STATISTICAL COMPARISON OF PHOTOGRAMMETRY CLOSE RANGE EQUIPMENTS AT LOW COST

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ABSTRACT

The terrestrial or close range photogrammetry at low cost is a hig potential tool for the measuring of heritage elements in the rural traditional architecture. It´s a quick technique, easy to use, which involves low cost and gives us enough accuracy for this goal.

The terrestrial photogrammetry at low cost is a great potential tool for the measuring of rural constructions. The measuring of traditional architectonic elements in the rural environment has a range of characteristic complexities. Generally, its location complicates the measurin with photogrammetry owing to the obstacles existence, which makes difficult the vision of the object. For this and some others matters it proves to be very useful to have available tools that let us improve the 3-D model quality of the construction created by means of architectonic photographic techniques at low cost.

Not all the photogrammetry architectonic equipments at low-cost are equally accurate. According to the components they´re made up of, they will give one accuracy or another. It´s interesting to know their performance in real working conditions in the country.

We have designed a statistical process to evaluate the behaviour of the different photogrammetry architectural equipments alt low cost in real working conditions in the country.

The developed method was applied to a study about a traditional rural construction that represents the difficulties we find in the countryside when we use photogrammetric techniques. The measuring of this construction was carried through by means of different architectural photogrammetry equipments al low cost.

1. INTRODUCTION

The close range photogrammetry is a tool of high potential to document construccions graphically. The field measurement is realized in a rapid way and the office work is relatively simple once you´re familiarized with the technique.

When we get ready to shape a close range photogrammetry equipment we can use several components, whenever they´re al low-cost. We can use different types of photographic cameras, targets and various softwares. Depending on how we combine between them a close range photogrammetry equipment will have one configuration or another and therefore it will give us an acuracy in the measurement according to its configuration.

The accuracy of a close range photogrammetry equipment can be contrasted in different ways. The datas can be taken in the field or in the laboratory, it´s possible to work with coordinates or distances and in two or three dimensions etc. The important thing a the moment of contrasting the results is that all of them have been generated in equivalent conditons.

In this artiche we will focus on the data management, that is to say the errors treatment generated by each equipment.

We will work on a traditional rural construction that is representative of the difficulties we have to deal with in the country when we employ this kind of measurements equipments.

2. MATERIAL

We mean by a close range photogrammetry equipment the combination of photographic camera, targets and photogrammetric software.

We have avaliable three types of targets to place on the arris of the construction: conical targets, spherical targets and natural targets. The natural targets are exceptional elements of the building that allow us an easy recognition of a chosen point. Equally, we have also avaliable three types of targets to place on the construction facades: flat targets type I, conical targets and subpixel marking targets.

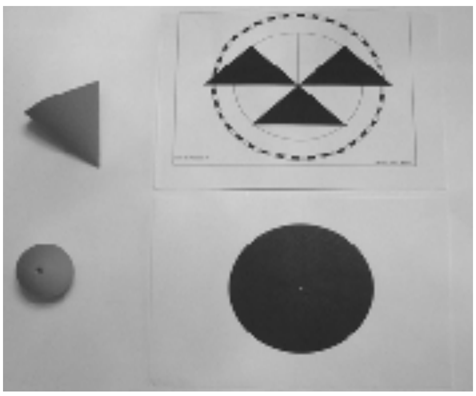

Figure 1.Targets

We employ trhee types of digital photographic cameras. High range cameras, medium and low range. Olympus Camedia C5060 (CCD: 5.100.000 Pixels. Resolution 3264x2448) High range, Hewlett-Packard Photosmart 735C (CCD de 3.200.000 Pixels. Resolution 2048x1536) medium range, WERLISA PX1310 (CCD de 1.300.000 Pixels, Resolution 1280x1024) low range.

The photogrammetric software used is PhotoModeler 5 Pro® (Eos Systems Inc). This is a common element for all the equipments, so it´s not considered as a variable at the moment of establishing the configuration of the photogrammetric equipment.

To determine the errors it´s necessary a reference measurement. This one has to be as close as possible to the real measurement. We´ve employed a total station, to be exact TOTAL STATION TOPCON GPT-6005.Accuracy in the measurement of ± (3 mm + 2 ppm). Angular accuracy (standard deviation based on the norm DIN 18723) 5" (1,5 mgon).

A fundamental element to realice the contrast is a traditional rural construction. This one was selected in a representative way of the existing difficulties in the country at the moment of working with photogrammetry at low cost. An hydraulic rural traditional mill was used.

To configurate the photogrammetry equipment we must combine the arris targets with the facade targets and the photographic cameras. Combining these three elements we get twenty seven different equipments.

3. DATA – TAKING METHODS.

To Determine the accuracy of the twenty seven methods we must measure with the same construction points one by one. They will be also measured with the reference equipment, total station, to calculate the errors in each equipment and in easch point. With thtat purpose a set of points are marked on the facade. Those will be located with the photogrammetric software by measn of the facade targets. The arris targets are used to create the constructioon wireframe. Every points, facade points and arris points are used for the spatial orientation of the 3-D model.

