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Query Automation for Preventing and Combating Fires Using a Spatial Database: A Case Study of the UFPR Campus

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Abstract:

Fire safety is a concern across various sectors of society, particularly in settings with high population density, such as universities. The risks associated with fires can lead to loss of life, significant property damage, and disruption of essential activities, as research laboratories often handle flammable materials and electronic equipment that heighten the risk of fires. In Brazil, regulations follow technical standards issued by entities such as the Brazilian Association of Technical Standards (ABNT) and Technical Procedure Standards (NPTs), which establish criteria for fire prevention and control in buildings. In this study, we systematically investigate fire safety conditions in university environments, highlighting how the integration of geospatial data can optimize prevention strategies. Our approach innovates by combining information on materials, building structure, and occupancy into a single database, providing broader access to risk analysis than conventional systems.

The increasing complexity of urban infrastructures and the pressing need for sustainable development demand innovative approaches that align with global frameworks. In this context, this work is directly aligned with the United Nations Sustainable Development Goals (UN SDGs), particularly those related to resilient infrastructure, sustainable cities, and quality education (SDGs 9, 11, and 4, respectively). By proposing the automation of fire prevention and combat project queries through a spatial database integrated into a WebGIS platform, this research also reflects the principles and recommendations of the United Nations Integrated Geospatial Information Framework (UN IGIF). This alignment underscores the potential of geospatial data infrastructures to support strategic decision-making and institutional resilience in the context of fire safety management.

Databases increase operational efficiency and maintain data integrity. The creation of a geospatial database focused on cataloging materials and risk-related structures is crucial for risk management, as it centralizes and standardizes information. Consequently, fire prevention and control projects become more robust, benefiting from information that can be readily accessed and updated. We therefore seek to develop a unified system that maps and manages data from different university environments, addressing the gap in integrated information regarding fire risk and prevention. By connecting UFPR CampusMap (UCM) (http://www.campusmap.ufpr.br) to fire prevention initiatives, we integrated a geospatial database into the system to support prevention projects. We aimed to model an existing database, identify workflow processes, and develop an interface for risk consultation. The study area includes Building PI, located on the UFPR campus in Curitiba, Paraná, Brazil.

In general, we determined the building classification, calculated the fire load (amount of combustible material), and established the risk level, providing guidance for project design and regular inspections. The research employed database modeling to catalog construction materials, space occupancy, risk classes, building types, and building height, as shown in Table 1. The methodology included data collection, UML diagram development, and functionality testing. We developed an interface prototype that unifies risk analysis and fire prevention, reducing the need for constant on-site visits and frequent consultations of technical standards. From the database structure presented in Table 1, we generated a class diagram (Figure 1) describing its relational framework for risk analysis and information management. This model standardizes data integration.

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USE	FINISHING AND COATING MATERIALS			AVERAGE FIRE LOAD (kg/m²)	RISK	BUILDING CLASS	BUILDING HEIGHT (m)
Occpancy	Floor	Wall	Ceiling				
Classroom	Vinyl	Wood	Plaster	12	Eletrical	E-4	10
Practical Lab	Ceramic	Plaster	PVC Panel	8	Chemical	I-3	10

