EVALUATION OF REMOTELY PILOT AIRCRAFT (RPA) AS A SUBSIDY IN THE REGULARIZATION PROCESS OF HERITAGE AREAS: FEDERAL RURAL UNIVERSITY OF RIO DE JANEIRO HISTORICAL BUILDINGS, RJ

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Abstract. The use of Remotely Piloted Aircraft (RPA) has grown significantly in recent years in several applications such as geology, environmental monitoring, mapping, precision agriculture, among others. Aerial photogrammetry using RPAS becomes an adequate alternative for mapping small areas by linking cost-benefit to engineering projects, allowing a cartographic product with quality, lower cost, and greater operational ease. However, the data regarding this technology need to be better interpreted and further scientific analysis are required to validate its application in different areas of knowledge. Aiming this problem, the present work consists in evaluating the positional accuracy and precision of perimeter and area measurement extracted from products generated by aerophotogrammetric survey with RPA. Based on the regularization of the historical patrimony heritage process in the Federal Rural University of Rio de Janeiro, this work aimed to compare the results produced by the photogrammetric survey with a classic topographic survey data executed in the same area, thus evaluating the potential use of RPA technology for this purpose. We concluded that, compared to classical surveying, the RPA technique in the scope of architectural heritage processes, proved to be solid and robust for the purpose of obtaining quantifiying buildings area and perimeter (planimetric coordinates and measurements).

Keywords: Aerophotogrammetry; Geoprocessing; Heritage Process; quality control; RPA.

AVALIAÇÃO DO USO DE AERONAVE REMOTAMENTE PILOTADA (ARP) COMO SUBSÍDIO NO PROCESSO DE REGULARIZAÇÃO DE ÁREAS TOMBADAS: PRÉDIOS HISTÓRICOS DA UNIVERSIDADE FEDERAL RURAL DO RIO DE JANEIRO, RJ

Resumo. A utilização de Aeronaves Remotamente Pilotadas (ARPs) tem crescido significativamente nos últimos anos em diversas aplicações como

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geologia, monitoramento ambiental, mapeamento, agricultura de precisão, entre outras. A aerofotogrametria empregando ARPs se torna uma alternativa adequada para mapeamento de pequenas áreas atrelando custo-benefício a projetos de engenharia, permitindo um produto cartográfico com qualidade, menor custo e maior facilidade operacional. Entretanto, os dados referentes a esta tecnologia carecem de interpretação e análises científicas mais aprofundadas que permitam validar sua aplicação nas diversas áreas do conhecimento. Visando tal problemática, o presente trabalho consiste em avaliar a acurácia posicional e a precisão na determinação de dimensões de perímetro e área extraídas de produtos gerados por levantamento aerofotogramétrico com ARP. Tendo como aplicação a regularização do processo de tombamento do patrimônio histórico da Universidade Federal Rural do Rio de Janeiro, buscou-se comparar os resultados produzidos pelo aerolevantamento com os dados obtidos pelo levantamento topográfico clássico executado na mesma área, avaliando-se assim a potencialidade do uso da tecnologia ARP para esta finalidade. Concluímos que, comparativamente ao levantamento topográfico clássico, a técnica ARP no âmbito dos processos de tombamento, mostrou-se sólida e robusta para fins de quantificação da área e perímetro das edificações (coordenadas planimétricas e medidas).

Palavras-chave: Aerofotogrametria; Geoprocessamento; Tombamento; controle de qualidade; ARP.

EVALUACIÓN DEL USO DE AERONAVES REMOTAMENTE PILOTADO (ARP) COMO SUBSIDIO EN EL PROCESO DE REGULARIZACIÓN DE ÁREAS *TOMBADAS*: EDIFICIOS HISTÓRICOS DE LA UNIVERSIDAD FEDERAL RURAL DE RÍO DE JANEIRO, RJ

Resumen. El uso de Aeronaves Remotamente Pilotado (ARPs) ha crecido significativamente en los últimos años en varias aplicaciones como geología, monitoreo ambiental, cartografía, agricultura de precisión, entre otras. La aerofotogrametría empleando ARP se convierte en una alternativa adecuada para el mapeo de áreas pequeñas, vinculando costo-beneficio a proyectos de ingeniería, permitiendo un producto cartográfico con calidad, menor costo y mayor facilidad operativa. Sin embargo, los datos referentes a esta tecnología necesitan una mayor interpretación y análisis científico para validar su aplicación en diferentes áreas del conocimiento. Con el objetivo de abordar esta problemática, el presente trabajo consiste en evaluar la exactitud posicional y la precisión en la determinación de dimensiones de perímetro y área extraídas de productos generados por levantamiento aerofotogramétrico con ARP. Teniendo como aplicación la regularización del proceso de volcado del patrimonio histórico de la Universidad Federal Rural de Río de Janeiro, se buscó comparar los resultados producidos por el levantamiento aéreo con los datos obtenidos por el levantamiento topográfico clásico realizado en la misma zona, evaluando así el potencial del uso de la tecnología ARP para este propósito. Concluimos que, en comparación con el levantamiento topográfico clásico, la técnica ARP en el contexto de los procesos de vuelco, demostró ser sólida y robusta con el propósito de cuantificar el área y el perímetro de los edificios (coordenadas planimétricas y medidas).

