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THE USE OF AUGMENTED REALITY IN THE BUILDING PERMITTING PROCESS

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Introduction

The digital transition, along with the adoption of Building Information Modelling (BIM), is transforming the Architecture, Engineering, Construction and Operations (AECO) sector. In Portugal, due to the ongoing housing crisis (ECFIN, 2024), BIM implementation is mainly industry-driven, with political efforts promoting its use through simplifications of building permit procedures, shifting to a successive building permit control process in most cases. These simplifications are introduced by Decree-Law 10/2024, divided into 3 speed categories according to implementation readiness, which can be seen in Figure 1.

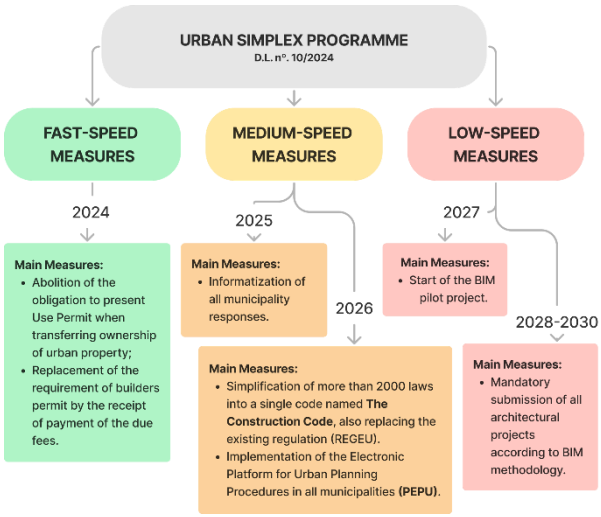

Figure 1:Government's measures: a three-speed process

Augmented Reality (AR) applications in AECO have expanded, supporting construction site progress monitoring (Wang and Chen, 2020), facility management using AR to interact with equipment of health care facilities (Williams et al., 2015), education, presenting students BIM information superimposed in the real-world Ashour et al. (2022), safety, rescue guiding mechanisms that allow firefighters to navigate through the buildings (Kuo et al., 2023), and automated inspections interconnecting automatic detection of building defects with computer vision (Tan et al., 2024). Although Unity remains a leading AR development platform (Unity, 2005), Web-Based AR is gaining traction due to cross-device compatibility, supported by frameworks like Three.js (Cabello, 2010), Babylon.js (David Catuhe et al., 2013), and WebXR API (IWWCG, 2016). The high cost of native AR platforms (e.g., Unity, Unreal) hinders adoption, making open-source alternatives preferable.

Handheld devices (HHD), the most accessible AR hardware (Goh et al., 2019; Syed et al., 2022), support Markerbased and Markerless tracking, including vision-based and location-based methods. Location-based methods alone provide sufficient tracking accuracy for some AR applications, and this can be improved with specialized techniques (Gomez-Jauregui et al., 2019). Although similar concepts have been presented (Gerger et al., 2023), the present work builds upon that foundation, further contextualizing the solution for specific legal, technical, and societal framework of Portugal. This project aligns directly with the ongoing URBAN SIMPLEX programme, which introduce post-inspection permitting logic and mandate BIM adoption. This introduces the opportunity of introducing new workflows in the formal municipal permitting workflow. In addition, the proposed solution focuses on low-cost AR access via handheld devices, making the platform viable for real-world deployment in a system where public engagement is now a critical part of the post-inspection enforcement model. Hence, this abstract presents a framework that integrates a Web-Based AR application in a workflow to visualize and audit new constructions under this new successive building permit control, leveraging BIM and AR for public engagement. This application adopts a Markerless location-based method.

Proposed Framework

The proposed framework integrates a web application with two parts: i) a City Viewer, ii) AR Viewer. The application enables citizens to have easy mobile access to BIM permit models. Figure 2 maps the proposed framework information flow. The appointing party submits valid licensing documents via municipality's existing platform, an automatic validation, which may include Level Of Information Need (LOIN) validation per the Information Delivery Specification (IDS), initiates a series of server-side actions.