Table 1. Database organziation model

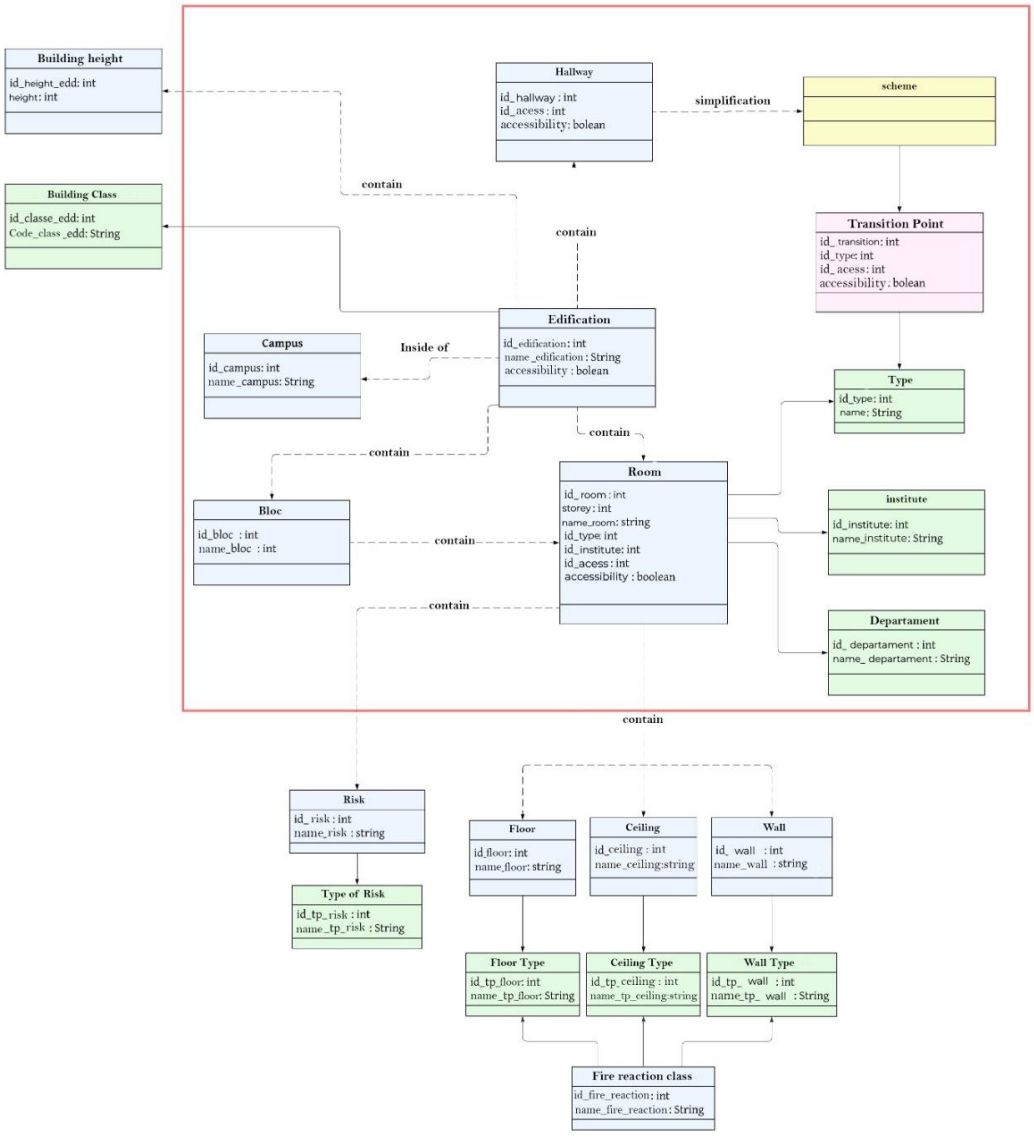

Figure 1. Database UML model

We created a prototype interface (Figure 2) that automates the development of fire prevention and control projects, minimizing recurring visits and repetitive reference to standards.

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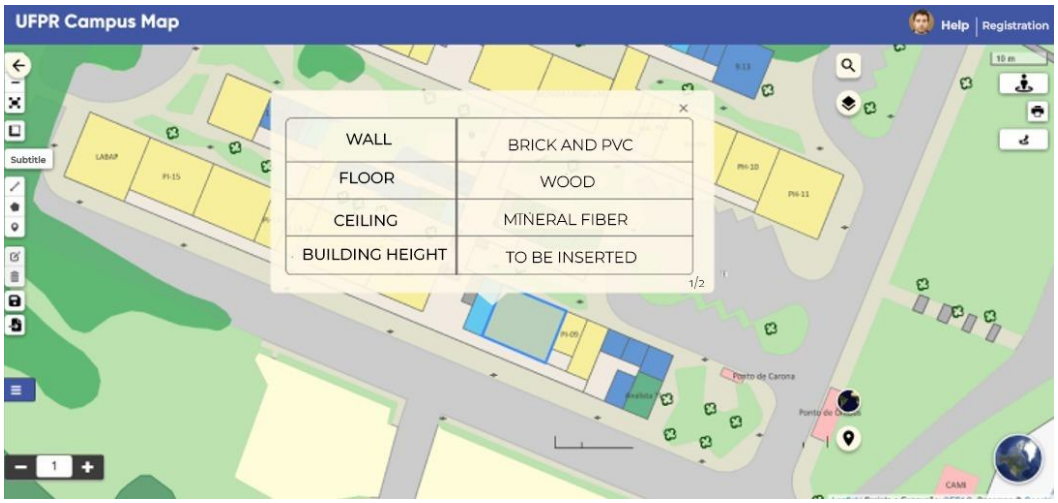

Figure 2. Prototype of the query interface

The results show that integrating a geospatial database with WebGIS improves the efficiency of fire safety projects and compliance with regulations in a swift and accurate manner. This outcome underscores the originality of the project, as it combines occupancy, material, and risk data into a single source, representing a novel approach to designing and maintaining fire control plans. Scientifically, our research produced a database accessible in a WebGIS environment, integrating types of materials, occupancy, and risk levels to inform fire safety planning. We conclude that using a geospatial database integrated with a WebGIS system streamlines and enhances the precision of fire prevention processes in educational institutions, illustrating the potential for expansion to other units. As a next step, we plan to extend the model to other UFPR units and improve the functionalities of CampusMap, aiming to encompass a broader range of spaces and strengthen the tool's capabilities. We propose implementing this technology at other universities, enabling a standardized fire prevention system that can redefine safety protocols in academic institutions.

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