Palabras clave: Aerofotogrametría; Geoprocesamiento; *Tombamento*; control de calidad; ARP.

Introduction

One way to preserve historical heritage is to record their current status in order to monitor and reference any future interventions. The use of geotechnology tools makes possible the knowledge about the dynamics of the territory efficiently and effectively (Borges et al., 2017; Pereira et. al., 2017). Also, according to these authors, with the development of low-cost technologies and free software, several possibilities of geoinformation production that were previously restricted due to lack of financial resources emerged. In this context, the use of RPAs (Remotely Piloted Aircraft) stands out for being a technique with wide potential for applications in various areas of the scientific field (Silva & Borges, 2017), including the study of historical heritage, allowing the acquisition of most diverse information in areas of knowledge (Komazaki et al., 2017).

RPAs can be defined as unmanned aerial vehicles (UAVs) equipped with a satellite positioning system (GNSS) and an Inertial System (IMU), responsible for airborne sensors (cameras) of various types. An RPA, therefore, allows the acquisition of information that can be used for the most diverse areas of knowledge (Komazaki et al., 2017).

The great advantage of RPA is its high performance over information and data acquisition. It is possible to survey large areas with a relatively lower operating cost and faster compared to conventional techniques (Borges et al., 2017). The use of RPA to support heritage processes is presented as an alternative to reduce time and cost. Thus, the main objective of this study is to discuss the feasibility of applying orthophotomosaics produced from sensors embedded in RPA and digital post-processing phases to delimit and regularize historic heritage sites by performing a data comparison between generated data from the vectorization of the images acquired with RPA and the products derived from a classical planimetric surveying.

Theoretical Review

Classical surveying can be defined as a set of principles, techniques and conventions used to measure dimensions, boundaries and relative points position land physical surface (Guimarães and Blitzkow, 2011). The main background of classical survey is built through geometry and trigonometry representation, and for this reason, Espartel (1987) states that topography does not take terrestrial sphericity into account in its calculations. Recognizing that, it's necessary to measure angular and linear observations on the Earth surface. After that, we can calculate the coordinates for each point taken in the Earth surface. The result obtained though classical surveying techniques are topographic maps.

For this set of operations that aims to represent the Earth surface by classical surveying is called Topographic survey (Espartel, 1987). Brazilian Standart NBR 13.133 dispose on topographic survey execution, splitting it into two subjects: the first one is named Planimetric Survey, which deals with the determination of planimetric coordinates (X and Y); the second one, Altimetric Survey, aims to determinate the vertical component (Z). These techniques combined gives rise to Planaltimetric Survey.

Aerial Survey can be defined as a set of techniques that capture geometric information using a bundle of georeferenced aerial photographs. Aerial survey processes are divided in many steps and are showed in the following article items:

(1) Interior Orientation: This step allow the reconstruction of the image perspective beam from aerial photographs to stablish a relationship between image space and measure system (Coelho and Brito, 2007).The principle assumes that the images obtained are isolated from each other and without any metric information associated with them, in other words, using only the digital image coordinate system.

(2) Exterior Orientation: The exterior orientation main objective is reference each photography to the space object by obtaining the position (X0,Y0, Z0) and attitude/orientation omega, phi e kappa (ω,ϕ and κ, respectively) from the camera. These six parameters can be easily solved by Colinearity Model (Coelho and Brito, 2007). Therefore, an image is externally oriented if the six Exterior Orientation Parameters

(EOP) for it are known, namely: coordinates of perspective the center in the object space and angles of rotation or attitude of the sensor (ω, ϕ and κ). The method approached differs from the classical Analogic and Analytic Principles of Photogrammetry, which are dived into two processes: relative and absolute orientation. The relative one reference each beam to its counterpart, reconstructing the exact position of a pair in space during the taking of photos.

Thus, the absolute one reference the stereoscopic pair to the terrain level (scaling and leveling the model).

(3) Aerialtriangulation: Uses the geometric relationship between adjacent photographs, sparse field control and approximate parameter value set by forming spatial triangles. Aerial Triangulation efficiently generates accurate coordinates of points in object space from coordinates of image space. Aerialtriangulation unknowns are the exterior orientation parameters, as well as the points coordinates in object space (X, Y, Z). It may be inferred that aerialtriangulation is the densification of control points used in the correlation between the aerial photos image and the mapping coordinate system, starting from a few known coordinate points in both systems (photographic and in the terrain) and which will be used in the mathematical solution for the bundle block adjustment.

