Modeling Geometry and Reference Systems on the Web of Data

Raphaël Troncy
EURECOM

Ghislain Auguste Atemezing
Mondeca S.A.

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Raphaël Troncy[1], Ghislain A. Atemezing[1],
Nathalie Abadie[2] and Cao-Vien Lam[1]

[1] EURECOM, Sophia Antipolis, France,
<raphael.troncy@eurecom.fr>
[2] COGIT-IGN, Saint-Mandé, France, <nathalie-f.abadie@ign.fr>

Abstract. For many years now, the Web of data has been dominated with the use of only one Coordinates Reference System (CRS), namely WGS84, to represent the location of geographical features on Earth. In this paper, we propose two vocabularies that take into account geometries defined in different CRS. We provide as well mappings with existing vocabularies to ensure compatibilities with existing implementations. Finally, we describe a REST service that supports the conversion of coordinates between several CRS.

Keywords: Ontology modeling, Geographic data, Coordinate systems, Geometry vocabulary, Linked Data, REST service

1 Introduction

Most of the resources published on the Web of data are geo-referenced through a single point described in terms of longitude and latitude coordinates. Some resources are also described in terms of polygons of points which enable to attach provenance information of how a particular geometry has been captured. This is typically the case of the LinkedGeoData[3] dataset built from logs of Open Street Map where the shape and the position of geographical features are described with geometrical primitives (points, lines and surfaces) defined by coordinates expressed in a given coordinates reference system (CRS).

The vocabulary used for describing such direct location information is generally the W3C WGS84 Geo Positioning vocabulary. The reasons for its adoption is the simplicity of this vocabulary (few core classes and properties) and the fact that it is described in a W3C namespace. However, coordinates represented through `http://www.w3.org/2003/01/geo/wgs84_pos#long` and `http://www.w3.org/2003/01/geo/wgs84_pos#lat` properties are limited to the WGS84 CRS. With the Open Data movement, more and more publishers including governments and local authorities are releasing legacy data that are geo-referenced using other CRS. For example, the French National Mapping Agency (IGN) releases data using different projected CRSs depending on the geographic extent of each dataset.

[3] `http://linkedgeodata.org/`

In this article, we propose two vocabularies designed for representing structured geometries defined with coordinates expressed in any coordinates system. Section 2 deals with the identification and description of CRSs. Section 3 presents a vocabulary for structured geometries. Section 4 describes a REST service for coordinates transformation.

2 Identification and Description of CRSs

Consistently with the Linked Data principles, the Open Geospatial Consortium (OGC) recommends also to use URI to identify CRSs. It maintains a set of CRSs URIs under the `http://www.opengis.net/def/crs/` namespace. For example, the WGS84 CRS can be identified either by `http://www.opengis.net/def/crs/OGC/1.3/CRS84` or by `http://www.opengis.net/def/crs/EPSG/0/4326` depending on the authority which provide the definition of this CRS (OGC or EPSG[4]).

In addition to the OGC proposal, several registries have been proposed by the geographic information community for cataloguing existing CRSs. The EPSG Geodetic Parameter Registry[5] allows querying the Geodetic Parameter Dataset gathered by the EPSG. The Information and Service System for European Coordinate Reference Systems[6] provides an access to ISO 19111 standard-based descriptions [5] of the main European CRSs. Unfortunately, in both cases, there is no direct access to these data through dereferenceable URIs. The Spatial-Reference.org initiative provides a URI-based access to the definitions of CRSs referenced in the GDAL library[7]. Unfortunately, the definitions of some deprecated CRSs such as the Lambert zone projected CRSs (which are still used in some French datasets) seem to be referenced only for the authority EPSG and not for IGN.

IGN maintains a registry of all CRSs defined and maintained by the agency (Figure 1). Each system is described within an XML file[8] following the ISO 19111 standard and identified by a URI such as `http://registre.ign.fr/ign/IGNF/crs/NTFLAMB2E` which refers to "NTF Lambert 2 étendu" projected CRS. We have developed a vocabulary for defining CRSs. This vocabulary is very close to ISO 19111 schema for CRSs description. We will use the prefix `ignf` to refer to this vocabulary which is available at `http://data.ign.fr/def/ignf#`[9].

[4] European Petroleum Survey Group
[5] `http://www.epsg-registry.org/`
[6] `http://www.crs-geo.eu`
[7] `http://www.gdal.org/`
[8] `http://librairies.ign.fr/geoportail/resources/IGNF.xml`
[9] The vocabulary is temporary available at `http://www.eurecom.fr/~atemezin/datalift/ign-onto/ignfV4.ttl`

REGION	COORDINATE SYSTEM	ELLIPSOID	PROJECTION SYSTEM	ALTIMETRY SYSTEM
FRANCE METROPOLITAN	RGF93	IAG GRS 1980	Lambert 93 and CC 9 Zones	
MAYOTTE	RGM04 (ITRF2000)	IAG GRS 1980	UTM 38 South	SHOM 1953
GUYANE	RGFG95	IAG-GRS 1980	UTM 21 22 North	
MARTINIQUE	WGS84	IAG-GRS 1980	UTM 20 North	
GUADELOUPE	WGS84	IAG-GRS 1980	UTM 20 North	
LA RÉUNION	RGR92	IAG-GRS 1980	UTM 40 South	GGR 99
NOUVELLE-CALÉDONIE	ITRF90	IAG-GRS 1980		
POLYNÉSIE	RGPF	IAG-GRS 1980	UTM 5, 6, 7 and 8 South	Tahiti IGN 1966
WALLIS ET FUTUNA	MOP87	International 1924		
SAINT-PIERRE ET MIQUELON	RGM01 (ITRF2000)	IAG GRS 1980	UTM 21 North	Danger 1950
ILE CLIPPERTON	Marine 1967	International	UTM 12 South	

