Using Unmanned Aerial Vehicles and Artificial Intelligence for automated detection in agriculture game damage

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Abstract
Agricultural damage caused by wild ungulates is a worldwide issue for a long time. In several countries (e.g.: France, Poland, Slovakia, Hungary) the compensation for wildlife damage is paid by hunting associations or hunters. However, the extent of the damage must be measured and mapped, therefore in Hungary experts are usually involved in the compensation process. The aim of this research is to examine the potential role of UAVs – with its possibilities and limitations – in automated damage detection and recognition caused by wildlife. In our study we monitored winter cereals and sunflower cultures during the growing season from germination to physiological maturity with a DJI Phantom P4 Pro quadcopter. The height of recordings were tested for the visual evaluation in order to identify damaged areas/plants during the post-processing and analysis. A database was created to be used as a training database for different artificial intelligence based neural network algorithms which are capable of recognizing pattern on UAV images.
Early results show that AI has a high potential to detect damage, assist experts to achieve higher level mapping with better results. By analysing the records we are planning further methodological improvements in damage mapping, automated identification and determining the degree of damage.
Keywords: UAV, Artificial Intelligence, Neural network, Wildlife damage

Introduction

Wildlife depredation is the act of animals causing damage to property resulting economic loss to the owner (Bleier et al. 2012). Wildlife damage to agricultural farms is often severe and many may result significant financial loss (Gilsdorf et al, 2002; Bleier et al. 2017). The expansion of ungulates populations leads to the increase of conflicting situations with human activities (Michez et al., 2016) and also between landowners and wildlife agencies.
A possible solution for this situation can be the use of unmanned aerial vehicles (UAVs) and their optical payloads (Michez et al., 2016) because of their easier access, flexible data acquisition possibilities and reduced costs. UAV platforms are nowadays a valuable source of data for inspection, surveillance and mapping (Nex & Remondino, 2013). Drones offer continuous coverage, collect data at centimeter resolution, require little training to operate, and can be deployed at short notice (Rutten et al., 2018).
In agriculture, UAVs have already been developed for multiple uses (Huang et al., 2013), however, the use of UAVs for the specific estimation of crop damage by ungulates has not been assessed (Michez et al., 2016).
Michez et al. (2016) and Kuzelka and Surovy (2018) recently showed how drones can be used to assess crop damage by wild boar in maize (corn) and wheat fields using generated photogrammetric digital elevation models from aerial photographs taken with a drone, however an automated processing flow is still desired.
Problems and limitations are still existing, but UAVs are a really capable source of imaging data (Nex & Remondino, 2013). Some issues restricting the wider use of UAVs for wildlife management and research include UAV regulations, and public perception, but one of the most important restrictions, however, is the need to develop or apply advanced automated image detection algorithms designed for this task (Gonzalez et al., 2016).

Materials and Methods

Wild ungulate damage and crop types

Some of the main crop and damage types were selected for this research based on our previous experiences with wildlife depredation and pattern recognition on UAV images. This research aimes to test neural network based algorithms for wildlife depredation recognition, thus some of the more unambigouos damage and crop types were selected as represented in Table 1.

Image collection

During the early stages of the project it became evident that flights and collected data have to be optimized for the most appropriate resolution. Therefore, calibration, planning and field researches made sure that the individual wildlife patterns appear on the aerial imagery with sufficient ground resolution, so automated pattern recognition algorithms can identify them. After calibrations and testing, 30 m data collection height was selected as a sufficient elevation for sensing most of the selected features (Figure 1.). Data collection was performed with a DJI Phantom 4 Pro. Optimization of technology was focusing on providing tools for field expert, thus the choice of UAV was representing a consumer grade

***Table 1:** Surveyed crop types, vegetation periods and wildlife damages (x: data collection)*

	cereals			sunflower				
	after germination until tillering	stem elongation-booting	milk developement and dough developement	after germination V2-V4	after germination V4-V12	sunflower bud R1-R4	flowering R5-R8	maturing R9
rooting	X	X		X				
browsing	X		X	X	X	X	X	X
trampling	X	X	X	X				

quadcopter, which is available for field experts, and can be widely prevalent.
The flights were automatically executed using the DroneDeploy application which allowed the accurate tuning of the key parameters such as height above ground level, sufficient overlap, flight speed and optimal direction.

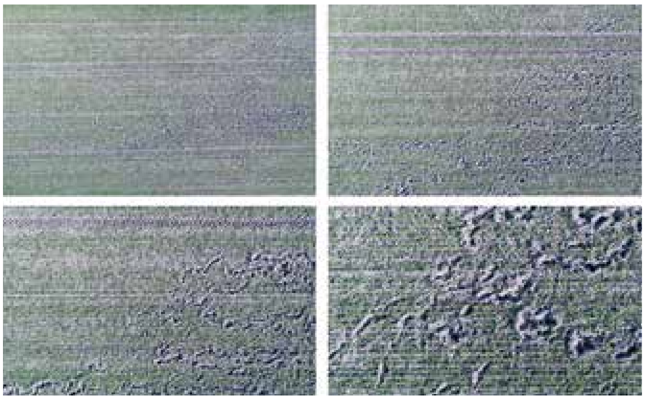

Figure 1.: Rooting damage in cereal from heights 30 m, 20 m, 10 m and 5 m

Ground evaluation and image annotation
During the field data collection process besides the UAV operators a wild animal damage expert was always present to identify the objects on the images and ground truth each feature after flight. Raw videos and images were uploaded to a custom designed online, cloud based video and image annotation tool and each feature has been flagged with the predefined classes, to provide a database for the development of the automated image classification algorithms.

Neural network for image classification
Neural network is one of the most used machine learning algorithms today. It is based on the biological neural networks of living beings. Originally, these networks help humans and animals to complete complex tasks. By repeating and learning new tasks, neural network of the brain makes new logical connections in order to learn new situations. The neural network used for machine learning uses the same principle by interconnecting artificial neuron-like units to make complex decisions. This artificial neural network can be trained by providing data - in our case: images - and adjusting responses of its neurons to achieve the appropriate result.

Results and discussion
During the vegetation period of the 2017/2018 growth year and the early vegetation period of 2018/2019 image and video collection has been successfully performed for sunflower including all growth stages, and for cereals the late growth stages. This resulted a database of several thousand images, where wild ungulate damage and other anomalies, along with unharmed and healthy vegetation have been captured and ground validated. The annotation of these videos and images have been performed through our custom designed online, cloud based annotation tool. This database building and image annotation process allowed, the start of the testing of the different algorithms for the automated image classification. Field experience is mainly in line with the early results of the algorithm development, and shows that for some cases especially for early growth stages the available ground resolution is hardly suitable, thus a lower elevation data collection or higher quality cameras are advised in these cases. For the later growth stages the available ground resolution is sufficient for the automated classification. The results show in general, that the larger the damage and more visible by human eye, the easier to classify by automated algorithms. As the results show rooting and trampling damage is easier to classify with high accuracy, while browsing damage requires higher ground resolution images, and has a lower accuracy during the classification process.
The current research is focusing on a limited number of crop and wild ungulatedamage types, but during the following vegetation periods the extension to other crops and damage types will be evaluated. The promising results show that UAV based surveys combined with AI based image classification are a potential objective and precise tool for field experts.

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