Open Source Tools for 3D Forensic Reconstructions - Part 3

Eugene Liscio, P. Eng.

November 2011

In the past several years, there have been some interesting developments and availability of open source software that allows people to create point clouds and models based on using nothing more than their digital cameras and free software available online. The development has been rather rapid and the options of using different packages has been growing with more research and individual programmers donating their time to provide solutions to the creation of 3D point clouds and meshes that can be directly imported into CAD or modeling packages. Not many people in the Forensics area have considered what open source can do for them nor might they be aware of the capabilities of using open source tools.

This article is the third instalment in a series of 4 articles that will present several open source solutions to creating point clouds and 3D models for use in Forensic applications and will look at some of the pros and cons of each.

In my two previous articles I provided two different methods of producing a point cloud using Microsoft's Photosynth and also a 3D meshed models using Autodesk's Photofly. Both of these products are based on the user having to upload a set of images to a server for processing and unfortunately, from a Forensics and Security standpoint, this is a major issue. Since photos cannot be controlled once they are uploaded to a private company's server.

However, there is another option available called VisualSFM that allows you to keep all the photos on your own PC and it has the ability to process dozens of photos to create a very dense set of point clouds.

Visual SFM

The basic concept of VisualSFM (Structure From Motion) began in 2006 and was led by Changchang Wu, a student at the University of North Carolina at Chapel Hill, while trying to find a project idea for a "3D Urban Modeling" seminar. After graduating, Changchang Wu joined the University of Washington GRAIL lab where "Photo-Tourism" (the predecessor to Microsoft's Photosynth) was born.

What makes VisualSFM interesting is right in the name, it's "visual"! This application has a graphical user interface and although it is still being improved with features and options, it has excellent capability to rapidly process hundreds of photos by taking advantage of the computer’s nVidia or ATI graphical processing unit (GPU).

Installation of the base package requires a few steps. You first need to ensure that you have an ATI or nVidia video card and then download VisualSFM here. (Note that I have an nVidia card on my system and have not verified this for ATI cards). The downloaded file is a compressed file called VisualSFM_windows_64bit.zip . Simply extract the file and a folder will appear with all the contents for the main part of VisualSFM. Also, VisualSFM is a self-running executable file and requires no installation; you simply double click on the executable file from the extracted folder.

However, if you would like to create dense point clouds, then you will also need to install the code, PMVS/CMVS from here. PMVS/CMVS is what actually does the dense matching and point cloud generation on the large set of images. Ensure that you place these files in the same folder where the VisualSFM.exe file is contained.

Lastly, in the case that you have an nVidia card, you should also download and install the CUDA Tookit directly from the nVidia website here. Be sure to choose either the 32 bit or 64 bit version for your version of Windows. The CUDA Toolkit comes with some files that allow you properly run VisualSFM. It's an extra step, but not so difficult. Just be sure to choose the "Complete" installation (not "Typical" or "Custom").

When launching Visual SFM, an empty main window will appear and look something like Figure 1 below. There is a "Task Viewer" to the right of the main application window that is often useful in watching the progress of the different processes (although you have the option to close the Task Viewer from the Tools menu).

