COMPARISON OF SURVEY AND REPRESENTATION TECHNIQUES FOR ARCHITECTURAL OBJECTS

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ABSTRACT

In recent years, some historical buildings in Turin have been the subject of surveying campaigns that have gradually used more modern techniques and instruments for both the survey and representation phases. The ex-San Giovanni hospital, and other relevant buildings, represents complex survey applications in that they are made up of different parts. As a whole, this complex is referred tos "the hospital" but it can be divided into different objects that are traditionally handled by different sectors of geomatics (topography, close range photogrammetry, aerial photogrammetry and terrestrial laser-scanning, among others). Each of these techniques has been used to surveying the building and has contributed to the geometric definition of the monument. Clearly, there should be only one reference system. This leads to problems connected to the geo-referencing of instrumental systems with different degrees of accuracy that allow a survey to be performed at different nominal scales. As a result, the surveys that have been conducted have different representation and accuracy characteristics.
Processed data can be compared when the deal with exactly the same area. It was deemed useful to compare the processed data in order to gain insight into the expediency of using a certain technique, according to the different scale and type of representation that was used. In terms of the representation of façade in raster form, photoplanes, orthophotos and true orthophotos were all produced.
These processed data use diverse digital reference models acquired by solid modelling.
Another important issue is the need to compare the products with their intended use, in order to verify the estimated costs and optimisation possibilities.
This paper presents the various experiments that have been performed and illustrates the methods and results that were obtained.

1. INTRODUCTION

The architectural and cultural patrimony is often in danger because of degradation, fire, and other disasters. Architectural surveying and recording should be considered a civil defence necessity of in the battle against its extinction.
Architectural archives of monuments and historic buildings, completed with geographical information of the surroundings, are valuable sources of information that can help to preserve, reconstruct and rehabilitate the Cultural Heritage.
Several organizations have been founded to protect the architectural patrimony and these reflect the great preoccupation that exists concerning its preservation. The most important examples are the *International Committee for Architectural Photogrammetry* (CIPA), the *International Council of Monuments and Sites* (ICOMOS), the *International Society of Photogrammetry and Remote Sensing* (ISPRS), which collaborate with the UNESCO to define the World Patrimony List.
These organizations established that the architectural patrimony that has to be protected and restored needs to be measured and documented: two modern techniques (digital photogrammetry and terrestrial LIDAR) are the means "par excellence" to obtain this aim.
The newest trend of Italian law concerning architectural heritage conservation extends the need of complete knowledge of the object. In the case of public property buildings, the law n. 109/1994 (concerning public building works) and the regulation n. 554/1999 deal with a process of knowledge and design is obtained in detailed manner.
One of the main goals of C.I.P.A. is to offer the possibility of sharing experiences between those who know the geometric survey techniques and those who know how to survey cultural heritage. The best way of obtaining this objective is to perform real and complete applications in order to highlight the degree of satisfaction of the customers and the real applicability of the proposed survey techniques.
The present work shows an application of several different techniques that were used to survey an architectural object: the ex-San Giovanni hospital that has been converted into the Regional Museum of Natural Sciences and which requires some restoration operations. The survey of a cultural heritage object, in order to support a restoration project, is not only a simple recording of the geometric aspects: there are many ways of recording and representing the geometry which depend on the different intended uses of the results.
In the application here presented, the classification of the decay, both the structural and decorative decay, and its correct location in a given reference system have the same importance as the purely geometric aspects.
While geometric problems can be correctly understood by photogrammetrists, the other aspects of the survey must be performed by specialists. The required knowledge is not covered by the typical engineering skills of photogrammetric researchers.
The measurement and documentation process should include the surrounding area. In this context, when the architectural patrimony is located in an urban area, it is necessary to create a 3D model of the surroundings in order to treat the complex information more easily.
This addition widens the range of users and promotes a link between preservation of the patrimony and urban administration.
Finally, the use of multi-media techniques to present and visualise geographic data enriches the architectural archives that are inserted into the 3D models. New techniques for data acquisition, processing, extraction, modelling and visualisation, which provide new means for the creation and spread of geographic information, become a priceless support for the preservation of architectural archives in areas such as historical studies and urban planning.
This article synthetically presents the work, in the form of a study case, that was carried out to produce architectural archives using different techniques. These techniques concern not only the extraction phase (monoscopic versus stereoscopic photogrammetry) but also the acquisition phase (laser scanner versus photogrammetric restitution). The results are also compared in terms of final accuracy and economic terms.

