Developing Data Model Managing Residents by Space and Time in Three-Dimensional Geographic Space

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Abstract. A major challenge currently of levels of government and construction contractors is how to manage population growth by geographic location and over time. The population increases by geographic location and over time leading to the increase of positive and negative aspects in the community. Managing people living and working on the territory by space and time is a very important and urgent job. The levels of government must regularly manage the people living and working on their localities, which are always associated with the management of permanent populations, temporary populations, blood relations, social relations, previous conviction relations, previous offence relations and birth or death relations that all of this management takes place at a specific geographic location and time. The paper proposes to develop a spatial - temporal - residential data model that is capable of managing human activities at the place of residence, at the workplace and at the location of the relations by geographic location and over time, this model is called STRDM. The paper illustrates empirical results with visual forms through the use of queries by space, time, resident, and search for ancestor and descendant. These empirical results show that it can be applied to residential data management systems in new urban areas.

Keywords: Relations · Spatial - temporal - residential data model · STRDM · Queries · Geographic location · Managing residents

1 Introduction

The increase in population by geographic location will always lead to a society with a strong development in both quality and quantity, in addition to the positive and negative issues in the community lead to archives which store of paper and books increasingly expanding. With large archives, extracting information is extremely difficult because it is difficult to properly and sufficiently extract it. Leaders at all levels and construction contractors can spend a lot of time making excerpts in the archives and not extracting enough material to link to the events, human with events, human with constraints of relations such as blood relations, social relations, previous conviction relations, previous offence relations, birth or death relations and also interested in basic human information that always changes over time. This difficulty has limited

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the provision of data, provision of the necessary information for levels of government, for different careers to harness the full potential of human to devise to set forth development policies, also social security policies which appropriate to demands and capabilities of human.

Recognizing the importance and necessity of managing the population according to geographical location and time is to manage the people living and working in the territory and require necessary computerizing the task of residential management, human management to provide timely to the levels of government making decisions and timely supporting information for the task of security protection, ensure social order and safety in the territory. Therefore, we need to focus on building three-dimensional (3D) GIS systems for residential data management, to build this system to adapt to all criteria then the modeling of data models is extremely important and urgent to serve the levels of government or construction contractors in tracing the history of blood relations, the history of social relations, history of previous conviction relations, history of previous offence relations, and history of birth or death relations.

In a blood relation, a person born into a family, also known as a clan, must have an ancestor of grandparents, parents, siblings, etc., called a blood relation. In a social relation, a certain person A and other members participate in a meeting, a seminar, a teach-in, etc., it is called a social relation. With a law relation, person A is a superior of person B, person B is a superior of person C, so person C is a subordinate of person A is called a law relation. In a previous offence relation, a person is referred to as a previous offence relation only when he/she has committed a violation of the law at the warning level, is subject to administrative sanctions, is not convicted by a court and is under the supervision of law. With a previous conviction relation, a person is called a previous conviction relation when he/she commits an offense and is convicted by a court. With a birth or death relation, every person born at birth must be confirmed as a member of a certain household and recorded in that household registration, and a person who dies will be declared dead and deleted in the household [1]. The above-mentioned relationships all took place at the location of defined geographical space and time.

The objective of the paper proposes to develop a STRDM model to manage relations and genealogy by geographic location and over time. This new model is capable of managing human activities at the place of residence, at the workplace and at the location of spatial and temporal relationships. This management will help the levels of government and construction contractors can trace the history of blood relations, the history of social relations, history of previous conviction relations, history of previous offence relations, and history of birth or death relations. The paper presents some experimental results using visual forms through some typical queries. Experimental results show that this new model can be applied to future residential data management systems to assist levels of government and construction contractors in policy making and decision making.

The remainder of this paper will be organized as follows. Part 2 presents an overview of the relevant studies and makes new comments and suggestions. Part 3 presents in detail the spatial, temporal and residential classes from which to propose the spatial, temporal and residential data model and includes some empirical results on the proposed model. Part 4 presents the experimental results on the proposed model using visual forms through a number of queries and search for genealogy. Part 5 presents the results and proposes future development directions. The last part of this paper is for reference.

2 Related Works

The construction of spatial, temporal, semantic and residential data models play an important role in new urban area management systems, especially, data models must participate in the residential data management systems in space, time, and relationships of human with human by events. The paper systemizes spatial and temporal data models according to each type of model.

2.1 The Data Models Based on the Boundary Representation Method

For good representation of 3D objects with boundaries, the boundary representation method (B-REP) is a good choice. This method represents a 3D object based on predefined elements, includes point, line, surface, solid and this method is suitable for representing 3D objects of normal shape. The models proposed by the authors in the past that have applied the B-REP method, include UDM spatial data model was proposed by Coors in 2003 [2]; 3D Cadastral model was proposed by Yuan Ding authors and colleagues in 2017 [3]; TUDM model was proposed by Anh N.G.T authors and colleagues in 2012 [4]; TLODs model was proposed by Dang P.V authors group and his colleagues [5]; VRO-DLOD3D model was proposed by Dang P.V authors and colleagues in 2017 [1]; CityGML model was proposed by Groger authors and colleagues in 2007 [6]; Kolbe authors and colleagues extended the CityGML model in 2009 [7]; Biljecki authors and colleagues improved the CityGML model in 2016 [8]; Dang P.V authors and colleagues proposed the ELUDM for 2.5D objects in 2011 [9]; Dang P.V authors and colleagues proposed the ELUDM for 2.5-3D objects in 2011 [10]; Löwner authors and colleagues proposed a new LoD concept and multi-representational concept for the CityGML model in 2016 [11]; Digital surface model proposed by Abdelkader El Garouani authors and colleagues in 2014 [12]; CityGML-TRKBIS.BI model proposed by Aydar authors and colleagues to meet the need to establish 2-2.5-3D objects at the national level in 2016 [13]; S_EUDM model was proposed by T.V. Phan authors and colleagues in 2020 [14].