(4) Ortoretification: Orthophotos are photographic representation of a region of the earth's surface, in which all elements have the same scale, free of errors and deformations, with the same value as a cartographic plane. They are produced by a set of aerial images (taken on an airplane or satellite) that have been digitally corrected to represent an orthogonal projection without perspective effects, whereby accurate measurements can be made, as opposed to a simple aerial photograph, which always shows deformations caused by the camera's perspective, altitude, or the speed with which the camera moves. This digital correction process is called orthorectification. Briefly, image orthorectification is the process that transforms photographs with central perspective into orthogonal perspective.

Aiming to establish a comparison and evaluation metric of cartographic products in analogical environment, was created by the Act 89.817, in June 20 of 1984, the

Cartographic Accuracy Standard (PEC). This standardization uses statistical indicators to ensure the positional quality of various cartographic products.

With technological evolution, the generation of these items, which use geospatial data and information, through digital means has become a very frequent procedure in Cartography, causing the act to be updated to reflect the observed reality and the demand of the users. To attend this demand, the Geospatial Data Set Product Technical Specifications (ET-PCDG) were created, which define the quality elements for each type of digital product. In order to align analogue to digital information to obtain a comprehensive study of cartographic accuracy and precision, the Cartographic Accuracy Standard for Digital Cartographic Products, better known as PEC-PCD, emerges.

The PEC-PCD uses two statistical indicators of Absolute Positional Precision (APA) and Cartographic Accuracy (EC) as the main elements for the analysis of cartographic quality in digital media. The following Table 1 illustrates the Cartographic Accuracy Standard (PEC) for digital planimetric products:

Table 1: Cartographic Accuracy Standard for Digital Planimetric Products.

PEC [1]	PEC-PCD	1:1.000		1:2.000		1:5.000		1:10.000	
		PEC (m)	EP (m)	PEC (m)	EP (m)	PEC (m)	EP (m)	PEC (m)	EP (m)
-	A [2]	0,28	0,17	0,56	0,34	1,40	0,85	2,80	1,70
A	B [1]	0,50	0,30	1,00	0,60	2,50	1,50	5,00	3,00
B	C [1]	0,80	0,50	1,60	1,00	4,00	2,50	8,00	5,00
C	D [1]	1,00	0,60	2,00	1,20	5,00	3,00	10,00	6,00

Source: DSG (2016).

Notes: EP= “Erro Padrão” or Standard Error; PEC= “Padrão de Exatidão Cartográfica” or Cartographic accuracy standard.

[1] Values determined or adapted based on the values of the Planimetric PEC provided for in Decree 89.817 of June 20, 1984.

[2] Digital Cartographic Products, based on the values used by the UK Ordinance Survey and National Joint Utilities Group, taken from ARIZA (2002, p. 87, where Cartographic Precision = 0.28 mm on the cartographic product scale and EP = 0.17 mm on the scale of the cartographic product).

Material and Methods

The Federal Rural University of Rio de Janeiro (UFRRJ) is a centenary institution whose construction of its permanent headquarters began in 1939 which consists of neo-colonial buildings and vast gardens, whose architectural set began its process of heritage in mid-1997. The State Institute of Cultural Heritage heritage process nº 412 (INEPAC, 2020) included the buildings which today hosts the University Central Administration (P1), the Institute of Biological and Health Sciences (IB), the Institute of Chemistry (PQ), the official Rector's Residence, in addition to the buildings where the Brazilian Agricultural Company (EMBRAPA - Agrobiology) and the Rio de Janeiro State Agricultural Research Corporation (PESAGRO) are situated. The study area is composed by these set defined as the original assets designed by Reynaldo's Dieserger architectural project and delimits the elements that assembles the university space. The area has approximately 181 ha and is located at Seropédica's city, in the state of Rio de Janeiro (Figure 1).

