Gas Pipeline Detection Using Satellite Images and Machine Learning Algorithms

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Introduction

SciGRID_gas aims at **building an open source model of the European gas transport network** and make it available to researchers. For that purpose, relevant data is extracted from conventional data sources as OpenStreetMap (OSM) (see Fig. 1). Such conventional data sources tend to be inaccurate or incomplete. To fill some of the data gaps, a new dataset shall be generated using publicly available multi-spectral satellite images. Different algorithms will be used to detect pipelines and extract their course.

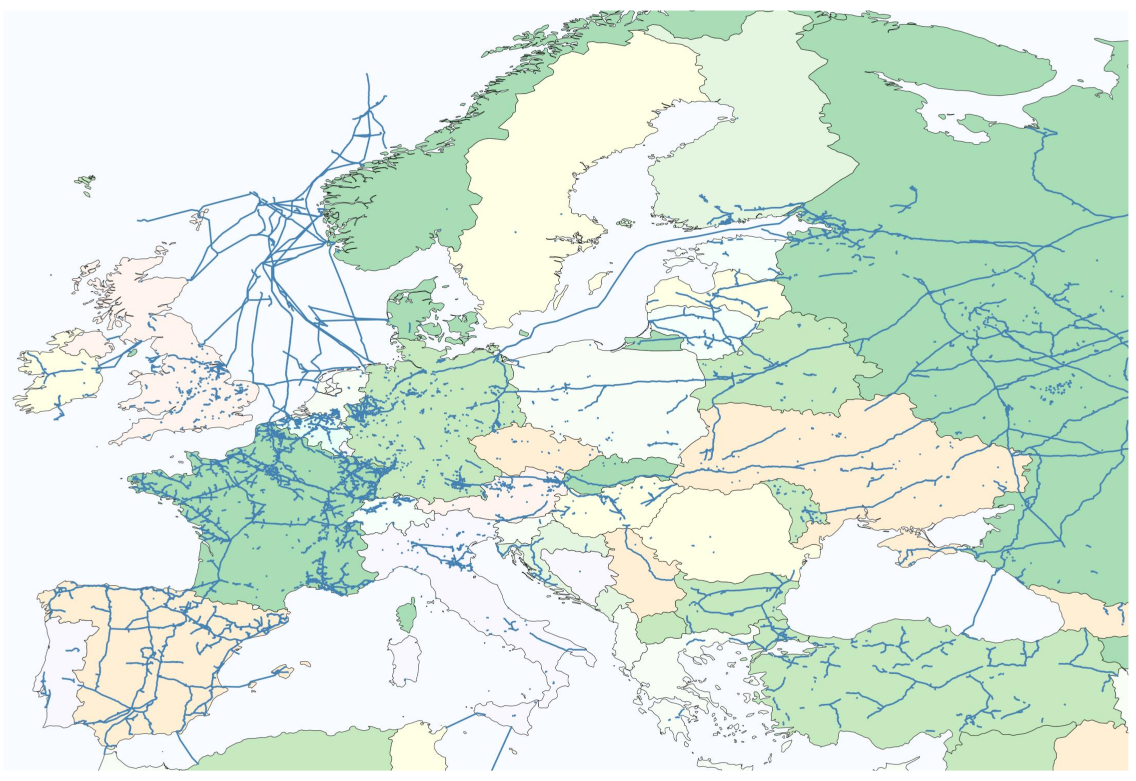

Fig. 1: Topological pipeline data from OSM

Satellite Imagery

For the detection of pipelines on satellite images publicly available multi-spectral imagery with viable resolution is needed. The images provided by the Landsat mission [1] and the Sentinel-2 mission [2] fit these criteria. Images by the Landsat mission are available since 1972 and for Sentinel-2 since 2015.

Preparation of Imagery

For machine learning algorithms to work on satellite images the imagery needs to be prepared so that pipelines are clearly visible for the human eye. A promising method for the pipeline course detection appears to be the use of images of a scene prior and during the construction of the pipeline.

