scanning during a project, 80% declared practicing their workflow regularly throughout a project’s lifetime, though the exact number of scans strongly depends on the client’s request.

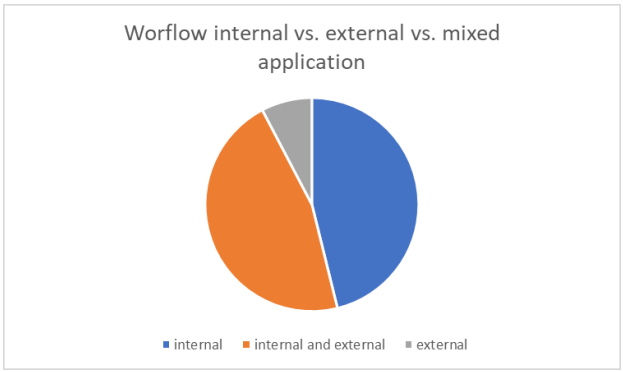

Figure 2 Workflow of scan-to-BIM methods internal vs. external vs. mixed approach

As for difficulties, one out of five participants stated that applying their workflow is not gaining them any efficiency. The exact number of participants identified their scanning results imprecisely.

(C) Potentials and Obstacles

33% of the participants stated scanning to generate as-built models a potential of scan-to-BIM approaches (see Figure 3 (l)). Also, the possibility of visualizing point clouds in VR and AR is high. Other identified potentials in early recognition of collisions amongst different industries, as well as the introduction of monitoring of construction progress and data for simulation models. Another often discussed aspect is the digital building submission which still needs to be compelling in Austria.

The biggest obstacle, stated by 80% of the participants, is data handling and file sizes (see Figure 3 (r)). 60% considered it is challenging to clarify the as-yet unquantified benefits for the client. Missing software solutions to generate BIM models through point clouds was the third most common mention by 40% of all participants.

The 93% who stated they still need to work with laser scans are seeing the most difficulty with the high cost of a laser scanner. Incentives such as funding, retraining, cost-benefit analysis for the building owner, and software-based solutions were listed.

Figure 3 Potential (l) and Obstacles (r) of applying scan-to-BIM methods

Qualitative Results

The participants were asked to give input and feedback as experts and potential users for the qualitative results. After each of the three main blocks of questions, a round of discussion was scheduled. Firstly, the intensity of using digital tools in practice was up for discussion. Less experienced participants regarding the application of scan-to-BIM methods were either part of a case study or used it several years ago without the intention to use a scan-to-BIM method repeatedly. The highly experienced participants often stated their use of scan-to-BIM methods for "new constructions" and projects concerning "redevelopment of existing buildings". They are working with BIM daily, even replacing 2D- and 3D- plans and models completely with BIM. These participants also identified using not always terrestrial laser scanners but more often "iPhones, or iPads, at all kinds of construction sites in daylight or appropriate lighting conditions", generating point clouds. While the "downside using tablets or phones instead of terrestrial scanners is the precision", the advantages like "usability", "point-clouds in RGB-colours", and the possibility to "link the point-cloud to AR [augmented reality]" predominated.

The second block of questions deals with the workflows and approaches of scan-to-BIM methods. It was identified that the application and use of scan-to-BIM methods no longer correspond to the usual sequential planning processes. Nowadays, different methods and devices are used by planners, but also by contractors, to make scans independently and to build up expertise in their own company. The participating service providers confirmed this trend. Large companies are now often commissioned as "consultants" and with "training", and only provide the services for liability reasons. They usually stick to the classic service for cost reasons if they work with SMEs.

After the third block of questions, potentials and obstacles were further discussed. Employees of construction companies could "not see the benefit behind the point clouds" in their position. They are asked and paid by the client, but "even the client cannot explain their benefits of the scans". However, there was unanimous agreement that having as-built scans could greatly benefit in a few years.

Proposed approach to implement scan-to-BIM methods into practice

The research project "Large Clouds to BIM" aims to develop algorithms and data structures to render and load datasets with hundreds of millions of points without pre-processing. Those developments are used for progressive and simultaneous generation of Level of Detail (LOD) structures and the simultaneous rendering these structures. To view and process 3D images from different sources and recognize and reconstruct surfaces, planes, and objects,

a 3D sensor fusion of the data sets is implemented to automatically compensate for different coordinate systems and scales of the input data. Developed prototypes have already been applied to actual photogrammetric data to bring freehand photos onto the coordinate system of high-resolution point clouds. Also, parallels emerged from independent photographs' texturing of point clouds and triangle-meshed surfaces.
Through the approaches of (A) manually generating BIM models based on point clouds and (B) developing an IFC generator, which allows an automated recognition and conversion of elements from point clouds to BIM objects, an interface to BIM ecosystems has been successfully established.

Implications

Gathering insights and feedback from practitioners regarding the industry's challenges bares the potential for the conducted research to answer those fields of interest. While the AEC industry is applying scanning methods and BIM and working with point clouds, there is not yet common ground on the benefit of integrating state-of-the-art workflows. The participants from the industry mention significant obstacles, such as the cost-benefit ratio and the non-existing software solutions for implementing a human-centered automated transformation of 3D point clouds to BIM. It was clarified that the through research identified challenges that are also faced by the industry and are therefore highly relevant to be further discussed.