Designing 3D Triangulated Irregular Network Data Structure for Surface and Subsurface Unified Spatial Data Model - Preliminary Work

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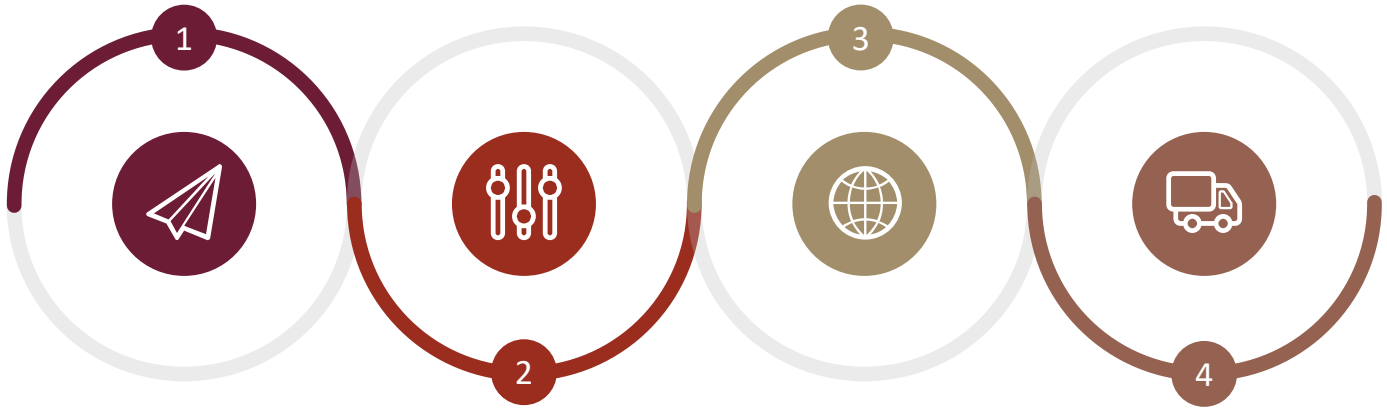
Contents

Introduction

The seamless integration of spatial objects in a three-dimensional (3D) framework is a **crucial**

TIN as a standout method due to its adaptability



There is a need for comprehensive methodologies for 3D TIN structures that integrate both surface and subsurface objects.

TIN advantages, establish it as a versatile and powerful tool in spatial data modeling.

It serves as a standardized geometrical model

TIN can be utilized to establish a unified topological relationship between aboveground and belowground components

Related Works

TIN Data Structure

R. chun Zhang, H. Li, M. fei Wu, and Y. qin Wang (2015)
E. E. Duncan, A. A. Rahman, C. B. Siew, and S. U. Baig (2012)
M. Wu, J. Shen, and Y. Wen (2009)
The 3D TIN data structure is justified for a unified spatial data model due to its ability to represent both natural and man-made features above, on, and below the earth's surface effectively

TIN Topology Structure

A. Belussi, S. Migliorini, and M. Negri (2020)
A generic 3D vector model has been introduced to merge limited 3D spatial data types with 2D topological relations to effectively implement 3D topological relations.

Surface / Subsurface Integration

F. Fadli et al (2018)
A variety of 3D spatial models depicting the integration between surface, terrain, and subsurface objects are increasingly crucial in recent years.

Al Kalbani & Abdul Rahman (2019) presented a framework for integrating both surface and subsurface 3D geospatial objects data structure into the Oman Spatial Data Infrastructure (SDI).

Related Works (Cont.)

3D Unified Spatial Data Model

Wu et al. (2021) unraveled the connection, interaction, and integration of three-dimensional partitioned units for buildings on the above surface, surface, and below the surface.

D. Che et al. (2019)
A 3D Unified Spatial Data Model comprises key components that establish a unified data model for data types, create mapping relations between entity data and virtual data objects, define data presentation views, and utilize object-oriented methods for spatial data modeling.

