3D modelling and analysis: ISO standard tools for air traffic

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Abstract

The Geographic Information Systems (GIS) applied to aviation use mostly modelling and analysis in 2D. Nevertheless, a tendency to represent and analyse in three-dimensions begins to emerge. It requires new descriptions and new operative tools for 3D objects in GIS. As an association of users and software producers, the Open Geospatial Consortium (OGC) has defined an ISO standard to describe two-dimensional and three-dimensional geometric objects. However, this standard does not permit a description of common Computer Aided Design (CAD) objects, a vital task remains for the modelling of 3D data and their uses, in the context of analysis (spatial query) or with the proposals of new primitives. In this research, our goal is to build a computing library fully compatible with ISO standard especially allowing characterising any gaps or parts requiring further development. In this paper, we present a solution validated by a use-case for modelling and analysis of aerial traffic in 3D on an ellipsoid of revolution that follows the ISO standard. In order to demonstrate whether new geometric objects that we propose are effective, in this simple approach, we have established a complete processing chain.

Keywords

1 INTRODUCTION

The Geometric modelling that is currently implemented in the GIS is mostly data and algorithms driven for 2 and 2.5 dimensions. However, the current studies on market analysis and representation of data in 3D space showed the increasing scenario of geometric modelling in 3D GIS [Ste05]. As shown in the work of Zlatanova [Zla08] many activities are still waiting concrete 3D GIS solutions. Current studies on GIS spatial objects show a categorisation following the application domain. The work of Danahy [Dan97] defines five groups for a 3D city model (e.g. vegetation, buildings, public utilities, traffic network and telecommunications). Nevertheless, it is also possible to separate from another group independently of a real representation (e.g. legal limits, institution, companies) for example in the case of cadastral modelling and analysis in 3D by Billen and Zlatanova [BZ03]. Currently, con-

sumer software such as Google Earth [1] or World Wind [2] have defined up the first opportunities visualisation of 3D geo-referenced data. Despite these solutions provide no tool for 3D analysis.

The primary cause of developmental delay of 3D analysis part in GIS is the modelling multiplicity solutions and exchange, because each software is using their own method add is a common geometric modelling must be defined as in CAD domain with STEP [TC 94] standard to facilitate the efficiency and depiction of real world. The work of Zlatanova [Zla99] has a first approach to the VRML [ISO04a] format standard. Nonetheless, only the display is in a standard format. The recovery and data analysis use a specific format content in the application and there is no end-to-end standardisation. This standardisation for GIS domain is supported by the OGC [3] through the "Geometry/Topology" standard ISO 19107 [ISO03]. This standard is currently under review by the Working Group "Simple Feature" as a complement of the revision of ISO 19125 [ISO04b].

Our work is to implement a Globe3D platform with analysis tools fully compatible with the ISO 19107

[1] www.google.com/intl/en/earth

[2] http://worldwind.arc.nasa.gov

[3] OGC: Non-profit organization created to address the problem of interoperability between systems that process geospatial data.

standard. Compliance with this standard also provides interoperability between modules (such as SWE [4] [ISO10], WCS [5], GML [ISO07b] ...). This application aims to demonstrate the capabilities of our modelling approaches and 2D/3D analysis in the field of GIS. In this context, we organise this paper as follows: in section 2, we present ISO 19107 standard covering the geometry of the object including spatial analysis in ISO 19107. Section 3 focuses on the development of a "Decision Tool", allowing the management of modelling and analysis of standard that takes into account output requirements and architecture of the modules. In section 4, we present our Globe3D platform that uses the ellipsoidal representation for the Earth geometry. Globe3D platform is superior to the current visualisation softwares which only use a simple sphere as an Earth surface approximation. Section 5 deals with the use case of air traffic taking into account the analysis and trajectory modelling with examples. In section 6, we describe a parametric curve which is usefull for aircraft trajectory. Specific focus is there for traffic representation in 3D space in section 6.1. The analysis and representation of air traffic are typically defined in a 2D space. The trajectories of an aircraft are represented by a set of geo-localised positions and a linear interpolation between each point (polyline) is performed. However, it is possible to use a different interpolation method, as for example, Catmull-Rom [Twi03] and NURBS [PT97]. The computational development for air analysis and visualisation in 3D space is made in collaboration between Geomatys Company and LSIS CNRS 7296 public lab, in the open source frameworks GeoAPI 3.0 [6] and Geotoolkit [7]. As we based our work on these public frameworks, we will release our code to permit GIS community to use 3D geometries and analysis in their specific applications. In section 7, we conclude the paper with the contributions we made and our future direction in this exciting field of 3D modelling and analysis.

