Orthophotomosaic of more than 400 24MP images, produced by photogrammetric processing—Actual pixel size:2.5mm

REAL ORTHOPHOTOS

An orthophoto is by definition a geometrically corrected image of uniform scale, resolution and quality. An orthophoto, may be created from a single or multiple photographs (hundreds or even thousands) which are processed using photogrammetric methods in order to produce an orthogonal projection view of a site (like a map) or a facade (like an elevation drawing). In this article we will call this kind of orthophoto, the "real" orthophoto to distinguish it from its recently introduced adversary, the pointcloud orthophoto.

Traditionally, and before the dynamic emergence of 3D laser scanners, surveying engineers specializing in photogrammetry would acquire large datasets of image data in order to geometrically document large areas, buildings or objects in large detail and deliver high resolution and precision synthetic imagery and 3D models. It can be said that photogrammetric surveys were the predecessor of high definition surveys. Through photogrammetric processing an engineer could always obtain a pointcloud and document the form of any given object or space according to any desired specifications for resolution and accuracy.

Photogrammetric methods were cast aside in a way as soon as laser scanners were introduced. Many thought that laser scanners would replace and possibly render redundant the photogrammetric workflows and for a rather large time this was almost

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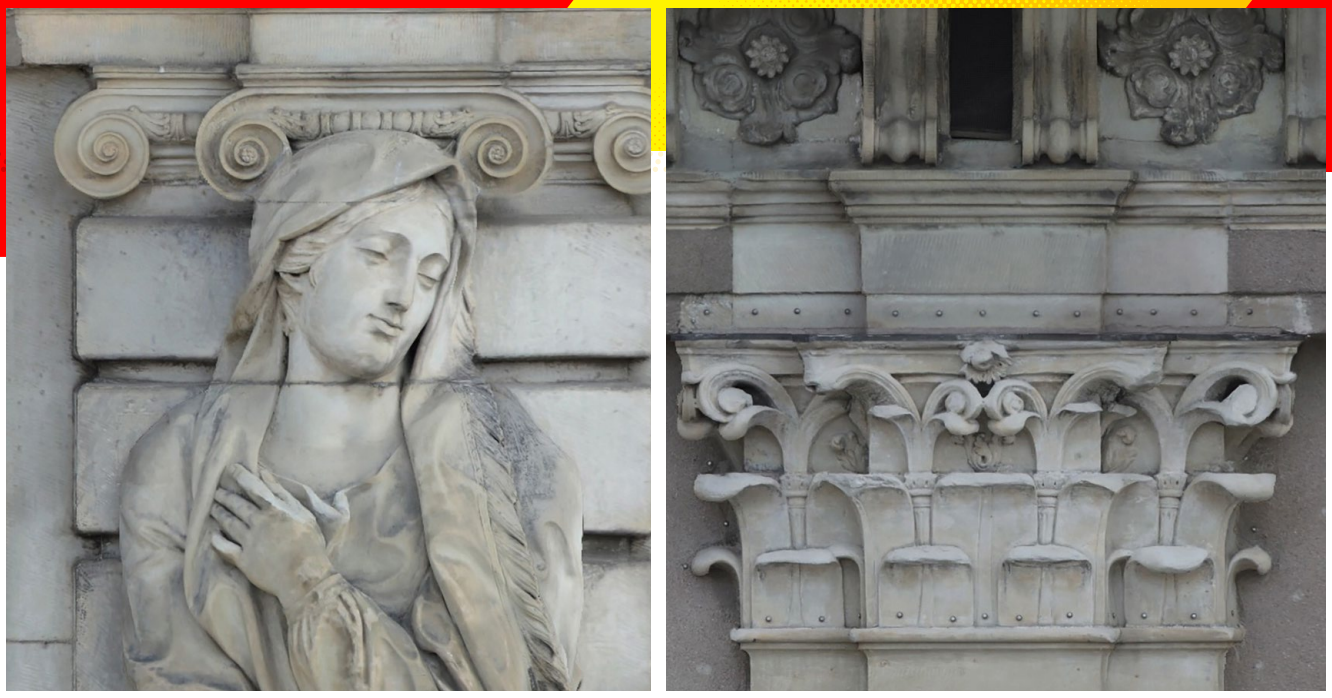