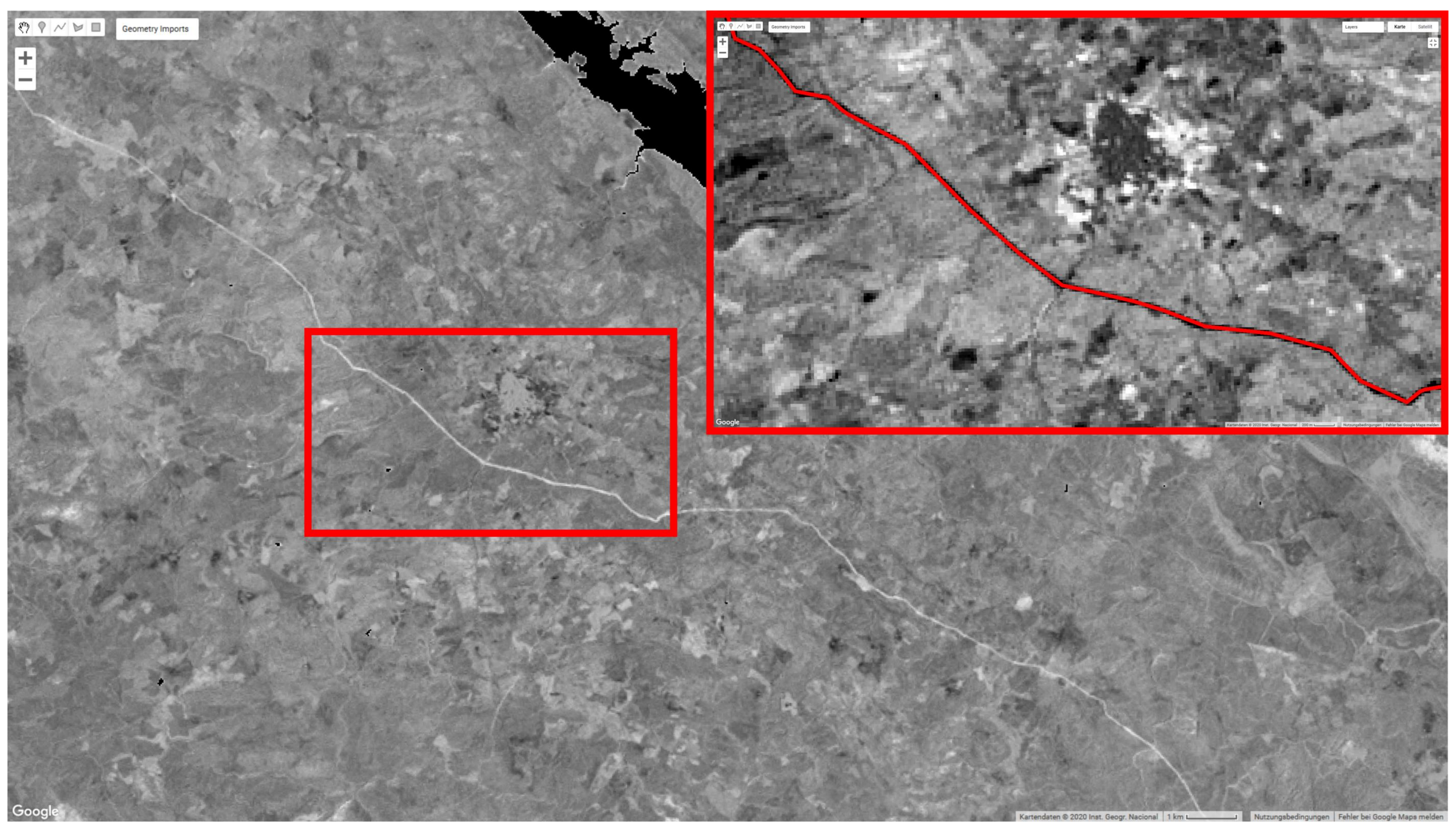

Fig. 2: Difference image of NDVIs prior to and during construction of MEG-pipeline near Córdoba, Spain, with OSM data overlay for red area (upper right corner).

The normalized difference vegetation index (NDVI) is an indicator for changes in soil and vegetation [3]. The pipelines are best visible using difference images of the NDVI prior to construction date and during construction phase of the pipeline due to changes of soil and vegetation during construction.

Planned Workflow

For the generation of an image usable for the pipeline extraction the construction date is requiered. Hence, the following workflow is planned for the detection and extraction of the pipelines from satellite images:

1 Find construction date:
Some of the construction dates have already been collated in the SciGRID_gas project using sources like press articles. It is expected that many pipelines are unknown to the SciGRID_gas database, which makes a second approach also necessary. For that purpose, a change detection algorithm applied to temporally different images of scenes surrounding known gas facilities, e.g. compressor stations, could be used.

