Using 'Bundler Photogrammetry Package' for SfM-MVS reconstructions

1. Setup

Hardware and software requirements:

Windows operating system, 64-bit computer, Nvidia graphics card.

Bundler Photogrammetry Package: download from http://files.neonascent.net/SFM.zip

Software installation

Extract SFM.zip to C:\

The *exact* path is important and others will not work. Ensure that the extraction has given you folders:

C:\SFM\ bin C:\SFM\ bundler_doc

C:\SFM\ bin64 C:\SFM\ cygwin C:\SFM\ examples

2. Carry out a reconstruction

Data preparation

1) Make a new folder inside C:\SFM\examples\ to hold your reconstruction project and copy in your image files (.jpg format) [NOTE – do not use spaces in your folder or image names]
2) Copy `MakeList.bat` from C:\SFM\ into your project folder and run the file (double-click). This creates a single file `list.txt` that contains a list of the images to be processed.

Structure-from-motion (SfM) sparse reconstruction

3) Copy `sparseRecon64.bat` from C:\SFM\ into your project folder and run it (double-click). This runs the SfM script – follow the instruction to hit a key to start. The first step is the SIFT feature extraction and you should see text similar to :

```
[Extracting Sift feature : 33%] – (1/9, 1807 features)
```

If there is an error, this is likely to be to do with your graphics card (SIFT processing is carried out on the graphics card) – a remedy for which is out of scope of these instructions. When SIFT feature extraction and initial matching has completed, you need to hit a key to start Bundler.

Bundler requires the sensor width of the camera to initialize processing. In most cases Bundler extracts this from either the EXIF header data of the images, or from a text file used by the software. However, if the data are not found, you will see

```
[Couldn't find CCD width for camera ...]
```

and you need to add the details yourself to the text file. To do this :

1) Find the CCD width of your camera in mm; values are usually given on manufacturer's website or at camera review sites such as DPReview (http://www.dpreview.com/).
2) You also need to determine the text in your image files that Bundler uses to identify which camera was used. In Windows Explorer, right-click on an image and go to Properties. Select the Details or Summary tab (clicking 'Advanced'if necessary), and find the value for the Camera Model property.
3) Using a text editor, insert a line containing you camera details to C:\SFM\bin\extract_focal.pl file in the same format as the lines for other camera data:

```
%ccd_widths = (
    …
    "YOUR CAMERA MODEL" => ww,
    …

);
```

where *ww* is the CCD width in mm. Note that anything written after a '#' character is a comment only and not used by the software. Save the file and retry `sparseRecon64.bat`. If the problem remains, double check that you have *exactly* the same text in your entry to the CCD list as in the image properties (including capitalization and spaces).

When Bundler is running then a sub-directory called `bundle` will be produced in your project folder. As the reconstruction proceeds, Bundler writes incremental output files in the form `bundle_nnn.out` and `pointsnnn.ply`, where *nnn* is the number of images that have been successfully incorporated into the model so far. The .ply files are ASCII format 3D point clouds which show the positions of the reconstructed cameras and the 3D surface. They can be viewed with a variety of software (see below).

Multi-view stereo (MVS) dense reconstruction
Once Bundler has finished, the SfM step is complete and the MVS dense reconstruction can be started:

4) Copy `denseRecon_batch.bat` and `denseRecon.vbs` from C:\SFM\ into your project folder and run `denseRecon.vbs`
5) Enter the values for the match parameters - the recommended ones usually give good result but the panel below explains more about the individual parameters

Images per segment: This sets the maximum number of images that will be clustered together (by CMVS) for simultaneous matching. More is better, but the maximum number is limited by RAM and will vary with the density of the reconstruction. Fewer means that more image clusters will be produced for matching one after another.

Reconstruction level and *Voxel size*: Both these parameters effectively vary the density at which the matching is carried out. Denser matching require more RAM and is much slower than less dense matching. The details are not straightforward, but *level* determines the number of times images are decimated before matching (i.e. *level* = 1 (recommended) represents images used at half-resolution). *Voxel size* determines how often a match is attempted – i.e. every n^{th} pixel in the x and y directions of the sampled images. For the recommended *voxel size* = 2, then a match is attempted for every fourth pixel in an image.

Reconstruction threshold: A threshold that is related to correlation values in the matching process and is used to filter out bad matches. Larger (up to 1.0) values mean fewer but more reliable points, smaller values retain more points, but the quality can be lower. A value of 0.9 is recommended.

The matching process may take some time. At the end there should be one or more .ply files within the subdirectory \pmvs\models of your project folder.

3. Visualise the results

All .ply files produced are in ASCII format and contain the point coordinates and color information after number of header lines. ASCII .ply files can be read directly by most point cloud processing software. Good freeware applications are:

Meshlab: http://meshlab.sourceforge.net/

Cloudcompare http://www.danielgm.net/cc/