2.2 The Data Models Based on Voxel Elements

To represent 3D objects with voxel elements such as pixels in 2D GIS, the voxel method is a good choice. This method represents a 3D object based on the idea of dividing an object into child elements, each of which is called a voxel [15]. An element is considered a geographic space and is assigned an integer [16]. Models proposed by authors in the past applied the voxel method include, 3D Array model proposed by Rahman in 2005 [17, 18]. Models have simple data structures used to represent 3D objects. The elements in the 3D Array have 1 of 2 values 0, 1. In which 0 describes the background value, 1 describes the value that each element in the 3D Array is occupied by the 3D object. If a 3D object is scanned in a 3D array, the elements of array are initialized to 0. After scanning onto the 3D object, the elements with value 1 represent the information for the 3D object. The Octree model was proposed by Gorger authors and colleagues in 2004 [19]. Octree is an extension of a tetrahedron to octal. Octree is a 3D representation model based on block basis. An octal tree gives us an image, which is a method of representing a tree data structure. In general, an octal tree is defined based on the smallest cube containing the 3D object to represent. The original cube will be divided into 8 sub-cubes. An octal tree is based on recursive decomposition.

2.3 The Data Models Based on the 3D Block Composite Method

To represent 3D objects by combining basic 3D blocks proposed by Rahman in 2008 [17]. CSG model represents a 3D object by combining predefined 3D elements. The basic 3D blocks are commonly used as: cube, cylinder, sphere. Relationships between these figures include: transformation and logical operands. Transformations include translations, rotations, and metrics. Logical operands include association, intersection, and difference. CSG is often used in CAD. CSG is very convenient in calculating the volume of objects, CSG is not suitable for representing objects with irregular geometric shapes.

2.4 Comments and Recommendations for the Data Model

To represent spatial features including residential houses, buildings, villas, apartments, etc. in a 3D space, applying modeling is the key to success. The criteria to consider models are the models must be able to represent spatial objects in 3D space, and must be based on the criteria of the outer surface, the inner surface, represents levels of detail but also has the ability to store spatial data, store temporal data, store semantic data, and store residential data. In 2013, Gia T.A.N. authors and colleagues presented a summary of GIS 3D and 4D data models [20], in which this group of authors proposed a summary presentation of the criteria that each GIS 3D and 4D data model must satisfy. These criteria include: representation of surface of objects, representation of inner surface of objects, representation of main elements, representation of data size, applying for applications, spatial data structure, spatial property queries, zero object location queries, semantic queries. Then in 2017, this same group of authors gave a brief survey of the current popular GIS 3D and 4D data models [21] with comparison tables according to characteristic criteria such as representation of face types, representation inner face of objects, capable of triangularization, not capable of triangularization, platform model, data storage size, and applicability to today's applications.

Through systematization and classification of data models has given us a clear view of the development of data models proposed by the authors. We found that these models mainly use B-REP method. This method represents a 3D object based on predefined elements, including: Point, Line, Surface, Solid, Prism, Body and this method is suitable for representing 3D objects of normal shape. From here, the paper proposes to build a STRDM model to manage population data including relationship management, permanent populations, temporary populations, and search for ancestors and descendants.

3 Spatial-Temporal-Residential Data Model Managing Residents

3.1 Temporal Data Class

Time data is an essential element of residential data management systems in 3D geographical space. Time data recorded the start and end times of relationships and basic information about human change. The temporal data class plays an important role in tracing the evolution of human relationships according to geographical location. Based on the factor of time, human can intervene in time to solve urgent problems and see things more precisely and clearly. The element of time can represent the processes taking place in human relationships such as social relations, law relations, previous conviction relations, previous offence relations and birth or death relations attached the geographical location in which takes place human relationships, places of residence, work locations and other basic information of human always change at a point of time or in a period of time.

Time data combined with spatial data and residential data will make the data stored in residential data management systems more abundant and meaningful to meet the needs of users, especially at levels of government and construction contractors. The time data used to trace the history of the beginning and ending of relationships and other information about human activities has become more explicit. Accompanying with three specific types of time data [5, 22, 23] having time data units in Table 3 with the conventions in Table 2. From the time data units in Table 2, the paper classified these time data units into three types of time data in Table 1 and obtained a classification table in Table 3. From the time data units in Table 2, the paper forms the time topology relations in Table 4.

Table 1. Table describing the time data types

Convention	Time data types	Describing the time data types
ET_s	Event time	The time that begins and ended in the real world, the starting yy-mm-dd h:m:s and ending yy-mm-dd h:m:s in real world
LT_s	Legal time	The time that is effective on legal documents, the starting yy-mm-dd h:m:s and ending yy-mm-dd h:m:s in legal documents
DT_s	Database time	The time that is written to the database, the starting yy-mm-dd h:m:s and ending yy-mm-dd h:m:s in the database