2. HISTORICAL ANALYSIS (SYNTHESIS)

A synthetic way presenting the historical survey of the part of the town where the ex-San Giovanni hospital was built, is to show how the urban tissue has evolved. A succession of images of the tissue, connected to various historical periods, was used. These maps can be found in "Torino nell'Ottocento e nel Novecento" (see References). This book is a detailed study that was used to form the town-plan in 1990 and is, therefore, an important example of how a scientific survey can support town planning and strategic financial investment programmes.

Figure 1. Part of the Turin map drawn by Carlo Morello in 1656, connected to the "Avvertimenti sopra le fortezze …", manuscript, Biblioteca Reale di Torino, Manoscritti militari, 178, 15v e 16r.

Figure 2. Part of the "Copia della carta dell'interiore della città", drawn in about 1765, Archivio di Stato di Torino, Carte, Carte top. Per A e B, Torino, 16

Figure 3. Part of the "Pianta geometrica della Reale città e cittadella di Torino", by I.A. Galletti, drawn up in 1790, Archivio Storico della Città di Torino, Tipi e disegni, 64-2-13

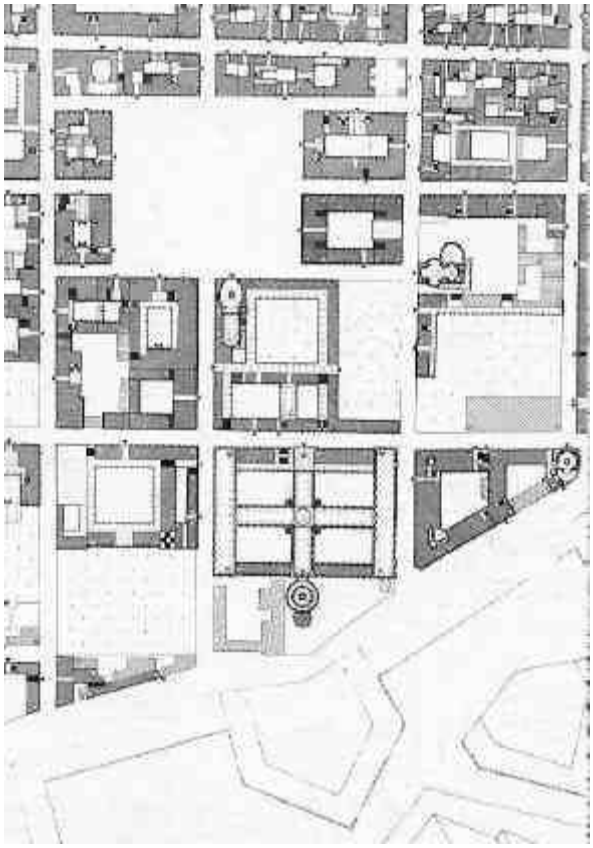

Figure 4. Part of the "Rilievo urbanistico filologico congetturale nell'ultimo quarto del Settecento" from: Istituto di Architettura Tecnica del Politecnico di Torino, "Forma urbana e architettura nella Torino barocca", UTET, Torino, 1968

Figure 5. Part of the "Carta geometrica della Real Città di Torino e sue adiacenze", by Andrea Gatti, Turin, 1823

