

Application Form

Title: Deep Learning for Satellite Monitoring of Illegal Amber Mining in Ukraine

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Executive summary (2 pages max)

Ukraine has a significant stocks of amber in Zhytomyr, Rivne and Volyn regions. There is evidence of amber mining in the Chernobyl zone of radioactive contamination. As a result of a complex of social, political and economic reasons, starting from around 2012, massive illegal mining of amber takes place in Ukraine. It is carried out without obtaining permits, with predatory methods, without further remediation of affected areas. Such extraction has irreversible damage to agricultural and natural landscapes, including within the objects of the natural reserve fund. Under threat are several biological species and whole habitats. The soil cover is destroyed, the hydrological regime of the territory is violated, morbidity among prospector increases, and the level of crime is increase. The purpose of the project is to provide free access to up-to-date and reliable information on the magnitude and consequences of illegal amber extraction in Zhytomyr, Rivne and Volyn regions of Ukraine through the development and pilot implementation of an open system of remote monitoring of amber extraction.

The open data and reports will be created as a result of the project, where for anyone will be provide information about the available areas and location of affected areas, and the consequences of extraction for the environment, as well as the opportunity to add information about the status of the affected areas by their own text, photo and video messages. Such a geoportal will promote the involvement of the public for a solving of the problem, promote the security of economic activities and travel safety, increase the ecological consciousness of citizens, and, in general, create conditions for effective combating of illegal amber mining.

The problem of illegal amber mining and the experience of its remote monitoring was covered by members of our team in the [50North blog](#) (2018).

Now in Ukraine there is a real ecological disaster. In an area that is equal to Belgium, it is illegal extraction of amber, which leads to the complete destruction of natural landscapes. Extraction is uncontrolled: without obtaining permits, without any previous projects, without further recultivation of the territory, in truly unknown volumes and on uncertain areas. Illegal mining of amber has turned into a large-scale criminal business in Ukraine today. Official attempts by the government to stop illegal extraction are useless and the area of destroyed landscapes is growing annually.

The negative ecological consequences of amber extraction:

- *Destruction of rare species; including those protected under international conventions (Bonn, Bern), included in the IUCN Red List and the Red List of Ukraine*
- *Destruction of habitats, including those having an environmental status in accordance with the EU directive on the conservation of natural habitats and species of natural fauna and flora (92/43 / EEC, 1992)*
- *Destruction of soil cover. Given the very slow recovery rate of soils, can predict the restoration of natural soils for at least 100 years*
- *Development of wind erosion, dispersion of sands*
- *Changing the mode of surface and underground drainage*
- *Contamination of groundwater*
- *Forest fires, as a result of burning of forests to clear up areas of extraction, and the air pollution which associated with it*

In the regions where illegal amber extracting takes place, the crime situation is sharply deteriorated. Numerous cases of clashes between the prospectors themselves and between prospectors with representatives of the government have been

recorded. The main participants of the process are local inhabitants who, for the sake of immediate benefit, destroy land and forest lands – the basis of their future. All this leads to an even worse deterioration of the situation in the already depressed regions and in the future may cause a wave of migration from Ukraine to the EU countries.

Prosperity of illegal extraction of amber is promoted by a situation of uncertainty and ignorance of wide circles of the public about the scale and consequences of illegal extraction of amber. Official data about the areas of disturbed lands do not correspond to reality. The detailed survey of mining sites in the area is not possible, since that it are controlled by criminal groups.

One of the most important conditions for combating the shadow mining is the maximum openness of information about the extraction process and its negative consequences for nature, the economy and society. It is possible to reach it by creation of the open data and reports where will be available to all interested users regularly updated geodata and monitoring results of illegal amber mining in the form of maps and statistical reports on the growth dynamics of mining areas combined with an open crowdsourcing platform for collecting ample information about amber mining and its consequences. Monitoring of amber extraction will be carried out on the basis of interpretation of space images and will be presented in the form of a series of different maps showing the areas of extraction and qualitative characteristics of the degree of disturbance of landscapes.

Our project is aimed to creation of a transparent information field on the coverage of the scale and pace of inaccessible amber mining. Taking into account the corruption situation surrounding this problem, we consider that for its solution it is necessary to inform as much of the population as possible, attracting the attention of both Ukrainian and world mass media.