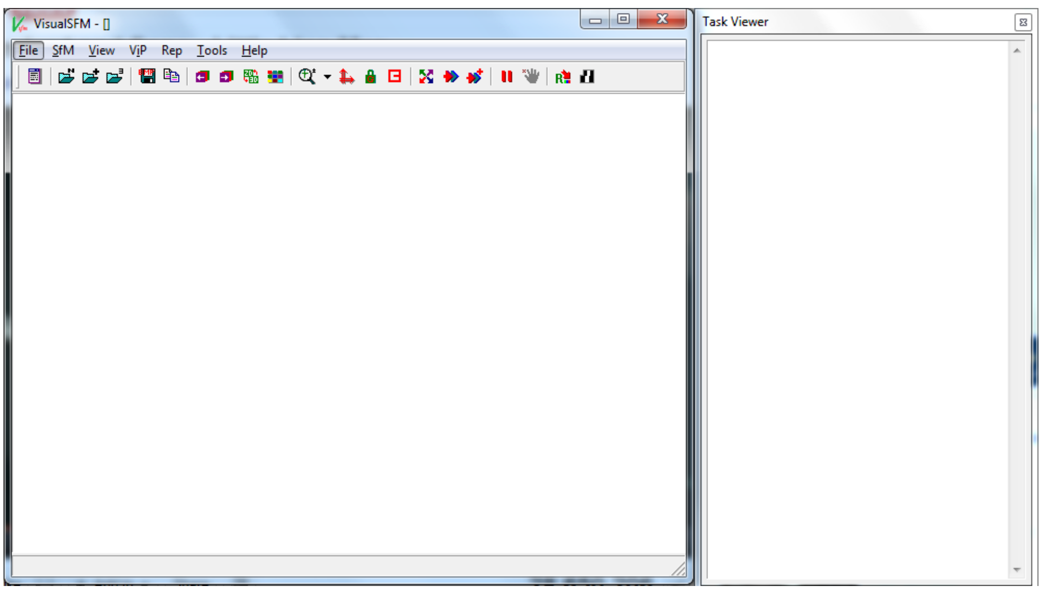

Figure 1. Interface for VisualSFM when first opened.

The first step of the dense point cloud reconstruction process is to load the desired photos using the highlighted icon shown in Figure 2, below. The software allows you to load dozens or hundreds of photos. In my testing, I completed a photo set of over 500 photos! Select all the desired photos and click "Open".

Figure 2. Open Multiple Images Icon

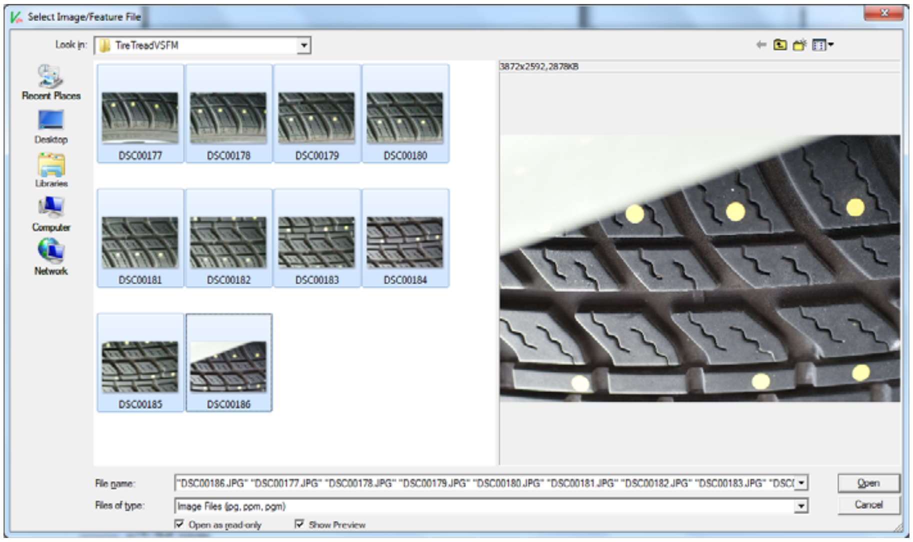

Figure 3. Selection of photos.

VisualSFM automatically loads some information of the photos and this process is normally quite rapid based on the number of photos. When completed loading you will indeed get a message in the Task Viewer saying that it is done.

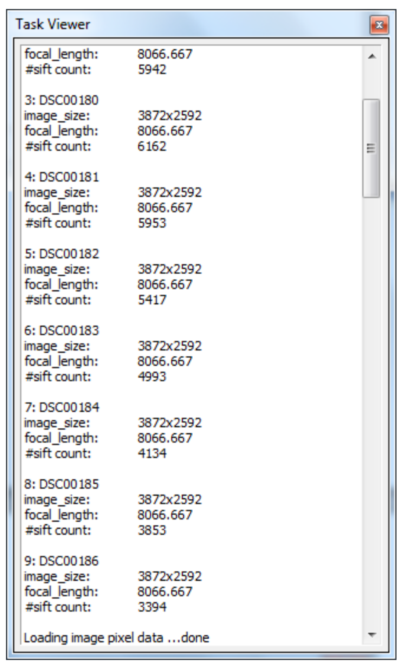

Figure 4. Loading images in Task Viewer window.