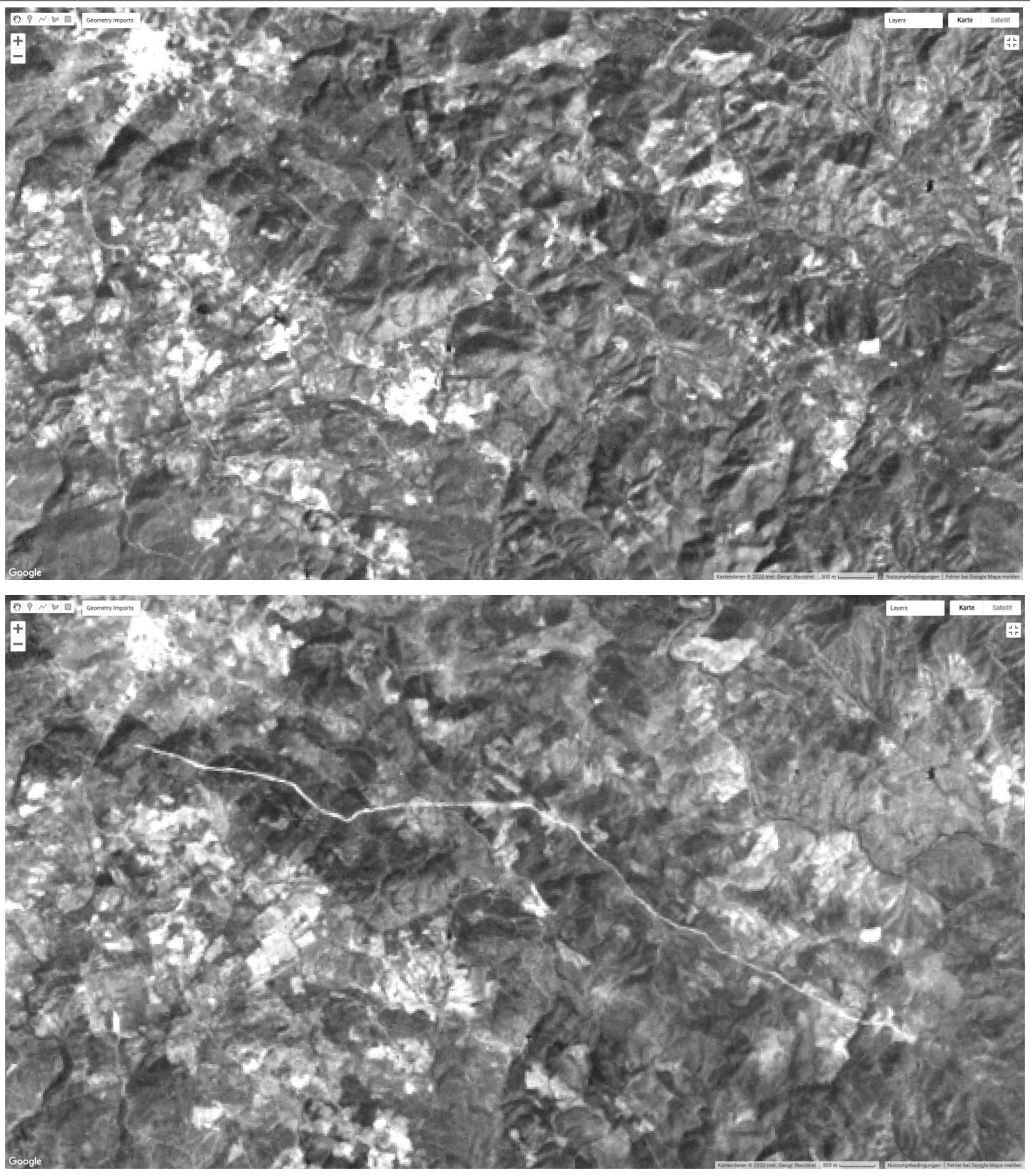

Fig. 3: Temporally different images of the same scene of the MEG-pipeline near Córdoba, Spain, before (upper image) and during construction (lower image).

2 Prepare images for algorithm:
For pipelines changes are best visible during construction phases. Changes can be even more pronounced by creating difference images of NDVIs prior to the construction date and during the construction phase (see Fig. 1).

3 Extract course of pipeline:
Finally, the pipeline can be read out by an edge detection algorithm (see Fig. 4). Possible filters are canny [3] or sobel [4]. Additional post-processing is necessary to remove unwanted structures and high-frequency noises.

