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Technology support for game monitoring as a tool for damages reduction of field crops

J. Jarolímek, M. Stočes, J. Vaněk, M. Ulman

All: Department of Information Technologies, Czech University of Life Sciences Prague, Czech republic

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Abstract. *Wild boars (Sus scrofa) are increasingly becoming the main cause of field crops damage in Czech Republic and central Europe area. There are many reasons why wild boars population is growing. The major reason is most likely change in the composition of field crops. In some areas in particular there is focus on oilseed rape and maize, for which there are also recorded the biggest losses.*

One of the key discussion topics is the issue of estimation of animal quantities and its traceability. In order to provide accurate counting and monitoring of wildlife, the Department of Information Technology at Czech University of Life Sciences Prague established a technological background that utilizes open applications for telemetric tracking of animals and online calculations of population density using Random Encounter Model. The Department also conducts research into new methods and standards of data transfer including the potential of Internet of Things (IoT). Used applications are provided as a service to agricultural companies, state company Military Forests and Farms and to other research subjects

Keywords. *wild animals, density, telemetry, drone, service, REM method, API, IoT, population count.*

Introduction

The need for accurate counting of animal population persists for several centuries and was mainly motivated by the need to register ones property. Later the estimates of animal population served to help maintain the necessary base numbers and today the census results are essential to determine the scale of hunting needed to keep stable population of wildlife. In most European countries, including Czech Republic, the population of cloven hoof animals is on the rise, which causes increasing damage to forests and farmed crops (Bartoš et al., 2010). The issue of accurate population estimates is one of the key topics of contemporary debate. The method of animal counting differs vastly across Europe, mainly being differentiated by local conditions and wildlife species structure.

While the need for and ramifications of accurate population estimates increased over the centuries, the actual methods and reliability of accomplished results did not change much and some parameters are ever worse. In order for the census to fulfill the required control function, its results must well approximate the reality. At present time, the employed methods of counting in Czech Republic only account for about 10-33% of the actual population. The most commonly used method is very basic direct unsystematic observation. The accuracy of the estimates can be examined by comparing the spring baseline population with amount of caught animals during hunting season (Kotrba et al., 2005). According to statistics from several countries, including Czech Republic, more animal were being caught than the amount the census established. That is why there is a need for alternative and more accurate methods.

Methods for establishing the animal census can be divided into two groups: direct and indirect. Direct methods are based on actually observing the animals. These methods allow to establish the size of the population as well as other differentiating parameters such as age, gender, health state and others. Observations can be done both during day and night, from ground, air or vehicles, using thermography, lighting, automated cameras or video camera recorders. Indirect methods do not involve actual counting of observed animals but rather parameters resulting from animal habitation, such as tracks, droppings, noises or impact on vegetation. These methods help establish relative population density which can then be recalculated into actual population census. Therefore it is not possible to obtain any other specifying information (like age or gender) using these methods, only the population estimate. Other issue is the accuracy of such calculation, which can often result in overestimates or underestimates. The last group of specialized methods are based on gamekeeper statistics, often also referred to as retrospective calculations. All the above mentioned methods differ drastically – some very simple not requiring much equipment, while others can involve airplanes equipped with high resolution thermo vision cameras. Better and more expensive equipment often yields better results but its usage alone does not guarantee the quality of outputs. All the methods however require the person conducting the study to be vested in the issue, willing to sacrifice time for data collection and processing and also they have to possess the basic underlying knowledge from the area.

The Department of Information Technology at Czech University of Life Sciences Prague has established a technological background to facilitate the counting and monitoring of wildlife using telemetric observation and online density calculation based on Random Encounter Model (REM method). Also, with the cooperation with the Department of Information Technologies, research is being conducted in the area of counting animals using image recognition of aerial photography, and drone photography respectively. Applications in use are provided as service to other research subjects (for instance Faculty of Forestry and Wood Sciences at CULS Prague, Mendel University in Brno, Military Forests and Farms etc.) and professional public.

Materials and methods

Online telemetric observation of wildlifee

Portal Game Online http://zver.agris.cz/ gathers and presents data from telemetric observations of various species of wildlife animals. Currently it tracks red deer, wild boar, sika deer and greylag goose.

