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STRUCTURING AND VALIDATION OF PHOTOGRAMMETRIC TERRITORIAL DATA

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Abstract. In the loving memory of Mariasofia Paparo, this publication focuses on the validation procedures of photogrammetric geographic information and the production and interpretation of complex reports, which are essential for handling the vast amount of generated data. Furthermore, sources of error in the structuring of geographic data and the quality parameters and conformity criteria necessary for the utilization of such data within the national geodatabase have been investigated.

Keywords: geographic database, data quality, INSPIRE, photogrammetry, GeoUML, quality controls, ISO/TC 211.

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1. Introduction

The original thesis work focuses on the structuring, validation, and quality of photogrammetric territorial data (Wolf et al., 2014). This activity was carried out by operating with existing databases to identify any errors in data subsets through the analysis of generated reports. Subsequently, attention was concentrated on the identified discrepancies to ensure a better adherence of the data to content specifications and interpretation rules as defined by national legislation.

To better understand the currently existing surveying techniques, the state of the art of the photogrammetric process and related techniques was initially analyzed. Then, the evolution of geographic information (Falchi, 2018) and the transition from printed maps to geotopographic databases were highlighted through the study of the Italian Ministerial Decree of November 10, 2011, along with its technical annexes.

Following this initial study phase, an in-depth exploration of the computer language used for database implementation (GeoUML) and the structure of geographic data using various tools developed by researchers from the SpatialDBgroup (SDBG, 2011) at the Politecnico di Milano is conducted. This step involved utilizing the PostgreSQL (n.d.) and PostGIS (n.d.) software for data structure loading, as well as the GeoUML Validator (SDBG, 2016a) and Catalogue (SDBG, 2016b) applications which were essential tools for the initial operations of automated data quality validation.

Finally, once the thorough study of data structuring was completed, the application areas and future development prospects were analyzed.

This work, in agreement with the family of Mariasofia, aims to present the results of the thesis, focusing on quality parameters, acceptable limits, and procedures for the validation of geographic data, highlighting the significant findings of the brilliant journey undertaken by Mariasofia Paparo.

2. State of the art

The entire geomatics field is undergoing a phase of modernization and change, driven by the advancement of new technologies and the need to support higher levels of accuracy. There has been a long journey from the early aerial photogrammetric mapping achieved with analog plotters to the use of digital methods, not only in data acquisition and restitution but also in the processing, storage, querying, and sharing of territorial data (Falchi, 2017).

While just a few decades ago, the sole output of the entire process was the original restitution on paper, a precious and unique result of weeks or even months of work, today, through digital cartography and early spatial information systems, geographic information can be stored within specialized databases known as Geotopographic Databases (DBGT), as defined in Annexes 1 and 2 of the Decree of November 10, 2011 (Italian Government..., 2012b, 2012c).

Furthermore, Directive 2007/2/EC of the European Parliament and of the Council, established on 14 March 2007, institutes the Infrastructure for Spatial Information in the European Community (INSPIRE). The primary objective is to achieve the integration of geographic information on a continental scale. This is to be accomplished through coordinated measures between users and information providers, facilitating the amalgamation of knowledge across various sectors (European Commission, 2007).

The creation of a European infrastructure serves as a coordinating entity for national structures, addressing issues related to the availability, quality, accessibility, and sharing of spatial information. The directive aims to rectify challenges in spatial data by introducing new measures for sharing, access, and utilization of spatial data and associated services.

3. Metodology

In the Ministerial Decree of November 10, 2011 (Italian Government..., 2012a), it was established to use Geotopographic Databases as tools for the formation, content, documentation, and accessibility of geographic information originating from various types of land surveying or remote sensing, as well as from any other source that can represent, in any capacity, the nature and evolution of the territory.

To define the conceptual model of these computer tools, the GeoUML model (SDBG, 2011) was used–an extension of the UML language suitable for describing the content of a geographic database independently of any technology involved. The Unified Modeling Language (UML) was created to establish a common visual modeling language, rich in both semantics and syntax, for the architecture, design, and implementation of complex software systems from both structural and behavioral perspectives.

The syntax, meaning the form of concept representation, of the GeoUML language is automatically generated by specific software tools developed by the SpatialDB-Group at Politecnico di Milano in collaboration with CISIS, (Interregional Center for Geographic and Statistical Information Systems), the former coordinating authority of Italian Regions for geographical data (CISIS, n.d.).

The GeoUML Methodology and GeoUML Tools (SDBG, 2011) have been developed with the purpose of supporting the management of a geographic Conceptual Schema (Reitz & Kuijper, 2009) and achieving the automatic validation of the conformity of a Data Product to a given Conceptual Schema (Belussi et al., 2011). The term *Data Product* refers to any type of spatial data organization, which can consist of a set of files or a database.