Notation: year-month-date hour:minute:second = yy-mm-dd h:m:s

Table 2. Table describing the meaning of time data units

Convention	Describing the meaning of time data units
T_{10}	The starting yy-mm-dd h:m:s took place of the human social relationship in the real world
T_{11}	The ending yy-mm-dd h:m:s took place of the human social relationship in the real world
T_{12}	The starting yy-mm-dd h:m:s took place human law relations in the real world
T_{13}	The ending yy-mm-dd h:m:s took place law relations of human in the real world
T_{14}	The starting yy-mm-dd h:m:s took place previous offence relations of human in the real world
T_{15}	The ending yy-mm-dd h:m:s took place previous conviction relations of human in the real world
T_{16}	The starting yy-mm-dd h:m:s took place previous conviction relations of human in the real world
T_{17}	The ending yy-mm-dd h:m:s took place previous offence relations of human in the real world
T_{18}	The yy-mm-dd h:m:s of human birth in the real world
T_{19}	The yy-mm-dd h:m:s of human death in the real world
T_{20}	The starting yy-mm-dd h:m:s recorded social relations of human in the legal documents
T_{21}	The ending yy-mm-dd h:m:s recorded social relations of human in the legal documents
T_{22}	The starting yy-mm-dd h:m:s recorded law relations of human in the legal documents
T_{23}	The ending yy-mm-dd h:m:s recorded law relations of human in the legal documents
T_{24}	The starting yy-mm-dd h:m:s recorded previous conviction relations of human in the legal documents
T_{25}	The ending yy-mm-dd h:m:s recorded previous conviction relations of human in the legal documents
T_{26}	The starting yy-mm-dd h:m:s recorded previous offence relations of human in the legal documents
T_{27}	The ending yy-mm-dd h:m:s recorded previous offence relations of human in the legal documents
T_{28}	The yy-mm-dd h:m:s of human birth recorded in the legal documents
T_{29}	The yy-mm-dd h:m:s of human death recorded in the legal documents
T_{30}	The starting yy-mm-dd h:m:s recorded social relations of human in the database
T_{31}	The ending yy-mm-dd h:m:s recorded social relations of human in the database
T_{32}	The starting yy-mm-dd h:m:s recorded law relations of human in the database
T_{33}	The ending yy-mm-dd h:m:s recorded law relations of human in the database
T_{34}	The starting yy-mm-dd h:m:s recorded previous conviction relations of human in the database

(*continued*)

Table 2. (*continued*)

Convention	Describing the meaning of time data units
T_{35}	The ending yy-mm-dd h:m:s recorded previous conviction relations of human in the database
T_{36}	The starting yy-mm-dd h:m:s recorded previous offence relations of human in the database
T_{37}	The ending yy-mm-dd h:m:s recorded previous offence relations of human in the database
T_{38}	The yy-mm-dd h:m:s of human birth recorded in the database
T_{39}	The yy-mm-dd h:m:s of human death recorded in the database
T_{40}	The starting yy-mm-dd h:m:s moving to the permanent population of humans recorded in the legal documents
T_{41}	The starting yy-mm-dd h:m:s registering the permanent population recorded in the legal documents
T_{42}	The starting yy-mm-dd h:m:s deleting the permanent population recorded in the legal documents
T_{43}	The starting yy-mm-dd h:m:s correcting the permanent population recorded in the legal documents
T_{44}	The starting yy-mm-dd h:m:s moving to the temporary population of humans recorded in the legal documents
T_{45}	The starting yy-mm-dd h:m:s registering the temporary population of humans recorded in the legal documents
T_{46}	The starting yy-mm-dd h:m:s deleting register of the temporary population of humans recorded in the legal documents
T_{47}	The starting yy-mm-dd h:m:s correcting the temporary population of humans recorded in the legal documents
T_{50}	The starting yy-mm-dd h:m:s addicting to drugs of human recorded in the legal documents
T_{51}	The ending yy-mm-dd h:m:s addicting to drugs of human recorded in the legal documents
T_{52}	The starting yy-mm-dd h:m:s relapsing into drugs of human recorded in the legal documents
T_{53}	The starting yy-mm-dd h:m:s registering marriage of human recorded in the legal documents
T_{54}	The ending yy-mm-dd h:m:s registering marriage of human recorded in the legal documents
T_{55}	The starting yy-mm-dd h:m:s remarrying of human recorded in the legal documents
T_{56}	The starting yy-mm-dd h:m:s changing full name of human recorded in the legal documents
T_{57}	The starting yy-mm-dd h:m:s changing year birth of human recorded in the legal documents
T_{73}	The starting yy-mm-dd h:m:s moving to the permanent population of human recorded in the database

(*continued*)

Table 2. (*continued*)

Convention	Describing the meaning of time data units
T_{74}	The starting yy-mm-dd h:m:s registering the permanent population of human recorded in the database
T_{75}	The starting yy-mm-dd h:m:s deleting register of the permanent population of human recorded in the database
T_{76}	The starting yy-mm-dd h:m:s correcting the permanent population of human recorded in the database
T_{77}	The starting yy-mm-dd h:m:s moving to the temporary population of human recorded in the database

Notation: year-month-date hour:minute:second = yy-mm-dd h:m:s

Table 3. The table classifies units of time data into three types of time data

Time data types	Describing time data units belonging to three types of time data
ET_s	T_{10}, T_{11}, T_{12}, T_{13}, T_{14}, T_{15}, T_{16}, T_{17}, T_{18}, T_{19}
LT_s	T_{20}, T_{21}, T_{22}, T_{23}, T_{24}, T_{25}, T_{26}, T_{27}, T_{28}, T_{29}, T_{40}, T_{41}, T_{42}, T_{43}, T_{44}, T_{45}, T_{46}, T_{47}, T_{50}, T_{51}, T_{52}, T_{53}, T_{54}, T_{55}, T_{56}, T_{57}
DT_s	T_{30}, T_{31}, T_{32}, T_{33}, T_{34}, T_{35}, T_{36}, T_{37}, T_{38}, T_{39}, T_{73}, T_{74}, T_{75}, T_{76}, T_{77}