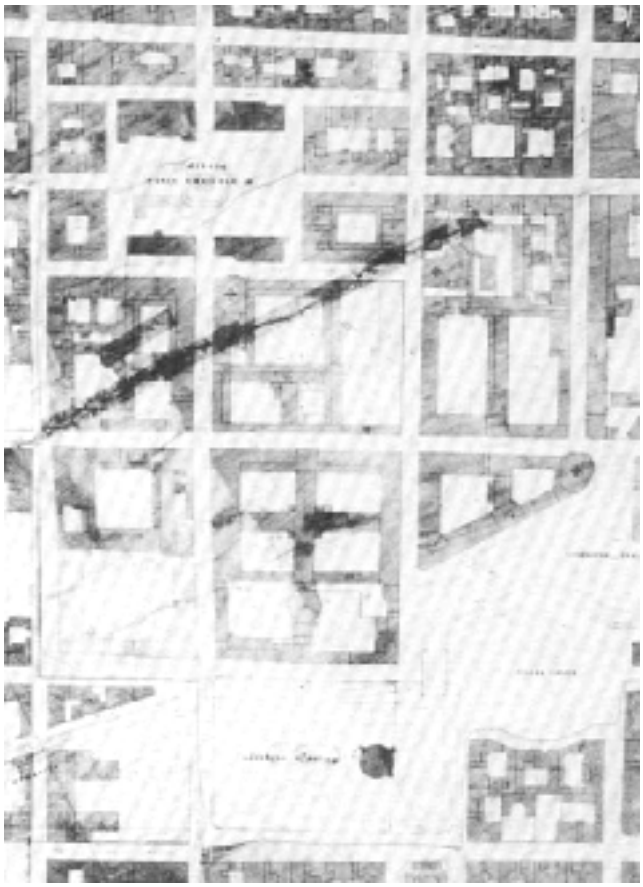

Figure 6. Part of the maps of "Catasto Rabbini", 17 maggio 1866, Archivio di Stato di Torino, Ministero delle Finanze, Catasto Rabbini

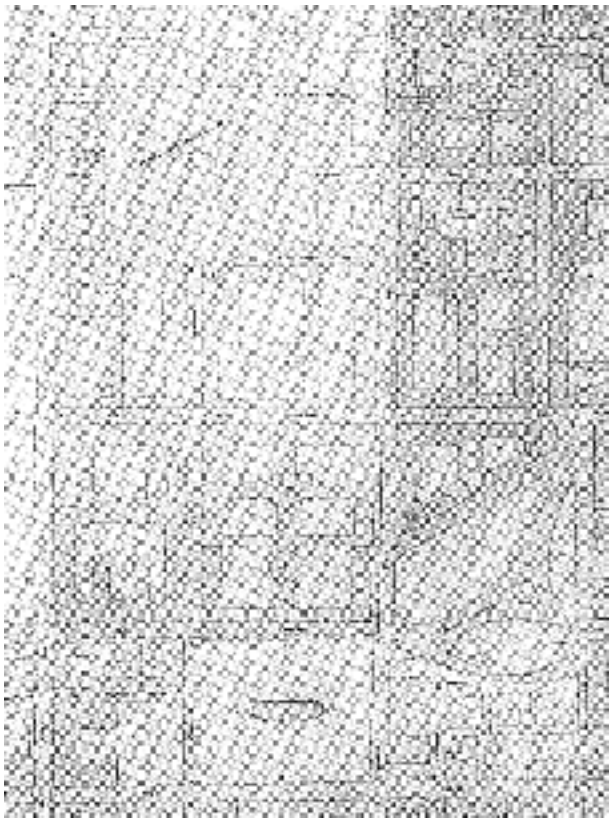

Figure 7. Part of the maps of "Catasto erariale", start of XX Century, Ufficio Tecnico Erariale, Torino

Figure 8. Part of the "Pianta di Torino coll'indicazione dei due piani regolatori e di ampliamenti", drawn up in 1925, Archivio Storico della Città di Torino, Tipi e disegni, 64-8-22

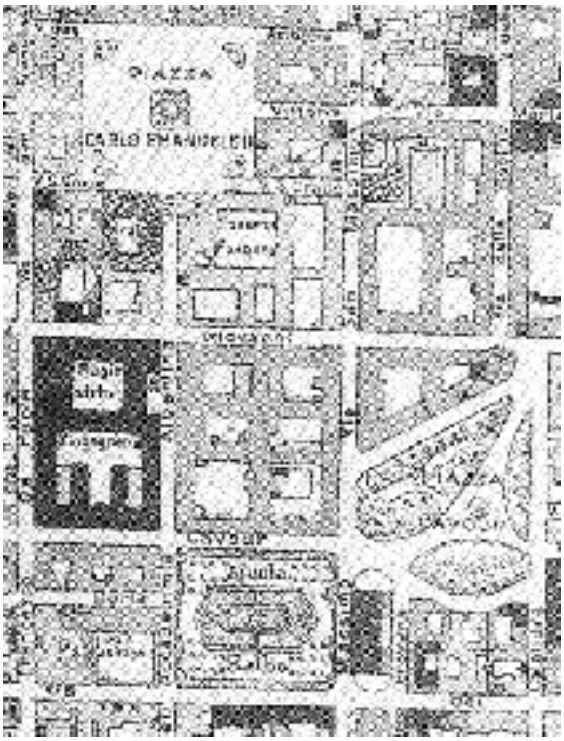

Figure 9. Part of the map that shows the damage to building in World War II, Archivio Storico della Città di Torino, Tipi e disegni, 64-8-22