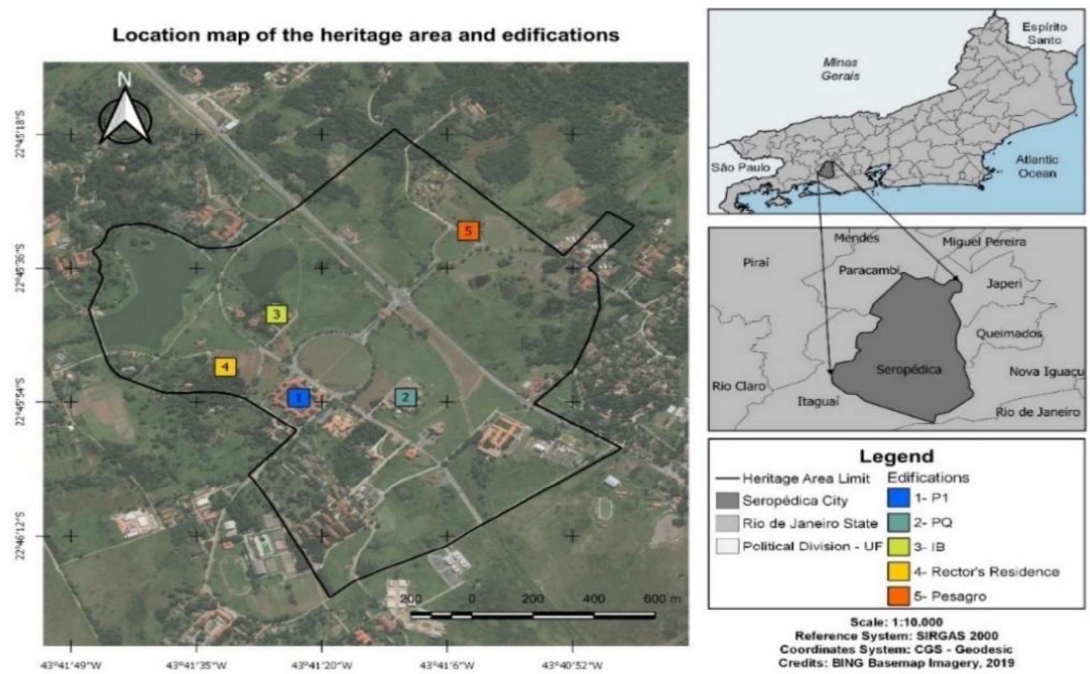

Figure 1. Study area location map. Unauthorized mapping of Embrapa's building (excluded). Source: Authors.

The limit of the heritage area was defined according to the pertinent information from INEPAC's document (INEPAC, Process n. E-18/001.540/98, 1998) which served as the main cartographic material for the graphic orientation in the vectorization process. The limiting feature of the study area was obtained through a GIS vectorization process using ArcGIS version 10.6 software. As the available file is in digital graphic format (extension ".pdf"), the vectorization had to be performed manually under a reference orthophotomosaic (sheet 2744-4-NO), obtained by free downloading, from Brazilian Institute of Geography and Statistics (IBGE) geoscience database website. The obtained orthophotomosaic (On scale: 1: 25.000) covers the entire region of Seropédica's city, where the UFRRJ campus is located.

For comparison purposes in this work, only the planimetric positions of the Classical surveyed points were considered, since the interest information was related only to the planimetry measurement (dimensions of area and perimeter). The survey was previously executed by the Survey Couse of the UFRRJ technical college with the assistance of the authors and reached a 1:1000 scale in class A of the Cartographic Accuracy Standard (CAC or "Padrão de Exatidão Cartográfica" – PEC, in portuguese) evaluation with an RMSE (discrepancies between North and East coordinates) about to 0.0271 m, approximately. The acquired data were associated with this work for comparative analysis.

As a legal device for comparison between the two methods researched, for the purpose of determining the area and perimeter of the buildings at cultural heritage processing, the legal device article 500 § 1 of the Brazilian Civil Code law nº 10.406 (Brazilian Civil Code, 2002) was used, where variations up to one twentieth are allowed and tolerated, corresponding to 5% of the total area of the properties in question. The classical survey execution steps can be seen in the follow flowchart described in Figure 2:

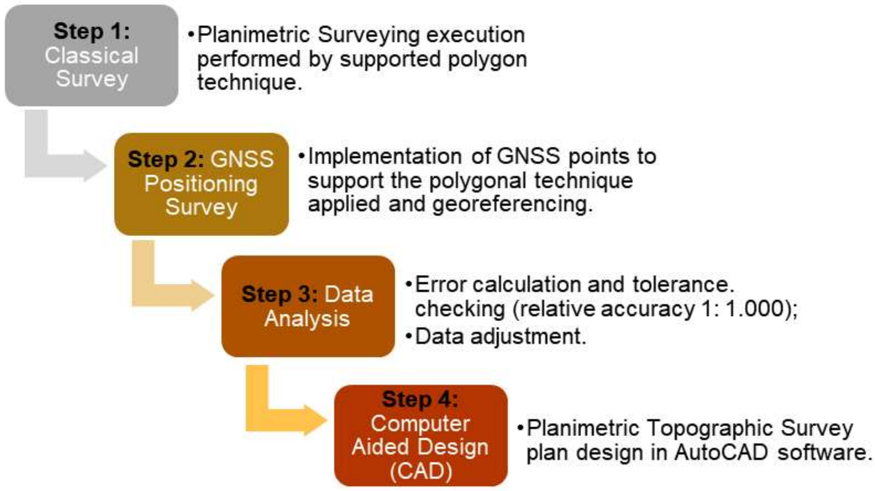

Figure 2. Flowchart of the Classical Survey Execution. Source: Authors.