The fundamental principles underlying this development are as follows:

- Adherence to ISO 19100 standards where relevant.
- Implementability with currently available technologies.
- Independence from any specific GIS product (commercial or open source).
- Maintenance of a clear distinction between the conceptual and physical levels.

The tool that manages the conceptual schema is called the GeoUML Catalogue (SDBG, 2016), and the model used to define the schema is referred to as the GeoUML model (SDBG, 2011).

The tool used to check whether a Data Product conforms to a given Conceptual Schema is called GeoUML Validator (SDBG, 2011).

To transfer a Conceptual Schema between different Catalogues or from the Catalogue to the Validator, a file called Specification File is used.

The Data Product to be validated must be implemented using one of several predefined Implementative Models (IMs). An *Implementative Model* defines the rules for transforming a Conceptual Schema into a Physical Structure.

The GeoUML Tools are entirely written in the Java programming language and can be used on any platform, and they are freely available to all public administrations and registered users on the website (SDBG, 2011). The products are subject to a license and can be used by the user on a non-exclusive and time-unlimited basis for non-commercial purposes.

4. Quality validation

The ISO 9000 standards (International Standard Organization [ISO], n.d.) defines quality as the degree to which a set of inherent characteristics meets requirements. The quality of data depends not only on its characteristics but also on the context in which it is used. Given the increasing use of Geotopographic Databases for delivering application services and conducting territorial analyses, knowledge of the reliability of their informational content has been developed through proper evaluation and documentation using specific quality parameters.

The quality requirements for the Geotopographic Database align with the quality categories proposed in the documents of ISO/TC 211 (International Standard Organization – Geographic Information/Geomatics), particularly in ISO 19157 (Geographic Information – Data Quality) (ISO, 2013). The latter should be considered as a reference for extracting the estimation methodology and description of criteria for verifying quality parameters to be used in the preparation of test specifications.

Furthermore, the Geotopographic Database is designed to allow continuous updating of the information it contains, with the possibility of multi-user updates. This management mode requires tracking every change, even on a single object of the Geotopographic Database. This cannot be guaranteed by the metadata (Brodeur et al., 2019) envisaged by the RNDT, National Territorial Data Repository (Agency for Digital Italy, n.d), and therefore, it is necessary to use instance or operational metadata.

Instance metadata is crucial both at the time of the initial setup and subsequently when the database is updated through different sources and/or by different users. The minimum content that instance metadata should have for effective management of the Geotopographic Database includes, for each object, the start date of validity and the end date of validity. Other highly desirable contents for detection include the source, positional accuracy, completeness, and thematic accuracy.

The overall quality verification of the Geotopographic Database must ensure that each individual parameter provides values within the limits set during design and declared in the technical specifications for surveying and testing in the tender or the requirements established for update activities.

4.1. Quality parameters

The quality parameters considered are described below:

- Logical Consistency;
- Positional Accuracy;
- Completeness;
- Thematic Accuracy.

The first parameter pertains to evaluating the degree of adherence to the content specifications of the Geotopographic Database, concerning both conceptual structuring and physical schema. It assesses conformity to the geometric model, related informational content, and spatial integrity constraints.

The second parameter assesses the quality of the territorial survey of objects concerning their planimetric and altimetric location (east, north, and elevation coordinates), based on direct measurements on the ground and the positioning of a sample of control points selected in the Geotopographic Database. It evaluates the deviation of coordinates from the actual position on the ground relative to the tolerance specified in the survey specifications. Depending on the topography examined, it checks whether the coordinates of the points fall within the planimetric and altimetric accuracies stipulated in the survey specifications.

The third parameter, completeness, provides the reliability of the presence/absence of a specific topographic object in the Geotopographic Database. The admissibility limits for completeness are expressed as percentages relative to all objects of a certain type present in the surveyed territory.

The fourth parameter assesses the accuracy in assigning qualitative and quantitative values to objects in the Geotopographic Database. The required degree of reliability for each type of object is expressed in percentage terms.

The ISO 19157 document (Geographic Information – Data Quality) (ISO, 2013) defines a more general parameter that evaluates the Temporal Quality of data, specifying temporal accuracy, temporal consistency, and temporal validity as individual elements referred to it.

Therefore, to manage the quality information covered by the mentioned parameters, quality metadata has been added to instance metadata. Compared to instance metadata, which pertains to accompanying information for individual objects belonging to the Geotopographic Database, quality metadata occupy an intermediate conceptual level between these and those contemplated in the National Territorial Data Repository (RNDT).

The percentages assigned to quality parameters are always calculated based on the results related to objects belonging to the sample identified for the verification tests. This sample may change over time due to updates made to the Geotopographic Database and is therefore traced by instance metadata. Only logical consistency is verified on all objects belonging to the dataset.

5. Conformity of a Geotopographic Database

The conformity of a Geotopographic Database must be verified for several new aspects that are unique to databases and defined by the specifications attached to the Italian Government Decree. It is important to distinguish between two different types of conformity that have different implications for verification and impact on data quality (Amadio, 2014b).

