Satellite Image Registration

Student

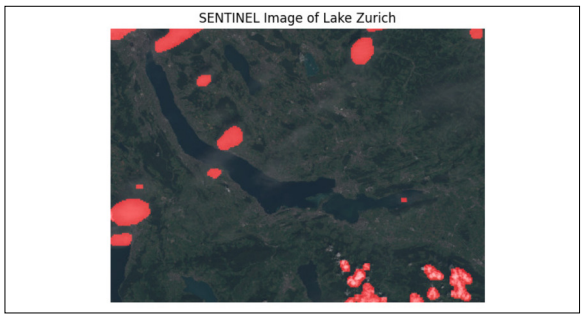
Robin Eberle

Introduction: Satellite imagery is a critical resource for applications ranging from environmental monitoring to urban planning. The ability to accurately align (register) these images is essential for meaningful analysis, yet traditional image registration methods often struggle with the unique challenges posed by satellite data, such as varying resolutions, atmospheric effects, and large datasets. This thesis explores the development and comparison of traditional and deep learning-based approaches to satellite image registration, with the aim of improving the accuracy and efficiency of this crucial process.

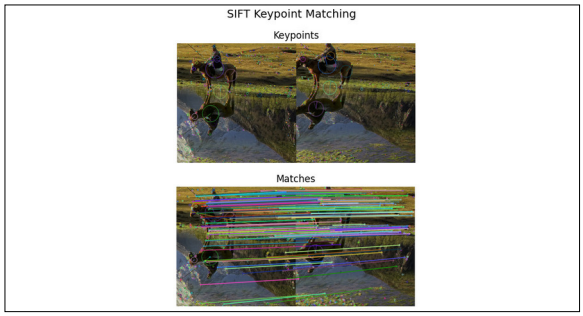
Approach / Technology: The research begins with a review of existing image registration techniques, focusing on both classical methods and recent advances in deep learning. A software tool was developed to automate the process of downloading and preprocessing Sentinel-2 Level 1C data, resulting in a comprehensive dataset of multispectral satellite images. Two registration approaches were implemented: a baseline algorithm using key points as the basis for feature matching, such as SIFT, FAST and ORB algorithms, and a state-of-the-art deep learning algorithm based on CNN. Another approach was to use pretrained networks such as a VGG or a ResNet to extract image features that could then be utilized to estimate the transformation between two images.
The deep learning models were first pre-trained on a dataset containing a variety of objects to learn the desired transformation, and then fine-tuned using the Sentinel-2 data to adapt them to the specific characteristics of satellite imagery.

Result: The comparative analysis was measured by the metrics of MSE, SSIM and PSNR. The baseline keypoint-based algorithm and the deep learning-based approach showed clear advantages of the deep learning method in dealing with the complex variability present in satellite imagery. Unfortunately, the deep learning model did not demonstrate superior accuracy and robustness in image alignment, even though traditional methods struggled due to non-linear distortions and varying atmospheric conditions.

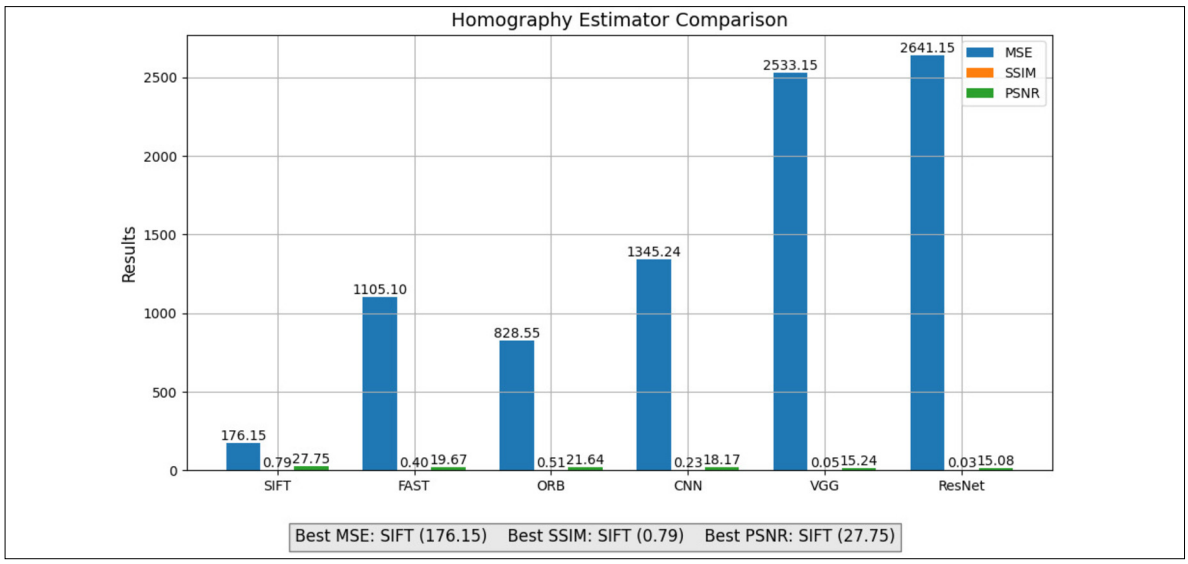
Sentinel-2 satellite image of Lake Zurich with marked clouds.
Sentinel API



Visualisation of the key points and matches between an original and a transformed image.
DIV 2k Dataset



The comparison of the different approaches SIFT, FAST, ORB, CNN, VGG and ResNet on the metrics MSE, SSIM and PSNR.
Own presentment



Advisor
Hannes Badertscher

Subject Area
Data Science

Project Partner
VeeMG GmbH, Binz, ZH