Investigating the use of Historical DSMs in the UXO Detection

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The remnants of war often affect the population decades after a war ends. Estimations suggest that up to a third of dropped bombs could have failed to explode. Analysis of contaminated areas are conducted with historical aerial imagery. 3D visualisations are not available, which is a limitation (Kruse et al. 2022)

A Structure from Motion (SfM) approach was applied in this research to reconstruct historic scenes based on aerial imagery from WW2. A usability study was conducted to examine the use of the historic landscape models.

DATA

Scans of Aerial imagery from allied reconnaissance flights from March & April 1945 were used to conduct the SfM pipeline. It is a multi-epoch dataset, as images from multiple flights and cameras were taken. The camera parameters are not known. The images are from three different case studies and display Gotha and Bamberg.

METHODOLOGY

After preprocessing via the HIP Pipeline by Knuth et al. (2023) or a manual crop and CLAHE processing, the images were detected and matched with SIFT in Metashape and the DL approaches SuperPoint/SuperGlue and DISK/LightGlue in a single multi-epoch block approach as Maiwald et al. (2023) suggest.

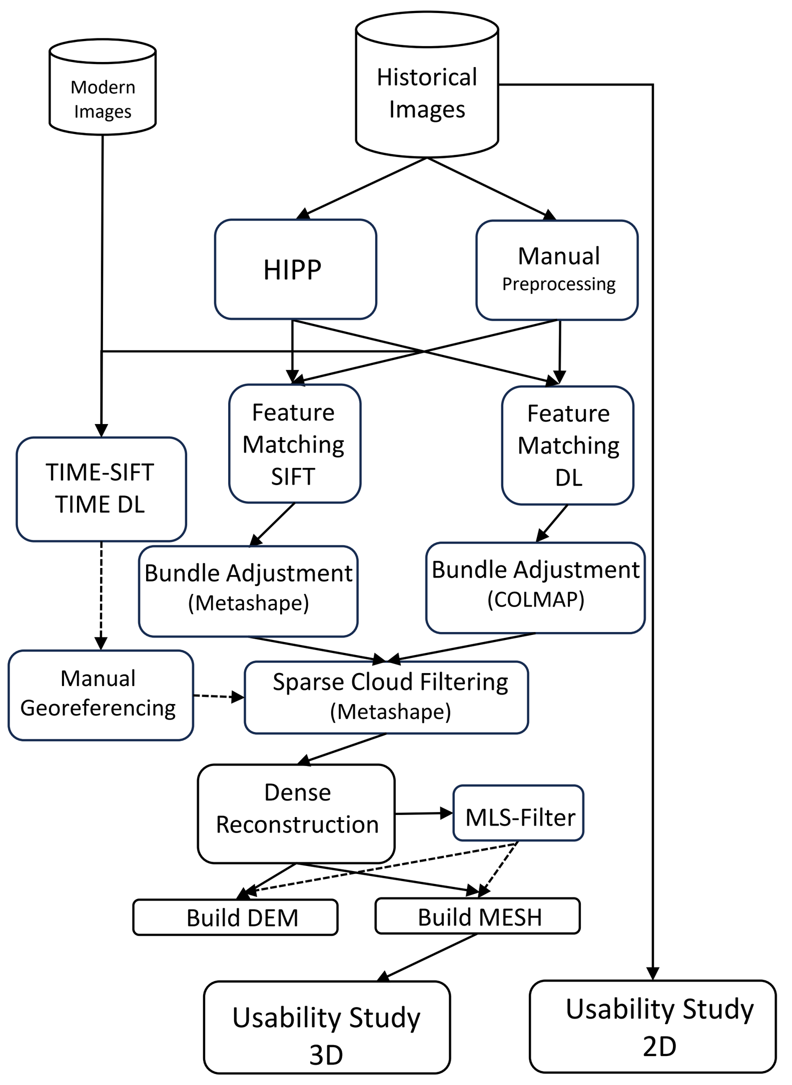

Fig. 1: Applied Workflow

Fig. 2: Created Model from the Gotha case study based on DL Feature Matching

The Bundle Adjustment was conducted in COLMAP Metashape. After the sparse clouds were filtered, the dense matching was the next step and MESH models were interpolated from the dense cloud. An accurate georeferencing and a meaningful filtering of the dense cloud failed.

