A Data Model for Unrecognised Historical Neighbourhood (Case study: Telukbetung, Indonesia)

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Abstract

Unrecognised Historical places, which are locations with history but lacking official recognition, particularly prevalent in Southeast Asia, often face a dearth of accessible historical information. To tackle this challenge, there is an urgent need to commence the collection and documentation of historical data concerning Unrecognised Historical places. This initiative aims to prevent the loss of history, given that such sites are frequently subjected to rapid development and commercialization. To date, City Geography Markup Language (CityGML), an Open Geospatial Consortium (OGC) standard 3D data format, has been developed for presenting city models along with semantic data and is often used in the heritage domain for preservation. It aids in digital infrastructure development and the conservation of urban elements. Furthermore, it provides a mechanism to extend the standard data model to meet the requirements of various purposes. While several CityGML extensions tailored to the documentation of Cultural Heritage already exist, there is currently no extension specifically designed to address the requirements of Unrecognised Historical places. The aim of this paper is to identify a suitable approach for developing a new standardised data model that integrates geometric and semantic information, which is demonstrated for the modelling of Telukbetung, an old city in Bandar Lampung through time.

1. Introduction

Unrecognised Historical (UH) places, or places with history but lacking official recognition, particularly in Southeast Asia, often suffer from a lack of available historical information. This is because they are not considered part of national history and are seen as representing 'only' the history of everyday people. However, historical records, whether in the form of spatial documentation, such as old photographs, maps, or 3D models depicting the evolution of a place over time, or non-spatial accounts, such as descriptive narratives captured in audio recordings or texts, play a significant role in preserving the history of a place (Bentkowska-Kafel and MacDonald, 2017).

To address this issue, the collection and documentation of historical information about UH places need to begin and continue to be updated. This is necessary to prevent the loss of history in these areas, as such places are often under pressure from rapid development (Chong, 2014) and commercialization (Kusno, 2013), which leads to the erasure of history (Roberts, 2017).

To date, 3D models with semantic information are used for preservation, serving as important digital infrastructure (Yang et al., 2024), aiding in the conservation of historical urban areas along with their history (Pepe et al., 2020). These models are facilitated by a standardized framework known as CityGML, developed for documenting, representing, and exchanging information about both the physical and semantic aspects of urban environments (Gröger & Plümer, 2012; Jang et al., 2021; Tegtmeier et al., 2014). The 3D CityGML can serve as a valuable tool for managing and visualizing the city during a specific period (Pepe et al., 2020), which can benefit the initial documentation of UH places.

To begin documenting the of UH places with its history, a method capable of integrating the documentation of both urban environments and their historical narratives is essential. Moreover, since these places require extensive information collection, a method that provides insight into their evolution over time is also necessary. However, the current CityGML modules, while it serves as a solution that combine 3D information and semantic information in a single data model (Prieto et al., 2012), cannot adequately support the description of the components of UH places.

Therefore, CityGML provides a mechanism to extend the standard data model to meet the requirements of various purposes (Van Den Brink et al., 2013; Yang et al., 2024). This process is frequently employed across various domains, such as urban planning and heritage, due to its capability to integrate data to create a 3D urban model (Li et al., 2020) including buildings and terrain (Diakité et al., 2022; Yan et al., 2019).

In the field of heritage, many scholars have endeavoured to extend its application for the purpose of preservation (Costamagna & Spanò, 2013; Mohd et al., 2017; Pepe et al., 2020; Yang et al., 2024). However, while several CityGML extensions for heritage have been released, they do not yet cover the elements suitable for unrecognised heritage or historical places. Their focus has gone beyond initial documentation, such as enabling interoperability and harmonization of spatial datasets (Freire, 2014), the maintenance of immovable cultural heritage (Yang et al., 2024), and valorization and the conservation of cultural heritage (Pepe et al., 2020).

Given that UH places are still in the early stages of preservation, there is a need for a new 3D data model capable of thoroughly documenting as much initial information as possible, regardless of its protection status and future conservation plan. The goal is to share the history of these places with their local communities, enabling them to learn about their own places, contribute additional information, and hopefully, thereafter, reflect on its value.