Real Conformity is defined as the correspondence between the observed information and the represented real world. This correspondence can only be tested through manual procedures. This type of conformity is characterized by the following aspects:

- It is a requirement for both Geotopographic Database productions and traditional cartographic productions, subject to cartographic testing rules.
- It must be tested based on statistical sampling, as exhaustive control is not possible.
- It must be tested manually because the interpretation of the real territory cannot be done automatically.
- This type of verification includes checking that objects in the real territory specified by content specifications have been surveyed and correctly classified, and that the survey meets the accuracy parameters and admissibility limits required by survey technical specifications.

Therefore, the quality parameters to document real conformity are positional accuracy, thematic accuracy, and completeness. The survey technical specification must declare the percentages within which the data can be considered compliant.

Some methodologies are under study that, leveraging the peculiarities of the conceptual model of Geotopographic Databases, aim to highlight possible errors of real conformity through semi-automatic operations. The chosen approach is to use software procedures to analyze Geotopographic Database objects that exhibit anomalies in context, geometric shape, cardinality, relative position, etc.

Intrinsic Conformity is defined as the correspondence between the information contained in the Geotopographic Database and the properties that this information must satisfy according to the specifications. This type of conformity is characterized by the following aspects:

- The testing of intrinsic conformity can be performed exhaustively, i.e., all produced information can be checked.
- The testing of intrinsic conformity can be performed completely automatically and does not require manual intervention if adequate instrumentation is available.
- This type of verification includes checking all types of information, particularly geometric types, checking the completeness of recorded attributes, and checking topological properties of represented objects, etc.

Therefore, the quality elements to document intrinsic conformity are related to the logical consistency parameter: conceptual, domain, format, geometry, and topology.

One aspect of intrinsic conformity that requires special attention is the implementation of the geometric properties of GeoUML. In fact, when defining geometric and topological properties, reference is made to the continuous Euclidean space, in which coordinates are real numbers. However, implementations are based on a vector representation of geometries with coordinates represented by numbers in finite precision. Hence, aspects related to the vector representation of geometries, problems arising from data processing, and rules necessary to avoid topological ambiguities.

The tool dedicated to supporting the verification of intrinsic conformity of Geotopographic Databases is the GeoUML Validator, which can read data produced according to a content specification defined with the GeoUML Catalogue and provides diagnostic information.

Compliance with real conformity, while meeting the criteria established in the design phase with reference to the application uses to which the Geotopographic Database is intended, may be subject to revaluations made both during the work and subsequently on the final product.

Conversely, intrinsic conformity is subject to much lower margins of flexibility and responds to criteria that consider the need to load and process data through software procedures and to be able to perform quantitative analyses on the data itself. Therefore, formal correctness is indispensable to obtain valid results.

To decide on the acceptability of a Geotopographic Database production from the point of view of intrinsic conformity, it is necessary to establish whether and to what extent any errors in the controlled aspects can be accepted and managed. For this reason, acceptability criteria have been established, and frequent case studies and guidelines have been identified.

With the update of the Territorial Data Catalog carried out in 2016, many of the issues that emerged in the realizations made during the first three years of the entry into force of the 2011 November 10, Italian Government Decree were intercepted and resolved through small revisions to the conceptual model.

However, it is possible that further specific situations may arise in the future with the extensive application of the specifications, and therefore, they should be managed to be classified as certified errors and therefore acceptable.

Regarding the acceptability of the identified error categories, the execution direction, in agreement with the testing committee, must carefully evaluate each case in relation to project purposes, specific management and maintenance flows within which the Geotopographic Database is inserted; it must also assess the criticalities of the applications that the latter must feed. Effective tools to support this task are the instance metadata for error certification used in conjunction with the summary report produced by the GeoUML Validator.

6. Anomalies in the Geodatabase

The current automatic control systems for Geodatabases are based on defining constraints on data in the form of domain constraints, geometry constraints, attribute relationship constraints, and topological constraints. These formal constraints help identify errors in domains or geometric data but do not necessarily detect all content errors. It is possible that in a formally correct database where all constraints are verified, there may still be incorrect data that escapes traditional validation systems (Savino & Rumor, 2014).

In a Geodatabase, an anomaly is defined as a feature whose characteristics do not conform to typical values for that type of object. An anomaly differs from an error as it does not violate any formal constraints. It is data that could potentially be incorrect.

In this context, new approaches have been used to search for "anomalous" data in datasets, identifying errors that may be impossible to detect with traditional control tools. These anomalies are then brought to the attention of a human operator who will verify their actual accuracy and the extent of the error.

A taxonomy of anomalies can be provided by dividing them into four classes:

- Form anomalies;
- Cardinality anomalies;
- Position anomalies;
- Network anomalies.