The telemetric observation include gathering, transfer and storage of large data collections. The large scale of data is given mostly by the continuous nature of its acquisition (one to three years) and its combination with high frequency (for instance GPS location is gathered every 30 minutes, activity data are averaged for every 5 minutes, etc.). Gathered position data of cloven hoof animals is regularly stored on database server MySQL 5, then cleaned by removing measurement errors. The web application itself runs on Apache web server. The core of the application is written using web programming language PHP 5 (hypertext preprocessor) utilizing the Nette framework 2. For visualizing the movement data, the application uses Google Maps from Google Inc. The communication with Google Maps is facilitated through JavaScript API V3 interface. The visualization extension uses JavaScript framework JQuery (Jarolimek et al., 2012).

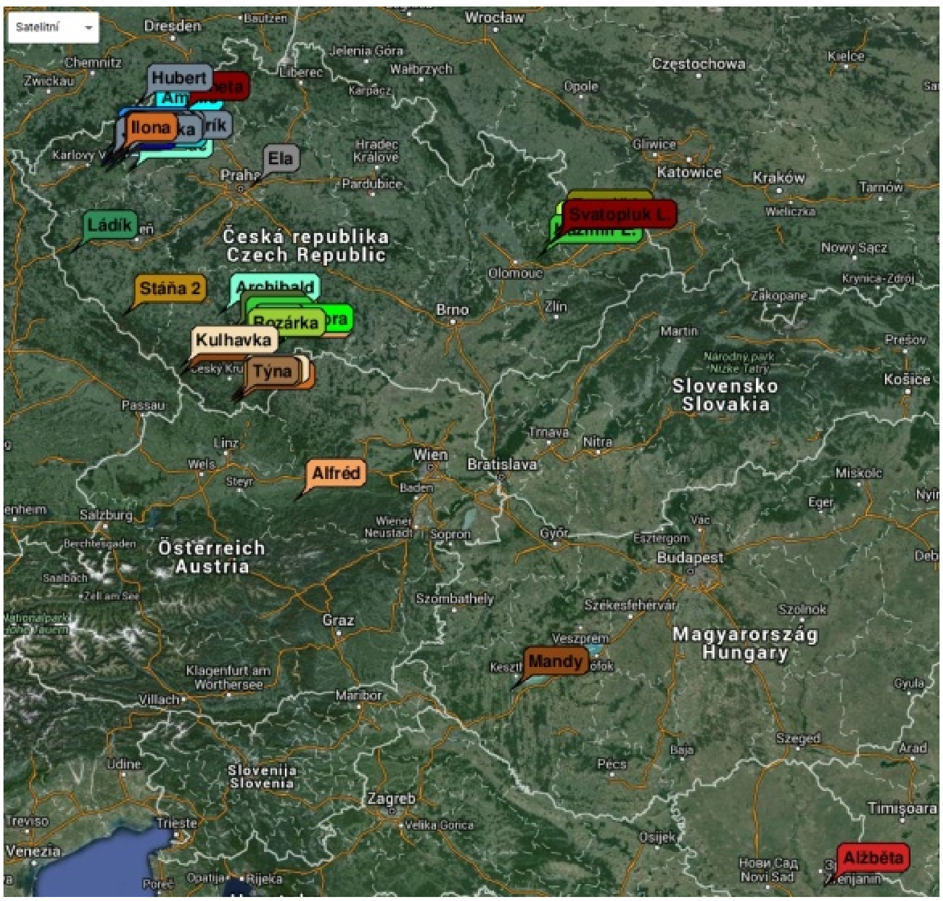

Fig. 1 Current position of tracked animals from Game Online web portal

Users can access the application using common web browsers, including mobile based systems. The visualization has five main features:

- Point position
- Movement trajectory
- Home region area – polygon

- Density of occurrence in home region – heat map
- Activity data

Utilizing these tools is very important for the research as well as resolving possible options of crop protection in specific agricultural companies as is further elaborated by (Jarolimek et al., 2014.)

Fig. 2 GPS/GSM collar by Vectronic

Random Encounter Model

Web application for online calculation of density applies REM method (Random Encounter Model) to data acquired from camera traps (Rowcliffe et al.,2008). The application is available to anyone interested in this particular technique of animal observation. Its pilot version is available at http://www.agris.cz/Content/pasti/www/. After registering, any user also has access to the data archive.