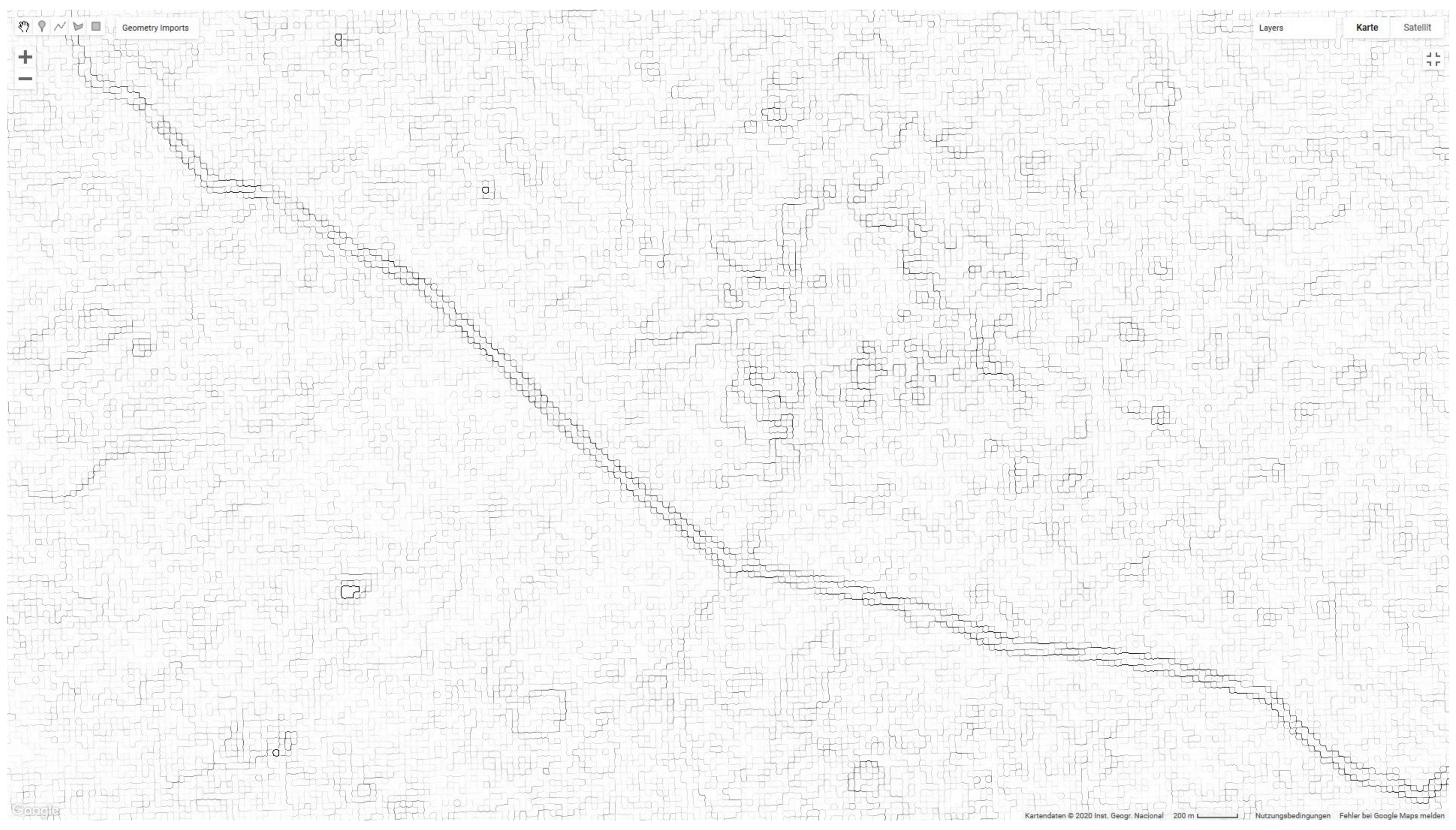

Fig. 4: Canny edge applied to a difference image of NDVIs for MEG-pipeline near Córdoba, Spain (See Fig. 2, red box).

Training Data

For the algorithms to work, proper training data is requiered. For Spain, highly accurate geo-referenced pipeline data is available within OSM (see Fig. 2). This data could be used to automatically create a labeled training data set.

Acknowledgement

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[1] https://www.usgs.gov/land-resources/nli/landsat)
[2] https://eos.com/sentinel-2/
[3] https://earthobservatory.nasa.gov/features/MeasuringVegetation/
[4] "A Computational Approach to Edge Detection" (J. Canny, 1986)
[5] "A 3x3 isotropic gradient operator for image processing. Pattern Classification and Scene Analysis." (Sobel, Irwin & Feldman ,1973