Form anomalies can be further divided into regularity anomalies and semantic dimension anomalies. The former involves objects whose shape does not adhere to the concept that natural objects have irregular shapes while anthropic objects have regular shapes. An example is a lake with a rectangular shape. The latter concerns linear or areal objects whose size is too small or large compared to their semantic value, such as a forest with a size of 10 m^2.

For cardinality anomalies, consideration is given to the total number or distribution. The first anomalies involve objects found in an unexpectedly high or low number. A high number of parking spaces in an isolated area is a singularity. Some may associate the type with a characteristic distribution.

Position anomalies refer to other features. They involve objects that are spatially too far from other logically

Table 1. Amadio G. – quality requirements

Quality requirements					
Quality parameter		Class	Spatial component	Attribute	Description
Comp-leteness	omission/excess	5%	5%	5%	Missing data compared to the expected ones (percentage of omitted items relative to the expected number)
Logical consis-tency	conceptual	0%	0%	0%	Adherence to conceptual schema rules (percentage of items adhering to the schema relative to the total number of items)
	domain	0%	0%	0%	Adherence of values to their domain (percentage of items belonging to their domain relative to the total number of items)
	format	0%	0%	0%	Degree of conformity with the physical structure of the dataset in which the data are stored (percentage of items with correct topological characteristics relative to the total number of items)
	topological	0%	0%	0%	Accuracy of topological characteristics compared to those explicitly encoded (percentage of items with correct topological characteristics relative to the total number of items)
Thematic accuracy	classification	5%	5%	5%	Accuracy of the classification assigned to the object and its attributes (percentage of correct items relative to the total number of items)
	non-quantitative attributes	5%	5%	5%	Accuracy of non-quantitative attributes (percentage of correct items relative to the total number of items)
	quantitative attributes	5%	5%	5%	Accuracy of quantitative attributes (percentage of correct items relative to the total number of items)

connected objects. A lighthouse far from the sea or an airport far from a runway are clear examples of irregularities.

Network anomalies are divided into classification anomalies, connection anomalies, and direction anomalies. The first concerns connected elements of a network where there is a sudden or repeated isolated change in classification. For the second, it is assumed that a network should mainly contain connected elements. The third occurs in the case of oriented edges, where anomalies can be detected by analyzing differences in edge directions. A river flowing uphill is a singularity.

The definition and detection of anomalies are based on concepts related to logic and common sense, representing a new paradigm in the field of control tools. It is important to define how correct data appears rather than focusing on incorrect data. This undoubtedly requires significant effort in definition, allowing the identification of otherwise undetectable errors (Savino & Rumor, 2014).

7. Limits of acceptability

Quality controls aim to assess and document the level of correspondence between the actual characteristics of the data and those specified in the project (specifications). The evolution of geographic data structuring has brought about the need to adapt survey specifications and data processing, as they were traditionally tied to the now-transformed photogrammetry field. The production has shifted from traditional numeric cartography to a different type of support (Amadio, 2014a).

Currently, a significant challenge is the misalignment of survey specifications with the creation of Geotopographic Databases in compliance with the Italian Government Ministerial Decree. To conduct an analysis of the real and intrinsic compliance of a Geotopographic Database, the following quality parameters (ISO, 2003) need to be analyzed:

- Completeness;
- Positional accuracy;
- Thematic accuracy;
- Temporal accuracy;
- Logical consistency.

The first four parameters are characteristic of real compliance and are therefore subjected to manual field checks and checks against other sources. The last one defines intrinsic or model compliance, where automatic checks of format, domain, geometry, topology, and alphanumeric relationships are delegated to the Validator tool.

In this specific case, only the first three parameters will be considered, defining acceptable limits on the number of samples analyzed in the report. The critical issue highlighted is the lack of a well-defined protocol for checking the compliance of Geotopographic Databases with the Italian Government Ministerial Decree guidelines.

To define verification parameters, questions must be posed. For example, what number of inconsistencies can be considered acceptable? Which errors are certifiable? What tolerance should be used to define the coincidence between two vertices or the inclusion of a point in a polygon? To address these questions, acceptability limits have been proposed and summarized in the Table 1.

Starting from the acceptability limits proposed by Gianfranco Amadio, a real conformity check was simulated, downstream of the partially conducted intrinsic conformity check using the Validator tool. This check was performed for the database under analysis of the Italian northeast municipality.

The acceptability limits were applied to the parameters of completeness and positional and thematic accuracy. A conformity check was conducted by comparing the reports generated by the Validator and another GIS software.

Using the desktop application of an open-source GIS software, QGIS (n.d.), that allows for the analysis, visualization, organization, and representation of spatial data, subsets of data from the Italian northeast municipality were loaded as vector layers.

Following the loading of spatial data into QGIS, specific classes were chosen for verification. To proceed with the analysis, a summary report was generated using a feature of the GeoUML tools, providing percentage data on errors for the available occurrences in each layer, unlike the analytical report.