2 ISO 19107 STANDARD

2.1 General definition

The concept of an object in ISO 19107 is defined by three strongly linked parts. The first two parts allow a description of objects defined hierarchically according to their spatial dimensions (point, curve, surface, volume) and their topologies (node, edge, face, solid) which are already been used by CAD industries. Each geometric ISO object is preceded as "GM_" and topological link by "TP_". Geometric objects have however

a third necessary characteristic: they are linked to geo-referenced coordinates (e.g. coordinate references on sphere, plane, geoid ...) with vector basis and mathematical projection. Each geometry is related to a Coordinate Reference System (CRS), as for an example the CRS WGS84. Besides, our work has made a proposal to add a new type of surface, constructed by revolution, which can possibly define the earth ellipsoid.

The standard also defines spatial analysis operations on geometric objects. There is no analytic (generic) way to process these methods, as their computation depend on the selected reference system and geometric description. Thereby, the spatial operations module supply analysis methods for aerial traffic, following ISO 19107 standard.

2.2 Geometry in ISO 19107

A geometric object respecting the ISO 19107 standard is represented by a GM_Object, defining a set of functions. The standard defines a hierarchical construction of geometric objects. A GM_Object may be described with different types. GM_Primitive object defines only a single object with its attributes, specific method "boundary" and geo-referenced position (GM_DirectPosition). There are 4 primary GM_Primitive (GM_Point, GM_Curve, GM_Surface and GM_Solid) with 31 coordinates objects (GM_LineString, GM_BSpline, GM_Triangle, ...). Further, we also describe a new GM_Object with GM_RevolutionSurface forward in this paper.

Each object has associated functions (distance, centroid, envelope, ...) and geometric description. The mathematical methods implemented by these functions may vary depending on the referencing system used. The calling function itself is not altered, but the calculus method differs from a CRS to another. These mechanisms of evaluation are not defined in the ISO 19107 standard. Moreover, the construction methods and the interpolations used for geometric objects are not described in this standard. The gap in the standard is due to the many degrees of freedom left for its implementation.

2.2.1 Spatial analysis in ISO 19107

This standard also defines spatial analysis methods on geometrical objects like "intersection", "difference" and "contains". As shown in Figure 1, the methods are described in two groups: "predicates" and "operations", depending on their action. Tests done by "predicates" return logical (i.e. boolean) value as in "intersect", whereas the "intersection" method returns a resulting geometric object. These two groups are complementary as "predicates" indicate the operation feasibility. The following section details the mechanism of a "decision tool" in choosing the method of
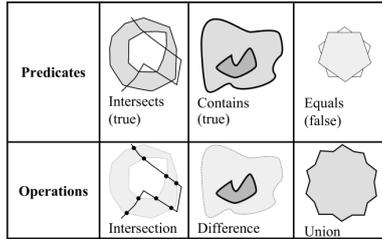

Figure 1: Predicates and operations analysis

modelling and analysis following its CRS or object type.