The second step is to now perform the feature matching between the images. This is done by pressing the icon with 4 opposed arrows shown in Figure 5. The results will immediately begin to show in the Task Viewer and a comparison of all the photos is done looking for similar features. This process uses the GPU and is relatively quick when compared to other non-GPU based feature extraction processes.

Figure 5. Compute Missing Image Matches

Once complete, the third step is to compute the sparse reconstruction. What happens here is that the relevant image matches between photos are now going to be calculated for their 3D positions in a relative coordinate system. This process is a precursor to the dense reconstruction, but is normally very quick. Figure 6 shows the highlighted icon and Figure 7 shows a sparse reconstruction for a set of images that were loaded for a portion of tire tread. The general form of the reconstruction is starting to take place and one can view the calculated points, camera positions and image planes in 3D. This can be manipulated using the left mouse button for pan, right mouse button for rotate and scroll wheel for zoom.

Figure 6. Compute the sparse 3D Reconstruction

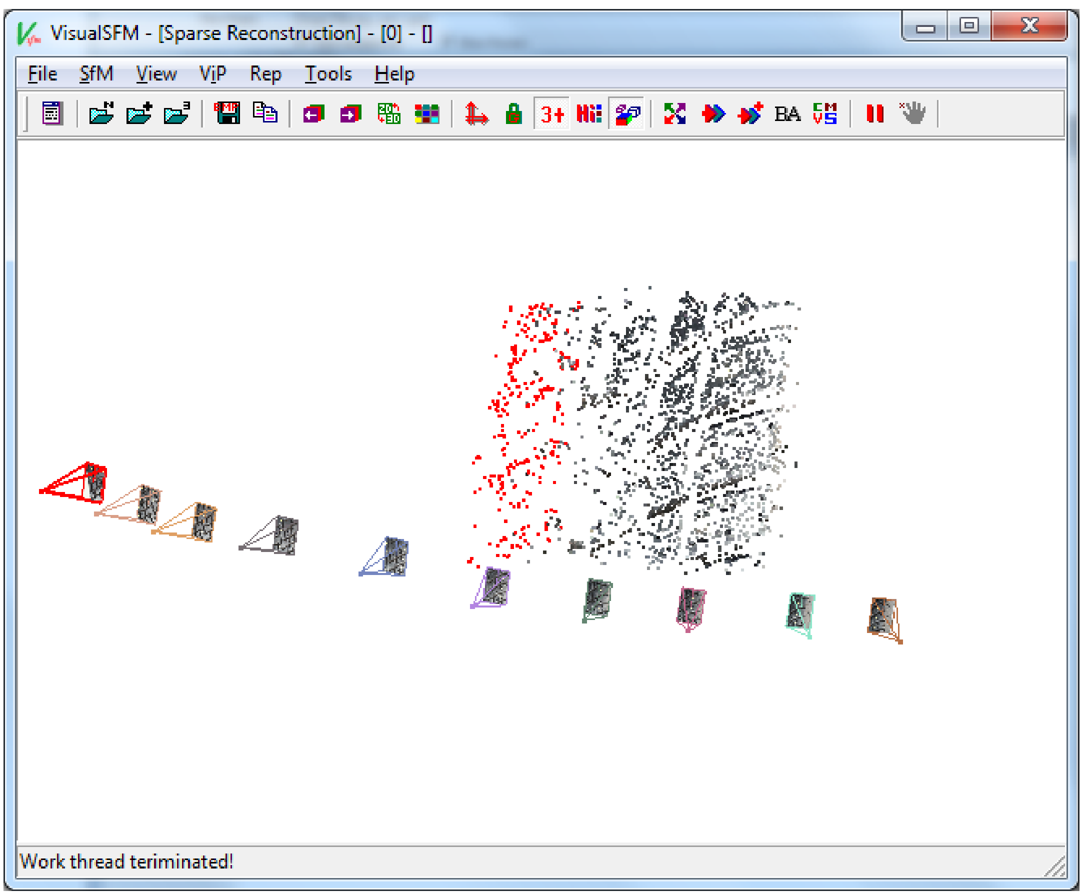

Figure 7. Results of 3D Sparse Reconstruction

The fourth main step in the process is the actual dense reconstruction itself. Simply press the CMVS icon as shown in Figure 8, below and there will be a browser window that appears asking you what to name the created point cloud and a location for where to place the data. Once the file name is chosen, Task Viewer will then begin to show the relative process of dense reconstruction. The time to complete the dense reconstruction could be anywhere from several seconds for only a few images to several hours for larger data sets.

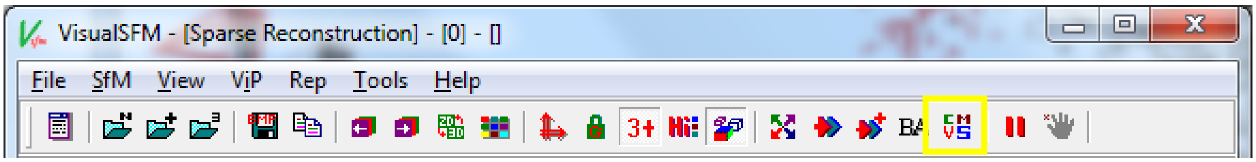

Figure 8. The CMVS icon runs the dense reconstruction.

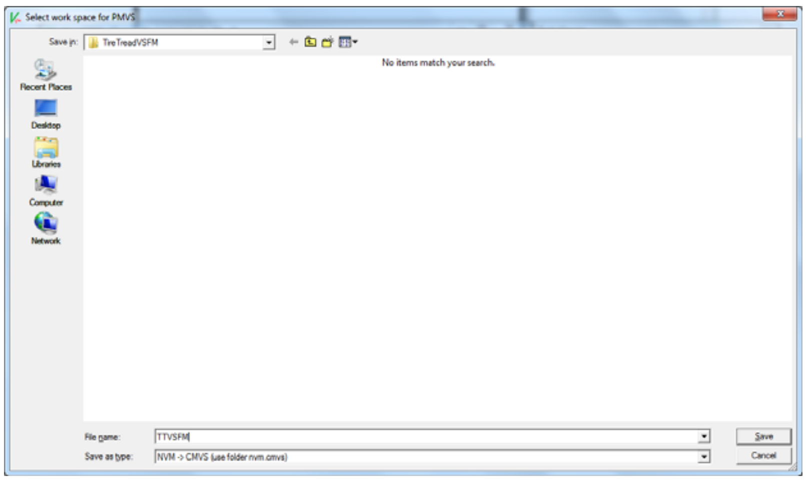

Figure 9. Choose a new directory to place the created models.