Table 4. Table describing the topology relationship of time data units

Relationships	Meaning	Relationships	Meaning
$T_{10} < T_{11}$	T_{10} happen earlier T_{11}	$T_{73} < T_{74}$	T_{73} happen earlier T_{74}
$T_{12} < T_{13}$	T_{12} happen earlier T_{13}	$T_{75} < T_{76}$	T_{76} happen later T_{75}
$T_{14} < T_{15}$	T_{14} happen earlier T_{15}	$T_{76} < T_{74}$	T_{76} happen earlier T_{74}
$T_{16} < T_{17}$	T_{16} happen earlier T_{17}	$T_{42} < T_{40}$	T_{42} happen earlier T_{40}
$T_{18} < T_{19}$	T_{18} happen earlier T_{19}	$T_{42} < T_{43}$	T_{43} happen later T_{42}
$T_{22} < T_{23}$	T_{22} happen earlier T_{23}	$T_{43} < T_{41}$	T_{43} happen earlier T_{41}
$T_{26} < T_{27}$	T_{26} happen earlier T_{27}	$T_{44} < T_{45}$	T_{44} happen earlier T_{45}
$T_{28} < T_{29}$	T_{28} happen earlier T_{29}	$T_{45} < T_{46}$	T_{45} happen before T_{46}
$T_{30} < T_{31}$	T_{30} happen earlier T_{31}	$T_{46} > T_{47}$	T_{46} happen later T_{47}
$T_{32} < T_{33}$	T_{32} happen earlier T_{33}	$T_{50} < T_{51}$	T_{50} happen earlier T_{51}
$T_{34} < T_{35}$	T_{34} happen earlier T_{35}	$T_{53} < T_{54}$	T_{53} happen earlier T_{54}
$T_{36} < T_{37}$	T_{36} happen earlier T_{37}	$T_{40} = T_{41}$	T_{40} happen coincidentally T_{41}
$T_{38} < T_{39}$	T_{38} happen earlier T_{39}	$T_{44} = T_{45}$	T_{44} happen coincidentally T_{45}
$T_{40} < T_{41}$	T_{40} happen earlier T_{41}	$T_{73} = T_{74}$	T_{73} happen coincidentally T_{74}
$T_{41} < T_{56}$	T_{41} happen earlier T_{56}	$T_{77} = T_{76}$	T_{77} happen coincidentally T_{76}

3.2 Residential Data Class

Residential data records relationships, permanent populations, temporary populations, stay populations, and other basic human information. Therefore, the residential class plays a very important role in organizing the storage classes of residential data. The residential data class was built to answer questions related to human activities at the place of residence, at the workplace, at the place of living and at the place of happening social relations, previous conviction relations, previous offence relations, birth or death relations. Levels of government or construction contractors often focus on questions related to human activities including spatial - temporal - residential location. Thus, this residential data class must be capable of answering the user's questions as follows. To answer question for what is that relationship? Which people or groups of people were involved in that relationship accompanied by the spatial location of the relationship at what time? To answer the question for what time it took place - who involved - what that relationship was - the spatial location of that activity. Also, from this residential data class can answer questions for the blood relationship or called the person's genealogy relationship (Figs. 1 and 2).

Fig. 1. A relationship representation consists of people - spatial - temporal – residential relation

Fig. 2. A relationship representation of space – people - time

3.3 Spatial Data Class

Spatial data records the shapes, sizes, and locations of objects in space. The spatial data class does an important task in residential data management systems. Spatial data class is used to manage the position, shape, and size of houses, buildings, bridges, and apartments, etc. but in houses, buildings, apartments, and villas is the place where human relationships usually take place at the living position, the working position and the position of taking place relationships. Nowadays, spatial position places spatial objects that are understood by humans in two aspects. Aspect 1, the coordinates of the spatial objects located in the 3D domain. Aspect 2, addresses are attached to spatial objects including houses, buildings, apartments, bridges, etc.

To store spatial data including spatial coordinates and interpretation semantics for spatial objects. The spatial object is a bridge, house, building, apartment, villa, etc. So, the spatial data class is built on top of the five base objects that are Point, Line, Surface, Body, Prism and two element objects, Node and Face [2]. In which, each Face is defined by three Nodes, each Surface is defined by four Nodes, each Body is defined by four Nodes and one height, each Prism is also defined as four Nodes and a height [2, 5, 24]. From the five base objects Point, Line, Surface, Body, Prism help us to efficiently store spatial and semantic data and very suitable for application in the management of residential data in space and time because it supports the representation of faces and blocks based on triangulation.

The analysis and researches on the data models in the above sections of related studies are suitable for future urban management. Because models mainly manage 3D objects such as houses, apartments, apartment buildings, etc. but does not manage residential data, does not keep track of changing history of relationships and does not manage basic human information that changes over time and space and human genealogy. In residential data management, the levels of government or construction contractors are particularly interested in two properties, the spatial and the temporal property. Therefore, the incorporation of the spatial data class, the temporal data class into the management of the residential data class is extremely important and is an urgent job for levels of government and construction contractors.

3.4 Combining Spatial, Temporal and Residential Data Class to Build New Model

Regarding the management of residential data, information about residential data is collected and stored in the residential data class including properties such as full name, year of birth, place of birth, gender, origin, nationality, ethnicity, portrait, identity card, occupation, and relationship with head of household. Levels of government or construction contractors find that people include properties that do not change over time and also have properties that always change over time. Properties that don't change over time, like citizenship number, blood type, fingerprints, place of death, and DNA. Properties that change over time include full name, year of birth, place of birth, gender, origin, nationality, ethnicity, portrait, identity card, occupation, and relationship with head of household. To describe the full name changing over time, we use numeric properties, citizen identifier, full name, event time type, legal time type, and database time type. To describe the social relationship that changes over time, we use house code property, citizen identifier, social relationship, event time type, legal time type, and database time. To describe the change of previous conviction relation over time, we use house code properties, citizen identifier number, previous conviction relation, event time type, legal time type, and database time, court sanction, count, judgment handling and enforcement results.