Methodology

- **Generating 2D and 3D**

- TIN is a digital data structure used to represent a surface.
- 2D TINs represent surfaces on a plane, typically used for terrain modeling.
- 3D TINs extend this concept to represent solid data or complex 3D structures.
- These files contain the vertices and faces of the model's representing terrain, surface (building), and subsurface objects

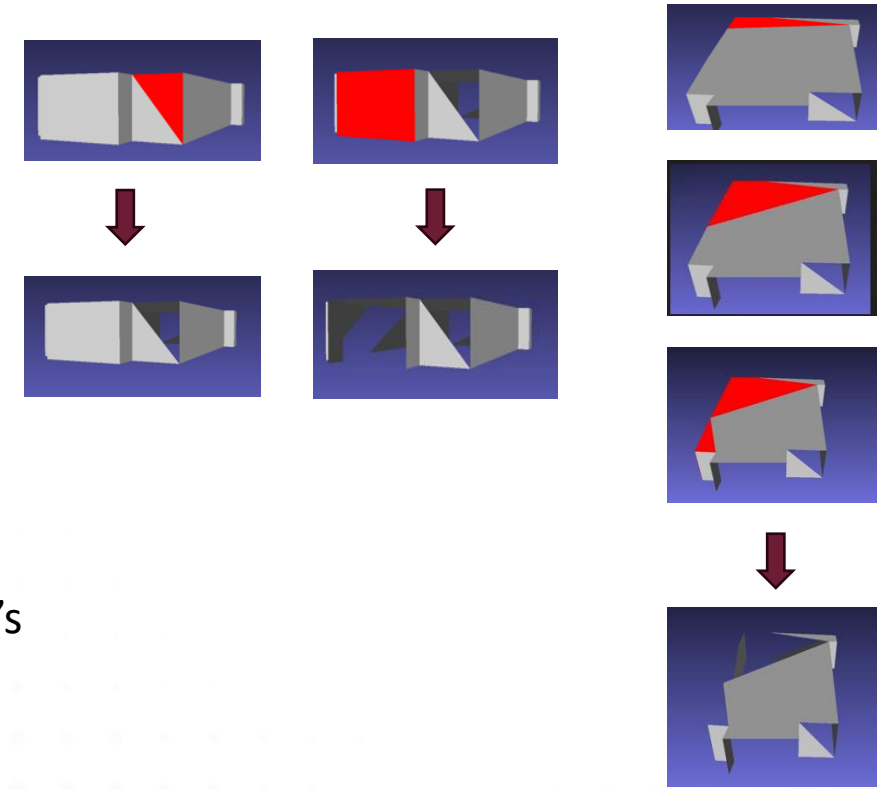


Fig. 1. typical OBJ file of a model indicating vertices and face.

Methodology (Cont.)

- **Triangulation of Faces**

- The faces of the structures are triangulated to ensure all faces are composed of triangles.
- This is done by converting faces with more than three vertices into multiple triangles.
- The input mesh data is analyzed to identify faces with more than three vertices

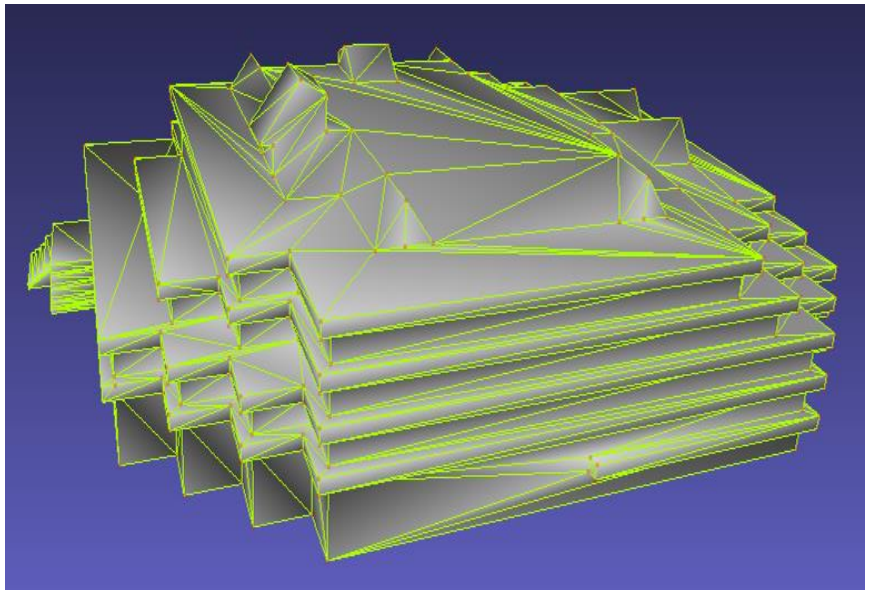


Fig. 2. Triangulation of faces of the Library Building

Methodology (Cont.)