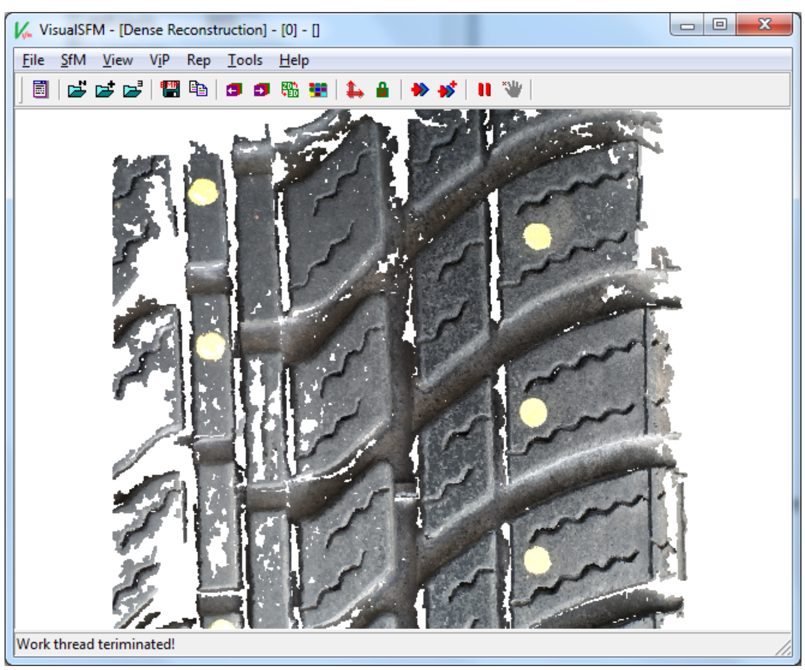

Figure 10. Dense reconstruction of tire treads.

Once complete you should have a densely reconstructed point cloud show up in the main window of Visual SFM. Also, there will be a folder created where you chose to save the file and this will have a "models" folder inside the main directory where all automatically created dense reconstructions will be placed in "ply" format. This file is what can be opened in MeshLab for further processing.

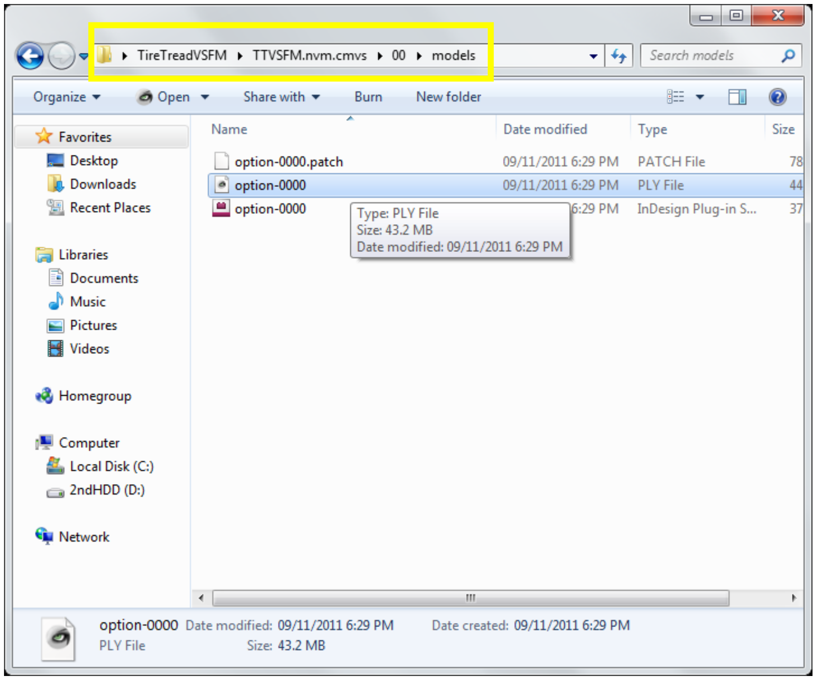

Figure 11. Folder location showing a generated model with initial name of 0000.