Figure 2. Facade targets and arris targets

We work with distances between points on the facade. In this way we avoid having to place every models in a common reference system, doing away with the errors this procedure origins, because to place the models in a common coordinates system, first its necessary to make an axis coincide and then adjust the position of the other two. For this reason depending on the axis we adjust the method will be more accurate in one direction than in another. This is what has led us to work in a more objective way and employ distances errors.

The facade points are placed in an aleatory way. We have 52 reliable points available and delivered facades. We got rid of every point where we suspect there has been a displacement of the target. So, we can work with 26 distances totally independents by measurement equipment, that is to say 26 error datas by equipment.

4. DATA TREATMENT METHODS.

We mean by error the measurement difference we got by means of photogrammetric methods with regard to the one we got with the reference method, the total station. The random variable used in the statistical analysis is the error in independent distances between targets. It´s done in this way to guarantee the random premise of the experiments designs and because of statistical treatments requests.

In the beginning we work with an analysis depth of millimetres. This makes that in some distnace difference we get the value of "0", that is to say, with that analysis depth level the error doesn´t exist. This phenomenon gives us problems at the moment´t of data treatment, vecause we take datas to homogenize logarithms, and as we all know the "0" logarithm doesn´t exist, in this way the more accurate values would be removed of the statistical treatment.

To sort out the afore mentioned provlem the analysis depth is increased till tenths of millimetres. With this order of magnitude we get rid of the problems with the logarthms.

We have 27 different equipments. We have 26 datas by equipment available. Therefore we have 702 datas to revise. The experiment is protected from possible strange slants because there is a high number of datas taken in a totally independent way. This experiment can be also considered as balanced because the sizes of the sample are equal in every case.

We consider as variable answer the error or its derived parametre, as treatment we condider the factor levels combination (configuration of the equipment) and as unitary elements the errors in the distances measurement.

We analyse the influence of 3 qualitative variables or variable factors (cameras, modelling targets, accuracy targets) abaut a quantitative varialble we´ll call variable answer or dependent.

We consider that we must use the Medium Quadratic Error (MQE) for a definitive classification according to the accuracy, because this variable answer implies two terms: the slant of each method an the variability. This makes it the most complete at the moment of establishing this clasification in a definitive way.

Medium Quadratic Error: $$MQE = \frac{1}{N}\sum_{I=1}^{N} \left(\hat{d}_i - d\right)^2$$

dî: Photogrammetry measurement.
d: Reference measurement.
N: Number of measurements.

In this way we´ll identify the variation sources and we´ll measure the influence of the data dispersion. This technique let us compare variation sources to determine whether the observed differences are caused by factors of interest or are just a consequence of the nature of things. The unidentified variation sources are considered experimental error.

Apart from the accuracy, the "reliability" of this measure must be taken into account, that is to say the proportion of occasions in which the method offers that accuracy. In this experiment this factor doesn´t alter the accuracy order, because the most accurate equipments are also the less variable, or rather the most reliable.

Once the classification by accuracy and reliability is established, a regression analysis is realized with the aim of testing the measurement adjustment of each method with regard to the reference measurements. This procedure let us check if the delivery of the data error is centred or not, and therefore the existence of slant. In the cases in which the delivery of datas is not centred, tha is to say there is a slant, and the variability of the equipment is low (reliable equipmen) we´ll be able to determine numerically that slant. Knowing the slant we´ll be able to make that the datas delivery of the equipment is centred. By means of this procedure is possible to improve the accuracy of those equipments whose errors delivery has slant. Knowing the slant we can reduce the systematic error of the equipment.

The value of the distances we got with each equipment against the distance we got with the reference equipmt is represented. Once the datas are represented a tendency line is added. In this way we check whether the delivery of datas is centred (case 1). In that case the equipment doesn´t generate any systematic erros, or if it does it, this one is imperceptible for our goal. When the delivery is off-centre, that is to say, there is a slant we have the possibility of reducing the systematic error of the equipment.

To mitigate the systematic error the slant is determined. The slant is the separation between the datas delivery that is off-centre and the theorical centred delivery. If the off-centre delivery is on the right of the centred one, the equipment generates a systematic error that makes its measurements are smaller than the real ones, therefore the slant value will be added up to these measurements. On the contrary, if the off-centre delivery is on the left of the theorical centred one, the tendency will be to measure excessively, and because of this the slant value will be taken away from the equipment measurements.

For reasons of space the 27 graphs of the regression analysis are not included.