Figure 1: Details of high resolution photogrammetric orthophotos

true. Those who had the means to invest in laser scanning equipment acquired such systems and started to change their workflows and market their new services. Naturally, and in line with the advantages that laser scanners offer, laser scanning surveys were promoted as more accurate, speedy and cheaper than the old-fashioned photogrammetric surveys. Another thing to consider is that as soon as laser-scanning systems started to populate the market and their use began to spread, photogrammetrists were still struggling with photogrammetric cameras turning from analog to digital but lagging in technology that would allow for direct acquisition of high-resolution imagery. This was such a big problem, that in the beginning, instead of using digital cameras, it was actually preferred to continue and use analog cameras, digitize the images and rectify in order to obtain high-resolution raw material for processing. In addition, photogrammetric software available at the time was better suited for processing of aerial imagery rather than for processing ground images for close range applications. Understandably, and under these circumstances, photogrammetric workflows for close range applications seemed rather cumbersome and presented challenges when compared to the highly efficient laser scanning survey methods. In this respect, laser scanning surveys started to gain significant ground in the documentation business market and gradually replace photogrammetric surveys.

However, despite the relevant challenges and the changes the photogrammetric methods have gone through in recent years, several applications have always been better served by photogrammetry rather than laser scanning. Two major areas were photogrammetry was always preferred rather than laser scanning were the applications of photogrammetric engineering in cultural heritage and industrial applications. For industrial applications, the main reason for the everlasting preference towards photogrammetric approaches has always been the high accuracy achieved by the relevant workflows. In the cultural heritage area however, the big and undeniable advantage of photogrammetric methods has always been the possibility to produce a wide range of high resolution and accuracy imagery products such as orthophotos. Orthophotos have always been the primer choice product in all cases where the qualitative documentation of an object, site or space was of importance.

For instance, orthophotos were always required from architects who were working on restoration projects, or from conservation professionals who needed to document a working area before and after interventions. Furthermore, the use of orthophotos is advised by the ICOMOS "*Recommendations for the analysis, conservation and structural restoration of architectural heritage*". This indicates strongly, that the photogrammetric methods should always be the primer choice for documentation of architectural heritage. Main reason for this is that photogrammetric orthophotos, "real" orthophotos are priceless tools for conservators and architects because they enable the complete and detailed documentation of areas of interest with uniform scale, resolution and quality. Photogrammetric orthophotos and other types of photogrammetric imagery

products like rectifications, developments, cartographic unwrappings etc will always be the premium media when it comes to the qualitative documentation of objects and sites.

Regretfully, for the longest time up to now, instead of investigating ways to combine photogrammetric methods and laser scanning, the largest part of the service providers from both areas have rather focused on competing against each other. Most focus on bringing new business in either one of the two areas, rather than investigating ways to allow for the combination of the two methods in order to harness the benefits that naturally rely in process integration. Instead of moving forward towards better products, several not as optimal solution seem to be promoted and preferred more than often.

Pointcloud orthophotos are one of the products that can be produced directly from pointcloud data sets by most available proprietary software. A "pointcloud" orthophoto, is the result of projecting 3D scanner pointclouds orthogonally onto a given plane. Although pointcloud orthophotos may be useful to a certain extend it is not possible to completely replace photogrammetric orthophotos. Pointcloud orthos may come cheap and be easy to produce, but their quality is limited by default as compared to the quality of real, photogrammetrically produced orthophotos. Main reason for the low quality, is that poincloud orthophotos highly depend on the quality of the scans used for their production and, although scale remains uniform and a fixed resolution is applied, quality decreases significantly in areas further away from the scanners (data grow thinner with distance) such as the highest floors of a multistory building and occluded areas are represented by gaps in the image.