Figure 10. Part of a true orthophoto of the City of Turin, 2004 (property of Città di Torino)

3. SURVEY PLANNING

In the same way as any other engineering job, this survey has also been planned according to:

a) a set of standard rules and specifications that was based on "Capitolato speciale d'Appalto…" (see figure 19 and references) in 1994. These documents contain several operative canons which allow the complete control of architectural survey phases, establishing practical guidelines, a content schema and ranges of accuracy;
b) a set of possible survey techniques that modern technologies make available to operators. These instruments offer applicative methodologies to produce final results. They are characterized by distinctive features which allow the user to find a correct solution to survey problems: this solution is optimal when the costs/benefits ratio is minimized in accordance to the standard specifications defined in a);
c) a set of particular details or parts of the building which makes up the surveyed architectural object: each part requires a different level of detail and several kinds of representation for a correct description. All of these details must be positioned in the same 3D reference system to permit the construction of the 3D model.

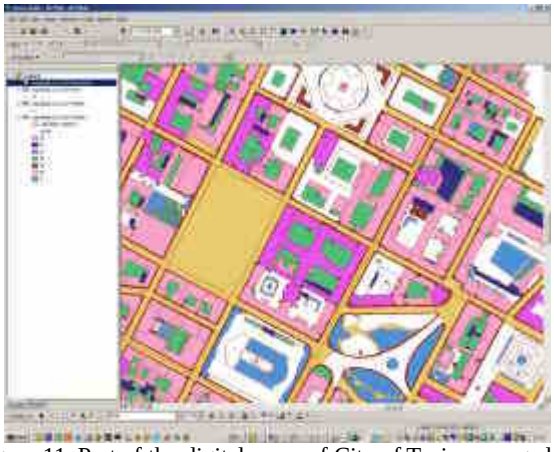

Figure 11. Part of the digital maps of City of Turin managed by GIS (property of Città di Torino)

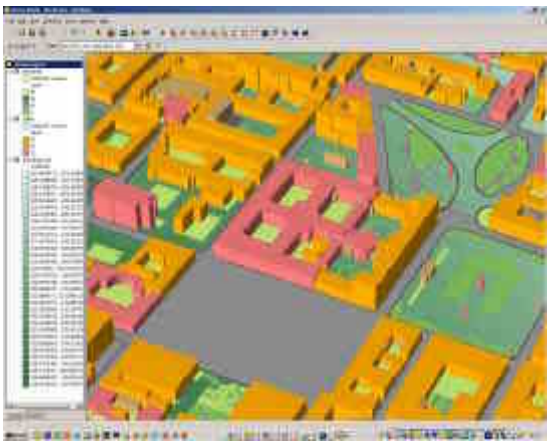

Figure 12. 3D model of the surrounding area of Ex-San Giovanni hospital

All survey technicians are well informed on the possibilities of modern architectural survey methods: total station with reflectorless EDM, digital photogrammetry, terrestrial laser scanner. These techniques have been used to describe a particular part of the object according to their geometric and radiometric characteristics.
The result of the survey planning is shown in Figure 13. This figure shows the several primary data acquisitions that were performed to survey an internal courtyard of "ex-San Giovanni

hospital": the 4 network vertexes (with the measurement schema) and the 6 auxiliary stations linked to the network (with the relative surveyed parts of buildings) in (A), the stereoscopic and monoscopic digital images and laser scanner acquisitions in (B).

4. A DIDACTIC PROJECT

The various aspects described in 3 constitute a didactic project that is part of the Degree course in Building Engineering at the Politecnico di Torino. The "Survey Laboratory" guides the students to compile a survey and representation operative study starting from an estimated budget of the expenditure and arriving at the final balance.
The Laboratory is a synthesis of several courses: 3 courses on topographic, cartographic and photogrammetric topics (instruments, methods and properties) and some courses on urban and architectural surveying and history which explore subjects inherent to "formal" topics, building materials, functional analysis and maintenance conditions.
Some examples of data acquisitions and processing have been shown in figures 14, 15, 16 and 17.