3   DISPATCHER MECHANISM

As we want to provide a library founded on ISO 19107 with an automatic processing phase analysis, we set up a module "Dispatcher" which has a goal to harmonise CRS and geometric objects definitions to prepare generic analysis phase. This phase exists in the availability of representing different types of geometric objects in a common mathematical model. Besides, the Dispatcher must take into account the constraints that are described in the standard output. That is to say, after all step of analysis and processing, the resulting object must be conformed to specification of the ISO 19107 standard prior to the translation in user specific format depending on the intended usage (e.g. visualisation, printing, storage ...).

3.1   Output requirements

The output model of the analysis step must be described in the CRS of the first object (ISO 19107 requirement). Thus, this strong restriction is taken into account by our "Dispatcher" module. It must determine whether the transformation from a CRS to another is possible. The translation possibilities depend on the libraries implementation based on ISO 19111 [ISO07a] standard. Another role of our "Dispatcher" module is to let it go in the output for GM_Object which is in compliance with the ISO 19107. For example, the intersection between a circle and a line (if it exists: predicate "intersect" returns true value) may be a set of GM_Point or a single one. In the case of an "intersection" between two ISO 19107 spheres (e.g. GM_Sphere) many resulting object types are possible, a GM_Point for just one intersection whereas polyline (GM_LineString), NURBS curve (generic object) for more than one intersections as described in François et al. [FRD10b].

3.2   Architecture

Our standard implementations rely on an architecture using input/output modules built around a core module containing the description of the ISO objects. Figure 2 describes in detail the three modules contained in the "Dispatcher" architecture, one that formalises the
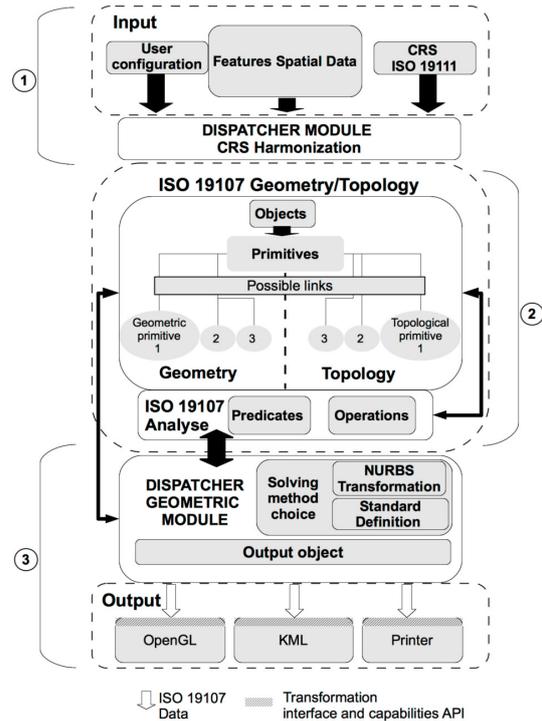

Figure 2: Dispatcher/ISO 19107 interaction

input data (module #1), a module that constructs and processes standardised data (module #2), and one that prepares the output data to user front end (module #3).

The first module is designed to prepare the data for the ISO 19107 part, taking into account user output specifications and reference of the main CRS. These last operations are done by the sub-module "CRS Harmonization" with the Geotoolkit library. However, if CRS source could not be transformed into a CRS destination or reverse transformation is not possible, the analysis process is cancelled. Figure 3 shows that the "Dispatcher", in a first step, verifies the compatibility of CRS objects A and B with the output CRS (CRS of object A) and also between them. The ISO 19111 library determines the list of compatible CRS. Unlike the JTS [DA03] library that uses only one cartesian space (e.g. WGS84 cartesian) for modelling and analysis, our "Dispatcher" allows the evolution of operations to another reference system (ellipsoid, spherical, ...). For example, an operation "distance" is already extended to ellipsoidal space.

The second module is the geometric kernel, it is composed of the ISO 19107 part with two submodules, "Geometry/Topology" and "Analysis" that strongly interact. The "primitives" must build the objects according to ISO standard specification (ex: GM_BSplineCurve object).