The next step consisted on performing the aerophotogrammetric survey with the use of an RPA to obtain an orthophotomosaic and the cloud points for the study area, aiming to map the university's heritage area and gather the structural and dimensional characteristics of its existing features. For the orthophotomosaic generation was used an RPA, Model Mavic Pro from the company DJI. Based on the heritage area limit vectorization, it was found that the extent of the area to be mapped with the RPA was very large. Thus, it was necessary to divide this area into 4 smaller ones to ensure a flight planning in which all mapping area could be covered.

To do the flight plan, it was then necessary to individually vectorize these four areas in GIS environment, generating four vector files (shapefile format), which were later exported in ".kml" format to be read in the DroneDeploy software, which was chosen for the planning. for the execution of flight planning. The definition of the size of each area was based on the limitations of the RPA used when performing aerophotogrammetric surveys, even in terms of covered area length (30 ha/battery at 120 m altitude) as much as flight autonomy (25 minutes). Flight planning was performed in the DroneDeploy Software, having as reference values the lateral overlap of 75% and longitudinal overlap of 80%. Some important parameters have been defined to guarantee the quality and precision expected in the aerial photogrammetric survey, like: the flight height was 122m, aiming to produce a Ground Sample Distance (GSD) of approximately 4cm, compatible with the analyzes to be done in this work; the flight direction lines was set to -44° in order to avoid the influence of the wind in the execution of the flight plan at the aerial survey date. To support and validate the aerophotogrammetric survey, a significant amount of control and verification points were planned and distributed throughout the four surveyed areas by creating a regular 100 x 100 meter grid over the whole heritage area, using as a cartographic reference the orthophotomosaic acquired by the IBGE website. This planning part was made at a GIS environment. The total amount of points collected in field was: 42 for Area 1 and Area 2; 25 for Area 3 and 4, totalizing 134 points in the study area. These points were separated into control and verification points, according to the percentages of 70% and 30%, respectively (Table 2).

Table 2: Quantity and distribution of the points collected in field.

Area name (ID)	Total amount of points	Number of control points (70%)	Number of Checkpoints (30%)
Area 1	42	29	13
Area 2	42	29	13
Area 3	25	17	08
Area 4	25	17	08
Total	134		

Source: Authors.

Prior to the flight's execution, the targets were pre-signaled in field. Then, the RPA aerial survey was performed. Photo identifiable control and verification points were pre-marked with crosshead and/or pennant-shaped marks and materialized on the ground with lime powder. The coordinates of these points were obtained by performing a GNSS Positioning survey using RTK, model Leica Viva GS16. Each area (1, 2, 3 and 4) and their respective support points were collected on separate flights (Figure 3).

