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Detection of Bark Beetle Infestation with ArcGIS Pro

Project Goal

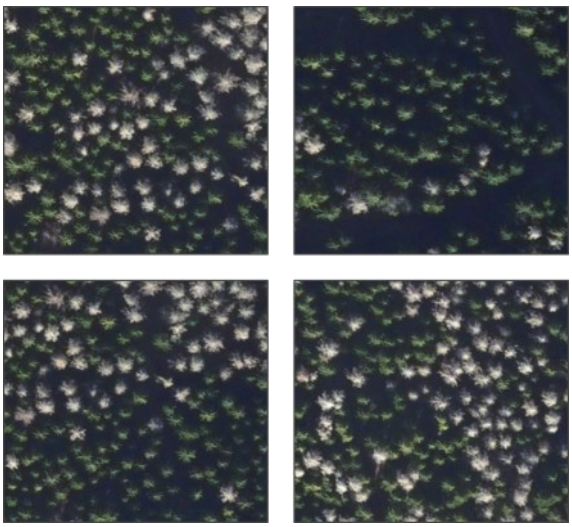
Bark beetle attacks destroy large areas of forests and became a serious threat for forest ecosystems. Different species of bark beetles are attacking healthy trees, damage roots, stems, seeds and fruits. By that millions of euros costs arise in damage to the forest and timber industry. Mapping and monitoring infested trees helps to take countermeasures to prevent the beetles from spreading.

This use case presents a scalable approach to train and apply neural networks within ArcGIS Pro to automatically detect and map dead trees in bark beetle infested areas. This enables valuation of the actual damage over large areas. By comparing results of aerial images over several years, the development of infestation can be monitored.

Dataset Used

The aerial images were provided by the German Lower Saxony Forests Ministry and cover an area of approximately 25ha of the Harz Mountains. They are geocoded RGBI images with a spatial resolution of 0.2m.

Training data was generated on one part of the area to train a model and process the whole area with it. The training images were labeled for bark beetle infested trees. To train a model the native ArcGIS Pro pipeline for Deep Learning was utilized. Training data generation, model training with an ArcGIS Python environment and the arcgis.learn module, as well as the model inference for detection could be incorporated with ArcGIS tools.



Examples of images used for creating model

Challenges

Model training requires large amount of data covering forest areas to get better results. For better results and analysis it is important to have historical data to access information from different years. This will show where and how the bark beetle attack started and progressed respectively.

Bark beetle infestations can be divided into different attack stages. Infested trees in the grey-attack stage are clearly visible and can be differentiated from living trees. In the initial green-attack stage the infected trees cannot be clearly separated from living trees on RGB images. For this reason the detections only cover grey-attack stage trees.

The Deep Learning Pipeline was build up using ArcGIS Pro from ESRI.

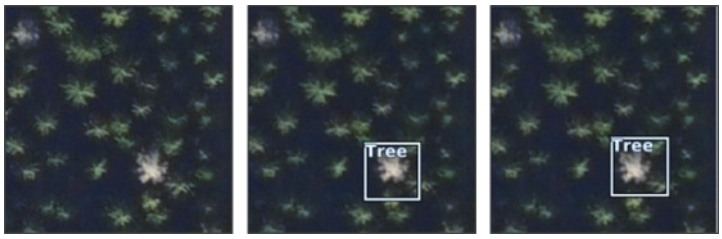
Applied Methods

To detect dead trees affected by bark beetles a neural network with the Fast RCNN architecture was used to generate a feature map. Training data is created using the latest features in the ArcGIS Pro application. The Python module arcgis.learn was used for data preparation, model training and processing. Input to the deep learning architecture were images with ground truth bounding boxes for each bark beetle infested tree of the training data.

