v0.02: Tested on a Ubuntu 22.04 system

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VisualSfM - Ubuntu installation

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Contents

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1 Introduction

In 2013 Changchang Wu, who worked on the Structure from Motion (SFM) part of the study 'Building Rome on a Cloudless Day' [1], created the graphical tool **VisualSfM**[1], which can be used for 3D reconstruction. The VisualSfM graphical tool combines several algorithms, for feature detection [3], feature matching [6], bundle adjustment [5], sparse & dense reconstruction [4].

For Windows those tools are bundled up, for Ubuntu more installation work has to be done. An installation tutorial for Ubuntu is given[2], yet this tutorial is based on the Long Term Support version of 2012 (Precise 12.04). This document gives the instructions needed to build it for modern versions (tested on Ubuntu 20.04 and 22.04).

2 Installation steps

To get the system working, six tools have to be built. This guide follows the steps from Scott Sawyer's tutorial, including the necessary modifications.

2.1 Getting Started

Scott was using working directly in his home-directory, `~/vsfm`, with several of the other tools installed in that directory. I preferred to work in `~/src/vsfm`, with the other tools build next to `~/src/vsfm`.

2.2 Setup NVIDIA CUDA (Optional)

I skipped this part, partly because not all laptops will have a NVIDIA GPU, partly because I am afraid of the legacy issues encountered when using CUDA-code from 2012. Our experience is that the program is fast enough to run on modern laptops without additional GPU.

2.3 Download the Necessary Software

These are 64bits versions of the six tools plus one support routine that are combined in the VisualSFM graphical user interface:

- **[VisualSFM:]** version v0.5.26
- **[SiftGPU:]** version v400
- **[Multicore Bundle Adjustment:]** version 1.0.5
- **[PMVS-2:]** fix0
- **[CLAPACK:]** version 3.2.1
- **[Graclus:]** v1.2
- **[CMVS:]** fix2

In the next sections we assume that you saved these downloads in your `~/Downloads/` directory.

2.4 Install Dependency Packages

Not all dependencies mentioned by Scott are still available. Instead, I used the following set:

```
$ sudo apt-get install libgtk2.0-dev libglew-dev glew-utils libdevil-dev libboost-all
    -dev libatlas-cpp-0.6-dev imagemagick libatlas-base-dev libcminpack-dev libmetis-
    edf-dev libparmetis-dev freeglut3-dev libgsl-dev libcanberra-gtk-module dos2unix
```

[1]`http://ccwu.me/vsfm/`

[2]`http://www.10flow.com/2012/08/15/building-visualsfm-on-ubuntu-12-04-precise-pangolin-desktop-64-bit/`

2.5 Install Legacy Dependency Packages

The PVMS-2 tool is Fortran based, which is an old programming language, which needs some libraries from 2008. These libraries are no longer in the default Ubuntu archive, but can still be accessed via `old-releases.ubuntu.com`.

To get this to work, add to `/etc/apt/sources.list` the following lines.

```
deb [allow-insecure=yes] http://old-releases.ubuntu.com/ubuntu/ hardy main universe
deb [allow-insecure=yes] http://archive.ubuntu.com/ubuntu/ bionic main universe
```

To load this repository do `sudo apt-get update`

Next, you should install the old version of the compiler with `sudo apt-get install g++-4.1` and `sudo apt-get install g++-5`. To activate these compiler you have to check which g++ versions you have with the command `ls /usr/bin/g++-*`.

In my case I had four versions of the compiler, which you can register as alternative. The last integer in each of these commands indicates the priority for this alternative, I used the $year - 2000$ as value for this priority.

```
$ sudo update-alternatives --install /usr/bin/g++ g++ /usr/bin/g++-4.1 8
$ sudo update-alternatives --install /usr/bin/g++ g++ /usr/bin/g++-5 15
$ sudo update-alternatives --install /usr/bin/g++ g++ /usr/bin/g++-9 19
$ sudo update-alternatives --install /usr/bin/g++ g++ /usr/bin/g++-11 21
```

Now you can select the current gcc-compiler interactively for `sudo update-alternatives --config g++`. The same can be done for gcc:

```
$ sudo update-alternatives --install /usr/bin/gcc gcc /usr/bin/gcc-4.1 8
$ sudo update-alternatives --install /usr/bin/gcc gcc /usr/bin/gcc-5 15
$ sudo update-alternatives --install /usr/bin/gcc gcc /usr/bin/gcc-9 19
$ sudo update-alternatives --install /usr/bin/gcc gcc /usr/bin/gcc-11 21
```

Select gcc-4.1 and g++-4.1 with `sudo update-alternatives --config`:

```
$ sudo update-alternatives --config gcc
$ sudo update-alternatives --config g++
```

Now you can do `sudo apt-get install libgfortran1`

When `libgfortran1` is correctly installed, you can comment out the two new `ubuntu.com` old-archive lines from your `/etc/apt/sources.list`, to prevent problems later.