Regarding the management of time data, to describe the time data types, we use the time data type code properties and the semantics of the time data type. To describe the time units, we use the properties of time data unit code, the time data type code, the name and the description. To describe the representations of year, month, day, hour, minute, and second for units of time data, we use the code properties representing the time data units, the code of the time data units is year, month, day, hour, minute and second. To describe time marks can be a point of time or a period of time, if the code representing the units of beginning time data is equal to the code representing the units of ending time data that is described as a point of time, but if the code representing the units of beginning time data is different from the code representing the units of ending time data that is described as a period of time.

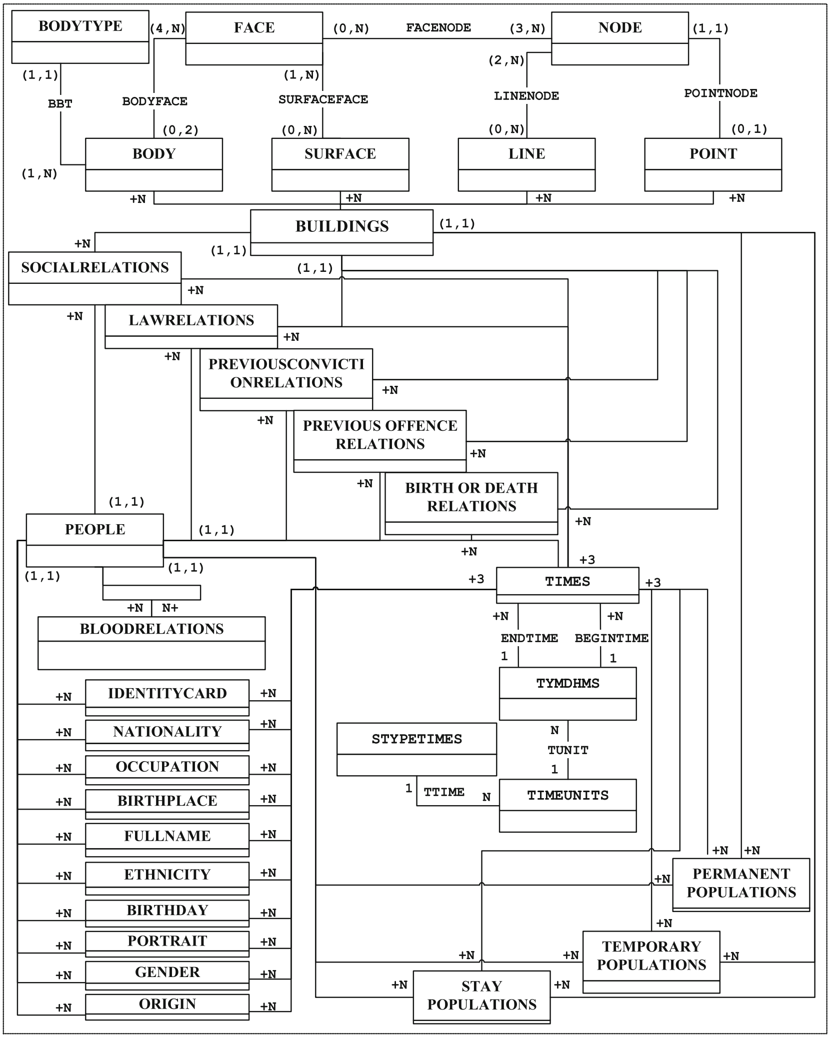

Fig. 3. The STRDM model manages the residential data in the 3D geographic space

Regarding spatial data, the spatial objects to be managed include buildings, apartments and villas, which are collectively called buildings for short. Buildings are where people live and work, and are also places where relationships take place. A building is a 3D master block constructed from various blocks that have or are defined as a set of bodies, which may contain more complex sub-shapes such as complex shape, prism shape, etc. In addition to these blocks, buildings can also contain other special geometrical objects such as lines, points, surfaces, etc. A building has many different levels of detail to be represented called 3D spatial detail levels in the 3D and 4D GIS [5, 8–11, 24].

Through the above analysis, the paper combines the spatial data class, the temporal data class and the residential data class to be a STRDM model (see Fig. 3). The new model is capable of storing and managing 3D spatial objects such as buildings, apartments, roads, houses, light lamps, bridges, relations, generations, and people over time and space. In addition, this data model also has the ability to query by time, to query by resident, to query space by time, to find ancestors and to find descendants, to trace the history of human relationships. Below, this is a summary of the relations for this data model and shows the size of a row (see Table 5).

Table 5. Decomposing the STRDM model into relations

No	Relations name	Bytes	No	Relations name	Bytes	No	Relations name	Bytes
01	Point	60	14	People	120	27	Origin	58
02	Line	70	15	Bloodrelation	110	28	Ethnicity	48
03	Surface	80	16	Buildingbody	48	29	Nationality	35
04	Body	100	17	Buildingsurface	48	30	Occupation	40
05	Bodytype	30	18	SRelations	80	31	Portrait	50
06	Face	30	19	LRelations	80	32	Identitycard	20
07	Node	34	20	PCRelations	80	33	PPopulations	90
08	Surfaceface	20	21	PORelations	80	34	TPopulations	90
09	Linenode	28	22	PDRelations	80	35	SPopulations	90
10	Facenode	28	23	Fullname	50	36	Times	90
11	Surfacenode	28	24	Birthday	40	37	Tymdhms	60
12	Facesurface	20	25	Birthplace	58	38	Timeunits	70
13	Buildings	180	26	Gender	48	39	Stypetimes	130
Total		**708**	**Total**		**922**		**Total**	**871**

3.5 Querying in Residential Data Management

Query 1: Finding and displaying the social relationship is "Meeting for dividing specialty for students of Faculty of Information Technology - Nguyen Tat Thanh University in June 2020" at the time "12/06/2020 09:00 AM" $\in T_{10}$ and is the starting ET_s, the information displayed includes: name of social relationship, space (buildings location and buildings shape), point of time, and composition of attendees.