This paper introduces an extension of the CityGML schema to offer a framework for conceptual modeling intended for the initial documentation of UH places, encompassing both spatial and non-spatial aspects. This extension focuses on modeling typical architectural features of UH places, as well as incorporating the stories provided by the local residents. The framework is also intended to facilitate future contributions from the local community to continue collecting historical information or their recollections of memory, which can be stored within one platform.

To create a 3D documentation of the UH places and their historical evolution, it is necessary to gather a series of graphic documents comprising views and representations of the UH area. However, since UH places often lack available data, as exemplified by Telukbetung in this paper, interviews are conducted to gather insights into its appearance in the past along with its story. These interviews were conducted between December 2022 and February 2023, resulting in the collection of individual recollections and memories, including descriptive narratives, as well as geometrical information such as old photos and maps.

These interviews were expected to contribute to the creation of a LOD3 3D model of specific buildings with history and memory of its community that can be presented in a digital platform. However, the data necessary to generate LOD3 is still lacking. Therefore, we argue that this CityGML extension should enable the platform to receive new spatial and non-spatial information, allowing for the reconstruction of a 3D model of Telukbetung over time for future development, as it cannot be presented immediately. This also means that the platform should be able to receive new information from local residents or anyone interested in learning about Telukbetung.

This paper presents the UML of a spatial schema for a UH place, incorporating initial historical data obtained from interviews. Additionally, the 3D models of some buildings from the use case were constructed based on the most recent available data, comprising photographs taken between 2021 and 2023. This decision stems from the insight provided by the interviews, indicating that Telukbetung has experienced minimal changes over the past 40 years.

2. Previous research and development

The CityGML has garnered notable success in 3D semantic urban modeling by offering a set of foundational modules, such as building, bridge, and land use (Kumar et al., 2019). CityGML serves as an appealing solution that integrates both 3D and semantic information within a unified data model (Prieto et al., 2012). This model is utilized for modeling topographic features and designed to meet a wide range of 3D semantic modeling needs across diverse geographic environments (Arroyo Ohori et al., 2018) and various purposes.

CityGML is an XML schema based on the Geographic Markup Language (GML), used for storing and exchanging 3D city geometries which support multiple Levels of Detail (LoD) (Van Den Brink et al., 2013). LoD 0 features 2D building shapes with a single height value, LoD 1 includes geometries extruded from 2D, LoD 2 provides detailed wall and roof shapes, and LoD 3 adds features like windows and balconies (Postert et al., 2021). This support of multiple LoDs suits the increasing need for storing and exchanging virtual 3D city models (Blut & Blankenbach, 2021).

In CityGML, objects are represented using three-dimensional geospatial coordinates (Saeidian et al., 2023), making it an effective tool for visualizing 3D city models. The versaltility of CityGML is evident in its use across various fields, including AR related applications (Blut & Blankenbach, 2021; Postert et al., 2021), digital twins (Diakité et al., 2022; Kamilaris et al., 2021), emergency response (Dilo & Zlatanova, 2011), space navigation (Yan et al., 2020), and indoor navigation (Ghawana et al., 2018; Xie et al., 2022).

The capability of CityGML, which allows for the management and visualisation of the 3D built environment, has proven beneficial in Cultural Heritage (CH) domain. Furthermore, it can present a city at a specific period and, at the same time, analyse its changes over the years (Yang et al., 2024). Therefore, various CityGML extensions related to CH are being developed, from supporting the documentation of heritage monuments (Yang et al., 2024) to monitoring and managing the lifecycle of buildings before and after restoration (Costamagna & Spanò, 2013). The function to monitor the building’s lifecycle is depicted in the extension’s UML diagram through attributes such as those concerning the time of its existence, deterioration, (Figure 1), and conditions over different periods (Costamagna & Spanò, 2013; Freire, 2014; Gkadolou et al., 2020; Noardo, 2018).