The following groups of users are interested in creating an open system for monitoring the illegal extraction of amber:

- *Establishment of a nature reserve fund of Ukraine*
- *Local Territorial Communities*
- *Environmental public organizations*
- *Mass-media*
- *Individual public activists*
- *Travel Agencies (to prevent accidents)*
- *Local state administrations*
- *State ministries and departments*

The beneficiaries of the project are specialized research institutes (more than 10), departments of state control in the field of environmental quality (environmental inspection, regional departments of ecology), local authorities and citizens

Project plan (15 pages max)

One more advantage of our project is the creation of a single, constantly operating platform on which a variety of relevant information about illegal mining of amber and its consequences can be collected. This will facilitate access to information and increase the effect of the project in the field of public information.

For the success of the project is required free access to the updated database, close contact with specialists in the regions where the extracting is distributed (foresters, biologists, environmentalists and journalists) for ground-based research and verification of the decoding methodic, contacts with mass media representatives for the information campaign, using UAV for detailed shooting in the mining areas in order to obtain detailed information about the conditions of disturbed landscapes and correction of the deciphering methodic.

The goal of the project is providing of free access of the public to up-to-date and reliable information about scales and consequences of illegal extraction of amber in the Zhytomyr, Rivne and Volynsk regions of Ukraine through the development and pilot implementation of an open system of remote monitoring of amber extraction.

The total estimated monitoring area is about 78,000 square kilometers, the area of current developed fields with a high risk of violations is about 24,500 square kilometers.

Objectives of the project:

1. Develop a set of models for recognition of illegal amber extraction based on open and proprietary satellite images (Landsat-8, Sentinel-1, Sentinel-2)
2. Develop algorithms for the classic search for changes in images related to the analysis of spectral changes over time.
3. Validate accuracy in the field
4. Develop a set of computer vision methods and methods for analyzing changes to achieve maximum recognition accuracy
5. Creation of a prototype of an open source service for generating data about new and abandoned mines
6. Conducting of information campaign aimed to covering the progress of the project, drawing attention to the danger of illegal amber mining for Ukraine and raising of the level of the ecology consciousness of citizens.

Detection of places of illegal extraction of amber according to space images will be based on comparison of the images occurring at different times received in the visible and infrared range. The beginning of intensive illegal mining of amber dates from 2013 - 2014. Accordingly, a series of images will be selected from 2010-2011. and ending with actual at the time of project startup images. The objects of decoding are open areas ("copy") and artificial water objects created during the mining ("canals"). It is these objects that prevail in the zones of violations.

For their diagnostics, it is planned to A) use of various spectral-spatial with using of shooting data in the visible and infrared ranges, performs traditional RS-analysis with raster classification (Random Forest), as well as a B) Deep Learning frameworks ensemble of models for objects recognition (SageMaker, uVGG, ResNet, TensorFlow, Amazon Rekognition.

Methodology Details

1. Data for training. We already have about 50% of the data needed for the training model, which we obtained in the early stages of the project. To achieve the goals we need to supplement the training samples. Creation of polygons and points for training is carried out in desktop GIS (QGIS & ArcGIS).
2. Visual image validation. For visual validation of desktop GIS images and a specialized web application for remote connection of schoolchildren and students, volunteers for markup and validation
3. Computer vision. We have experience in using various algorithms and libraries such as uNet, Tensorflow, ResNet, RetinaNet. To achieve maximum accuracy, we will need to test several of the most suitable algorithms and adjust them depending on several basic types of landscape, in which amber is mined. Both the pits themselves and the typical patterns of infrastructure such as canals, embankments, roads, residential areas and so on will be recognized. Selection, testing and tuning of algorithms is the main part of our work.
4. Analysis of changes over time will be carried out by automatically comparing pairs of consecutive images using the methods of classification with training. To reduce the number of classes prior to segmentation, pre-filtering of images will be applied. Change analysis data will be applied to the overall model to improve accuracy.
5. During field work on abandoned mines, the model will be verified. Field work will be carried out only in safe abandoned areas - in places where mining has long been completed, either due to the fact that all amber has already been mined or due to low concentration of amber. Field work will be led by staff of local reserves
6. To ensure the continuous operation of the web service, a web system hosted in the cloud service will be used. We have the experience for AWS. After the project is completed, we will be able to maintain the system with our internal resources.
7. After the project is completed, the model will be refined as feedback is received. The main focus for clarification will be the definition of landscape restoration parameters, which can be delayed for decades and more.