As the report was generated during validation using default metric and geometric parameters, some sample checks were performed to verify the accuracy and reliability of the reporting information.

For this analysis, a simple class was chosen as the first example, and QGIS functions were used to find an automatic methodology for the validation process. The chosen class, "Province," shows a 100% error in the number of analyzed samples in the metric control section of the report. The error type resulting from the Validator's analysis is "too many vertices," associated with the geometric attribute extension of the Province layer.

The process involved selecting the item for analysis in the software and applying the function to extract the layer's extension. To perform this operation, simply select *Vector*, *Research Tools*, and *Extract Layer Extension* from the menu (Figures 1 and 2).

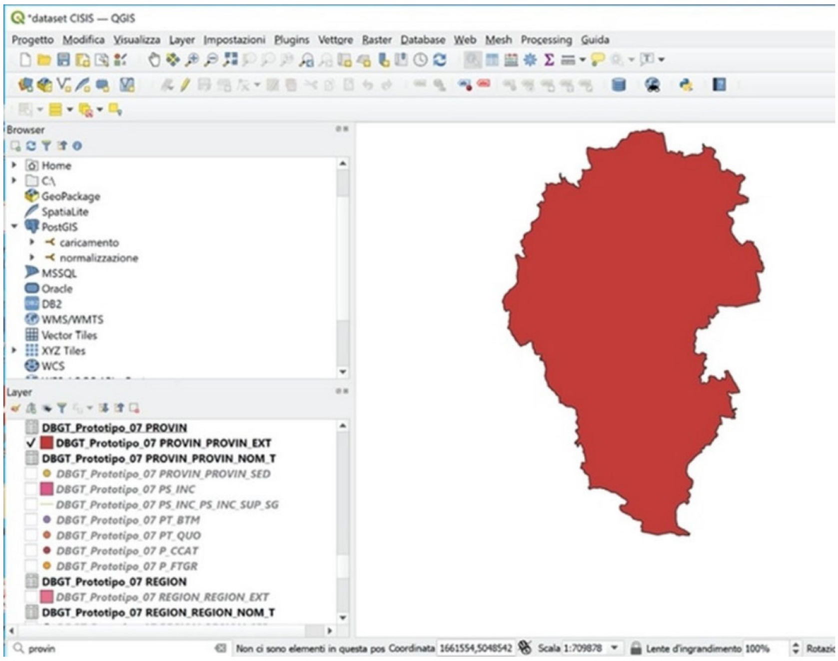

Figure 1. "Province" class selection on QGIS

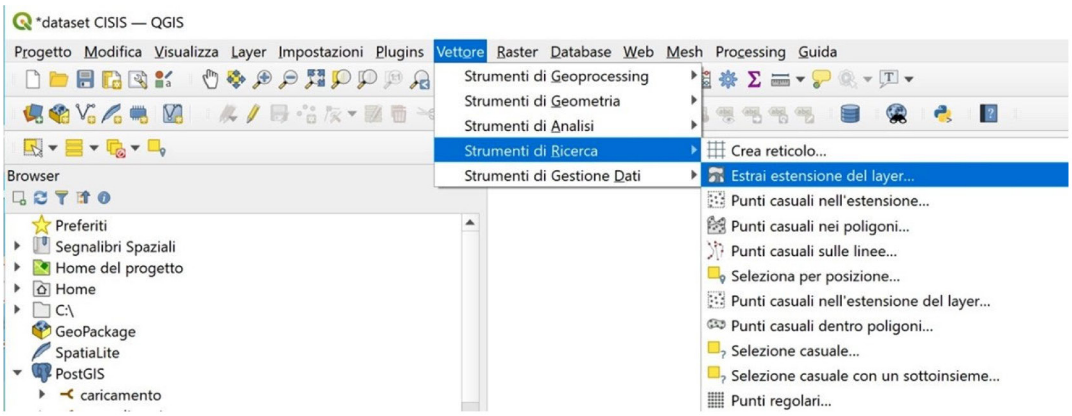

Figure 2. Layer Extension Extraction on QGIS

The extent of the layer is displayed as a rectangle that covers the entire province. Since the error was localized on the vertices of this extension, using "geometry tools", they were extracted and displayed on the screen (Figure 3).

In the description of this additional layer (vertices), the software reported a higher number of elements than those displayed. Through "search tools," specifically "random points within the layer's extent," it was possible to plot a point on the screen that did not correspond to any of the vertices. This confirmed the validity of the report (Figure 4).