Query 2: Finding and displaying the previous offence relation is “Illegal drug use” at the time “13/05/2020 11:55 AM” $\in T_{14}$ and is the starting ET_s, the information displayed includes: name of previous offence relation, space (buildings location and buildings shape), point of time, and composition of users.

Query 3: Finding and displaying the permanent populations of the householder is named “Dang Thi Van”, the information displayed includes: space (house location and house shape), householder, populations along with the householder relationship.

Query 4: Finding and displaying the descendants of a person’s lives have a citizen identification number “11” and named “Vinh” (see Fig. 4), the information displayed includes: descendants of a person’s lives and generations (Table 6).

Query 5: Finding and displaying the ancestors of a person’s lives have citizen identification number “53 or 51” and named “Khoi or Yen” (see Fig. 4), information displayed includes: ancestor of a person’s lives and generations (Table 7).

Query 6: Finding and displaying the children of a person named “Nguyen”, information displayed includes: parents and children.

Query 7: Finding and displaying father and mother of a person named “Khoi”, the information displayed includes: parents and child.

Query 8: Finding and displaying the temporary populations in a house of the householder named “Tran Anh Minh”, information is displayed including: space (including house location and house shape), householder, members along with the relationship with the householder.

Query 9: Finding and displaying where “Pham Thao Nguyen” was born, the information displayed includes: place of birth (house location and house shape) and full name.

Query 10: Finding and displaying where Pham Minh Ngo died, the information displayed includes: place of birth (house location and house shape) and full name.

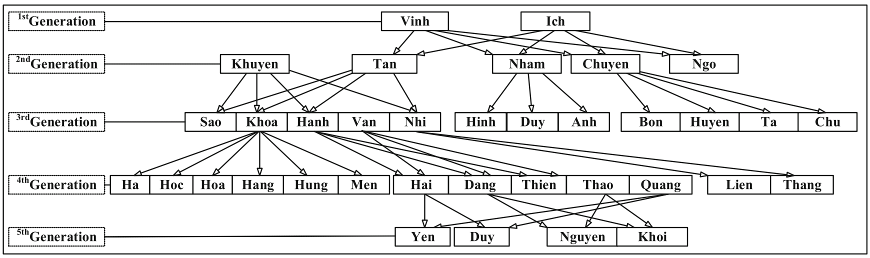

Fig. 4. Describing a family tree including ancestors and descendants of a lineage

Table 6. The table listing of generations by each generation of the person named "Vinh"

Input data	Output data *(Description the results found the descendants of a person named "Vinh")*	
"Vinh" *(In 1^{st} Generation)*	2^{nd} Descendant (2^{nd} Generation)	Tan, Nham, Chuyen and Ngo
	3^{rd} Descendant (3^{rd} Generation)	Sao, Khoa, Hanh, Nhi, Hinh, Duy, Anh, Bon, Huyen, Ta and Chu
	4^{th} Descendant (4^{th} Generation)	Ha, Hoc, Hoa, Hang, Hung, Men, Hai, Dang, Thien, Lien and Thang
	5^{th} Descendant (5^{th} Generation)	Yen, Duy, Nguyen and Khoi

Table 7. The table listing of generations by each generation of the person named "Khoi"

Input data	Output data *(Description the results found the ancestor of a person named "Khoi")*	
"Khoi" *(In 5^{th}Generation)*	4^{th} Ancestor (4^{th} Generation)	Dang and Thao
	3^{rd} Ancestor (3^{rd} Generation)	Hanh and Van
	2^{nd} Ancestor (2^{nd} Generation)	Tan and Khuyen
	1^{st} Ancestor (1^{st} Generation)	Vinh and Ich

3.6 Recursive Query Techniques in Residential Data Management

Input data	Recursive query	Output data	
Applying query 4: Citizen identification number: 11 of the person named "Vinh" (In 1^{st}Generation)	**Select** **Sys_Connect_By_Path** (Name, '- > ') **As** FamilyTree, **Lpad**(' ',6*level-1,'-')‖ Name Descendant, Level + 1 As Generation **From** Bloodrelations br, People p, tblName n **Where** br.Idchil = p. Idcin and p.Idcin = n.Idcin **Connect by** Idpar = **Prior** Idchil **Start With** Idpar = **'11'** **Order Siblings by** Name **Desc**;	2^{nd} Descendant (2^{nd} Generation)	Tan, Nham, Chuyen, Ngo
		3^{rd} Descendant (3^{rd} Generation)	Sao, Khoa, Hanh, Nhi, Hinh, Duy, Anh, Bon, Huyen, Ta, Chu
		4^{th} Descendant (4^{th} Generation)	Ha, Hoc, Hoa, Hang, Hung, Men, Hai, Dang, Thien, Lien, Thang
		5^{th} Descendant (5^{th} Generation)	Yen, Duy, Nguyen, Khoi

(*continued*)

(*continued*)

Input data	Recursive query	Output data	
Applying query 5: Citizen identification number: **53** of the person named "**Khoi**" (In 5th Generation)	**Select Sys_Connect_By_Path** (Name, '- > ') **As** FamilyTree, **Lpad**(' ',2*level-1,'-')‖ Name as Ancestor, Level + 1 As Generation **From** Bloodrelations br, People p, tblName n **Where** br.Idpar = p. Idcin and p.Idcin = n.Idcin **Connect by Prior** Idpar = Idchil **Start with** Idchil = **'53' Order Siblings by** Name **Desc**;	4th Ancestor (4th Generation)	Dang and Thao
		3rd Ancestor (3rd Generation)	Hanh and Van
		2nd Ancestor (2nd Generation)	Tan and Khuyen
		1st Ancestor (1st Generation)	Vinh and Ich

4 Experiment

The paper has detailed the spatial data class, the temporal data class and the residential data class, then combine these three classes together to build a STRDM model. The paper uses Oracle database management system [25, 26] to install STRDM model, using Oracle's spatial data type to store spatial data. This spatial data type makes the time displaying spatial data of buildings in a 3D geospatial space faster and more intuitive. It is then combined with the C# programming language [5, 24, 27] to visually represent some forms with typical queries. The paper selects presenting five visual forms through five queries to find and display relationships, permanent population, and find ancestors and descendants. In each form the user must provide input and output parameters.