Fig. 1. Coordinate Reference Systems used in France. Source: `http://geodesie.ign.fr/`

3 A Vocabulary for Geometries

We have already surveyed in [1] numerous vocabularies for representing geographical features and their geometries, either using a literal à la WKT or a structured representation à la NeoGeo. We ended up this survey with some recommendations for geometry descriptions:

- the distinction of geometry versus feature and a property linking both classes
- the ability to represent structured geometries (e.g. for attaching provenance information on how some points of a geometry have been collected)
- the integration of any coordinate reference system

In order to fulfill these recommendations, we have developed a new vocabulary that re-uses and extends the existing vocabularies for representing geometries, namely:

- `http://www.opengis.net/ont/geosparql#` (prefix `gsp`[10]). This vocabulary provides the basic concepts to represent geographical data such as `SpatialObject`, `Feature` or `Geometry`. A Feature is linked to a Geometry via the relation `gsp:hasGeometry`. The geometries are typed strings (`gsp:gmlLiteral` or

[10] All prefixes used in this paper are in line with the prefixes recommended by the Linked Open Vocabulary (LOV) initiative

  `gsp:wktLiteral` corresponding respectively to the properties `gsp:asGML` and `gsp:asWKT`). The vocabulary contains also spatial functions.
- `http://www.opengis.net/ont/sf#` (prefix `sf`): This vocabulary is based on the OGC standard Simple Features for SQL. The class `sf:Geometry` is a subclass of `gsp:Geometry`.

We will use the prefix `geom` to refer to the vocabulary we propose available at `http://data.ign.fr/def/geometrie#`[11]. In the GeoSPARQL standard, the property `gsp:hasGeometry` links a resource of type `gsp:Feature` to a resource of type `gsp:Geometry`. In our case, we left the domain empty to accept any type of resource links to a geometry. We use the property `geom:geometry` to link a resource to a given Geometry.

The naming convention used for the `geom` vocabulary follows the terms used by the Simple Features vocabulary. The French translation of terms is based on the glossary of multilingual terminology of ISO/TC 211 available at `http://www.isotc211.org/Terminology.htm`.

Axiom 1 *A resource of type `geom:Geometry` should be associated to exactly one resource of type `ignf:CRS` via the property `geom:crs`.*

Regarding alignments with some existing vocabularies, the class `geom:Geometry` is a subclass of both `sf:Geometry` and `ngeo:Geometry`. The class contains in addition the property `geom:crs`.

Axiom 2 ***A POINT** is a subclass of a **GEOMETRY**.*

Axiom 3 *An instance of the class `geom:Point` is associated with exactly one instance of `ignf:CRS` via the property `geom:crs`. An instance of a `geom:Point` has exactly one coordinate X and exactly one coordinate Y. The coordinates are `xsd:double` and referred to the following properties:*

- *`geom:coordX` refers to, in an ellipsoidal CRS, the longitude of a point and within a projected CRS, the value of false easting of a point.*
- *`geom:coordY` refers to, in an ellipsoidal CRS, the latitude of a point and within a projected CRS, the value of false northing of a point.*

On the current usage of georeferencing resources on the Web of data, it is assumed that the coordinates should be in WGS84, and hence the definition of the point. However, publishers might have data in different CRSs according to the location. Thus, our proposal is to define a more generic class for a POINT with the benefit of choosing the CRS of the underlying data, as depicted in the Listing 1.1.

```
geom:Point a owl:Class;
  rdfs:label "Point"@en, "Point"@fr;
  rdfs:subClassOf geom:Geometry;
  owl:equivalentClass
```

[11] The vocabulary is temporary available at `http://www.eurecom.fr/~atemezin/datalift/ign-onto/GeometryV8.ttl`

```
[a owl:Class ;
      owl:intersectionOf
            ([a owl:Restriction;
               owl:onDataRange xsd:double;
               owl:onProperty geom:coordY;
            owl:qualifiedCardinality "1"^^xsd:nonNegativeInteger]
      [a owl:Restriction;
               owl:onDataRange xsd:double;
               owl:onProperty geom:coordX;
               owl:qualifiedCardinality "1"^^xsd:nonNegativeInteger])
] ;
rdfs:subClassOf sf:Point.
```

Listing 1.1. Definition in Turtle of the axiom defining a POINT.

4 A REST Service for Converting Geo Data

As we have seen, geodata interpretation relies on a coordinate reference system, and while the WGS84 CRS is the de-facto standard for GPS devices, many other CRS are in used. For example LAMBERT 93, RGM 04 or RGR 92 are respectively used for georeferencing points of interests in France continental, Mayotte or La Reunion. We have developed a REST service that is capable of transforming one dataset using a particular CRS into another one. The algorithms implemented are the ones described at `http://geodesie.ign.fr/index.php?page=algorithmes` and available within the standalone Circé software[12]. Some existing tools like Circé or the the world coordinate converter[13] are good as a standalone tool for end user, but not so great for developers, as they can only use them to test their result. There is no possible way to use their fully function algorithm unless develop it again. At the moment, the following features are implemented: (i) from/to WGS 84 to/from WGS 84 UTM ; (ii) from/to WGS 84 to/from Lambert 93 and (iii) from/to WGS 84 UTM to/from Lambert 93. The API can also convert a file with space separated values. The API supports JSON as one of the output format. The code of the REST service is available at `https://github.com/vienlam/Geo`.

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