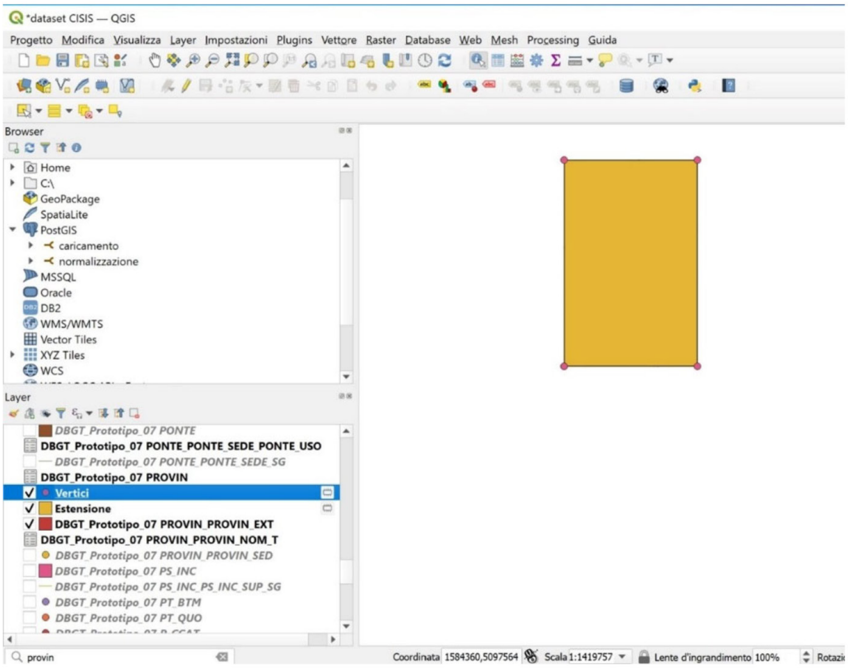

Figure 3. Extension Vertices Extraction on QGIS

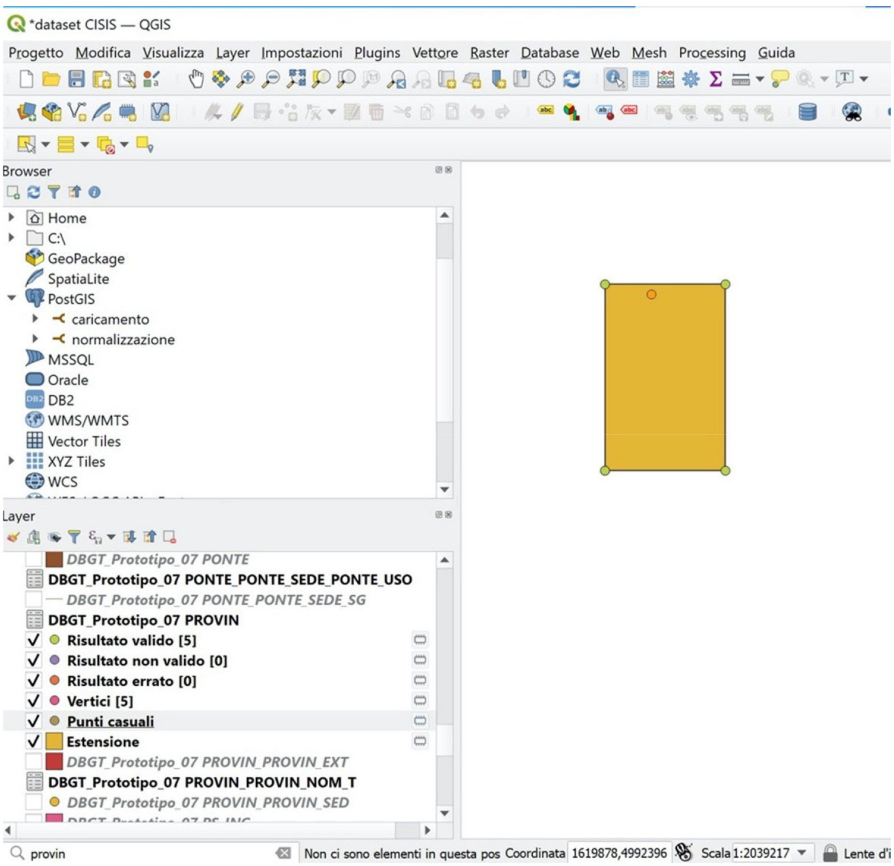

Figure 4. Random Point Extractions in the QGIS Extension

However, this methodology is not applicable to all classes and all types of errors resulting from the synthetic report, but only to a scenario similar to the one just analyzed. Using a QGIS plugin, it was possible to verify the geometries of some randomly chosen classes after analyzing the types of errors resulting from both synthetic and analytical reports (Figure 5).

The same default geometric parameters used in the Validator for report generation were then set, and the class to be subjected to verification was selected. As a first test, the "minor buildings" class was chosen. The geometry check revealed a total of 27 errors. With this application, it is possible to fix the selected errors by creating new layers. Only one error could not be modified to comply with the imposed standards (Figure 6).

The second class subjected to verification did not present any errors during the automatic geometry check. This class is the "Equipped Soil Area" (Figure 7).