- **Topology for 2D and 3D**

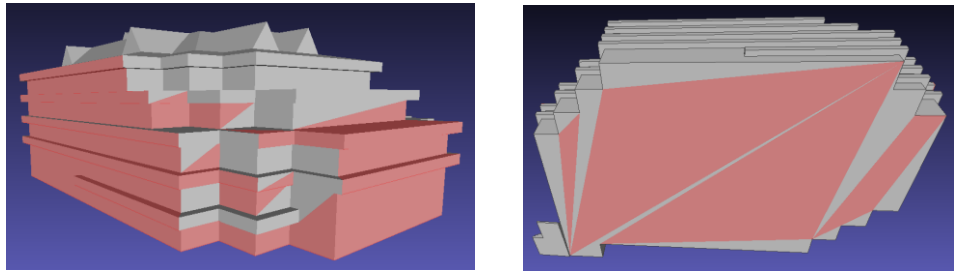


Fig. 3. Visual representation of Building topology

- Topology in TIN refers to the spatial connections among the elements (points, edges, and triangles) composing the framework.

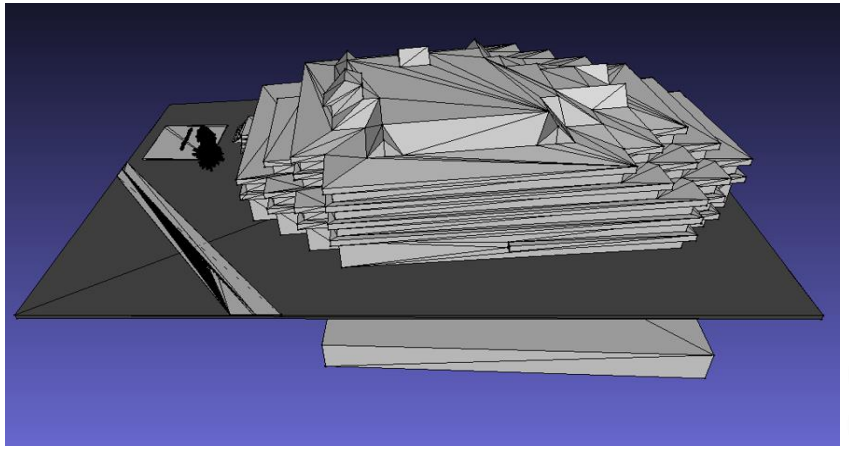