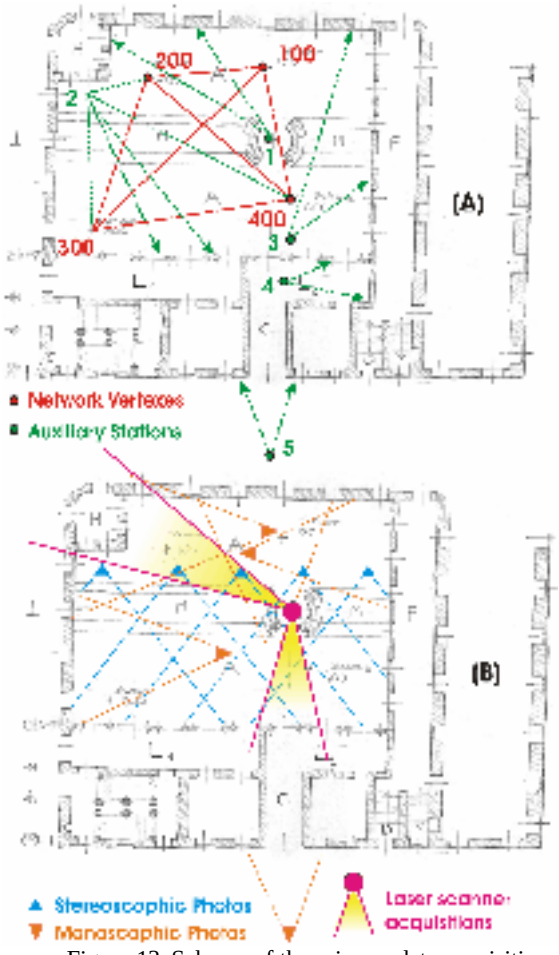

Figure 13. Schema of the primary data acquisitions

5. COMPARISON AND INTEGRATION

The already completed didactic project aims at integrateing the knowledge obtained by students in past courses.
The survey concerned a part of façade in the north-west courtyard of the ex-San Giovanni hospital. Each student had to be completed with a report survey. This report had to include some drawings of the object and the surrounding area in orthogonal projections (Frontal views, top view, vertical sections, horizontal sections) and in 3D views.
The drawings of the object during this practical lessons were in a 1:50 scale.

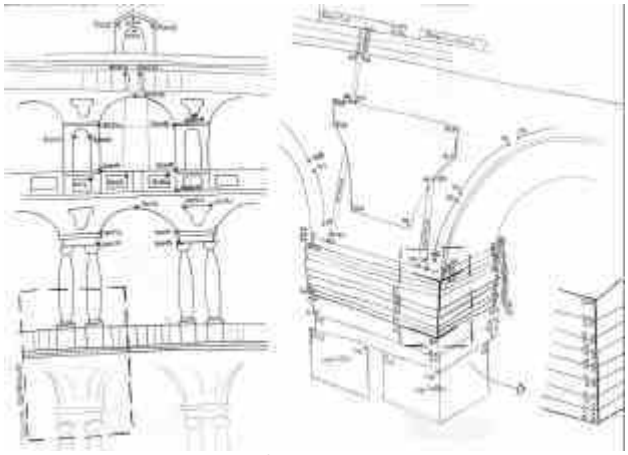
Figure 14. An example of a sketch to plan the measurements


Figure 15. An example of stereoscopic images


Figure 16. Two rectifications of monoscophic images

At the end of the these activities, a comparison was made of 3 different results:

1. theoretical model studies in an architectural style;
2. drawings from rectified images;
3. drawings from measured points using indirect techniques (total station and digital photogrammetry).

6. CONCLUSIONS

The design of both new and restored buildings, is a complex activity composed of several factors. This complexity is regulated by Italian law n. 109 of 1994, which controls public building works and by the regulation n. 554 of 1999, which contains specifications of the law (see figure 18).

This law is founded on the complete definition of each part of a building at each construction phases.
The law imposes that three should be a good degree of knowledge of the present state of the building in order to correctly manage the various construction stages: the preliminary design, the final design, the construction design. The study that was performed is able to supplied this knowledge.

