# Image Registration and Object Detection for Assessing Unexploded Ordnance Risks - A Status Report of the DeVisOR Project*

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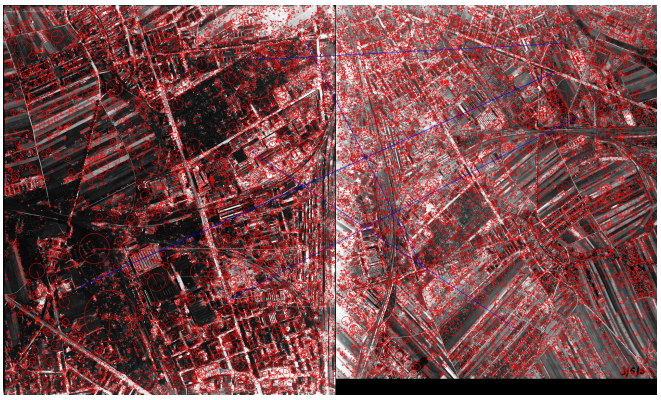
## I. INTRODUCTION

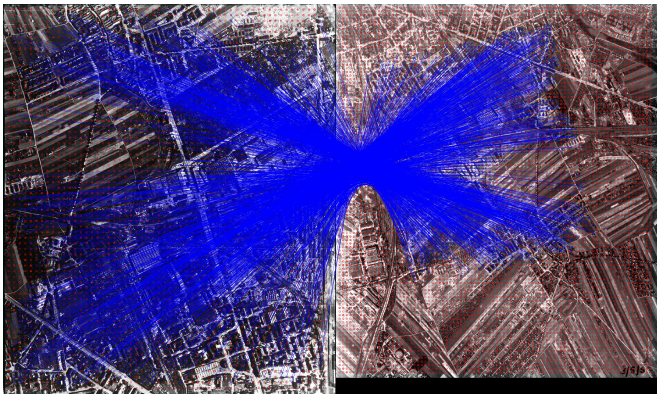
Although the last acts of war in Central Europe date back to the times of World War II, Unexploded Ordnance (UXO) from that period still poses a serious hazard for population and construction projects [3]. For a preliminary estimation of UXO risks, specialized companies retrieve and interpret aerial images from WWII surveillance flights over the area of interest. This process includes the registration of historic aerial images to modern satellite images, and the detection and mapping of certain objects that indicate increased combat activity in the surveyed area. Currently, these tasks are performed in time-consuming manual work. The DeVisOR project, which was started in 2016 as a cooperation between the Computer Vision Lab and the Information Engineering Group (TU Wien), as well as the Luftbilddatenbank Dr. Carls GmbH as an industrial project partner, aims at supporting the above named tasks with computer vision and visualization techniques. This paper gives a half-time status update of the project achievements as well as an outlook for the final year.

## II. IMAGE REGISTRATION

The registration of WWII aerial images to modern satellite images is particularly challenging because the landscape has changed drastically in the course of seventy years. Not only buildings and roads, but also vegetation, agricultural use and the courses of rivers may have changed, so that it becomes difficult to find reliable common features [4], [5]. Additionally, the available images are partly in suboptimal condition. We therefore propose a semi-automatic framework for the registration process, in which first the easier task of registering the historical images among each other is performed automatically. Due to the varying conditions even among the historical images (seasonal changes, weather, destruction, image noise) and the absence of *a priori* information about their relative rotation and translation, only feature-based registration methods, such as SIFT [2], are applicable. We found that automatic scale space feature detection is too unstable for the given image data; however, for each image the approximate aircraft altitude and the focal length of the camera is known. We can therefore normalize the scales of the images and perform a dense sampling of features at a fixed scale, which significantly improves the matching stability. Figure 1 shows an example. To refine the resulting registration and account for parallax effects resulting from uneven terrain and different capturing angles, we successfully applied a deformable fine registration approach, that was originally designed for the registration of multi-modal medical data [1].



(a) Scale space extrema



(b) Densely sampled features

Fig. 1: Comparison of feature matching stability

Guided by an interactive visualization of the registration results, the user can then select the most suitable historical image and manually georeference it; all the other images are then registered transitively.

We are also working on a novel registration algorithm that is currently able to register about a third of the WWII images in our test data set directly to modern satellite images and thus supplement the above named framework.

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## III. OBJECT DETECTION

An UXO risk for a region of interest is derived from various indicators of combat activities on historical aerial images. These could be destroyed buildings, anti-aircraft artillery positions, trenches or bomb craters; the latter ones are by far the most numerous and simultaneously the most difficult to reliably identify on aerial images, as they can easily be confused with other small round objects such as trees [3].

The development of strategies for automatic detection of such combat indicators is scheduled for the current year. We are planning to adapt state of the art machine learning approaches to the problem; we hope to be able to exploit the fact that typically a time series of registered aerial images is available for the region of interest. As the task at hand is a critical one, a human expert will always be required to validate and refine the results. We will thus, just as for the registration problem, aid the user with an interactive visualization component for parameter exploration.

## IV. IMPLEMENTATION

In order to maximize both the benefit to our industrial project partner and the usage and testing of our methods, we have been developing software tools that blend in to their daily workflow, namely in the form of plug-ins for their preferred GIS software. The first working prototype of the registration component was delivered in February 2017 and tested in both the German and Austrian branch of the Luftbilddatenbank GmbH. Apart from minor bugs and usability issues, the overall feedback was positive and encouraging.

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