Therefore, it is possible, through this QGIS application, to intervene semi-automatically on geometric checks, choosing the classes to analyze each time to avoid overloading the software.

These verifications, carried out through the cross-use of analytical and synthetic reports and QGIS, allowed us to verify the quality of the aforementioned and ascertain that not all attributes presented in the form of vector layers are included in the reports, as they do not have errors. These verifications belong to the analysis of logical consistency and, therefore, intrinsic conformity.

Moreover, reports of geometric and topological errors can also be documented graphically after examining the database with the Validator using an OpenJUMP plugin (16) (OpenJUMP, n.d.). This plugin also allows exporting reports in shapefile format.

To proceed with the verification of real conformity, the procedure is more meticulous as it must be carried out manually. This verification provides feedback on the quality of the collected data, their representation in databases, and compliance with the accuracy parameters

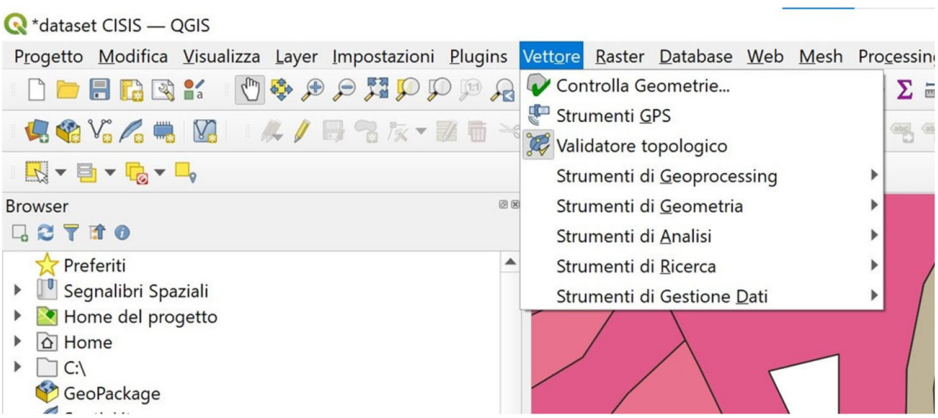

Figure 5. Automatic Geometry Control tool on QGIS

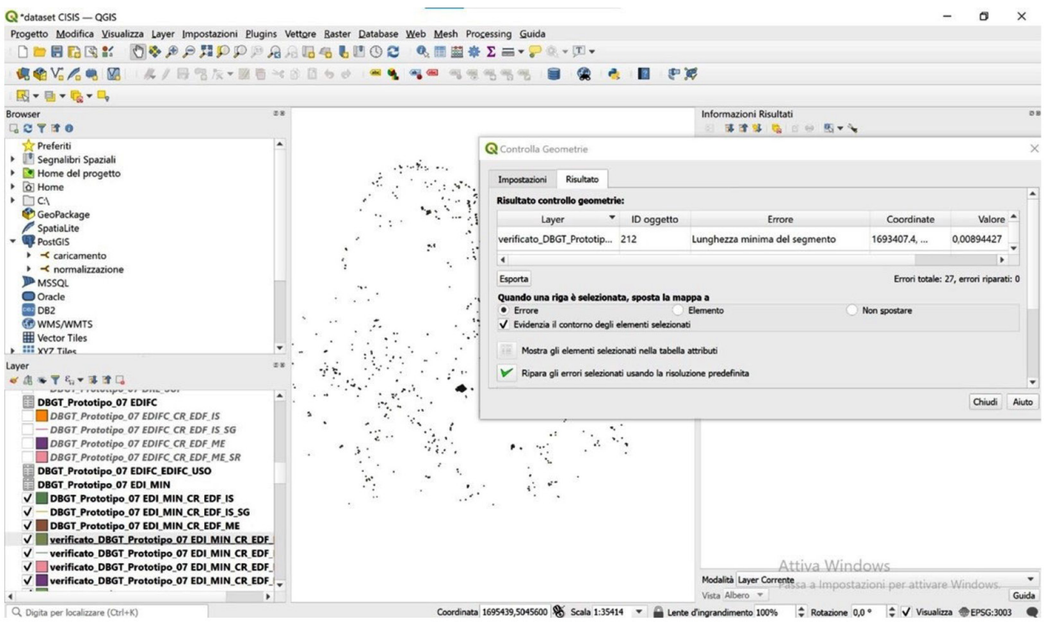

Figure 6. Check "Minor Buildings" Geometries

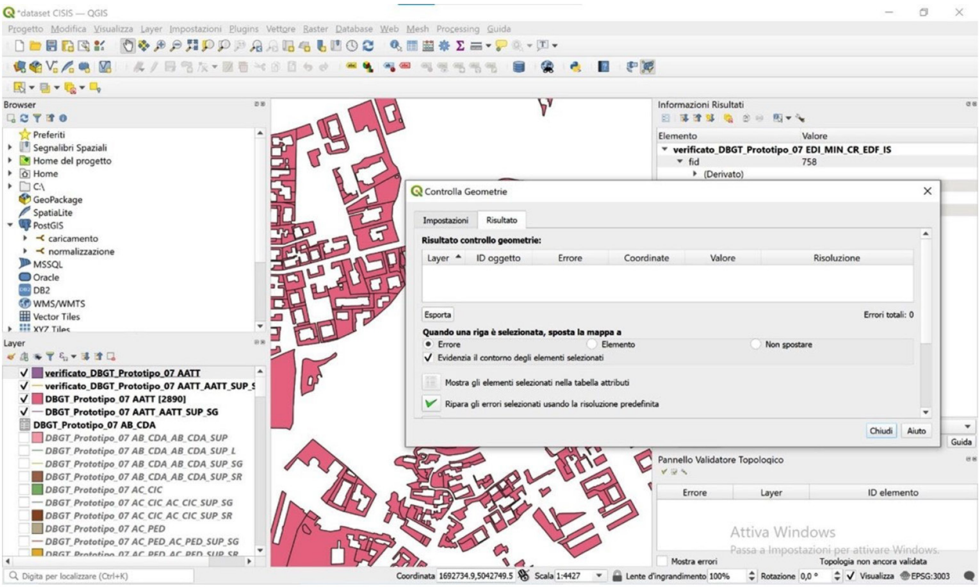

Figure 7. Check "Equipped Soil Area" Geometries

and admissibility limits required by the survey technical specifications.

To perform a real conformity check, we must select a sample of data to validate, for example, through QGIS, choose classes to analyze, and set acceptability limits, such as those proposed in Figures 6 and 7. For example, format, conceptual, domain, and topological errors on classes, spatial components, and non-quantitative attributes are not allowed as they would render the Geodatabase entirely unusable. The correspondence between the informative content of the dataset and the portion of the real world to which the dataset refers must be sought, in relation to the content specification. This procedure carried out during testing is entirely manual.

Once the classes to be analyzed are chosen, for example, "Buildings," it is necessary to define acceptability ranges for the parameters of Completeness, Logical Consistency, and Thematic Accuracy.

If we choose to analyze completeness, we need to check for missing data within the database compared to the expected ones and ensure that they fall within the minimum required percentage range for the data to be acceptable. To perform this check, it is necessary to compare the data with on-site checks during testing and other sources suitable for certification, depending on the chosen class for analysis. It is crucial to pay attention to the consistency of the data under analysis, especially regarding the analysis of thematic accuracy. For each parameter used to analyze the data database, the acceptability percentage, defined on the number of samples available for each class, must always be considered.

8. Conclusions