In contrast to the limitations of the pointcloud orthos, photogrammetric orthophotos are very versatile tools priceless for applications such as architectural documentation and conservation. The production of photogrammetric orthophotos always requires quite a bit of processing and skill, and therefore always costs more than pointcloud orthos. However, photogrammetric orthophotos are the only way to produce high quality orthogonally projected imagery of uniform resolution, accuracy and scale. If built according to project specifications for resolution and accuracy, the value of real photogrammetric orthophotos more than justifies the related cost.

In the last couple of years, this situation seems to change mainly due to the emergence of drones. Drones are becoming so popular and their use so widespread, that the market is currently revisiting photogrammetric workflows

Figure 2: The Royal Palace of Stockholm. Winter 2010 (Photo: Ulf Hägnefelt)

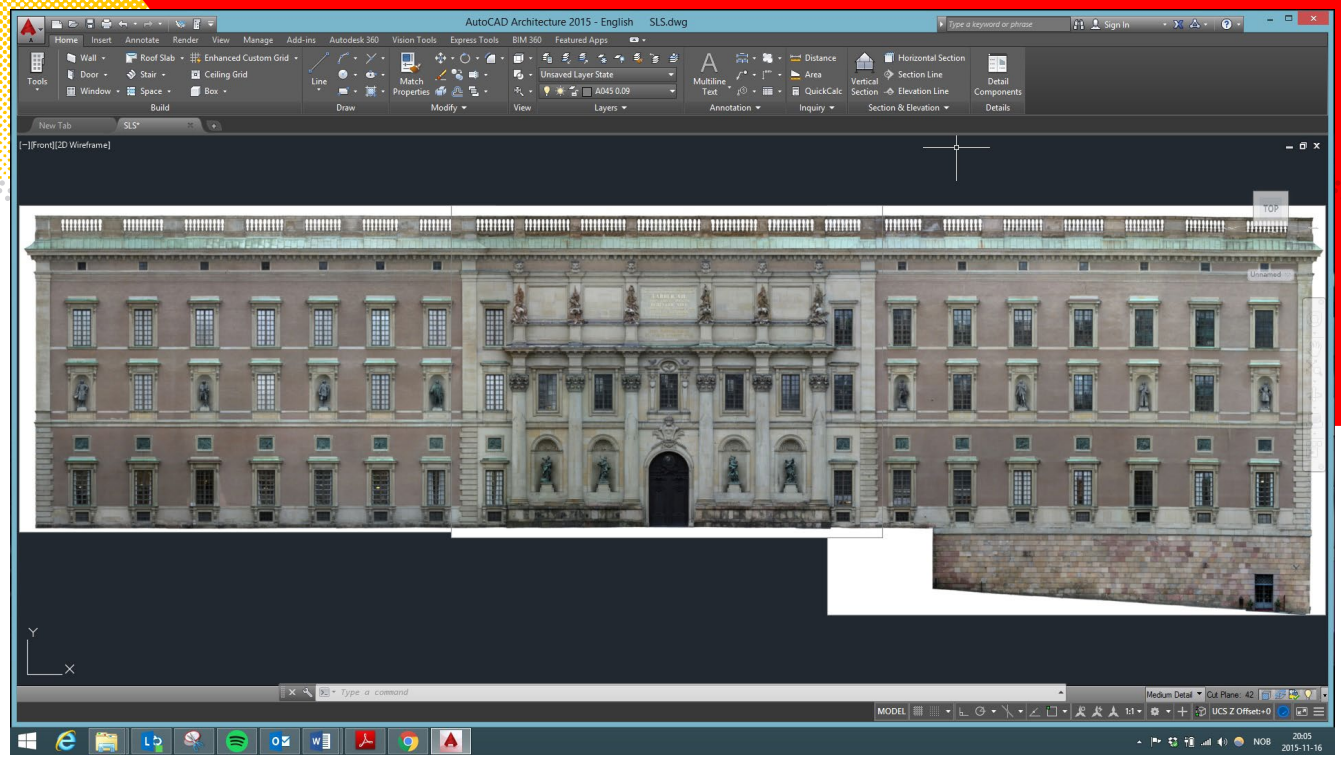

Figure 3: High resolution orthophoto in AutoCAD environment.