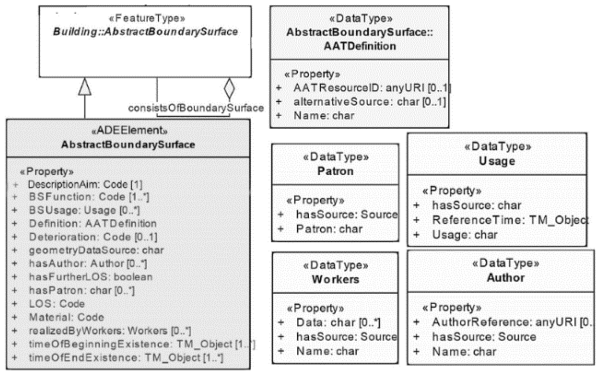

Figure 1.Extension of Architectural Heritage. Source: Noardo (2018).

Furthermore, scholarly reviews of the current development of CityGML extensions in heritage indicate that this domain is still evolving and remains of interest to many scholars (Biljecki et al., 2015; Costamagna & Spanò, 2013). These extensions have addressed most preservation needs such as integrating spatial datasets of CH within Europe. Within INSPIRE directive a data model for CH was developed to enable the interoperability and harmonization of spatial datasets and services across Europe, ensuring that data integration occurs seamlessly without the need for repetitive manual intervention. (Chias & Abad, 2015; Freire, 2014). Furthermore, INSPIRE model contains very detailed attributes to cover all possible needs for storing information related to CH. These include details such as the protected heritage name, address, status, responsible agencies, management plan types, and details of protected cultural entities.

Other CH extensions, besides aiming to document the details of CH elements, also focus on additional objectives such as developing approaches for creating web visualizations at an urban scale (Prieto et al., 2012). Furthermore, scholars have attempted to develop extensions for preserving the specific architectural features of particular CH sites, such as ancient theatres (Gkadolou et al., 2020) and Budhist Grottoes due to their distinctive artistic value (Yang et al., 2024). Additionally, some scholars have directed their extensions towards assessing the potential risks encountered by historical buildings (Costamagna & Spanò, 2013), as well as communicating architectural heritage information. This includes exploring the representation potentialities of high LOD 3D models (Noardo, 2018).

The CityGML extensions from previous studies have recorded some proposed new classes such as ‘protected site’, which then be followed by attributes like ‘responsible agency’, ‘ownership’, ‘preservation authority’, and ‘site management plan type’ (Freire, 2014; Noardo, 2018). Similarly, Prieto et al. (2012) proposed ‘heritage monument’ and ‘heritage protection site’ for their ADE of the documentation of built heritage. Gkadolou et al. (2020) proposed classes for elements of ancient theatres, similar to Yang et al. (2004), who proposed extensions for the detailed elements of Buddhist niches. Costamagna and Spanò (2013) proposed various architectural elements from structural plans and foundations to decorative elements.

These developments are beneficial and enrich the potential for the promotion of CH and its further management. They also introduced new classes and attributes tailored to the specific needs of CH types, which can sometimes be very specific, as seen in cases such as ancient theatres and Buddhist grottoes. Furthermore, it goes beyond the preservation needs to also encompass risk prevention and exploration of the 3D representation.

However, as it extends to address various preservation needs, it overlooks places with future heritage potential that have not yet been officially designated. Consequently, certain elements expressed by classes and attributes do not align such as 'heritage protection state,' 'preservation authority,' and 'site management plan'. Nevertheless, some of the classes and attributes can inspire the development of a CityGML extension for UH places, as they have similar characteristics, such as classes related to architectural elements, details of the building's identity, and the state of the building's condition and deterioration.

Hence, a CityGML extension that comprehensively covers the relevant aspects, including classes and attributes, specific to UH places, while also incorporating elements from existing CityGML and prior CityGML extensions, is required.

3. Use case and interviews

3.1. The use case and brief history

The use case presented in this paper is an old area within the city of Bandar Lampung called Telukbetung. Before the 1980s, Telukbetung was an individual city that covered the coastal area, and it had a twin city called Tanjungkarang, which covered the higher terrain. In 1983, Telukbetung and Tanjungkarang were united and renamed Bandar Lampung. After the unification, the names Telukbetung and Tanjungkarang were still used to represent areas, but no longer as separate cities. (PORTAL Berita Resmi Pemerintahan Kota Bandar Lampung, 2023).