Form 1: Applying query 1 to find and display social relationships based on the name of relationship and point of time (see results in Fig. 5 and Fig. 6)

Input: The name of relationship is "Meeting for dividing specialty for students of Faculty of Information Technology - Nguyen Tat Thanh University in June 2020" at the time "12/06/2020 09:00 AM" $\in T_{10}$.

Output: The information displayed includes: name of social relationship - buildings space - time – attendees and ET_s.

Form 2: Applying query 2 to find and display previous offence relations based on the name of relationship and point of time (see results in Fig. 7).

Input: The name of previous offence relation is "Illegal drug use" at the time point "13/05/2020 11:55 AM" $\in T_{14}$.

Output: The information displayed includes: previous offence relation - space including buildings position and buildings shape – time – attendee and ET_s.

Form 3: Applying query 3 to find and display permanent populations based on citizen identification number and householder's name (see results in Fig. 8).

Input: Householder with identification number and full name "Dang Thi Van".

Output: The information displayed includes: relationship with householder - space including house position and house shape - people.

Form 4: Applying query 5 to find and display the ancestor of a person's lives having citizen identification number and full name (see results in Fig. 10 and Fig. 11).

Input: Citizen identification number "53 or 51" and first name "Khoi or Yen"

Output: Ancestor of person's lives named "Khoi" or "Yen"

Form 5: Applying query 4 to find and display the descendants of a person's lives having a citizen identification number "11" and first name (see results in Fig. 9).

Input: Citizen identification number "11" and first name "Vinh"

Output: The information displayed the descendants of a person named "Vinh".

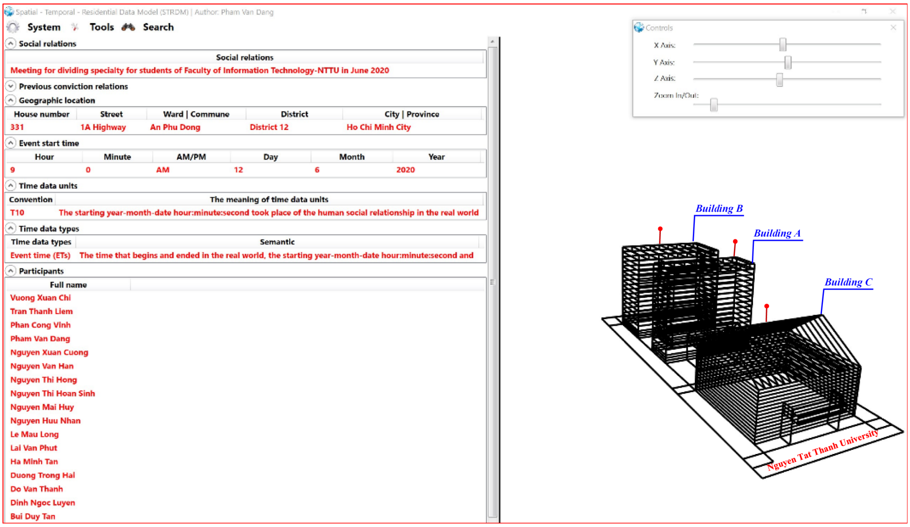

Fig. 5. An instance of a social relationship - space including buildings position and buildings shape - time – people (*view A*)

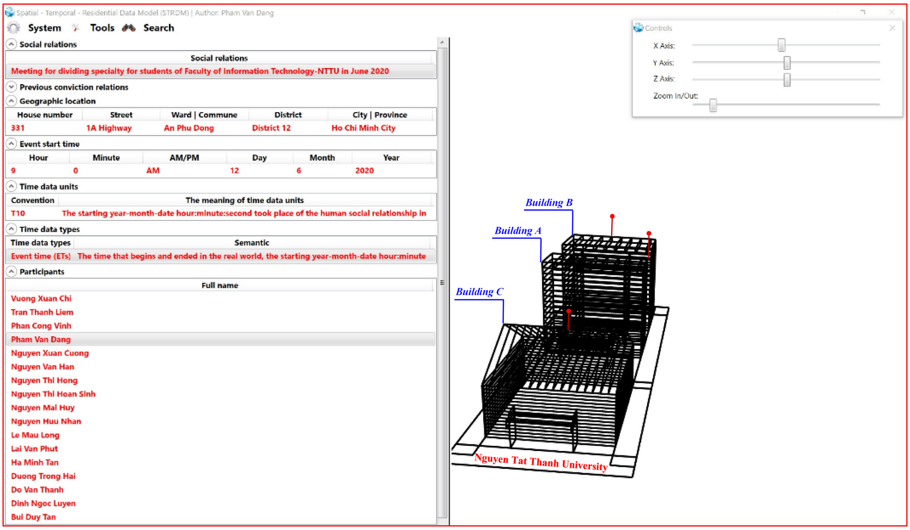

Fig. 6. An instance of a social relationship - space including buildings position and buildings shape - time – people (*view B*)

