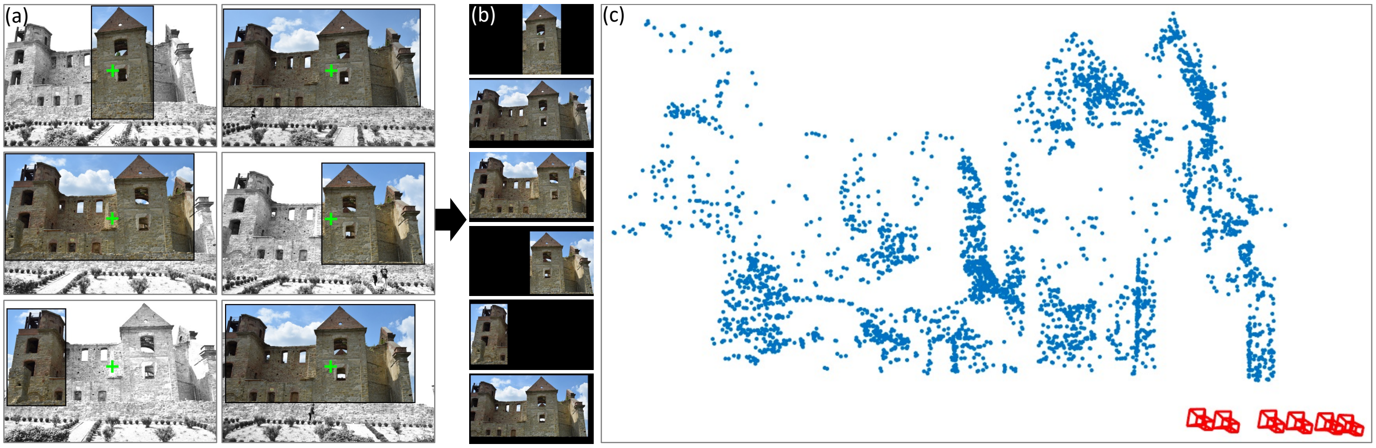

Fig. 1. The Zagórz Carmelite Monastery dataset [19]. We arbitrarily crop six images from the dataset (a). Note that parameters remain fixed apart from the principal point which can be outside the cropped image. Our SfM pipeline for this scenario estimates per-image principal point (our estimates shown as green crosses). This allows alignment of images by their estimated principal point (b) which could then be used with any existing SfM tool that assumes fixed principal point. The high quality point cloud reconstructed by our method is shown in (c). We compare this to ground truth acquired with a terrestrial laser scanner.

Appendix

A. Experiment setup

In this section we describe a procedure we used to evaluate the quality of our pipeline. We used two software tools for comparison, a very popular comercial Agisoft Metashape and a state of the art open-source software - COLMAP. Due to the fact that COLMAP does no have an implementation of EPGS coordinate systems, like NSIDC Sea Ice Polar Stereographic North (EPSG::3413) used in a glacier study, but uses ECEF (Earth-Centered-Earth-Fixed) or to ENU (East-North-Up) coordinates, we decided to create a more controlled data set that would be better suited for this setup. This way we could compare the same data sets in the same coordinate system thus eliminating potential transformation errors.

B. Zagórz Carmelite Monastery dataset

Zagórz Carmelite Monastery dataset consists of around 1,000 images of the interior and exterior of the ruins of a church. All images were taken with Nikon D5300 (24.2MP, sensor 23.5mm $\times$ 15.6mm) camera with Nikkor AF-S lenses (f=18-70mm). Since this is a contemporary data set all internal camera parameters are stored within images meta-data. We chose six images and cropped them in a way that would resemble a tourist preparing the images for better visual effect. For ground truth we used 5 registered point clouds from a terrestrial laser scanner Z+F IMAGER 5010c. Scans were taken at the same time as the images with average resolution of 20mm and 9mm average registration/alignment error.

C. Detailed description of experiment results

We show quantitative results in Tab.2 in the main body of the paper. E_{geo} is the point to point distance between reconstructed point cloud and ground truth in metres. E_{pp} is the PP error in pixels (after adding the bounding box corner coordinate for the cropped images). We show mean and standard deviation for the cropped images since we get a different PP estimate for each image. Ours is the only method able to reconstruct a model from the cropped images with a geometry accuracy comparable to state-of-the-art methods on uncropped images. In the bottom two rows, we use our output to resample the images to a common PP and image size then provide camera parameters and these resampled images to the two comparison methods.

Note that there is a disagreement of 47.9 pixels in the PP estimate between two state-of-the-art SfM pipelines on the original uncropped images. We achieve a mean PP error of only 73.2 pixels on the cropped images, including estimating PP well away from the cropped image centres (see Fig. 1, green crosses). We perform an ablation of the exposed area constraint, whose removal more than doubles the PP error while increasing the geometry error by 7.2%. It is worth to mention that since GCP cannot be implemented directly into COLMAP, the GCP analysis, standard when using Agisoft, could not be performed.

D. Experiment importance

In this experiment, we find a real world application scenario in which our method is applicable and outperforms standard pipelines. Our approach can be used as a tool to normalise images by reprojecting to a common PP and resolution and embedding all the estimated meta-data to enable dense reconstruction using other existing tools. Hence, our approach can either be seen as a standalone SfM pipeline for arbitrarily cropped images or as a preprocessor that enables such images to be processed with existing tools.