

POINT CLOUD GENERATION AND RECONSTRUCTION OF SMALL TO MODERATE SIZED OBJECTS FROM VIDEOS USING VISUAL SFM AND MESH LAB

Aishwarya Chandel¹, S.K.S. Yadav², Joyeeta Poddar³

^{1,2,3}Remote Sensing Application Center, Lucknow (UP)

ABSTARCT: *Photogrammetry has many aspect as we all know and can be used in many ways and several time for detection and storage of the object. The main aim of this study is to present a new measurement method to improve the positioning verification phase in the part dimensional validation process of creating 3D models, and to store it for further use. This enhancement would improve the measuring procedures for certain types of components. A photogrammetry-based system was implemented to take advantage of its capabilities, adding new functions to the existing capacities. In addition to a new technology focused on modeling photogrammetry and processing of images, a measuring technique based on optical and vision system requirements was developed.. The limited availability of conservation and restauration funds, the digital documentation objects and monitoring of deformations caused by the climate are increasingly critical for maintaining the cultural heritage. Our Study sheds light on advances in digital image capture and processing to document objects with a focus Calibration of mobile/digital camera, near range imaging and photogrammetric simulation of complex structures using image Alignment methods or photographic sequences and developing an point cloud data through it and buy introducing it into mesh lab software to develop a 3-D model out of it so that it could be stored and can be further used for betterment our reconstructing of the object.*

Keywords: close-range photogrammetry, mobile camera/digital camera, image/photographic sequence, surface and geometric deformations, ortho-photographic model, Visual SFM and Mesh lab software, GUI(graphical User Interface) application.

INTRODUCTION

Close-range photogrammetry (CRP) is simply photogrammetric data collection and processing where the subject is less than 1,000 feet away. Methods of collection can be both land- or aerial-based, and the final output can be made either in two or three dimensions. Several factors made this a valuable tool for professionals in the geospatial field. The best of these is the recent emergence of 3D photogrammetry, also called "multi-ray photogrammetry": a technique that takes overlapping, stereo-paired images, transforming them into 3D point

clouds. Instead, these point clouds can be processed using the same 3D scanning software used. Applications for this technology abound. Each of these technologies has its advantages and disadvantages (regarding the resulting accuracy for various distances of scanning vs. imaging, mobility, radiometric and geometric resolution, or purchase cost). Currently, a number of criteria – primarily high precision, level of detail, sophistication and reliability of data, which in turn must be of geometric and visual quality with efficient collection and low volume, are placed on the resulting data obtained by each of these technologies. One of the big developments in 3D surface reconstruction, computer modeling and cultural heritage documentation is only achieving a low purchasing cost while at the same time obtaining accurate results that will meet the above requirements. The new laser scanning and digital photogrammetry technologies and methods satisfy these criteria to a large degree, but in some situations the purchasing cost of the hardware and software might still be too great. Photogrammetry-dependent modeling is considered one of the best practices for processing image data which provides accuracy and detailed 3D data.



Fig. 1: Point cloud data of Human body in Visual SFM software

This method increases the determination of the accuracy and reliability of parameters and control points (CPs) of data calculated picture connection points, which are the locations of comparison / comparison points in two or more adjacent digital pictures, and is used to connect

photographs to them. It therefore includes at least two images and can then extract the 3D knowledge from the use of projective geometry and perspective. Photogrammetry is much more than a mere tool used to create topographic maps for the surface of the Earth; it is a general physical measurement device with the most broad fields of applicability in science, technology and art. In photogrammetry of close range, the range of the distance of object to camera is limited. Some speak for it the maximum limit is 300 metres, while the minimum is the distance to cover macro- and microscopic images is virtually zero (say a fraction of a millimetre).

STUDY AREA

The work is performed under different materials to understand the variety of products which could be studied in by these software. Now a days we have many ways of construction which could be used to construct the models in the same manner it was just we have to input the feature which was there in the structure which we want to be constructed again. We have taken many similar objects from non-living to living objects which where further used for capturing the data either through mobile camera or digital camera. We can develop a video or can take series of photograph of the object which is needed to be captured for the process. The video captured should be further processed with the help of the video to JPG convertor software. These photographs taken will be futher used in the Visual SFM software.