Over time, the development of the city has concentrated more on Tanjungkarang rather than Telukbetung. This preference is attributed to Tanjungkarang's higher elevation, which the Dutch government during the colonial era deemed a more desirable location due to its lower risk of tsunamis and more favourable temperatures, whereas Telukbetung was regarded as excessively hot.

This causes Telukbetung to be left behind, with many old buildings abandoned, yet it holds a long history. This history includes its renowned as the world's ‘pepper basket’ (Kusworo, 2014), and its witnessing of significant events such as the Krakatoa eruption and Dutch and Japanese colonization (Tayar et al., 1984). Despite this, Telukbetung has not garnered significant attention, resulting in a lack of historical information, which has the potential to lead to a lack of awareness of its history.

3.2 The interviews

As information about Telukbetung is very limited, both spatially and non-spatially, we have conducted interviews with residents and professionals to collect as much information as possible. Our aim is to gather information related to its appearance in the past, which could include old photographs, maps, videos, or even descriptive stories from the memories of the people we interviewed. This effort constitutes an attempt to create a digital record for Telukbetung in the form of 3D.

From these interviews, we have collected geometric data such as old maps and photographs, although the quantity is still quite small. Among these items, we obtained an old map from 1912 (Figure 2) and several photographs capturing roads and buildings. The interviews focused on five famous old buildings and four roads depicted in the 1912 map, using them as clues to gain historical insights from the interviewees.

Figure 2. 1912 Dutch Map

The interviews revealed that out of five buildings and four roads, four old buildings and three roads hold memories for residents. Among these, two buildings, namely Al-Anwar Mosque and Thai Hin Bio Temple, have historical importance strongly linked to events such as the Krakatoa eruption and Dutch colonization, as well as the spread of Islam and Buddhism in Lampung province. The remaining two buildings, both of which functioned as cinemas, represent Telukbetung during its heyday era from the 1950s to the 1990s.

The interviewees provided vivid descriptions, recounting their experiences such as watching movies in cinemas and recalling specific details about the cinema's appearance at that time. They mentioned instances such as uncomfortable chairs infested with bugs causing itchiness after watching. Furthermore, they mentioned their fondness for the shape of the mosque's dome, which has since been altered due to a government decision made without consulting the mosque's congregation. They also discussed the annual Barongsai performance held by the temple during Chinese New Year, an event they longed for during childhood.

While this information cannot immediately be used to reconstruct the 3D city model of Telukbetung due to the lack of geometric data, it could inspire the conceptual design of the proposed CityGML extension. The proposed extension should encompass elements similar to those in the UH place, including roads and buildings. Furthermore, it should also incorporate parts of the buildings, as the characteristics of the mentioned buildings vary. For instance, mosques and temples typically have additional elements within their boundaries, such as fences, gates, or specific outdoor features like minarets for mosques (Figure 3). Meanwhile, the cinemas do not have such features, but they are remembered by the interviewees for their indoor spaces.

Figure 3. Elements of two use case buildings

Although the general elements of UH are similar to CityGML's existing elements, such as roads, buildings, rooms, and outdoor elements, and it shares characteristics with prior CityGML extensions related to CH, it is important to note that UH places are not officially designated or validated. Thus, there should be room for improvement and correction. Furthermore, the difference between UH places and CH lies in the fact that UH is still in the phase where the collection of initial data to reconstruct 3D models is necessary, unlike official CH sites, which usually have well-established databases and documentation. Hence, a data model is needed that not only enables the presentation of a 3D city model based on the available data but also facilitates the continual collection and correction of information pertaining to UH places.

4. Method

In regard to creating a CityGML extension schema, several steps have been taken. Firstly, analysing the classes and attributes from CityGML version 3.0 and prior heritage extensions that are relevant to be used for the UH places. Secondly, defining new namespace, classes and attributes based on insights gained from interviews. Thirdly, determining the relationships and multiplicities, and finally, creating a UML schema.

Although the interviews were intended to contribute to achieving LOD 3 of the Telukbetung Neighbourhood over time, the data obtained is still insufficient to create a 3D model. Therefore, specific classes were introduced to allow a further contribution of geometric details. The geometry is organised as an attribute to the objects following the approach presented in Emgård & Zlatanova, 2008. Additionally, since the buildings remained unchanged for a long period, it was decided that the 3D model of the roads and buildings be constructed using their most recent appearance, derived from current photographs and maps, using SketchUp.