Switch back again to the default gcc-11 and g++-11 with `sudo update-alternatives --config`.

2.6 Install VisualSFM

Building VisualSFM from source, so we will use a prebuild version. Luckily Alberto Mardegan has a prebuild version:

```
$ cd ~/src
$ unzip ~/Downloads/VisualSFM_linux_64bit.zip
```

This installs the framework with all its subdirectories in `/src/vsfm`, only the executable is missing.

```
$ snap install visualsfm-mardy
$ cp -p /snap/visualsfm-mardy/current/bin/VisualSFM ~/src/vsfm/bin
```

We cannot use the snap-version directly, because it depends on an older `libgsl.so` library.

2.7 Build SiftGPU

In this guide we have chosen to circumvent CUDA installation issues, we build SiftGPU without CUDA support. CUDA support is per default on, so the makefile has to be adjusted.

```
$ cd ~/src
$ unzip ~/Downloads/SiftGPU.zip
```

Open the `makefile` and set `siftgpu_enable_cuda=0`. Although you did already `sudo apt-get install libdevil-dev` in Section 2.4, you can also set `siftgpu_disable_devil = 1`.

Now everything should be ready for a build.

```
$ cd ~/src/SiftGPU
$ make
$ cp bin/libsiftgpu.so ../vsfm/bin
```

2.8 Build Multicore Bundle Adjustment (a.k.a. “pba”)

Again we build the version without CUDA support. To build this tool we need to make some minor adjustments in the header files.

```
$ cd ~/src
$ unzip ~/Downloads/pba_v1.0.5.zip
```

Scott suggested to add a line `#include <stdlib.h>` to two files: `SparseBundleCU.h` and `pba.h`, which both can be found in the directory `pba/src/pba`. During our testing it also worked without this addition. You can make both files better readable with the command `dos2unix`.

```
$ cd ~/src/pba
$ make -f makefile_no_gpu
$ cp bin/libpba_no_gpu.so ../vsfm/bin/libpba.so
```

2.9 Hack PMVS-2

Scott recommends a hack to temporary save `mylapack.o` before building from source, but this fails because this file was compiled with an outdated option. Instead we will also build clapack from source.

To do that, we need the definitions of clapack.

```
$ cd ~/src
$ tar -xvf ~/Downloads/pmvs-2-fix0.tar.gz
$ cd ~/src/pmvs-2/program/base/numeric/
$ tar -xvf ~/Downloads/clapack.tgz
```

```
$ cd ~/src/pmvs-2/program/main/
$ mkdir include
$ cd  ~/src/pmvs-2/program/main/include
$ ln -s ~/src/pmvs-2/program/base/numeric/CLAPACK-3.2.1/INCLUDE clapack
$ cd  ~/src/pmvs-2/program/main/
```

Now edit in the main-directory the Makefile, and add the new include-directory to the compiler with the line `YOURINCLUDEPATH = -I include`. Now you should be able to build the executable pmvs2.

```
$ make clean
$ make depend
$ make
$ cp pmvs2 ../vsfm/bin
```

2.10 Build Graclus 1.2

The Graclus is per default configured for 32-bits computers, so only a small modification is needed to build this tool.

```
$ cd ~/src
$ tar -xvf ~/Downloads/graclus1.2.tar.gz
```

Edit `Makefile.in` and set `-DNUMBITS=64`. That is enough to build this tool.

```
$ cd ~/src/graclus1.2
$ make
$ cp graclus ../vsfm/bin
```

2.11 Hack CMVS

To build CMVS, we need some of the previous build libraries.

```
$ cd ~/src
$ tar -xvf ~/Downloads/cmvs-fix2.tar.gz
```

You need to modify two source files. Add two lines (`#include <vector>` and `#include <numeric>`) to `~/src/cmvs/program/base/cmvs/bundle.cc`. Add one line (`#include <stdlib.h>`) to `~/src/cmvs /program/main/genOption.cc`.