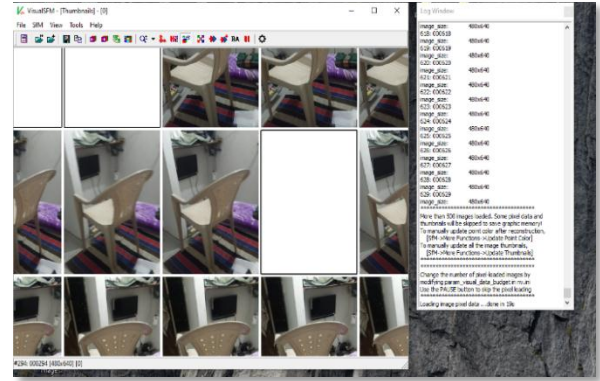
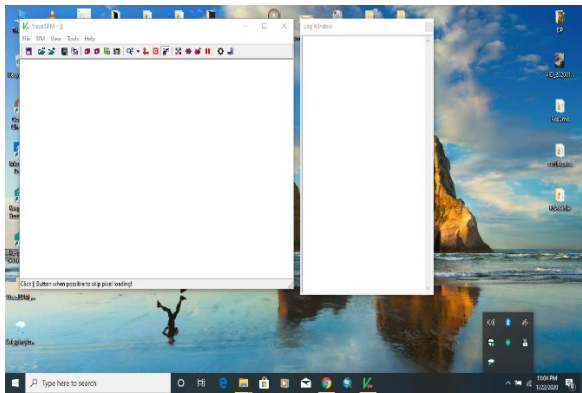


Fig. 2: Visual SFM software in image (1) and adding image sequence of chair in image (2)

So, we have taken different objects cum experimental materials to perform the experiment. The objects are given in the photograph below A) Scooty, B) Helmet, C) Concrete Colum and D) Joyeeta Poddar mam (Mentor mam). As the object presented are of different shape and size so we can say that it can be used on any time to material but as for small scale only because we have to take as 360° view of the object. So for that we have to cover each and every angle of the object so that each portrait can have layover to each other which will further help in generating point cloud data.

The SfM (Structure from Motion) process , which requires the simultaneous identification of the interior and outer orientation parameters and reconstruction of image captured 3D or MVS (Multi-View Stereo structure) representing an image algorithm matching a set of stereo pairs of different images, are two key images principles on which certain program sections run. In the past, surface reconstruction algorithms were based such principles were especially useful for visualisation purposes and not for photogrammetry and mapping purposes.



A). Scooty



B.) Helmet



C.) Concrete Coloum



D.) Joyeeta Poddar Mam



Fig.3 : Experiment required the given elements for generation of point cloud data and 3D model

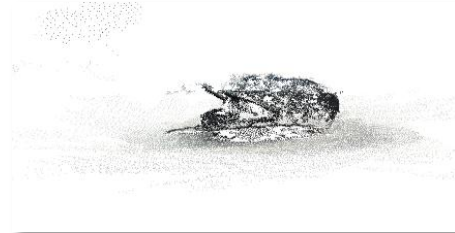
METHODOLOGY

Structure from Motion (SfM) is a photogrammetric range imaging technique for estimating three-dimensional structures from two-dimensional image sequences that may be coupled with local motion signals. It is studied in the fields of visual perception and computer vision. Structure from Motion (SfM) is a technique that reconstructs the 3-dimensional structure of a scene or object using a collection of 2-dimensional images. SfM is able to generate 3-D-based point cloud models similar to LiDAR. Through going through it, humans experience more knowledge about the three-dimensional structure of their world. As the observer moves around them objects move various amounts depending on their distance from the observer. It is known as motion parallax and can be used to produce an accurate 3D representation of the world around them from the depth knowledge. Finding motion structure presents a similar problem to finding stereo-vision structure. The correspondence between the images and the 3D object reconstruction needs to be found in both instances. Over time the function trajectories are then used to recreate their 3D positions and the motion of the camera. An alternative is the so-called direct approaches, where geometric knowledge (3D structure and camera movement) is derived directly from the images, without intermediate abstraction to features or corners. There are many solutions from motion to structure. A somewhat intermediate approach is out of core SfM, where several partial reconstructions are computed that are then integrated into a global solution.

So as we have been told before we have to take a variety of regular pictures of the object from each and every point covered so that it can be conveniently overlaid. The other approach is to simply render a video around the object by rotating around it in 360 manner and then using a converter to convert the video in image sequence format to the .JPG format. These .JPG format will further be processed in the visual SfM software by copying and

pasting into to the panel of Visual SfM software. The steps which will include to drive a image sequence to point cloud data of that object will be done by the following flowchart given below;

A). Fig : Point cloud data of helmet in visual SfM software



B). Fig : Point cloud data of coloum



C). Fig: Point cloud data of Joyeeta mam



Fig. 4: Point cloud in Visual SfM

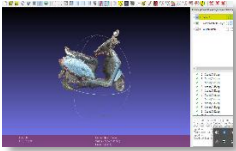
Steps for using Visual SfM:

Open Visual SfM. Then open the image set you want to use by selecting the open-multi images icon and locating the images. Once all images have been uploaded, go to Tools - Enable GPU - Set Maximum Dim. You can raise the maximum dimensions if you are using higher resolution images in order to get for information from the photos. Otherwise, Visual SfM will automatically down res your images. This might be necessary depending on the amount of memory your computer can use. Select the Compute Missing Matches icon from the tool bar to begin feature detection and matching. Once the matching has finished, select the Compute 3D Reconstruction icon from the tool bar to begin the sparse reconstruction. Select the CMVS icon to begin the dense reconstruction. You will be prompted to save out the folder that will be created during the dense reconstruction inside your Visual SfM folder as a nvm.cmvs file. A finished dense reconstruction. You can toggle between the sparse and dense reconstruction view at any point using the tab key. Once the dense reconstruction has finished. It will be automatically saved in the folder you created. VisualSfM can be closed and your ready for MeshLab.