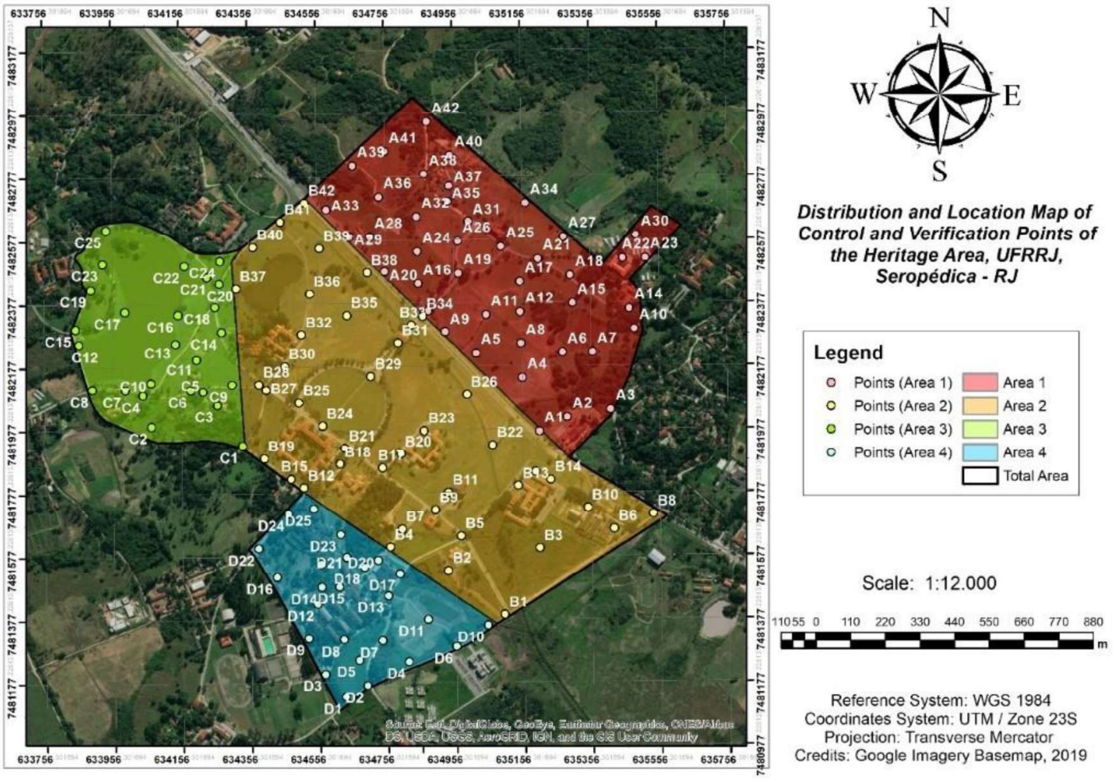

Figure 3. Distribution and location map of the support points (control and verification points) for in the study area. Basemap by Google Imagery. Source: Authors.

The images collected at the end of the entire survey were processed in a computational environment using the digital ARP image processing software Pix4DMapper, version 4.3.31, in order to produce the orthophotomosaic of the study area. The processing steps can be seen in the flowchart described in Figure 4 below:

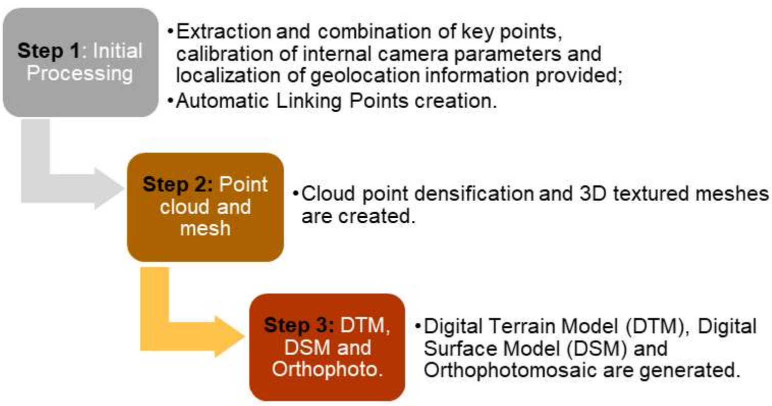

Figure 4. Flowchart for the performed processing executed in Pix4DMapper software. Source: Authors.

Based on the processing report generated by Pix4DMapper software, we sought to frame the aerial survey according to PEC-PCD. The Cartographic Accuracy Standard for Digital Cartographic Products or PEC-PCD (DSG, 2016) uses two statistical indicators of Absolute Positional Precision (APA) and Cartographic Accuracy (EC) as the main elements for the analysis of cartographic quality in digital media.

As a result of the aerial survey, an orthophoto was generated, with a terrain image pixel size (GSD) of 4.02 cm with a mean RMS error equal to 0.0194 m in georeferencing. Using as a basis the calculation of the RMSE resulting from discrepancies between the North and East coordinates, thus framing the cartographic product in PEC-PCD class A, with maximum scale of 1: 500 (which are superior than the obtained cartographic PEC-PCD scale 1:1000).

Based on the orthophotomosaic generated for the study area, the listed heritage buildings were vectorized. In order to define the best viewing scale, the orthophotomosaic was framed according to PEC-PCD. Also, based on the value of the Mean Square Error (RMSE), the generated product was classified in the planimetric PEC-PCD classification as class A on the 1:1.000 scale. Therefore, to perform this step vectorization, it was necessary to set the image viewing scale at 1: 500, which is compatible with the quality of the product generated by the RPA, measured by GSD. This procedure was performed in GIS environment and took into consideration the photointerpretation of the structural features of the building's roofs. It is noteworthy that this procedure limits the evaluation of the structure, since the orthogonal image does not allow the determination and vectorization of the features of walls, pilasters and other building elements. To overcome this limitation, it was necessary to measure the horizontal distance between the roof edge (used as the primary base for vectorization) and the wall. This technique was performed using classical surveying, using a total station capable of making measurements without prism. The eaves measurement procedure was adopted for all buildings present in the study, since each architecture had different structural dimensions associated with their respective roofs. Based on the values found, the boundaries of the previously vectorized areas were offset in order to delimit the area, considering the walls boundaries. This process was performed in the QGIS software, version 3.6.3, using the QAD plugin.