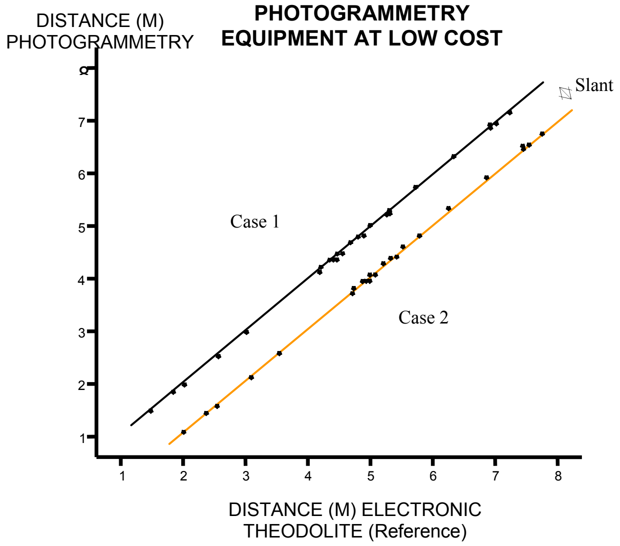

Figure 3. Standar graph of the regresion analysis

5. RESULTS

Photogrammetry Equipment	MQE (%)	Variability (%)
OL,edge:SPHERICAL,facade:SUBPIXEL	0,37	1,03
HP,edge:SPHERICAL,facade:SUBPIXEL	0,38	1,26
HP,edge:Conical,facade:SUBPIXEL	0,76	1,30
OL,edge:CONICAL,facade:PLANE 1	0,88	1,81
HP,edge:SPHERICAL, facade:PLANA 1	0,93	2,55
WER,edge:SPHERICAL,facade: SUBPIXEL	1,14	2,36
WER,md:NAT,facade: SUBPIXEL	1,30	2,62
HP,edge:CONICAL,facade:PLANE 1	1,33	2,78
WER,edge:Conical, facade: SUBPIXEL	1,57	2,09
OL,edge:NAT,facade:PLANE 1	1,98	3,29
WER,edge:CONICAL,facade:CONICAL	2,35	3,66
OL,edge:SPHERICAL, facade:PLANA 1	2,42	2,49
WER,edge:NAT,facade:CONICAL	2,66	4,30
HP,edge:CONICAL,facade:CONICAL	2,94	4,22
HP,edge:NAT,facade:PLANE 1	3,17	2,57
HP,edge:NAT,facade:CONICAL	3,25	4,96
WER,edge:SPHERICAL, facade:PLANA 1	3,43	3,08
WER,edge:SPHERICAL,facade:CONICAL	3,46	3,59
OL,edge:NAT,facade:CONICAL	3,80	4,03
OL,edge:CONICAL,facade:CONICAL	4,65	4,65
WER,edge:NAT,facade:PLANE 1	5,00	2,81
OL,md:NAT,facade: SUBPIXEL	5,36	5,93
OL,edge:SPHERICAL,facade:CONICAL	6,13	6,11
WER,edge:CONICAL,facade:PLANE 1	8,51	5,50
HP,md:NAT,facade: SUBPIXEL	8,55	5,44
OL,edge:Conical, facade: SUBPIXEL	11,30	6,40
HP,edge:SPHERICAL,facade:CONICAL	12,09	9,18

OL: Olympus Camedia C5060
HP: Hewlett Packard Photosmart 735C
WER: Werlisa PX 1310
Edge: Target de arista
Facade: Target de fachada
NAT: Natural Targets
CONICAL: Conical Targets
SPHERICAL: Spherical Targets
PLANE: Tipe 1 Plane targets
SUBPIXEL: Subpíxel marking target

Figure 4. Classification by accuracy and reliability

The comparison of the reference equipment datas with the others we got from the different photogrammetric equipments, permit us to notice that there are two groups, one of them that includes the methods centred with regard to the reference equipment, and the other one that shows a tendency to underestimate the measuring generated by the reference equipment. Among the last ones, it´s noticed there are medium and low precision equipments, but both of them have a hig reliability. In these cases, the statistical analysis of the associated errors can lead to improve the accuracy of these methods. If the equipment presents a constant deviation with respect to the measuring generated by the reference equipment, the estimation and correction of the slant provides a more accurate equipment being equally reliable.

6. CONCLUSIONS

We consider the methodology shown in this article for the comparison of the architectonic photogrammetry equipment at low-cost is simple and agreeable. It let us to determine the accuracy of our equipment in a convenient, reliable and within the reach of everybody. Besides, in case our equipment generates systematic errors we can mitigate their effect on the measurements we got. This is a phenomenon of great importance if there are no way of getting a more accurate equipment.

In the analyzed equipments the decisive parameter to achieve a high accuracy with the measurements by means of photography is the combination of targets. For the most favourable combination of targets, spherical targets in arrises and subpixel marking targets on the facade, will be more accurate the better the photographic camera is. A high range photographic camera doesn´t mean a high accuracy in photogrammetry, but a high photographic quality of the documentation.

The ideal thing, whenever there is no severe limitation of economic sources, to get a high accuracy with architectonic photogrammetry at low-cost is to combine a digital photographic camera of high range (Olympus Camedia C5060 in our case) with spherical targets in arrises and subpixel marking target on the facade.

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