Then modify `~/src/cmvs/program/main/Makefile` with the following lines 10-17 (don't forget to comment out line 10, 13, 16):

```
#Your INCLUDE path (e.g., -I/usr/include)
YOUR_INCLUDE_PATH = -I/home/yourname/src/pmvs-2/program/main/include

#Your metis directory (contains header files under graclus1.2/metisLib/)
YOUR_INCLUDE_METIS_PATH = -I/home/yourname/src/graclus1.2/metisLib

#Your LDLIBRARY path (e.g., -L/usr/lib)
YOUR_LDLIB_PATH = -L/home/yourname/src/graclus1.2
```

This tool will not compile with the default compiler, so you should change your compiler to gcc-5.5 and g++-5.5 with:

```
sudo update-alternatives --config gcc
sudo update-alternatives --config g++
```

Now you can start the build

```
$ cd ~/src/cmvs/program/main
$ make
$ cp cmvs ~/src/vsfm/bin
$ cp pmvs2 ~/src/vsfm/bin
$ cp genOption ~/src/vsfm/bin
```

Don' t forget to switch back to the default gcc-11 and g++-11 again with `sudo update-alternatives --config`.

3 Running VisualSFM

Finally, add the executable VisualSFM to your path by adding the following lines to your `~/.bashrc` file.

```
export PATH=$PATH:/home/yourname/src/vsfm/bin
export LD_LIBRARY_PATH=$LD_LIBRARY_PATH:/home/yourname/src/vsfm/bin
```

Activate these extensions with the command `source ~/.bashrc`. Now you should be able to start the graphical tool with the command `VisualSFM`, or run without graphics with a command like `VisualSFM sfm+pmvs ./images ./result.nvm`, as indicated in the documentation[3].

As an example, you can download a small dataset of 119 images recorded with the front camera of a RAE robot driving less than a meter in a small maze.

```
$ cd /home/yourname/src/vsfm/
$ mkdir results
$ mkdir -p data/small_maze
$ cd data/small_maze
$ wget https://staff.fnwi.uva.nl/a.visser/education/VAR/2024/small_maze.tgz
$ tar -zxvf small_maze.tgz
```

Now you can perform the four steps indicated in the VisualSFM documentation:

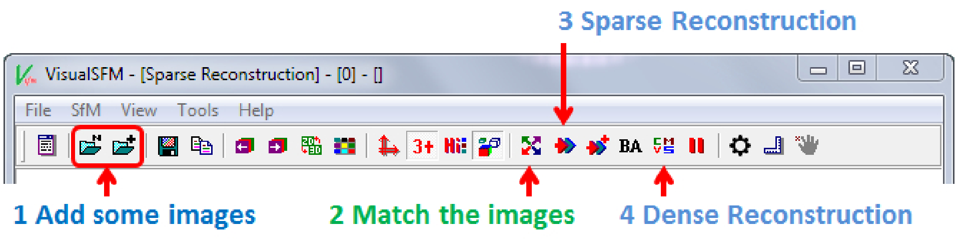


Figure 1: The VisualSFM toolbar

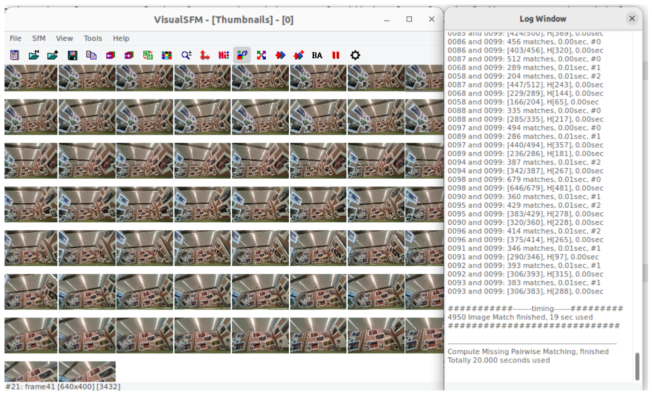
3.1 Add some images

Here you can add the 119 images you unpacked in the `/home/yourname/src/vsfm/data/small_maze` directory. The nine-colored-block button in the toolbar allows you to see the thumbnails.

[3]`http://ccwu.me/vsfm/doc.html`

3.2 Match the images

When you select this button, the library `libsiftgpu.so` you built in Section 2.7 will be used:

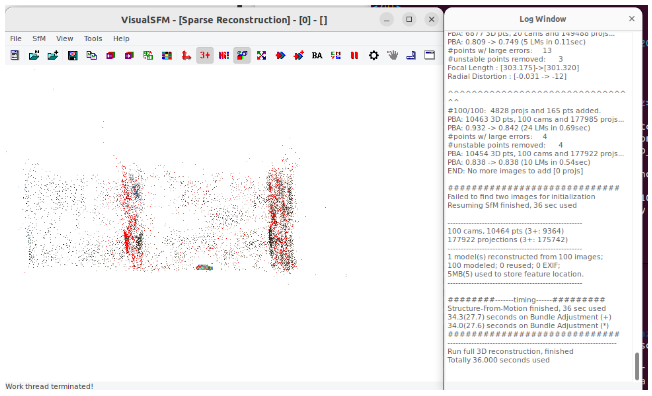


```
0085 and 0099: [424/500], H[369], 0.00sec
0086 and 0099: 456 matches, 0.00sec, #0
0086 and 0099: [403/456], H[320], 0.00sec
0087 and 0099: 512 matches, 0.00sec, #0
0068 and 0099: 289 matches, 0.01sec, #1
0058 and 0099: 204 matches, 0.01sec, #2
0087 and 0099: [447/512], H[243], 0.00sec
0068 and 0099: [229/289], H[144], 0.00sec
0058 and 0099: [166/204], H[65], 0.00sec
0088 and 0099: 335 matches, 0.00sec, #0
0088 and 0099: [285/335], H[217], 0.00sec
0097 and 0099: 494 matches, 0.00sec, #0
0089 and 0099: 286 matches, 0.01sec, #1
0097 and 0099: [440/494], H[357], 0.00sec
0089 and 0099: [236/286], H[181], 0.00sec
0094 and 0099: 387 matches, 0.01sec, #2
0094 and 0099: [342/387], H[267], 0.00sec
0098 and 0099: 679 matches, 0.01sec, #0
0098 and 0099: [646/679], H[481], 0.00sec
0090 and 0099: 360 matches, 0.01sec, #1
0095 and 0099: 429 matches, 0.01sec, #2
0095 and 0099: [383/429], H[278], 0.00sec
0090 and 0099: [320/360], H[228], 0.00sec
0096 and 0099: 414 matches, 0.01sec, #2
0096 and 0099: [375/414], H[265], 0.00sec
0091 and 0099: 346 matches, 0.01sec, #1
0091 and 0099: [290/346], H[97], 0.00sec
0092 and 0099: 393 matches, 0.01sec, #1
0092 and 0099: [306/393], H[315], 0.00sec
0093 and 0099: 383 matches, 0.01sec, #1
0093 and 0099: [306/383], H[288], 0.00sec

###########-------timing------#########
4950 Image Match finished, 19 sec used
#############################

-------------------------------------------------------
Compute Missing Pairwise Matching, finished
Totally 20.000 seconds used
```

Figure 2: Matching the SIFT image features

3.3 Sparse reconstruction

When you select this button, the library `libpba.so` you built in Section 2.8 will be used:

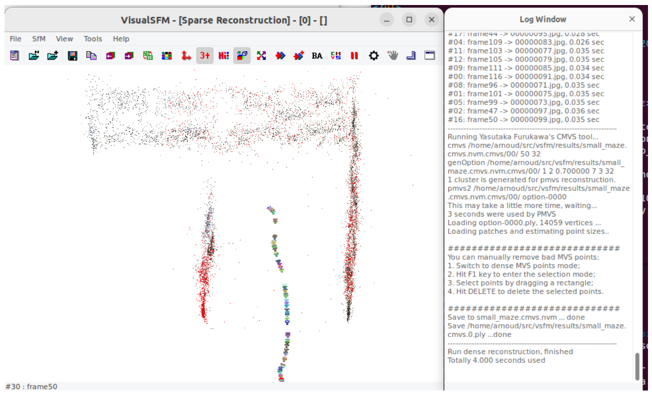


```
PBA: 6877 3D pts, 20 cams and 149488 projs...
PBA: 0.809 -> 0.749 (5 LMs in 0.11sec)
#points w/ large errors:    13
#unstable points removed:     3
Focal Length : [303.175]->[301.320]
Radial Distortion : [-0.031 -> -12]

^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^
^^
#100/100:  4828 projs and 165 pts added.
PBA: 10463 3D pts, 100 cams and 177985 projs...
PBA: 0.932 -> 0.842 (24 LMs in 0.69sec)
#points w/ large errors:    4
#unstable points removed:     4
PBA: 10454 3D pts, 100 cams and 177922 projs...
PBA: 0.838 -> 0.838 (10 LMs in 0.54sec)
END: No more images to add [0 projs]

#############################
Failed to find two images for initialization
Resuming SfM finished, 36 sec used

--------------------------------------------
100 cams, 10464 pts (3+: 9364)
177922 projections (3+: 175742)
--------------------------------------------
1 model(s) reconstructed from 100 images;
100 modeled; 0 reused; 0 EXIF;
5MB(5) used to store feature location.
--------------------------------------------

########-------timing------#########
Structure-From-Motion finished, 36 sec used
34.3(27.7) seconds on Bundle Adjustment (+)
34.0(27.6) seconds on Bundle Adjustment (*)
#############################
-------------------------------------------------------
Run full 3D reconstruction, finished
Totally 36.000 seconds used
```

