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"PHOTOGRAMMETRY IN CULTURAL HERITAGE: IS IT ONLY SFM SOFTWARE?"

First, my personal idea is that Photogrammetry is not SfM. They use the same primary data (i.e. images) but address scientific communities with different background and are developed for different tasks and needs.

"Fulvio, let's define photogrammetry…"

Photogrammetry comes from surveyor community whose main task is to define the shape and the dimensions of an existing (or existed) object, in a fixed instant of its life, by assessing the precision and the accuracy of the results. As a paradox, we can say that the most important information are not the coordinates of a set of points but their quality. Photogrammetry asks for a correct planning of the taken images by considering the required precision. The problem is solved by using the non-linear approach, which requires an approximation of the unknowns and an iterative procedure to find the final solution. The solution is than discussed by looking for gross, systematic and out of range random errors before to produce the final results. So, photogrammetry requires a more critical approach, with a deep discussion after every step to find out possible gross and systematic errors.

"…and let's define SfM…"

SfM comes from CV community which main aims are the quick reconstruction of 3D scenes to drive virtual users or robots: in this case, the achieved precision is not important because the locations are almost continuously updated by considering new images of the same scene. However, it must be recognized that SfM specialists offered a quick way to calibrate every kind of camera just by using tie points and in some cases, this is a good starting point for a rigorous photogrammetric application. This approach allows the use of non-conventional imaging systems (e.g. cellular cameras, amatorial cameras, video cameras, etc.) without considering the lack of precision coming out from a not serious consideration of systematic errors. The exterior orientation parameters estimation performed by SfM uses a linear approach that speeds up the computations and, usually, offers a solution when the taken geometry is out of control. So, SfM offers an almost automatic tool that can be used by unskilled operators that are not asked to discuss the quality of the results.

"and what about the Heritage field?"

In Cultural Heritage 3D survey, it must be considered that the required 3D models have to face different goals: for each of them different accuracy and precision requirements must be considered, therefore is not correct to use indifferently Photogrammetry or SfM. If it is not interesting to extract metric information from the 3D processing (i.e. 3D results are used for VR/AR applications), SfM-based solutions can be accepted. If metric information has to be extrapolated from 3D models, each of them must be certified in metric quality to allow a correct use of them for restoration projects or monitoring applications. The coordinates of the points are not "numbers" but measurements and they must be used as they are and not as "we think they are". A measurement is expressed by the estimated mean and the estimated mean square error (so at least a couple of numbers) but also by the tested accuracy when the 3D model is built-up. This sensibility is typical of surveyors that, traditionally, certified it and the user of the 3D model can trust them. However, if no one certify the precision and accuracy of the survey, which is the level of reliability of the 3D model? How the professional who need metric information can use them? Especially in Cultural Heritage domain, it must be known that the metric survey is not the end of a work but the starting points of many applications, which results strongly depend on the metric quality of the metric survey.

"…so, could we talk about an illusion for SfM"?

In my opinion, SfM software can give the illusion that everyone is able to make a 3D survey without any basic knowledge of metric survey. As scientific community (surveyors and photogrammetrists), we have to fight against this assumption. The metric survey is an intelligent action and cannot be solved automatically: all the possible automation must be used but, a critical analysis of the achieved results has to be exploited gradually: camera calibration, estimation of exterior orientation parameters, dense matching, segmentation and modelling. Yes, also segmentation and modelling phases are part of the metric survey: the point cloud is not a 3D model because the points are not topologically connected. Therefore, the surveyors have to check in which way the points are used to extract the geometric break-lines to drive the modelling phase. The smoothing effects, which arise when a point cloud is roughly transformed by an automatic modelling (strategy usually adopted by SfM software), could destroy the quality of the metric survey. In Cultural Heritage the segmentation and modelling phases require a knowledge about the history of the surveyed object and, in the same time, a knowledge on metric survey: it is difficult to find both competencies in a unique brain.

"Fulvio, what is the take-away message?"

In all metric survey applications in the Cultural Heritage field, a multidisciplinary approach is needed: no one can replace the work of others and manage alone the complete process. So, why look for shortcuts?