and solutions, which have evolved a lot. Most survey grade UAV systems come with proprietary software that allows for mission planning and offline image data processing for the production of image based reconstruction pointclouds, orthophotos and textured models. Today's solutions own their evolution both to photogrammetric and computer vision algorithms. Furthermore, most of photogrammetric software today provides the option to insert, visualize and utilize point cloud data of different sources and formats. Utilizing laser scanner pointclouds into photogrammetric workflows enhances productivity and yields results of improved quality. Of course, there are always those service providers either in the laser scanning business or in the drone business that lack the required background and skill required to provide their clients with the optimal solutions and results.

Those interested in acquiring services of 3D and 2D documentation should always make sure that they select service providers with adequate experience, capacity and knowhow to assist them in selecting the services that better fit their project requirements and specifications. It cannot be denied that many of the potential clients that would be better served with a product such as a photogrammetric orthophoto are not aware of this and also the service providers who are not able to deliver this kind of thing many times discourage a potential client from looking into this option, just because they cannot deliver a product like that.

It is therefore upon surveying engineers who specialize in photogrammetry to educate the industry on the benefits of photogrammetric methods and products. Currently, with the development of 3D and image data acquisition and processing systems, there are so many options available that a serious amount of work needs to be done in order to make potential users of this technology aware of the potential, the alternative solutions and also the relevant fall traps in order to allow them to make informed decisions.

Except for the training and discussion that would be required to bring the entire industry up to speed, there is a serious shortage of good practice examples when it comes to photogrammetry, photogrammetric orthos, and the potential of these methods. In an effort to help make readers and colleagues revisit their views on the use of photogrammetry and the absolute supremacy of real photogrammetric orthophotos, the authors share some of the results of a real case study, which completed last year. The project in question involved the laser scanning and photogrammetric documentation of the entire façade area of a prominent landmark, namely the Royal Palace of Stockholm.

In 2010, after the release of a relevant feasibility study, it was decided to run a project for the "Long term maintenance of the facades". After investigating several alternatives and running several demo projects, the project stakeholders compared all proposed documentation options and decided that in order to carry on the work for the conservation of the facades, it would be necessary to document the entire façade area with laser scanners, high resolution images

and produce high quality photogrammetric imagery. For this project, it was decided that the desired orthophotos, which would be used as means for qualitative façade area documentation and as a basis for line-drawing production, should have a pixel size of 2.5mm, should cover the entire façade area and would be employed for the production of elevations in scales of 1:50 and 1:20.

Upon project completion, hundreds of scans were acquired and processed into surface models to be used for the orthoprojection of more than 9.000 images that were also obtained during fieldwork. Final results included more than 50 pieces of orthophotos that covered the entire façade area with uniform pixel size, uniform scale and uniform accuracy. All imagery was delivered into TIFF format for archiving, and into JPG format for direct use into cad software. Conservation work, which is being carried out currently, is based on the high resolution orthophotos that were created for the project and the line drawings and work that was carried out based on the orthophotos. According to all teams involved in the ongoing conservation work, the orthophotos that were produced for the entire project area are invaluable and used on a daily basis.

One may argue that it is not possible for all projects to allocate funds for photogrammetric documentation of such quality and extent and that this is a rather extravagant case and application of such methods. However, in reality, the production of these drawings helped the project team save a lot of money and time from site visits for more data. When working for a small building, this cost may be too small to consider as inspection for inventory normally requires a team of at least 2-3 people to inspect the entire façade are from "arm's length distance". However, for a building of this size, with elevations as high as 35m and many areas that require a very wide range of lifting equipment and complex maneuvering, the associated cost can skyrocket. Instead, a fraction of the money that would be required for this process are used for image acquisition and production of orthophotomosaics that are produced once, are used throughout the entire project life-cycle and serve as proper documentation of the existing situation prior to restoration.