Figure 3: Sparse Reconstruction

3.4 Dense reconstruction

When you select this button, the tool `cmvs` you built in Section 2.11 will be used:



```
#17: frame44 -> 00000095.jpg, 0.028 sec
#04: frame109 -> 00000083.jpg, 0.026 sec
#11: frame103 -> 00000077.jpg, 0.035 sec
#12: frame105 -> 00000079.jpg, 0.035 sec
#09: frame111 -> 00000085.jpg, 0.034 sec
#00: frame116 -> 00000091.jpg, 0.034 sec
#08: frame96 -> 00000071.jpg, 0.035 sec
#01: frame101 -> 00000075.jpg, 0.035 sec
#05: frame99 -> 00000073.jpg, 0.035 sec
#02: frame47 -> 00000097.jpg, 0.036 sec
#16: frame50 -> 00000099.jpg, 0.035 sec
-------------------------------------------------------
Running Yasutaka Furukawa's CMVS tool...
cmvs /home/arnoud/src/vsfm/results/small_maze.
cmvs.nvm.cmvs/00/ 50 32
genOption /home/arnoud/src/vsfm/results/small_
maze.cmvs.nvm.cmvs/00/ 1 2 0.700000 7 3 32
1 cluster is generated for pmvs reconstruction.
pmvs2 /home/arnoud/src/vsfm/results/small_maze
.cmvs.nvm.cmvs/00/ option-0000
This may take a little more time, waiting...
3 seconds were used by PMVS
Loading option-0000.ply, 14059 vertices ...
Loading patches and estimating point sizes..

#############################
You can manually remove bad MVS points:
1. Switch to dense MVS points mode;
2. Hit F1 key to enter the selection mode;
3. Select points by dragging a rectangle;
4. Hit DELETE to delete the selected points.

#############################
Save to small_maze.cmvs.nvm ... done
Save /home/arnoud/src/vsfm/results/small_maze.
cmvs.0.ply ...done
-------------------------------------------------------
Run dense reconstruction, finished
Totally 4.000 seconds used
```

Figure 4: Dense Reconstruction

You can combine those steps in a single command with `VisualSFM sfm+pmvs /home/yourname/src/vsfm/data/small_maze /home/yourname/src/vsfm/results/small_maze.cmvs.nvm`.

4 Conclusion

When you are able to make a dense reconstruction for a small example on your local Ubuntu machine, you could try larger datasets. This will require more computation time. Scott Sawyer wrote his tutorial while working on a cluster of 64 compute cores [2]. So, future work could be an update of this Ubuntu installation guide for a cluster including GPU-support.

References

[1] J.-M. Frahm, P. Fite-Georgel, D. Gallup, T. Johnson, R. Raguram, C. Wu, Y.-H. Jen, E. Dunn, B. Clipp, S. Lazebnik and M. Pollefeys, “Building Rome on a Cloudless Day”, in “Computer Vision – ECCV 2010”, pp. 368–381, Springer, 2010, doi:10.1007/978-3-642-15561-1_27.

[2] S. M. Sawyer, K. Ni and N. T. Bliss, “Cluster-based 3D reconstruction of aerial video”, in “2012 IEEE Conference on High Performance Extreme Computing”, pp. 1–6, 2012, doi:10.1109/HPEC.2012.6408681.

[3] C. Wu, *Geometry-driven Feature Detection*, Ph.D. thesis, University of North Carolina at Chapel Hill, May 2011, doi:10.17615/a8q4-8h80.

[4] C. Wu, “Towards Linear-Time Incremental Structure from Motion”, in “International Conference on 3D Vision – 3DV 2013”, pp. 127–134, 2013, doi:10.1109/3DV.2013.25.

[5] C. Wu, S. Agarwal, B. Curless and S. M. Seitz, “Multicore bundle adjustment”, in “IEEE Conference on Computer Vision and Pattern Recognition – CVPR 2011”, pp. 3057–3064, 2011, doi:10.1109/CVPR.2011.5995552.

[6] C. Wu, B. Clipp, X. Li, J.-M. Frahm and M. Pollefeys, “3D model matching with Viewpoint-Invariant Patches (VIP)”, in “IEEE Conference on Computer Vision and Pattern Recognition – CVPR 2008”, 2008, doi:10.1109/CVPR.2008.4587501.

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