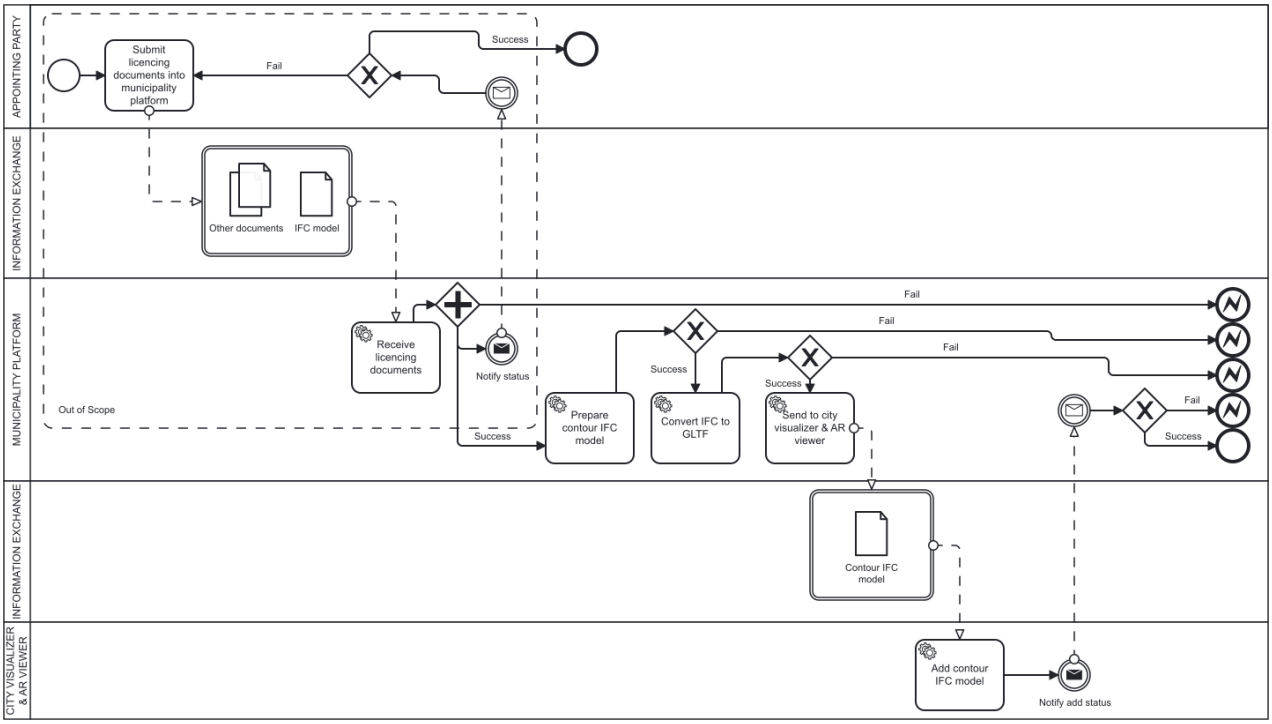

Figure 2: Business Process Model and Notation of the proposed use case

Subsequently, a script generates a new IFC model containing only the exterior contours of the building. This ensures data-privacy and reduced file size for web deployment. This process is semi-automated, municipal technicians should review and adjust to account for any corner cases (e.g., unclassified external walls).

Once validated, this IFC contour model is then converted into GLTF format using IfcConvert (IfcOpenShell, 2011), and the georeferencing data is extracted and mapped from EPSG:3763 (PT-TM06/ETRS89) to WGS84 using Proj4js

(Warmerdam, 2013).

Lastly, the GLTF model and the respective georeferencing coordinates are transmitted to the web application, updating a shared JSON database, and refreshing both City Viewer and AR Viewer through a script. A confirmation message completes the workflow. If errors occur, they are prompted for the technician intervention. The entire process employs Free and Open-Source Software (FOSS), including: Bonsai in Blender for BIM modeling, Cesium.js and Three.js for City Viewer (Foundation, 1994; IfcOpenShell, 2024; Cabello, 2010; Cesium GS, 2023; IfcOpenShell, 2011), and AR.js with WebXR for AR functionalities (Jerome Etienne et al., 2024; IWWCG, 2016).

Research Methods

The present research is mainly qualitative. The study focuses on developing, testing, and evaluating an AR-BIM platform, which involves understanding user experiences, such as usability and implementation feasibility, but also the legal and technical analysis of the Portuguese construction law. The required performance testing of the proposed platform, evaluation of AR-REGISTRATION accuracy, as

well as usability metrics such as error rates, task completion time, which can be present in some included studies, are of quantitative nature. Considering the mixed nature of this research, the research methodology that better fits the current research is Design-Based Research.

Implementation of the Proposed Framework

The proposed framework responds to the challenges of Portugal's new successive building permit control system, integrating and deploying a Web-Based AR-BIM application that addresses two primary types of users: municipal technicians and ordinary citizens.

Municipal technicians in Portugal, who routinely work with the Geographic Information System (GIS), can benefit from the City Viewer by accessing cost-free, automatically integrated building models sourced from the municipal licensing platform. Additionally, the IFC models are directly generated from appointed party submissions, which ensures a re-utilization of existing building permit processes and BIM data, in a semi-automated manner, for purposes of urban planning. Streamlining these processes allows municipal technicians to focus on other critical urban planning tasks, instead of routine administrative work. The Augmented Reality (AR) viewer adds value innovation, since the development of IFC models of buildings is a laborious and expensive task, and Portugal's municipalities

currently lack a way to overlap IFC models in the real environment for urban planning purposes.

Ordinary citizens can access the web-based application via a mobile device, which displays a digital map presenting all available IFC contour models. When in proximity to a digitalized building, especially one under permitting or

construction, citizens can launch the AR viewer by clicking an 'Start-AR' button, enabling a preview of the proposed building in the permit process. Citizens can quickly report any inconsistencies that they may find relevant to municipal services. This is the actual added value of the proposed framework.

Preliminary tests on the initial prototypes of the web application indicate that the City Viewer information workflow is straightforward to implement. However, some challenges remain to achieve accurate georeferencing of the IFC model and textures of the building model. Moreover, the AR-Viewer requires further refinement for accurate AR Registration of the IFC building model. Further developments are being conducted to address these challenges.

Conclusions

This abstract presents a framework integrating a webbased AR application to support the building permit process in the Portuguese context. A free and open-source software (FOSS) application is proposed, leveraging on openBIM standards, such as IFC, EIR and IDS. The key requirements include precise georeferenced IFC models, with the "isExternal" property identifying contour elements. Although not yet fully developed, the initial prototypes sound promising and show room to deepen the integration of AR in the AECO sector.

Acknowledgments

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