It must use the geometrical part of the standard, but also the topological part as well. An analysis between
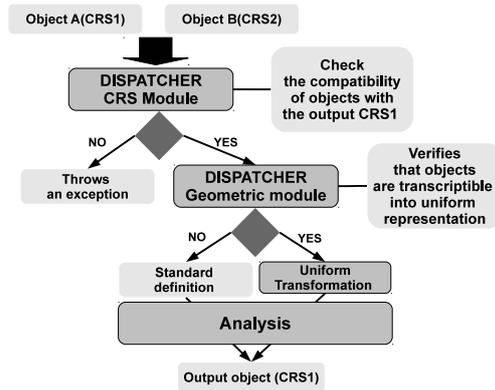
Figure 3: Dispatcher transformation process

Figure 4: Definition of revolution surface

two objects implies a call to "predicate" module and depending on the result of the operation, a new object ISO is created. Special attention should be paid to CRS transformations: it causes a degeneration that spreads after each operation and can result in analysis errors. The architecture presented here does not cover actually this type of problem, but it is capable enough to calculate maximum error transformations via Geotoolkit library.

The sub-module "Dispatcher Geometric" manages the analysis module, it determines the most appropriate method to perform the processing. As shown in the detailed schema (see Figure 3), there are two possibilities: objects can be converted to a uniform representation, or they are of basic types (GM_LineSegment, GM_Point). In a worst case scenario, objects can not be converted and consequently the analysis is based only on their standard definitions. The output module takes into account the constraints of output interfaces with features such as printer, rendering engine using libraries like OpenGL, Java3D, file export formats (XML, KML [8], ...), or our software Globe3D. In the following section, we present the first step in developing our platform in modelling the Earth following an ellipsoid geometry.

4 MODELLING AN ELLIPSOID FOR THE EARTH GEOMETRY

4.1 Using a revolution surface

Current applications (World Wind, Google Earth or ArcGIS Explorer [9]) model the terrestrial globe by a simple sphere (GM_Sphere). The sphere representation is not sufficient in current methods. As CRS WGS84/World Mercator is widely used and rely on an ellipsoidal description of Earth surface, retro-projection is needed to obtain spherical coordinates from ellipsoidal one, eroding data quality.

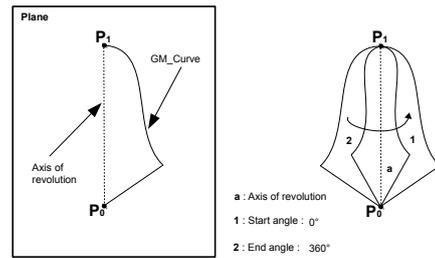[8] Keyhole Markup Language
[9] www.esri.com/software/arcgis/explorer/

Moreover, the advantage of an ellipsoid based representation is the multiple possible formulations, like parametrical surface or implicit formulation with:

$$x^2/a^2 + y^2/b^2 + z^2/c^2 + 1 = 0$$

These formulations are used in the analysis and in the calculations.

François et al. [FRD10a] described a conversion process of a rational GM_Sphere surface (NURBS) to describe the ellipsoidal. Our approach here is to introduce a new surface family with revolution surface that was described in Shukla [Shu10] (family associated with GM_RevolutionSurface). It permits us to define the ellipsoidal Earth with a simple GM_Arc object. The new surface allows the ISO 19107 standard to create open or close surfaces. Its shape is defined by the rotation around an axis of a GM_Primitive type: GM_Curve. This type of surface creates a wide range of surfaces depending on the selected curve and its orientation.

The curve used for the revolution is called the "generating curve", in the case of a curve defined in 3D space, it should be reduced to planary projection to achieve revolution. However, the generator curve, GM_Curve, can be built by a set of sub-curves as shown in Figure 4.

It is possible to obtain an open GM_surface by specifying starting and ending angles of rotation. Nevertheless, it should lie between 0 and 360 degrees (see Figure 4). The positive value of the surface is defined by its rotation, and it defines outer normals, default value is counter clockwise. In this example, the result is a closed surface.