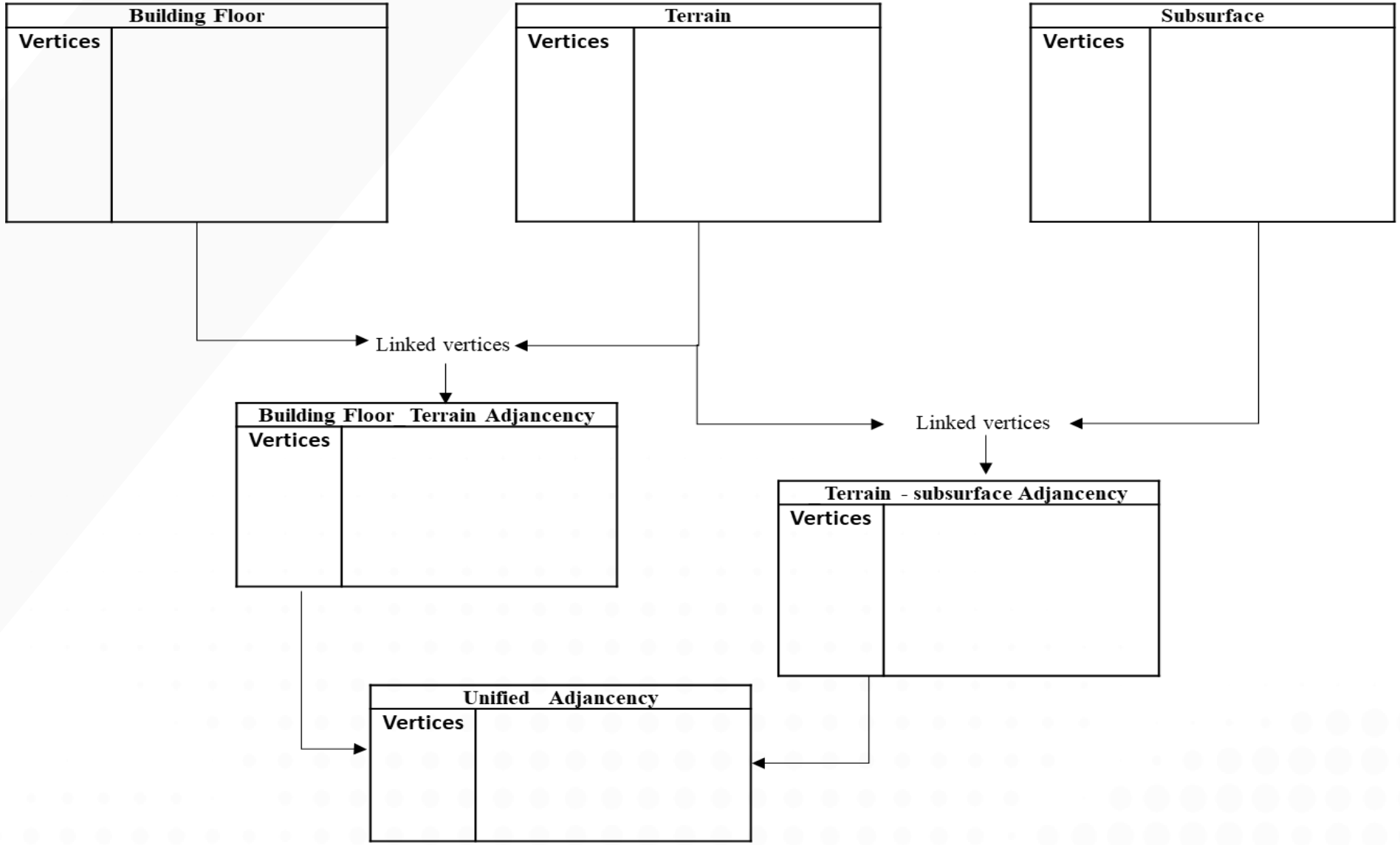
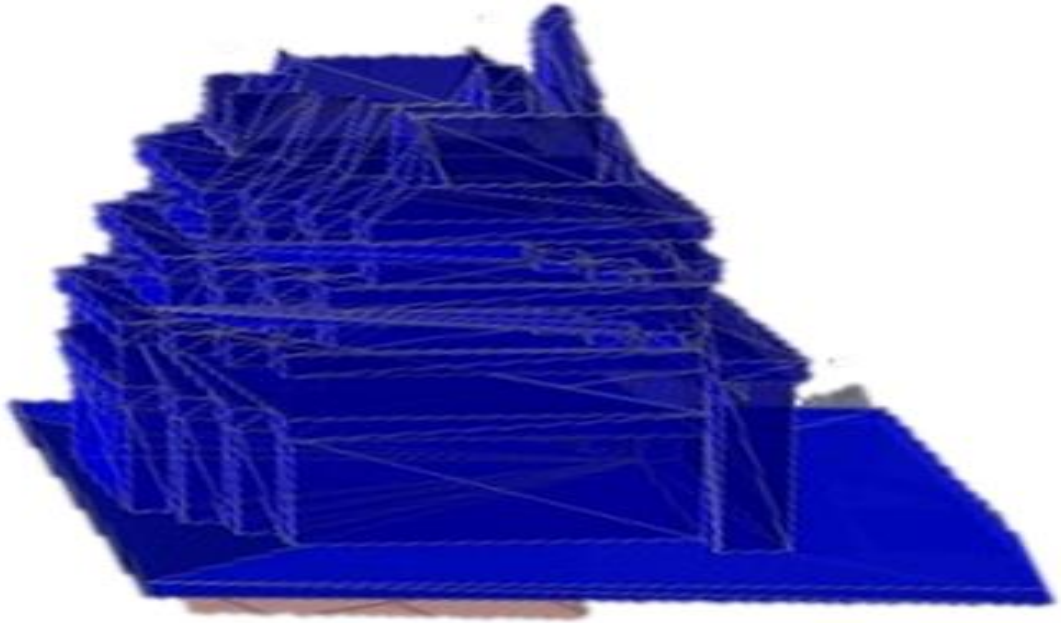


Fig. 4. Visual representation of Building, terrain, and subsurface topology

Table .1 showing adjacent (topology) vertices for surface, terrain and subsurface



Methodology (Cont.)