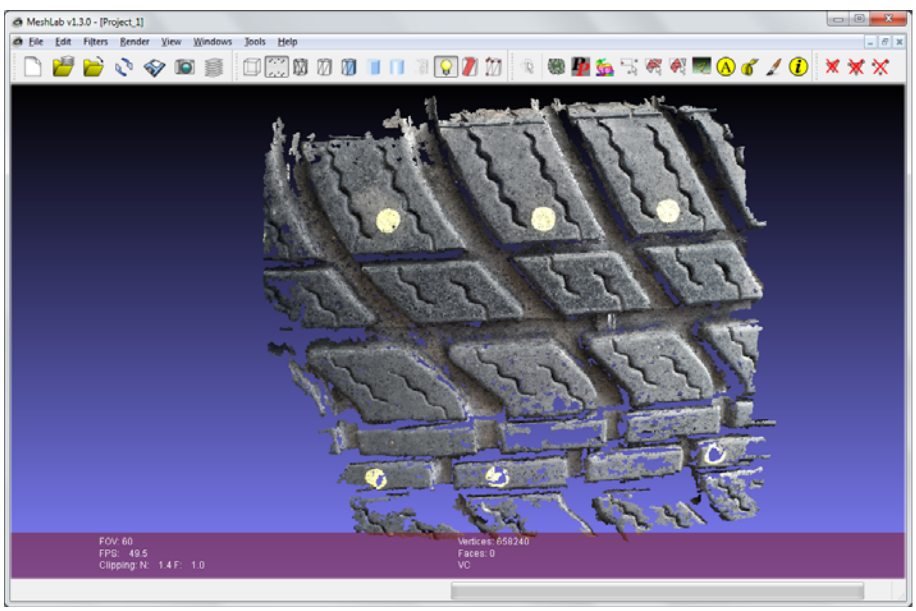

Figure 12. Generated ply file in MeshLab

Note that VisualSFM tries to match all the photos, but depending on how the photos were taken, any areas that are not able to be matched may cause a fragmented set of models and multiple models of dense reconstructions may be created in folders with sequential naming of 01, 02, 03…etc.

There are several more options with VisualSFM that can be useful like tapping into the settings file and making adjustments to the dense reconstruction so that more points are matched. You can even manually assist the matching of photos when the application has problems finding a relationship between photos sets. Additionally, it is often useful to export a high resolution image of the current view using the "save current view" icon.

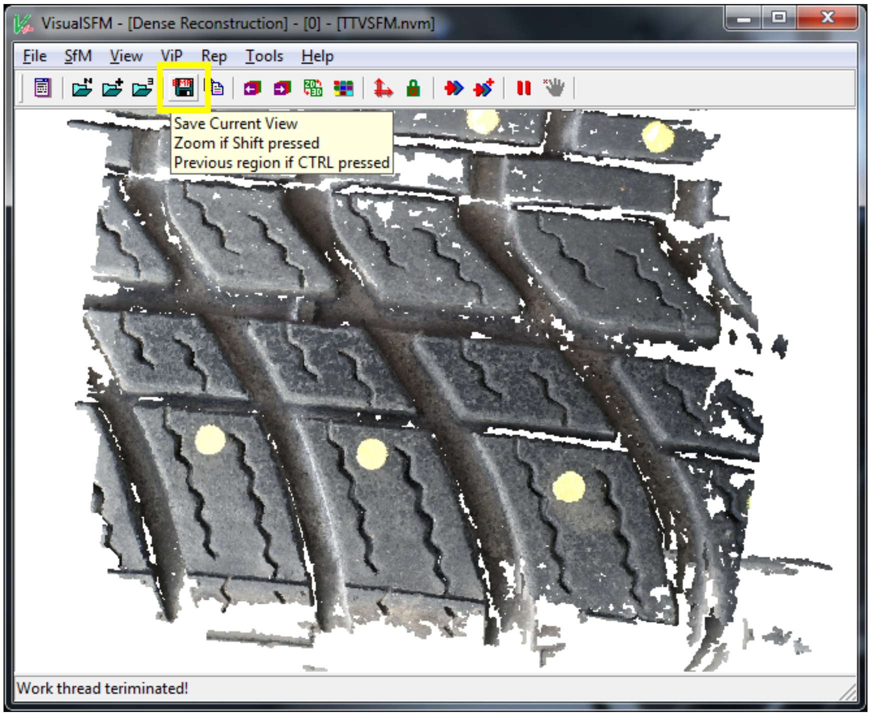

Figure 13. Save Current View Icon

For further information on usage and help documentation, please visit the following link, http://www.cs.washington.edu/homes/ccwu/vsfm/doc.html#usage.

Eugene Liscio, P. Eng, is the owner of AI^2-3D. A company that specializes in 3D Forensic Measurement, Analysis and Visualizations. AI2-3D, Toronto, Ontario, 416-704-2695, information@ai2-3d.com, www.ai2-3d.com.