After the correct features' vectorization, North and East (N and E) coordinates were extracted from the vertices of the building's polygons, for both observations (Classical Survey and RPA). In addition, each building had its vertices matched to each other to allow a correct comparison between them. The ArcGIS Spatial Join tool was used to allow a correct comparison between the observed points. In this process, 272 points were generated, Renamed from A to E and numbered in the following order: Points A00 to A89 (Rectory Central Building - P1), Points B00 to B20 (Rector's Residence), Points C00 to C45 (Institute of Biology and Health Sciences headquarters - IB), Points D00 to D16 (Pesagro headquarters) and Points E00 to E97 (Institute of Chemistry headquarters - PQ). Nevertheless, from the vectorization of heritage buildings, we extracted the area and perimeter values for each building analyzed. Based on the points comparison, by taking in reference (truth) the coordinates obtained by the classical surveying executed, the linear error was calculated according to equation 1 below:

$$\text{Linear Error} = \sqrt{\Delta N^2 + \Delta E^2} \qquad (1)$$

Where: ΔN = Difference between north coordinates calculated for the points vertices.

ΔE = Difference between east coordinates calculated for the points vertices.

This procedure was made for each building's vertexes. Afterwards, the average linear error was calculated for the total set of vertices, as well as the individual linear error calculation for each building. In addition to comparing each vertices coordinate raised by classical surveying and the vertices derived from the vectorization by the RPA images, a comparison was made about the total area and perimeter of each construction, besides the sum of all areas and perimeters.

Based on the produced data, descriptive statistical analysis was performed to evaluate the two main questions of the extracted information from the orthophotomosaic generated by the RPA. The first analysis was made based on the points vertices coordinates and its main objective is to evaluate the positional quality (precision) of the extracted features in view of the most probable occurrence value of each point in the field, given by the classical surveying.

The second analysis was made taking into consideration the area and perimeter values of the total and individual samples of the heritage buildings. This analysis aims to compare and evaluate the applicability of the RPA technique for real estate registration purposes, in which currently the classical survey is applied. In order to compare these data, the differences in perimeter and area between the two technologies (classical survey and RPA) were calculated and then, their percentages were calculated taking the classical survey as truth. For validating purpose, the area and perimeter values obtained through the aerial survey with RPA, a 5% difference was accepted in relation to the values obtained by classical surveying, as mentioned above.

Results and Discussions

Table 3 below presents the results of the descriptive statistics performed under the linear error data calculated for the total and individual buildings samples at a confidence level of 95%.

Table 3: Descriptive Statistics for data samples linear error.

Sampling data		Descriptive Statistics*			
Description	**Vertices**	**Average**	**Standart Deviation**	**Mínimum**	**Maximum**
P1	90	0.0431	0.0193	0.0373	1.1755
PQ	98	0.0449	0.0302	0.0377	1.2267
IB	46	0.0361	0.0217	0.0591	1.0859
Pesagro	17	0.0354	0.0333	0.0634	1.1026
Rector's Residence	21	0.0540	0.0212	0.1371	0.9386
Total	272	0.0429	0.0255	0.0373	1.2267

Source: Authors.

Note: *unit: meters (m)

It can be observed that the mean values for the vertices linear error, indicated in Table 3, are within the range of the approached the accuracy of both surveys and have less than one pixel (4.02 cm) distancing each other. The total standard deviation value indicates that only 25% of the sample data are far from the average, showing a homogeneity in sampling sites. Table 4 below shows the results obtained in the second analysis, performed under data samples related to the area information of the evaluated buildings:

Table 4: Area analysis of the studied buildings data samples

Description	RPA Area (m^2)	Classical Survey Area (m^2)	Difference (m^2)	Percentage (%)
P1	6276.857	6521.072	244.215	3.74
PQ	3716.953	3641.931	-75.021	2.05
IB	2683.779	2704.872	21.093	0.78
Pesagro	663.037	686.272	23.235	3.38
Rector’s Residence	282.286	275.282	-7.004	2.54
Total	13622.913	13829.431	206.517	1.49

Source: Authors.

Table 4 shows that in the measurements there is an absolute difference between the RPA and the classical survey, with an increase of about 1.5% for the latter. With the exception of PQ and Rector’s Residence, all other areas were larger when measured by classical survey. The Pesagro Building, despite having a relatively smaller area, presented a proportionally high absolute difference. This fact may be due to the greater difficulty found in identifying the structural features of this building in the vectorization process. Considering the 5% threshold previously established in the Brazilian Civil Code (2002) procedure as the maximum tolerance for differences in area values, no feature showed such a discrepancy. This statement is reinforced by observing the minimum and maximum percentage values of area (0.78% and 3.74%) and perimeter (0.34% and 2.88%). Table 5 below shows the results obtained in the second analysis performed under the data samples related to the perimeter information of the evaluated buildings.