The UML schema was created with Sparx Systems Enterprise Architect. The classes inspired by prior extensions and CityGML are color-coded blue, while the proposed new classes are represented in yellow (Figure 6).

5. CityGML extension for UH places

5.1. The UH place’s entity and memory

All unrecognized historical entities have a story to tell, including their past names, year of construction, and the year from which the building's appearance serves as the basis for creating a 3D model. The year of construction and demolition are already recorded in CityGML schema. In our model we propose including past names obtained through interviews, as some roads may have been known by different names in the past compared to their official ones.

Furthermore, the 'buildingModelForYear' attribute is introduced to inform the year of the building being represented through a 3D model in the system. Since buildings can undergo changes over time, and the availability of geometry data is anticipated to grow, updating the year of a building to align with changes in the 3D model is feasible. For example, due to limited geometry data availability, the 'buildingModelForYear' is set to 2022, as it displays the 3D model of the building based on photos taken in that year.

The extension is here described, from the more general objects to the smaller details. For example, the attributes of the Core class ‘Building::_AbstractBuilding’ were extended for the identification of the UHbuilding (Figure 4). Similarly, the Core class 'Road' was extended for identifying UHroad, and 'CityFurniture' was extended for identifying UHoutdoorelement.

As the UHbuilding class primarily addresses the exterior of buildings and does not encompass indoor spaces, a child class called 'room' has been introduced. The objective is to gather and store information pertaining to the interiors of buildings, as highlighted by interviewees who often recall more memories associated with indoor spaces rather than exteriors. For instance, some interviewees vividly remember details of cinema studios, including its furnishings.

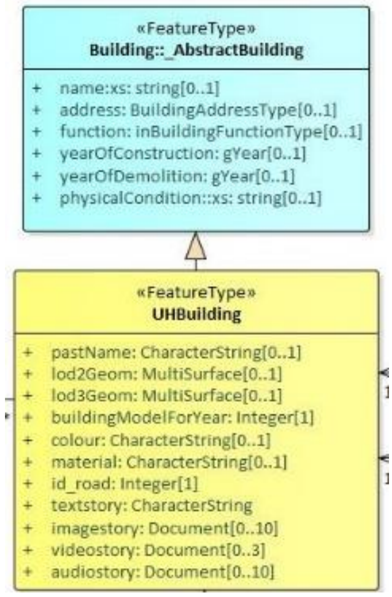

Figure 4. UH Building and its parent class

Another proposed class is contribution, which aims to enable the participation of the local community in adding information. This includes providing new information, such as providing old

photographs of specific buildings, or correcting existing information that has been uploaded into the system.
In the 'contribution' class, several attributes are specified, including the name of the contributor, date of contribution, uploaded document (indicating the type of document being uploaded), and description (Figure 5). The description field is intended for explaining the contribution, whether it involves providing new information or correcting existing information. Since the story of this UH place has not been validated yet, there is a possibility that it may not be accurately presented.

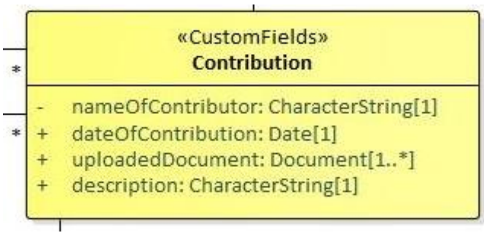

Figure 5. Contribution class in the UML

5.2 The Relationship between class

Generalisation is utilised to illustrate relationships between core classes derived from both the existing CityGML schema and the proposed classes. For instance, UHBuilding inherits from Building::_AbstractBuilding, UHRoad inherits from Road, and UHOutdoorElement inherits from City Furniture. The 'Room' class inherits from 'UHbuilding' class. This structure is inspired by CityGML schema which places 'room' as 'Building''s sub class. In this paper, 'Room' serves as a subclass of 'UHBuilding' to represent specific rooms within a building which has story (Figure 6).

However, there is no necessity to append 'UH' to 'Room' as its relationship to 'UHBuilding' is through generalisation. This means a room only exists if the building exists. The multiplicity between room and UHBuilding is one to many, as one building can have multiple rooms.