4.1.1 Integration to standard

This new GM_Object belongs to the surface family type and is naturally integrated as GM_Surface object. The class GM_Revolution Surface defines a surface of revolution. Two constructors are allowed, the first takes a parameter curve generator and an array containing two revolution angles (first and last). The second defines an axis of revolution, unlike the first constructor that uses OY by default. There is also a set of 4 subclasses that inherit directly from GM_RevolutionSurface. Their goals are to specify simple shapes (cylinder,

cone, sphere). The current standard does not define an axis for the surface of revolution, consequently it was added to a new class GM_Axis. To define an ellipsoid with a surface of revolution, one can use the ISO GM_-Arc object as generator curve. This object can be constructed in two different ways with only three positions, or using the offset of the midpoint (bulge) between the start and end points.

4.1.2 Advantages

The first contribution is in the quantity of data used to define an object through revolution method versus classical way. Another advantage is the possibility to create an open surface, like an hemisphere with the same formalism.

4.1.3 Harmonization of generator curve GM_-Arc

In order to generalize mathematical operations between curve objects, we describe an arc with a parametric curve (see in François et al. [FRD10b]). The object ISO 19107 is transcribed into a rational representation with Non-Uniform Rational Basis Spline (NURBS) as in Faux and Pratt [FP79] to facilitate the processing analysis module ("Dispatcher"). This representation uses a control polygon to define the curve. Let $(x_0,...,x_{n-1})$ be coordinates of a point in the working space. These points can be represented in homogeneous coordinates $(x_0',...,x_n')$ with $x_i = x_i'/x_n'$ and $x_n' \neq 0$. The NURBS curve is defined as a perspective projection centred to the origin and the hyperplane $x_n = 1$. The general expression of a NURBS curve is given by equation 1 with the basis functions $N_{i,k}(t)$ and weight w_i (a more detailed definition is available in Piegl and Tiller [PT97]).

$$C(t) = \frac{\sum_{i=0}^{n} w_i P_i N_{i,k}(t)}{\sum_{i=0}^{n} w_i N_{i,k}(t)} \text{ for } C(t), P_i \in \mathbb{R}^3 \quad t \in [0,1]$$

(1)

The first advantage of using a NURBS representation for revolution surface is to control the generating curve parametrisation. It is then possible to obtain any position on the curve with t parameter.

The control polygon can be defined with 3 or 4 vertices, it uses the tangent to the circle of R radius (see Sederberg [Sed09] and Lu [Lu09]).

4.2 Terrestrial globe

As we get a precise parametric definition of an ellipsoid, we use this model to define a globe in 3D space respecting the WGS84 coordinate reference system. An important advantage of parametric description is that discretisation can be made according to process constraints (precision, speed, density, ...).
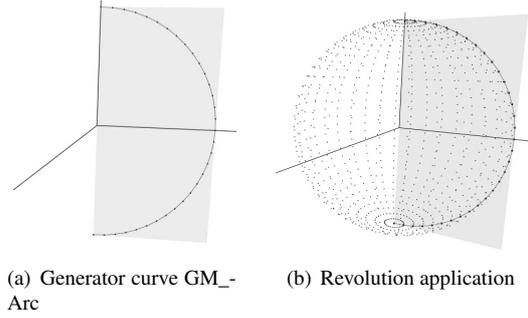