The main issue encountered was the lack of clear guidelines regarding survey specifications. Currently available software has limited applicability for partial checks and does not support exhaustive verification of the components of a database. This implies that human intervention during testing is still essential.

Another issue identified, highlighting the need for further development and improvement of current tools, was the difficulty in generating reports with the available applications and the complex interpretation of these reports. The process remains cumbersome and not very intuitive. Specifically, an incorrect structuring and incompleteness of the database related to a commonly used municipality were highlighted. This difficulty led to the use of an alternative database for quality analysis.

For the latter, the focus was on understanding the meaning of intrinsic and actual conformity, initially providing purely theoretical examples with a comparison to Professor Rumor's studies. Subsequently, through the analysis and comparison of analytical and synthetic reports and the QGIS software, the verification of certain classes with detected errors was conducted. Viewing the database on QGIS revealed that the process of analyzing and searching for errors is lengthy and cumbersome. This can be attributed to the fact that the better the structuring, the larger the amount of data to process, making the search for inconsistencies more meticulous and challenging.

In order to achieve a general improvement in the validation procedure of geographic information, it is conceivable, in the short to medium term, to refine the structure and organization of data, leading to a subsequent update of still incomplete national databases. Furthermore, another short-term development could be to establish more accurate and detailed guidelines regarding survey specifications, providing stakeholders with a shared protocol to homogenize the operational phases of acquiring geographic information through various available sensors.

Finally, as a long-term development, it is desirable to explore and develop automatic procedures for quality assessment to reduce the subjective component in data checks and provide the research and professional community with an effective tool that fully adheres to national and international standards.

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This publication aims to pay tribute to the work and commitment of Mariasofia Paparo, who tragically passed away two weeks before defending her thesis at the University "Parthenope" in Naples, Department of Studies in Sciences and Technologies, within the master's degree in Navigation Sciences and Technologies. The University has chosen to award Maria Sofia a posthumous degree to commemorate the completion of her academic journey and to lovingly remember her as an individual, her enthusiasm, her abilities, and her value. Mariasofia Paparo will live on in our hearts, and her smile will forever brighten our days.

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