- The Unified Spatial Data Model

combines **surface**, **subsurface,** and **terrain** spatial data to capture their interconnections in a cohesive **framework**

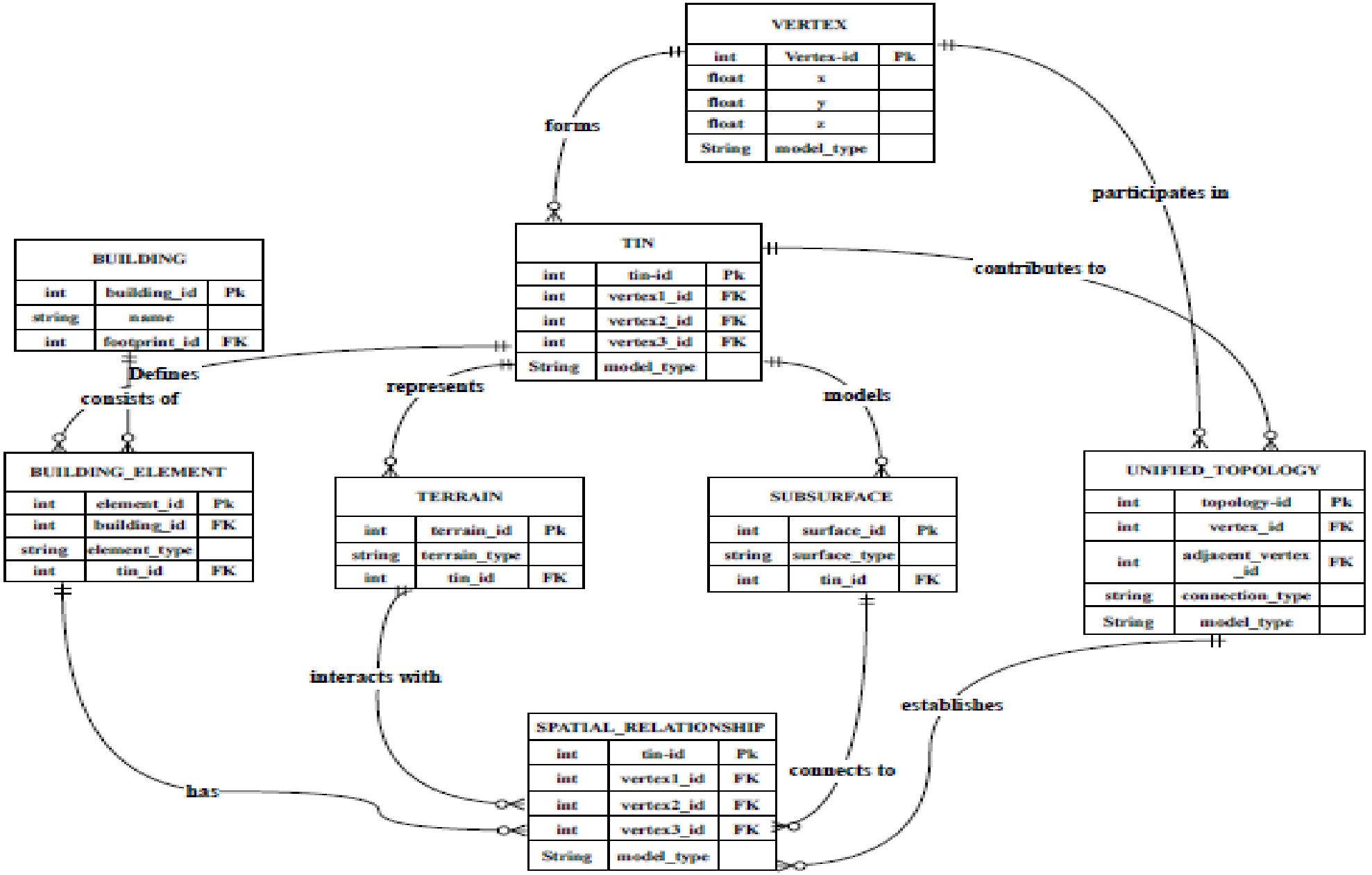


Fig. 5. A conceptual unified spatial data model for surface and subsurface

Challenges

- Maintaining consistent topological relationships among spatial objects.
- Correctly representing complex geometries within a **unified TIN** requires a thorough understanding of object relationships.
- The connections and topology between faces, especially concerning intricate **geometries and their corresponding topology tables**, are critical issues in this research phase.
- Extensive topological tables that describe the relationships among various faces of surfaces, terrain, and subsurface features have not yet been addressed in this study.

Conclusion

- Correctly connecting and maintaining topology between faces, particularly in intricate geometries, underscores the critical importance of developing topology tables

- **The future work will focus on:**

Refining the **integration** processes.

Enhancing the detailed **topology** tables.

Ensuring that the TIN data structure faithfully represents all **spatial objects** involved

- The future work aims to overcome these obstacles and achieve a **unified spatial data model** for real-world visualization.

THANK YOU

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