(a) Generator curve GM_-Arc   (b) Revolution application

Figure 5: Example of a spherical object with GM_RevolutionSurface

The two images in Figure 5 show the different steps used for globe modelling. The rendering application uses a geocentric coordinate referencing system, allowing three spatial coordinates (X, Y and Z). Z coordinate is used as an elevation value. As shown in Figure 5(a), the generator curve used is GM_Arc in the *XY* plane defined by three positions (GM_DirectPosition), the middle position of the arc uses the equatorial radius (6 378.137 km) given by semi-major axis *a* of WGS84 CRS. The first and last positions are centred on the *Y* axis and distance from the semi-minor axis *b* (6 356.752 km) from the origin is calculated with a flattening factor $f = (298.257)$ also given by the CRS:

$$f = \frac{a-b}{a} \text{ where } b = a(1-f)$$

Figure 5(b) shows the result of a rotation $\theta = 2\pi$ applied to a GM_Arc object contained in a plane, and that creates a GM_SurfaceRevolution. This GM_Surface can be rendered with a set of GM_Triangle or GM_-Polygon due to new implemented functions "asToTriangles" and "asToPolygons". One advantage of this discretisation by ISO 19107 library (e.g. GM_Triangle) is to pre-calculate the normals of each face before sending data to the rendering module. It can also permits to manage the discretisation method (homogeneous, based on curvatures, distances, ...).

Once the revolution surface defined and discretised respecting interoperable methods, the results thus obtained are then sent to a 3D engine, based on the widely used OpenGL API and Ardor3D, which is useful to handle 3D context events and objects visualisation. Figure 6 shows the result of our Earth ellipsoid in the rendering module. We add a "Blue Marble" [10] NASA [11] texture as adding on a GM_Surface. Nevertheless, it is possible to observe as predicted by the WGS factor a small crushing of the Earth at poles. We also represent the Earth's atmosphere with another GM_SurfaceRevolution encompassing the geoid of the Earth.

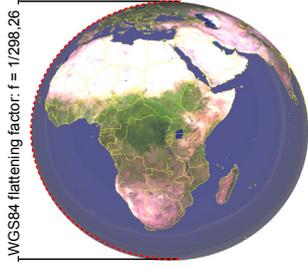[10]www.earthobservatory.nasa.gov/Features/BlueMarble
[11]www.nasa.gov

Figure 6: ISO Earth ellipsoid with country boundaries and "Blue Marble" texture

(a) Line discretisation crosses the Earth

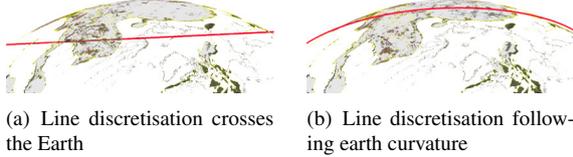(b) Line discretisation following earth curvature

Figure 7: Example of curve discretisation if parametric curves are used

5 TRAFFIC REPRESENTATION

5.1 Analysis and trajectory modelling

We import aircraft trajectories in our 3D globe with a set of GM_Curve primitives. These trajectories are loaded from a KML (see Reed [Ree07]) file, each of them is defined with a set of line string objects. Thanks to the interoperability between KML and ISO 19107 standard, these elements are then translated into GM_-Curve parametric, that can be discretised in a set of GM_LineString.

As shown in Figure 7(a), there exist cases where the trajectory crosses the Earth. This is due to excessive distance between the positions that composes a GM_-Segment (see Figure 7(b)). In this case it is necessary to calculate a parametrisation in accordance with the curvature of the ellipsoid. Equation 2 defines the equation of the Earth ellipsoid.

$$
\begin{cases}
x = 6378,137\cos(\alpha)\cos(\beta) \\
y = 6356,752\cos(\alpha)\sin(\beta), & \text{for } -\dfrac{\pi}{2} \leq \alpha \leq \dfrac{\pi}{2} \\
z = 6378,137\sin(\alpha), & \text{and } -\pi \leq \beta \leq \pi
\end{cases}
\tag{2}
$$