The models were examined by UXO analysts, that performed a task of bomb crater detection. One group on the 3D model and one group on the corresponding imagery

RESULTS

The matching of corresponding features differed between the approaches and the intra/inter-epoch characteristics of the image pairs. While SIFT and SP+SG were able to do a steady intra-epoch matching of images, the inter-epoch image could only rarely be matched. The Gotha dataset were the best performing dataset. DISK was not able to match significant number of features.

The datasets were challenging to all approaches because of bad scanning quality, low contrast, different scales and illumination conditions. Fig. 3 shows challenging image pairs with high overlap. The successfully matched areas are of high contrast and usually built-up structures

Nevertheless, the reconstructions, shown in Fig.2, are characterized by noise and data holes and therefore lack accuracy for a consistent detection of bomb craters. A filtering of the point cloud led to the loss the bomb craters as detailed features were too much part of the noise.

The usability study revealed that only in a specific, flat region with no other distinctive features, bomb craters could be equally detected between the groups. The detection in the urban area was differing within and between the groups

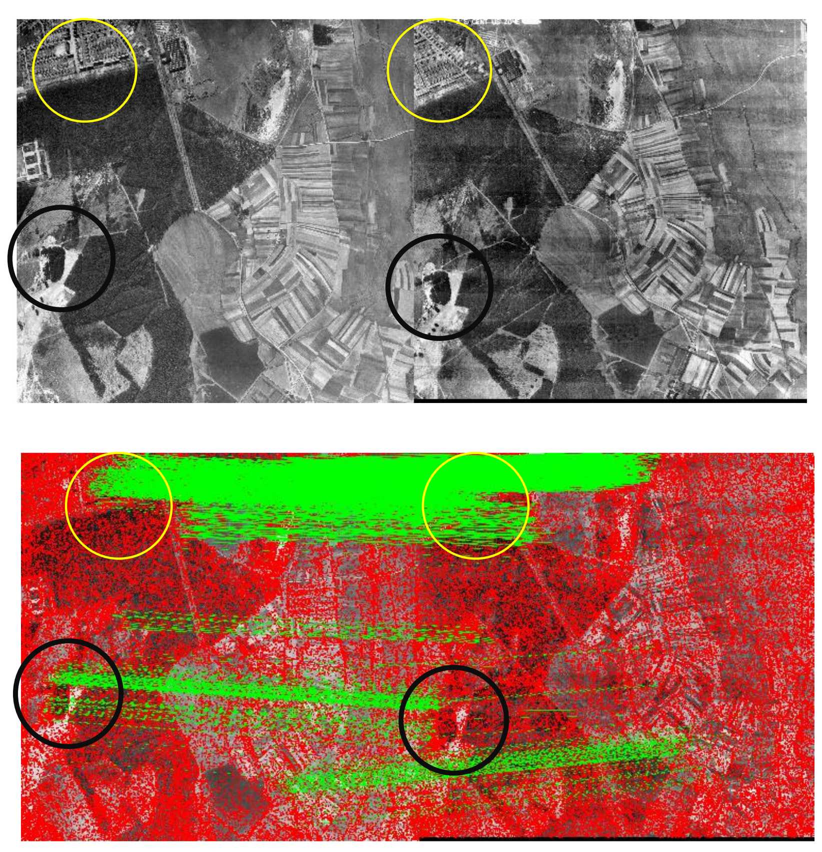

Fig. 3: Inter-Epoch image pair

CONCLUSION

Although it was possible to reconstruct a scene based on 80-year-old imagery, state of the art matching procedures still struggle with datasets that do not provide high texture, contrast but features scale and illumination differences and distortions. This results in inaccurate modelling.

The difference between detecting bomb craters in 3D and 2D is especially strong in urban environments. Yet, as also the images do not provide ground truth, no distinct conclusion can be drawn.

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