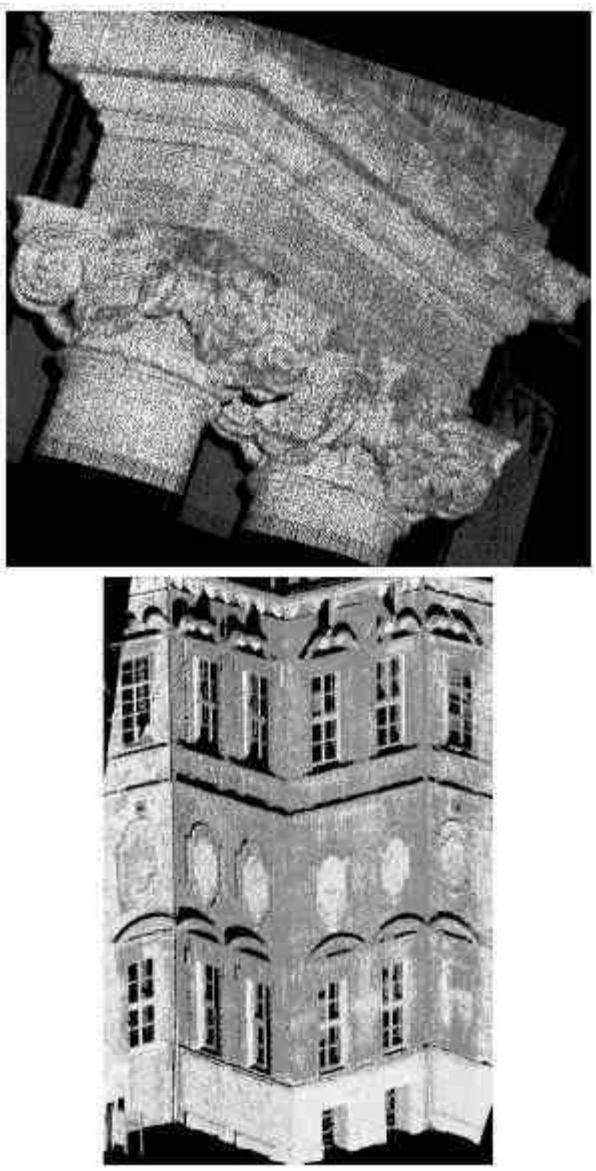

Figure 17. 3D view of two laser scanner acquisitions

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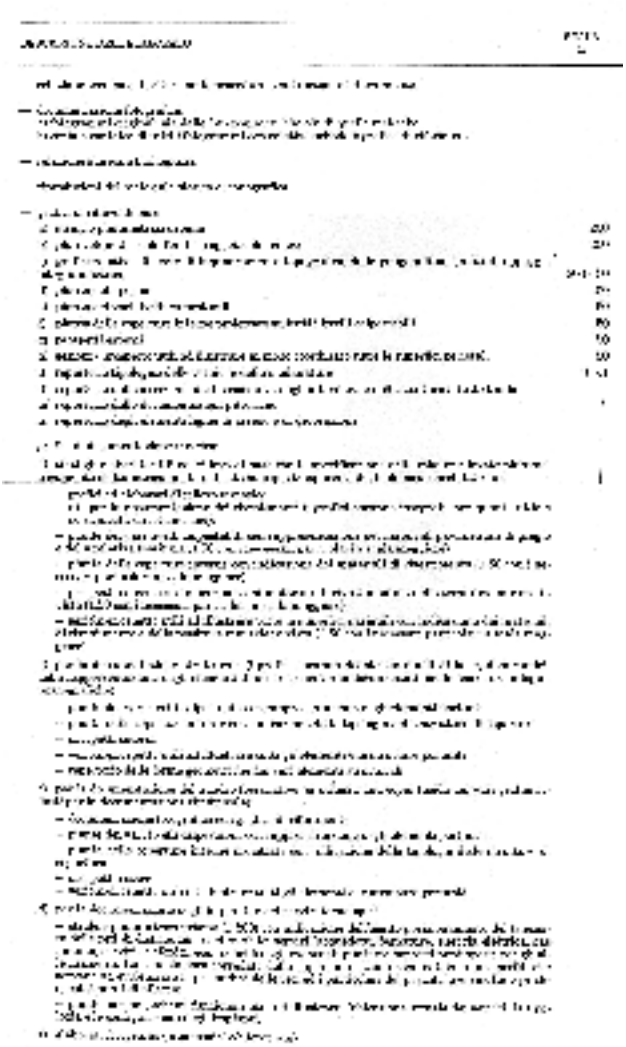

Figure 18. Index of italian technical specifications