Table 5: Perimeter analysis of the studied buildings data samples

Description	RPA Perimeter (m)	Classical Survey Perimeter (m)	Difference (m)	Percentage (%)
P1	1188.933	1194.153	5.220	0.43
PQ	763.913	760.981	-2.931	0.38
IB	598.404	604.333	5.929	0.98
Pesagro	152.463	156.295	3.83	2.45
Rector's Residence	88.424	85.942	-2.481	2.88
Total	2792.138	2801.706	9.567	0.34

Source: Authors.

It is observed in Table 5 that the difference values between the two measurement techniques were even smaller than those of the total areas, indicating that there is no relationship between the perimeter value and the absolute difference between classical survey and RPA. The same is verified when considering the percentage values of the samples.

Although, we obtained a 1:1000 accurate ortophotomosaic scale for this data and vectorized on the 1:500 scale, Da Silva et al. (2014) indicates high accuracy with scale up to 1:400 for hexacopter type UAV. Uysal et al. (2015) suggest that is possible to use the UAV Photogrammetry data as map producing, surveying, and some other engineering applications with the advantages of low-cost, time conservation, and minimum field work. According to Gruen et al. (2012), UAVs are highly suitable and effective for archeology and cultural heritage applications, combining high flexibility in data acquisition and fast operation at relatively low costs. Also, according to Idoeta et al. (2004), the scale achieved in this work is suitable for municipal management in planning and control.

Da Silva et. al. (2014) & Silva et al. (2015) showed that orthomosaics which are generated using ground control points present high quality in geometric and cartographic accuracy - as obtained in this study - and don't revealed problems in East and North coordinates components, like shifting, in detriment of those who don`t use control points. Also, it claims that the PEC-PCD methodology - Decree-Law no. 89,817/84 (DSG, 2016) - based on trend and accuracy analysis used in this present study, proved to be efficient for assessing positional accuracy as well as systematic errors from orthomosaics generated by RPA.

Borges et al. (2017) found promising values for data acquired and processing from RPA technology aiming at infrastructures topographic characterization, with centimeter discrepancy values, using a density of 6629 surveyed vertices, 12 control points and only 3 photoidentifiable verification points. Taking into account the vertexes density and photoidentifiable points used in Borges et al. (2017) and making correspondence with this study, it is plausible to state that the research achieved extremely consistent results, with discrepancies in the decimetric place with the use of 272 survayed vertices and 134 points divided into control and verification, for the areas of monitoring and maintenance of patrimonial structures, being a viable alternative to the execution of classic tropography in heritage processes. It is worth mentioning that the study was committed to the robustness of data processing, validating the product obtained with a superior portion of verification points (total of 42 points) uniformly spaced in the study area, differently from the one used in Borges et al. (2017), ensuring an better accurate and precision evaluation of the orthophotomosaic produced and reinforcing the importance and applicability of this research in heritage processes.

As the present study is supported by the 5% tolerance guideline for area and perimeter analysis, mentioned in the Brazilian Civil Code (2002), it can be said that the data produced reached consistent and acceptable values, reinforcing the quality of products from RPA technology and, consequently, its applicability in heritage processes and maintenance of patrimonial structures.

The research presented here reached a product with a higher scale (more detailed) than that verified by these authors; also presented acceptable discrepancies for the surveyed vertices in the decimetric place, with no trends in the planimetric coordinates. However, the authors point out that the precision and accuracy assessed in digital mapping depend on the purpose of the generated product. It is worth mentioning that the orthophotomosaic vectorization lacks details compared to the classical survey, because it cannot detect complex features such as columns, walls and other details whose classical survey is better capable to describing.

Conclusions and Recommendations

It can be concluded that, when compared to classical surveying, the technique of obtaining images and extracting information through RPA in the scope of heritage processes, proved to be solid and robust for the purpose of obtaining and quantifying buildings area and perimeter. Considering the 5% threshold adopted, it is possible to state that in all cases the objective of quantifying area and perimeter was achieved.

Further studies about the use of RPA for these purposes are recommended, modifying the distribution and density of photogrammetric support points in order to improve the overall positional quality of orthophotomosaic and consequently the geometric positional quality of vectorized vertices, achieving a better level of precision.

It is suggested that, for vectorization purposes, the operator fixes a viewing scale that completely covers the entire feature to be vectorized, as well as ensuring its correct photoidentification. It is noteworthy that this scale must be compatible with the GSD obtained in the orthophotomosaic produced so that positional accurace and precision can be achieved. Ideally, the operator should perform all vectoring steps so this process can reliably represent the features.

Nevertheless, it is suggested the use of RPA, in its entirety, for the purpose of regularization and conservation of the historical heritage in Brazil in order to raise resources for the proper maintenance and conservation of its buildings, as this technology links efficiency and low cost to time responses in a short time.

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