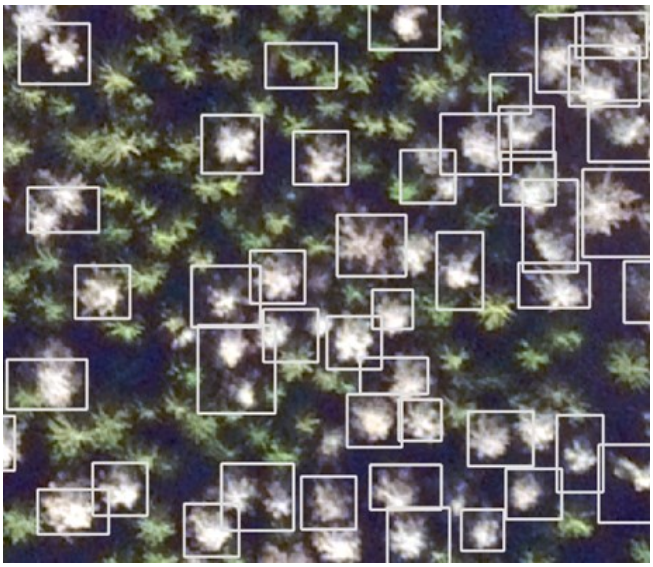
Project Outcome

The trained model achieved 98.6% recall with respect to ground truth labels on certain test data images. Up to 88% intersection over union based on the available labeled examples were reached. With this model large forest areas can be analyzed fast and reliable to assist humans in monitoring forest health.

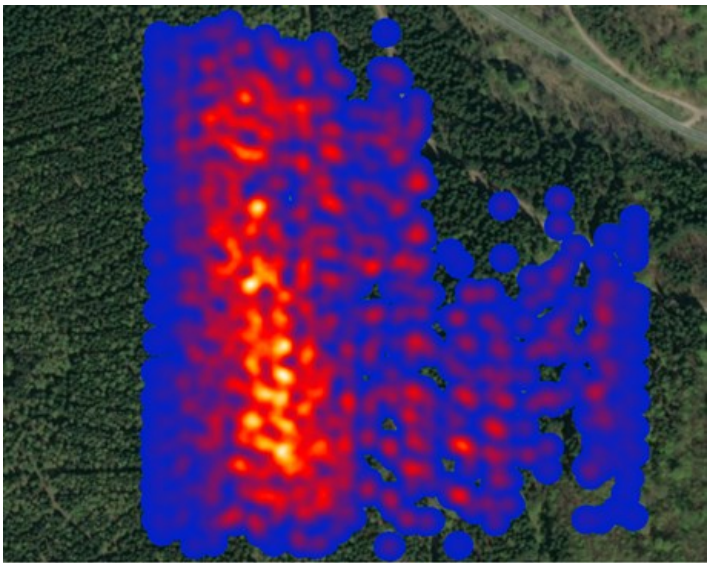
By creating heat maps in ArcGIS Pro infection hotspots become clearly visible and the spread over several years can be visualized in a simple way.



Input | Ground Truth | Prediction



Detected bark beetle infested trees



Heat map of the forest area based on detection data

Potential Applications

The trained model is optimized for the specific forest and image data. For a better and more generalized model, training data from other parts of the forest or different forests could be added. Alternatively the same pipeline could be used to train specific models for other forest areas. They could also be extended to differentiate between different tree families and diseases and support health monitoring and reforestation efforts.

Mapping of the dead trees can support the planning for removal and transportation of them. This way efficient routes, efforts and costs can be estimated based on the information in the ArcGIS Pro platform.

Images with multiband data, other than RGB bands can be applied for accessing further information on bark beetle infestation. By using infrared bands along the RGB bands a normalized difference vegetation index (NDVI) can be calculated and possibly be used to also detect green-stage infestations of bark beetles.

This pipeline can be also modified and applied for natural disaster impact assessment like damaged building detection, waste detection on oceans, bushfires, etc. The resulting data of the models can also be fed to further AI applications. These can be adapted to custom requirements and can be integrated into end-to-end solutions that feed results back into geodatabases, map layers or AutoCAD models.