An association is used to express the relationship between 'UHroad' and 'UHbuilding', as well as between 'UHbuilding' and 'UHoutdoorelement'. This implies that buildings may be associated with UHroads, while outdoor elements may be linked to buildings. For instance, a minaret is a component of a mosque, and the mosque is situated along one of the UH roads. This association also signifies that each class can exist independently.

The association is also utilised to establish relationships between the 'contribution' class and all the proposed classes. The objective is to link the contribution, whether it involves new information or corrections to existing information, to the specific class to which it contributes. The multiplicity between the contribution class to its corresponding class is one to many since one class can have many contributions.

5.3 The Attribute Type

The used attribute types in the UML schema are: 'CharacterString' for text; 'Integer' for numbers; 'Document' for enumeration when referring to the type of data (e.g., JPG, PNG, PDF, WMA, etc.), ‘Surface’ for LOD1 solid, ‘multisurface’ for LOD2 and LOD3 geometry.

In the square brackets, the possible minimum and maximum number of attributes are indicated. The asterisk (*) signifies 'more than 1', with the maximum number varying for image story, video story, and audio story due to the characteristics of the data type itself.

For example, for image story, the range is given as [0..10], allowing for the non-existence of images initially, but expecting a maximum of 10 images as more people can upload their collection of old photographs, albeit after selection for upload into the system.

Similarly, the minimum and maximum for audio story are set to zero and ten, respectively. This allows for the collection of rich audio data from new interviews with old residents. While limiting uploads to a maximum of 10 to ensure the quality of audio to be uploaded into the system.

In contrast, video story needs to be more carefully selected. As the characteristics of video consists of large size file, it is limited to three videos. Furthermore, even one video needs to be thoroughly crafted before being presented in the system. Therefore, three videos are determined to be the appropriate amount to upload to the system.

5.4 Enumeration

To specify the types of data that can be used in the system, document types are described by enumeration. This also serves to limit the formats for upload, anticipating further participation from the locals for additional data. The types of data are selected based on the most commonly used formats, such as:

a. JPG and PNG for photographs
b. PDF for documents
c. WMA, MPEG, WAV for videos
d. WAV and MP3 for audio files

Additionally, considering that prospective users of this platform in the future may include college students, especially those in fields related to 3D technology, DAE format is selected to enable them to upload 3D models. The UML diagram for UH extension is displayed in the (Figure 6).