Let $P = \{P_i\}_{i=0}^{n}$ associated to each P_i the pair of angles (α_i, β_i) and $\forall i \in \{0,...,n\}$, we find that:

$$
\alpha_i = \arcsin\left(\frac{z_i}{6378,137}\right)
$$

and

$$
\beta_i =
\begin{cases}
\arccos\left(\dfrac{x_i}{6378,137\cos(\alpha_i)}\right), & \text{or} \\
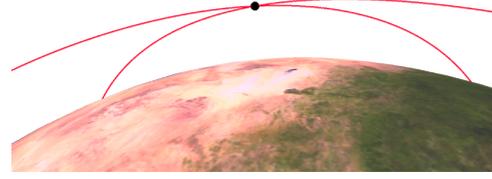\arcsin\left(\dfrac{y_i}{6356,752\cos(\alpha_i)}\right)
\end{cases}
$$

Figure 8: Examples of aerial trajectory analysis with trajectories intersection

N be the number of segments between two points P_j and P_{j+1}. The curvilinear abscissa L for each segment of $C(t)$ curve is defined by the following equation:

$$
L_i = \int_{P_j}^{P_{j+1}} c(t)dt
$$

and the overall curve is given by:

$$
L_c = \sum_{i=0}^{N-1} L_i, \quad \text{with } N+1
$$

Thus, it is determined by a discretisation on curvilinear abscissa distance L_c with p (for example, one point for a range of 500 m):

$$
segmentsNb = L_c/p
$$

As presented in Section 4.1.3, we use the "Dispatcher" which prepares the processing of the spatial analysis between two GM_Object (GM_Point, GM_Curve, GM_-Surface, ...). Every curve representing the trajectories of the aircraft is transformed by the "Dispatcher" in a generic NURBS object. This processing step depends on the nature of the GM_Object used for analysis. For example, in case where the trajectories are represented by a GM_Arc or set of arc with GM_ArcString.

5.2 First examples of analysis and modelling

As shown in Figure 8, the application displays an example of analysis between two trajectories in 3D space, the example illustrates "intersect" and "intersection" operations contained in ISO 19107. The result is a GM_-point object centre of a small Ardor3D [12] sphere. We can also perform this analysis across the complete aerial network.

The Globe3D application also supports analysis with another GM_Object. The decision tool ("Dispatcher") will determine whether it exists intersections with bounding boxes, and then run the analysis between
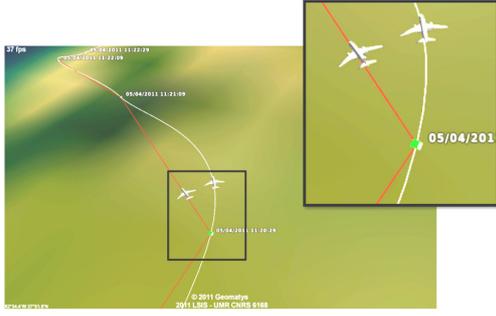
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[12]www.ardor3d.com

Figure 9: Multi-trajectories definition (linear polyline and spline curve)

Figure 10: Analysis examples for influences zones along two trajectories (collision detected)

GM_Object. Resulting intersection points are given in 3D space along with recomputing altitude given by transformation matrix of WGS84 3D CRS (e.g. EPSG:4329 [13]).

6 PARAMETRIC CURVE FOR AIRCRAFT

In most current software, the trajectories of aircraft are modelled by linear interpolation (polylines) between positions. Our application allows the use of ISO 19107 parametric interpolation curves, of Catmull-Rom type [DB88][Twi03]. In commercial aircraft navigation, arcs are used to define trajectories, these primitives are based on underlying parameter objects.

The curve passes through all the points that define the trajectory. A new derivative is calculated at each new point of the curve and these derivatives can determine the direction of the aircraft. It forced also to keep C^1 continuity (tangency). In addition, this level of continuity allows us to obtain a smooth curve. This object is defined in ISO 19107 by GM_CubicSpline.

Figure 9 shows the two types of curve for the same positions series. These curves share the same timestamps, this time value is defined in the KML file for each position. The red line represents the linear interpolation GM_LineString, the white curve is the parametric interpolation specified with GM_SplineCurve.