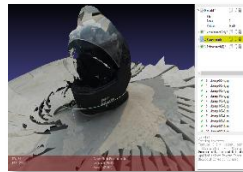
Then as the process is been done on one platform of Visual SfM we can go for another one which is Mesh Lab software

which basically used to generate 3D models of the object with the help of file generated in the Visual SFM software with (.nmv) and (.ply) file extension. And the point cloud data which is been generated in visual SFM software could be stored for future use. These

A). Scooty 3D model generated in the mesh lab software



B). Helmet 3D model generated by the mesh lab software



C). Human structure (Joyeeta mam) 3D model generated with the help of mesh lab software

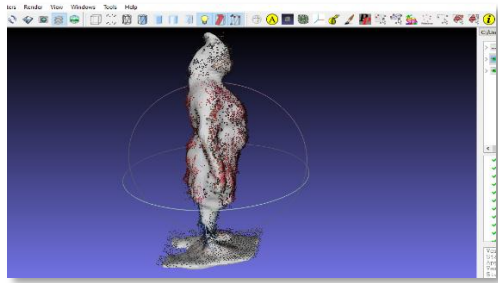


Fig.5 : Models created in mesh lab

Steps for using Mesh Lab

Open MeshLab. Go to File - Open Project and navigate to the .nmv.cmvs folder generated in Visual SFM. That should bring you to a folder labeled 00. Select the bundle.rd.out file. Next, you will be prompted to select a text file named list.txt. Select this. Go to File - Import Meshes. Navigate to the models folder in the same nmv.cmvs folder. Choose the .ply file in this folder. There may be multiple .ply files for larger point clouds. Import all .plys at the same time. These are your dense reconstruction. Now you can go in and clean the dense point clouds. The sparse reconstruction is only needed for camera placement, so from now on we will only be working with the dense point cloud. Go to Filters - Normal, Curvatures, and Orientation - Compute normal for point set. If your dense point cloud is divided into multiple .ply files, turn on all .ply layers, turn off or delete the sparse point cloud layer, right click any visible layer and select Flatten Visible layers. This will merge you dense point clouds into one. This will also remove the color information from the point clouds. Select the Show Current Raster Mode icon to check if the cameras are aligned correctly to the dense reconstruction. If the alignment is way off, the error probably occurred in Visual SFM, and you may want to regenerate the point cloud. Now you can

generate your mesh from the point cloud. Make sure that your dense point cloud layer (misleadingly named mesh or merged mesh) is highlighted. Go to Filters - Point Set - Surface reconstruction: Poisson. Clean up the resulting mesh if needed using the Face Selection icon and the Delete Vertices icon to select and remove unwanted parts of the mesh. The model has to be manifold in order to build the texture. Go to Filters - Selection - Select non-manifold edges. Clear the selection by clicking the Delete Vertices icon in the toolbar. Go to Filters - Texture - Parameterization from registered raster. Then go to Filters - Texture - Project active raster's color to current mesh, filling the texture. From this step you should get the color information projected onto the mesh, not the final texture. A color file will automatically be saved and exported. Next, to Filters - Texture - Parameterization + Texturing from registered raster. Once you've finished this step you should see the texture projected into the mesh. The texture file will automatically be saved and exported. Finally, go to File - Export Mesh as... - and choose your preferred mesh file type such as Alias Wave front Object.

RESULT

The 3D model and point cloud was generated data of all objects considered for this experiment and is further stored for the future corrections or editing processes. The motive of generating 3D models was done by the help of these two very basic and freeware software. The objective of getting the best way out for deriving the point cloud data of the material in the very easy form is been presented in the experiment performed. As the objective of achieving the 3D point cloud data is also been done by this process. The technology which is so much advance and easy to perform and also easy to store. This could be further easily edited or converted according to the requirement in the future with the help of BLENDER or CLOUD-COMPARE software.