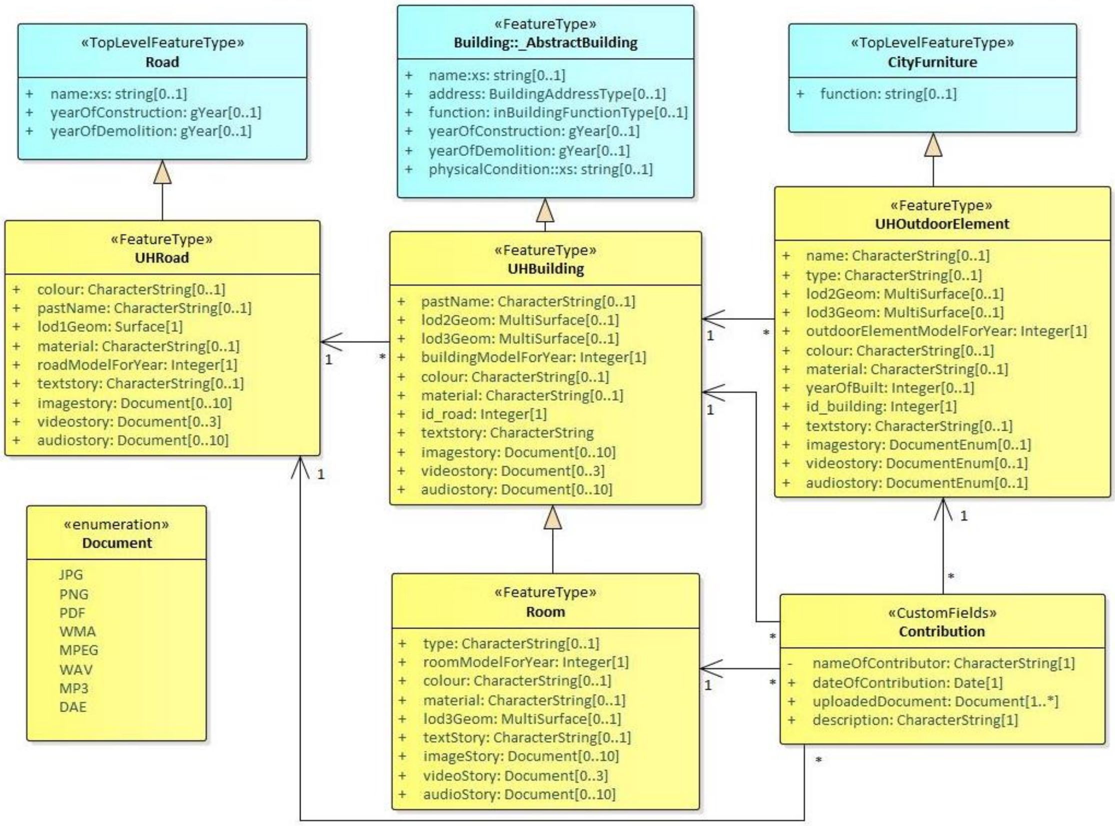

Figure 6. Unrecognised Historical Place UML Schema

6. Implementation

To illustrate the proposed model, several examples have been created. One such example is drawn from a UH building—a mosque. Mosques serve as places of worship and typically feature minarets, as well as fences and gates to demarcate their boundaries. For mosques or similar sites with multiple buildings or elements, each component needs to be documented separately following the CityGML structure.

With this extension, each element can be documented: the main building is classified as a UHbuilding, while the minaret, fence, and gate are classified as outdoor elements. Additionally, the road where this mosque stands can be classified as a UHroad (Figure 7).

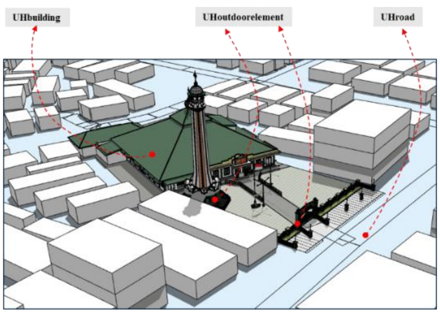

Figure 7. Classifying UH Buildings in 3D Models Using a Mosque as an Example.

Another example is to present the 3D model along with its attributes such as building name, address, function, etc. The 3D models will be accompanied by their attributes, presented in the form of semantic information. In the next phase of the work, the system should support querying to obtain specific information from each UH building (Figure 8).

Figure 8. Example of 3D model and its semantic information.

This contribution has been peer-reviewed.
https://doi.org/10.5194/isprs-archives-XLVIII-4-2024-247-2024

7. Conclusion

CityGML provides a standardized way of representing and exchanging 3D city models. It allows users to describe the geometry, semantics, and topology of urban environments, facilitating interoperability among different systems and applications. CityGML has inspired numerous extensions and adaptations to address specific requirements across various domains, such as urban planning, architecture, transportation, and heritage.

These extensions often tailor CityGML to meet the specific needs of different users and applications, thereby enhancing its utility and versatility. This also means it can provide any places in a country like Indonesia with an opportunity to document its built environment at a very early stage of preservation, even before the heritage has been defined and officially designated.

This type of documentation is expected to provide the vulnerable local built environment with another opportunity to capture its memory within the physicality of its surroundings using 3D technology before it is inevitably demolished, as it is at risk of destruction due to its lack of recognition as national heritage.

The UML of UH places in this paper provides the necessary information for documentation based on UH characteristics. These characteristics include the lack of validated history and the scarcity of historical information, highlighting the need for further spatial and non-spatial data. Additionally, the ongoing collection of data from UH residents contribute to enriching the platform.

Future work will center on implementation, encompassing the design of database schema and visualizations to ensure a comprehensive representation of the data (Ishar et al 2022). This process will entail the selection and integration of various software tools, such as GIS, design, game engine, and DBMS software.

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