While some may argue that such work may be redundant or that not all projects are as important to justify an

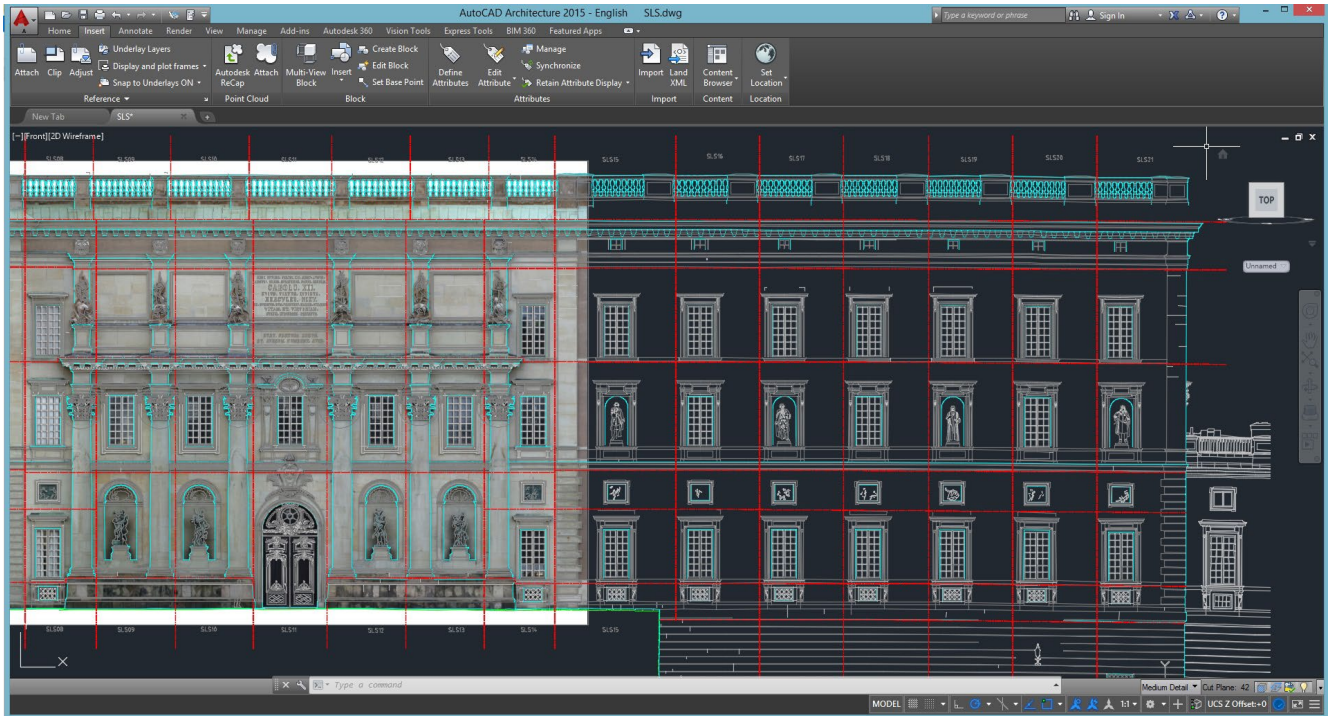

Figure 4: Production of line-drawings based on high resolution orthophotos

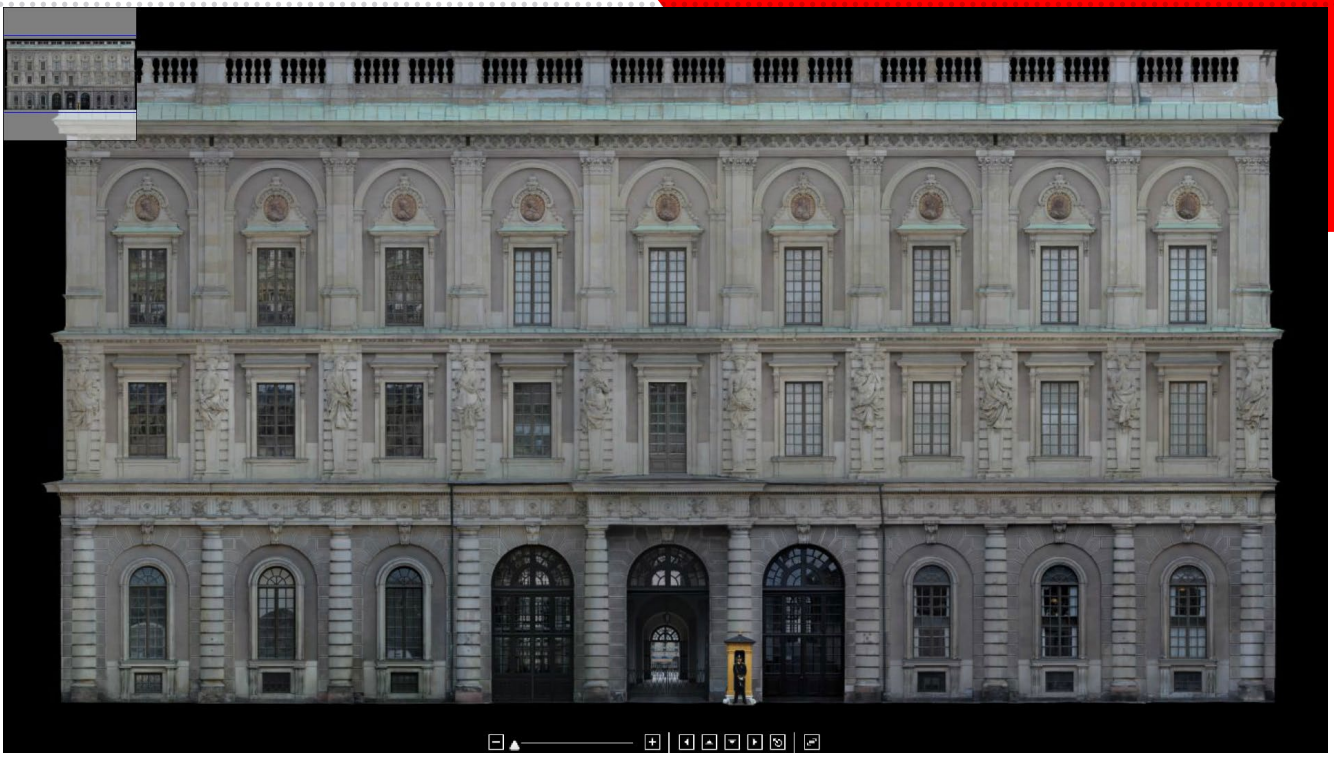

Figure 5: http://aiolos.survey.ntua.gr/palace/FullScreen.htm

investment in such detailed documentation, most professionals active in this area would definitely argue against to that. In many cases, the production of elevation drawings for several applications involves drawing several details that are not possible to trace adequately from less detailed base maps such as pointcloud orthos. In these cases, the architects that undertake such projects have to visit their project site many times to make additional sketches and acquire additional measurements, and then be very inventive, and resourceful in order to complete their drawings. In general, this practice requires so much time from the architects who undertake the line-drawing production, that the relevant benefit in a price difference between pointcloud orthos and real photogrammetric orthophotos is usually spent in extra detailing and drawing time, and in the end project deliverables include only line-drawings whereas orthophotos would have been also included if these hidden costs were also considered.

It is beyond doubt, that all methods and products are useful in their own right and suitable when they fit the requirements and specifications of a project. On the other hand, especially when it comes to real photogrammetric orthophotos, their value cannot be denied. The related cost can always be gained from other costs that are saved in the process of a project that is underway. The authors would like to encourage readers revisit their views regarding orthophotos, and help educate the industry to look for high quality results that fit the exact purpose of any given project.

It is very likely that many readers have seen many "pointcloud" orthos but have never seen a "real" orthophoto. **Figure 5** shows an orthophoto produced from hundreds of images using photogrammetric methods for the interested readers dive into!

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