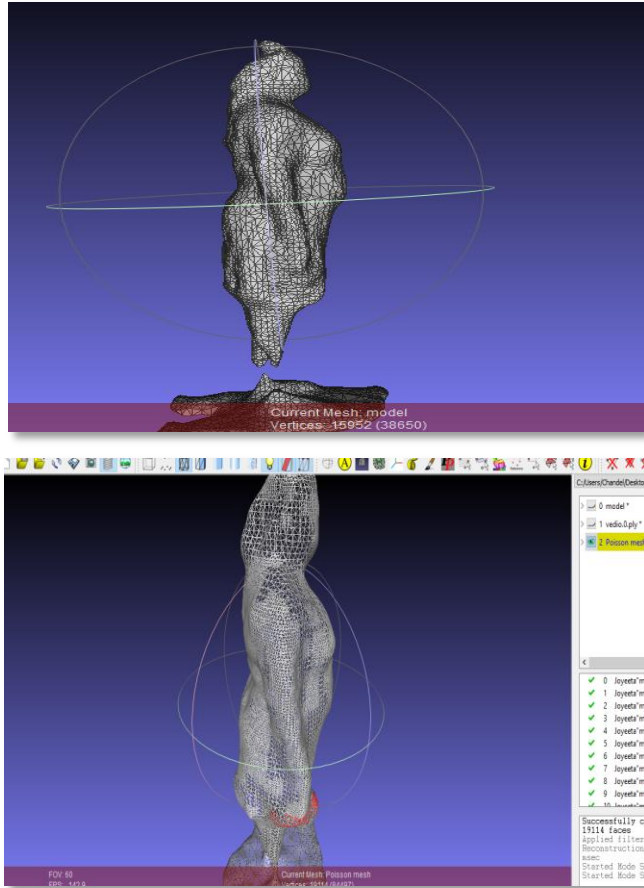


Fig. 6: Tin Model of the human structure could be generated and can be further edited.

Technology used for capturing the object and generating the 3D models of the object is the simplest way to develop as nowadays people do have cellphones with them they just have to take 360 view of the object and generate the image sequence so that point cloud could be generated. Point cloud generation with the help of other technologies is also present like LiDAR but they are too expensive and mobility of the device is also difficult. As well as they require some other features in their software which are also expensive and require only the licensed version to work as there is no freeware software for that. As of accuracy good quality camera could give a better result as compared to low Megapixel camera either in cellphone or in digital camera. Overall the requirement of developing the 3D models and point cloud data we can achieve the target by these simple process.

CONCLUSION

By the terminology we can get the idea to generate point cloud of small and minute object to a medium scale of object with the help of simple mobile/digital cameras or we can say simple photogrammetry, and which could further

help in generating and storing the 3D models of the object or the materials. These are the simplest parameters which is best and cheapest in the case of point cloud data and 3D model generation. As the materials used in the generation didn't require any other medium as we have cellphone and the software used are the freeware (open source) softwares and have the ability to generate many number of small to medium size of point cloud of that object.

REFERENCES

1. Falkingham, P. L. (2013). Generating a photogrammetric model using Visual SFM, and post-processing with meshlab. Brown University, Tech. Rep.
2. Wu, C. (2011). VisualSFM: A visual structure from motion system.
3. Martens, O. (2017). Automated Tool for Visual Progress Monitoring in Construction.
4. To, T., Nguyen, D., & Tran, G. (2015). Automated 3D architecture reconstruction from photogrammetric structure-and-motion: A case study of the One Pilla pagoda, Hanoi, Vietnam. *The International Archives of Photogrammetry, Remote Sensing and Spatial Information Sciences*, 40(7), 1425.
5. Karmacharya, S. K., Bishwakarma, M., Shrestha, U., & R  ther, N. (2019, June). Application of 'Structure from Motion'(SfM) technique in physical hydraulic modelling. In *Journal of Physics: Conference Series* (Vol. 1266, No. 1, p. 012008). IOP Publishing.
6. REKITTKE, J., & NINSALAM, Y. (2014). Head in the point clouds-feet on the ground. *Peer Reviewed Proceedings of Digital Landscape Architecture*, 198-207.
7. Kersten, T. P., & Lindstaedt, M. (2012). Automatic 3D object reconstruction from multiple images for architectural, cultural heritage and archaeological applications using open-source software and web services. *Photogrammetrie-Fernerkundung Geoinformation*, 2012(6), 727-740.
8. Kersten, T. P., & Lindstaedt, M. (2012). Potential of automatic 3D object reconstruction from multiple images for applications in architecture, cultural heritage and archaeology. *International Journal of Heritage in the Digital Era*, 1(3), 399-420.
9. Gupta, S. K., & Shukla, D. P. (2017, May). 3D reconstruction of a landslide by application of UAV and structure from motion. In *20th AGILE conference on geographic information science* (pp. 9-12).
10. Nyimbili, P. H., Demirel, H., Şeker, D. Z., & Erden, T. (2016, September). Structure from Motion (SfM)-Approaches and Applications. In *Proceedings of the International Scientific Conference on Applied Sciences*, Antalya, Turkey (pp. 27-30).