The various variants of possible models will be tested with the further choice of the optimal variant based on objects interpretation of the well-surveyed areas with authentically diagnosed in the field by extracting areas sites. Then the images will be compared with the "source (reference)" images (2010-2011). Reference images will be obtained by comparing of the index images for the period 2010-2013. Example: if the dynamics of images on the same territory during a certain season (spring-autumn?) does not exceed 90% (?), then the picture is considered a reference. That is it fixed the starting point of intensive poaching. For verification of the developed Methodology for identifying of extraction zones, as well as developing a methodology for assessing and differentiating of the degree of disturbance of landscapes from amber extraction, the results of field research will be used based on remote sensing data. In the field conditions will be carried out identification on the terrain of the degree of disturbance of landscapes in zones previously determined by the results of decoding the space images (with the departure to the points specified by the results of the decoding of the photographs by coordinates) and comparing the results of the field interpretation with the space survey data. It is also planned to use UAV for validation.

Also as a result of the project implementation, will be developed a methodology for automated determination of amber mining zones and estimation of the time dynamics of distribution of mining zones based on the decoding of space images, developed and published of training materials for widespread use of this methodology, and created of open geoportal on which everyone who interested will be available information about available areas and location of disturbed sites, as well as the opportunity to add information about the status of disturbed territories by their own text messages, photos and videos.

- To solve the problem, separate attempts were made for separate small territories without using neural networks and computer vision.
- The use of convolutional neural networks and the accompanying complex of algorithms will allow a much higher quality since the mines have clear patterns that can be recognized. The only known attempt to use computer vision to solve a problem was a test one, as part of the work, only one algorithm was tested which showed poor quality but drew attention to the problem.
- The use of classical approaches to detect changes in addition to the methods of machine vision will increase the accuracy of the model. This will be implemented for the first time to solve the problem of monitoring mines of amber.
- An important factor is the adjustment of algorithms depending on local conditions of the landscape. This is an open task that will be implemented for the first time.
- As a result, an open data service will be launched that will automatically download satellite data, recognize new copies and changes in the states of active and abandoned mines, generate a stream of open data. This is an important practical part of the project that does not require large resources but allows to significantly increase the speed and quality of studying and managing the problem.

Summary of Outputs and Results

1. Model of recognition of mines and associated infrastructure, customized for types of landscape and seasonality consisting of two main parts - spectral-spatial and pattern recognition. Model documentation
2. Web and mobile applications for crowdsourcing data collection, which will be used as a source of information for monitoring illegal excavations.
3. Prototype of Information system for processing open and proprietary satellite data and generating open data on a regular basis. Web system documentation
4. The updated open geodatabase about illegal amber mining. Data will be available in the form of spatial services available for connection to other applications – desktop, mobile, web as layers (WMS, WFS etc). The services will be updated regularly
5. Documentation for users and developers for a work with the geodata received from the automated system of monitoring amber mining for use in their own research
6. Recommendations of the use of data and maps with current examples of use for the main interested of user groups: public administrations, communities, media, NGOs, foresters, farmers, national parks, tourists, research institutes and universities. The professional community will obtain data to improve the quality of research and problem management, including the pre-term problem of restoring landscape and biodiversity, managing environmental risks, predicting carbon sequestration.

Evaluating

The numbering of indicators corresponds of the numbering of the expected results of the project.

1. The results of verification of method with field researches at control sites in mining areas. The area of control areas is 10% of the total research area.

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3. Regular automatic updating of reports about the selected sites of amber mining. Indicators will be assessed and updated: the areas of the extracted zones, their exact coordinates, administrative position, assessment of the degree of violation.

5. Regular updates and data availability.

Timeline

Q4 2019 - Aggregation and analyzing of archived field data and remote data from Sats and UAVs

Q1-Q2 2020 - Selection and testing of suitable models and algorithms

Q3-Q4 2020 - Setting up models for working in various types of landscapes, Field verification

Q1-Q2 2021 - Setting up models for work in different seasons of the year, preparation of publications

Q3-Q4 2021 - Field verification and model refinement, development of a web system and open data service

Q1 2022 - Preparation of documentation, conducting presentations and trainings on project results

Q2 2022 - Preparation of documentation, conducting presentations and trainings on project results on examples of use

Forecasted credits

Sentinel Hub Credits. We plan to monitor 25.000 sq. km area over a period of two year, for which we estimate to require cca. 2 MIO processing units. Within this area we will be using mostly Sentinel-2 data.

We plan to use AWS Services for model development, data-processing, cloud computing. We predict that we will need about 50,000 credits for the development and testing of the model using specific services and data storage.

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