Linear interpolation involves lack of accuracy. Conversely, a parametric interpolation type Catmull-Rom spline can better fit the data, GM_SplineCurve representation also provides continuity at least C^1, which gives a smooth curve. We can conclude that a parametric curve is more relevant than the linear representation because it provides more degrees of freedom. However, the curves Catmull-Rom does not define a speed value between two positions. Using a B-spline or NURBS curve allow this type of integration with the addition of other parameters such as pitch, roll, yaw of an aircraft.
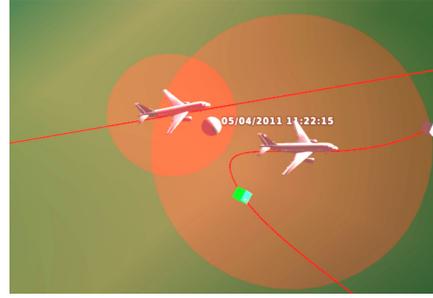
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[13]http://spatialreference.org/ref/epsg/4329

The following section presents a new analysis module that adds value for a specific case of air traffic.

6.1 Collision detection

To demonstrate the advantage of using 3D in the domain of air traffic management, we have developed a module to support collision detection in 3D space. This module identifies possible risks for air traffic. So, a sphere covers each aircraft and represent the position uncertainty.

Several choices are available for analysis with our application. These operations are done only for analysis between two objects. For the calculation, we use the timestamps in each trajectory. The time value t between two time t_0 and t_1 on the curve f is determined by the curvilinear abscissa of class C^1. The equation 3 defines the arc length L representing the distance traveled between two time values, and where $\|df/dt\|$ is the norm of the displacement speed vector.

$$L = \int_{t_0}^{t_1} \|\frac{df}{dt}\| dt, \quad \text{for } t \in [t_0, t_1] \tag{3}$$

We will assume that aircrafts have a constant speed K value between two GPS positions. Therefore, we have:

$$L = K \int_{t_0}^{t_1} dt = K(t_1 - t_0), \quad \text{for } t \in [t_0, t_1]$$

Figure 10 an example of analysis between two trajectories taking into is an account the time data. In a first step, the influence areas are initialised with a sphere. Figure 10 shows the result when a collision is detected. The gray sphere represents the time value of the collision. This method uses the analysis operation "contains" of ISO 19107 between two GM_Sphere.

7 CONCLUSIONS

This article has highlighted the capabilities of IS0 19107 standard to provide interoperable modelling and analysis. Our work was to model Earth's geoid with revolution surface (see section 4.2), based on the CRS ellipsoid WGS84, has yielded a better precision for modelling and analysis. Moreover, Globe3D entire platform is based on standardised modules as ISO 19111 for the referencing part in contrast to solutions proposed by Autodesk [14] or RhinoTerrain [15].

Section 6 has mounted the interest of using parametric curves to define trajectories. These curves offer a modelling closer to reality with the addition of degrees of freedom. However, it is possible to administer these degrees of freedom by using other curve like B-spline or NURBS. From this perspective, our future works are oriented with the ability to integrate semantic information on the aircraft as pitch, roll, yaw. This would produce a curve even closer to the real movement.

Further, we would like to study and add a new GM_-Primitive family in ISO 19107. For example, the extrusion surfaces are not currently referenced in the standard. These new surfaces would represent a tunnel or envelope of uncertainty around an aircraft parametric trajectory. We hope that this will be useful to realise intersections between volumes and trajectory (buildings, mountains, extrusion of country boarders). Our focus will also be on the formulation of curves in spherical or elliptical spaces rather than going through Euclidean projections.

From the application perspective, the next steps will also be integrating other standard interfaces enabling to extend its application to other domains such as management of marine data in real time with sensors addition (SWE) or permit the planning of air transport with geographic data connection like WFS [16], WCS or WMS [17].

8 ACKNOWLEDGEMENTS

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