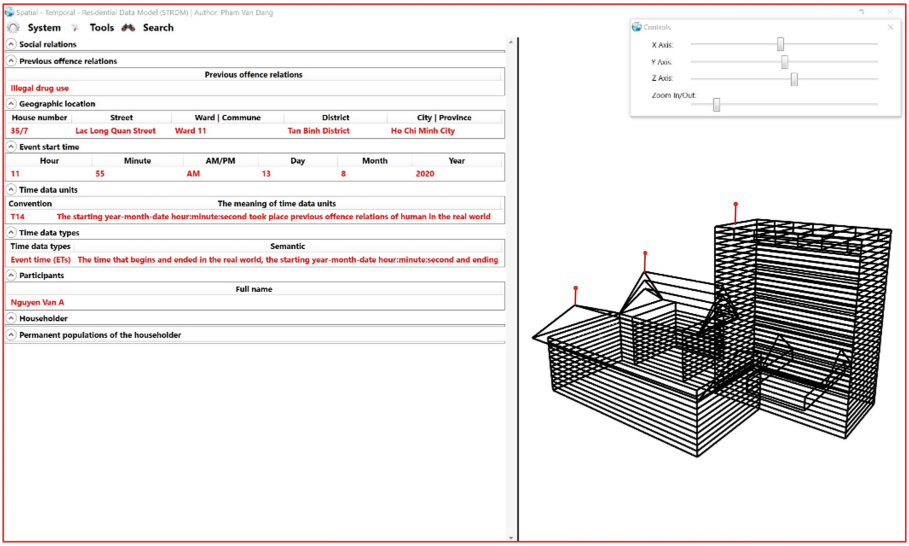

Fig. 7. An instance of a previous offence relation - space including buildings position and buildings shape - time – people

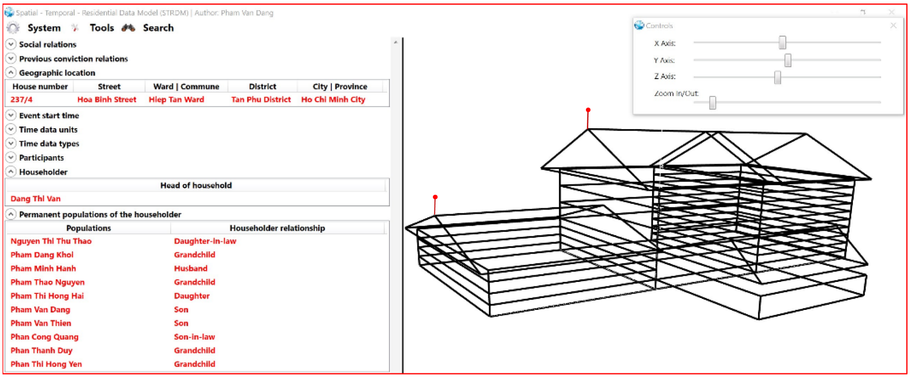

Fig. 8. An instance including relationship with householder - space including house position and house shape – people

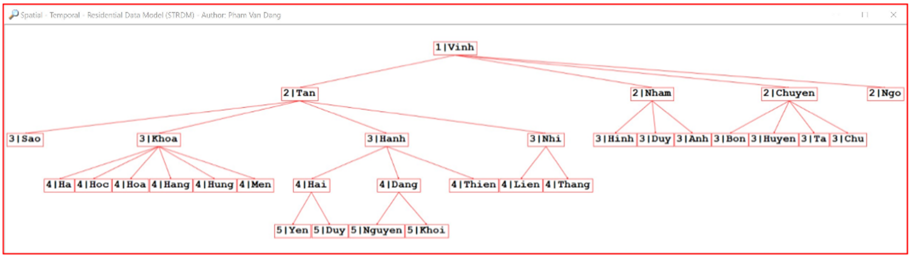

Fig. 9. An instance of descendants of a person named “Vinh”

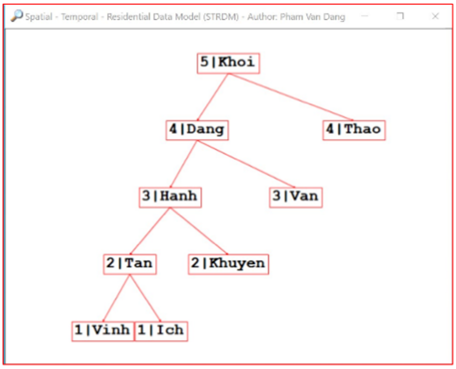

Fig. 10. An instance of ancestors of a person’s lives named “Khoi”

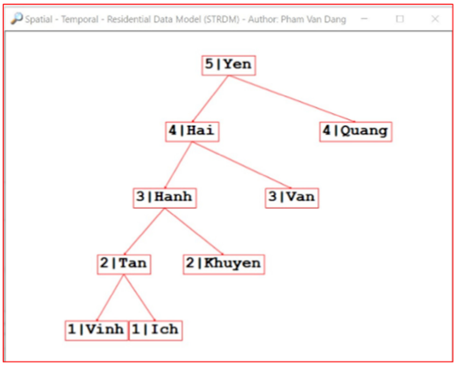

Fig. 11. An instance of ancestors of a person’s lives named “Yen”

5 Conclusion

The paper presented an overview of the spatial and temporal data models and then gave some comments and suggestions. The paper details the construction of the spatial data class, the temporal data class, and the residential data class, then combines these three classes into a STRDM model. This model showed its availability and opened up new directions in supporting the method of storing residential data over space and time. This model is not only capable of querying relationships, querying permanent and temporary populations, querying space and querying process change basic human information over time but also have the ability to find ancestors and descendants. The paper also illustrated some visual forms whose results are derived from the above queries, in these queries, there are instances of point of time, period of time and semantics of describing residential data. In addition, this model can also develop and expand the semantic inheritance classes for both the space and the residence and other classes such as colors, patterns, styles for spatial objects which are buildings in 3D geospatial space intending to serve other extended storage purposes without affecting the structure of this model.

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