Working with the application:

1. Entering base information: location, season, animal species, movement speed (default or manually)
2. Entering specification of the came traps (individual)
    a. Camera trap type (can be default or manual)
    b. Time of expiry T (in days)
    c. Amount of detected animals Y (species based, specified in point 1)
3. Application calculates D value for each camera trap (equation (1)) and total density value (equation (2))

(1)

$$D = \frac{y}{t} \times \frac{\pi}{v \times r \times (2 + \theta)}$$

D= density

Y= number of positive animal detection

T= time of camera expiry (days)

V= average distance traveled in a day (km/24h)

R= radius of effective camera trap range (km)

θ = angle of animal detection (radians)

(2)

$$Ds = \frac{\sum D * g}{Ns}$$

D_s= total average density

G= average size of group (units)

N_s = number of camera traps in selected region

The accuracy of the calculation is determined by density of employed camera traps and their respective positioning. The second part of the application helps optimize this by generating the ideal camera trap positioning on given sector. All it takes is to specify the area and number of camera traps and the application will generate the best possible positioning – it calculates coordinates and azimuth for each trap.

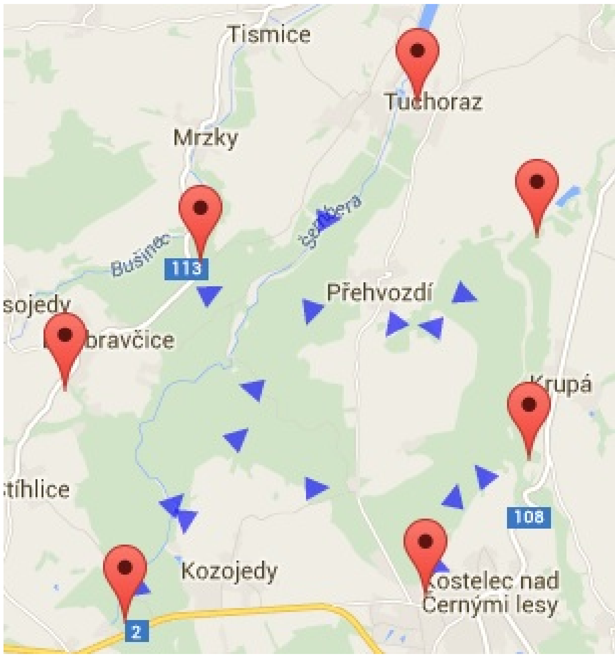

Fig. 3 Ideal network of camera traps in chosen area (map visualization)

Fig. 4 Photography from camera trap – wild boar family

Automated recognition of animals in agricultural and forest undergrowth

The recent development in drone usage and tools for artificial intelligence in regards to image recognition brings new potential to apply methods of aerial counting and animal monitoring. Methodics for finding effective solution to wild boar and deer counting (the main perpetrators of crop damage) is under development by multiple informatics based departments at Faculty of Economics and Management CULS Prague. The research focuses on utilizing standard CCD cameras with high definition and cameras with night vision – infra, and other types of devices in automated data processing using artificial intelligence. It is experimental research aimed at finding suitable basis for future commercially applicable solutions.

Part of the research is also analysis of published information sources from aerial counting of wildlife and different methods of data acquisition, processing and utilization. Counting animals from airplane or helicopter is currently being conducted in Scandinavian countries for instance (Liberg et al., 2010). Thermography is also commonly used (Gill et al., 1997, Focardi et al., 2001 and others) but mainly with ground based solutions. In USA and Canada however, the concurrent use of thermography with aerial imaging is becoming increasingly popular. The research analyses sources ranging over 40 years from multiple countries (Graves et al., 1972; Bayliss and Yeomans, 1989; Boonstra et al., 1994; Belant a Seamans, 2000; Burn et al., 2009; Fuentes et al., 2015).

Results and discussion

Devices used to track animals generate data that have to be transferred into computers or servers for further analysis. The collection of data can be divided into two main categories:

- Offline wildlife data collection
- Online wildlife data collection

Both of these have their advantages and flaws and can be used in different scenarios. Selecting a correct method depends mainly on the nature of the data and parameters of the sensor.

With offline data collection, a person has to be physically present to manipulate with the device. The data is transferred from the device's internal memory onto different medium or by replacing the memory card. The main advantage of this method is the fact that the device does not consume as much energy (there is no continuous connection required) and the volume of data transferred can be quite large (GB). The need for personnel presence is the main disadvantage and with moving objects (animals) sometimes this method is downright impossible.

Online data collection works very quickly or sometimes with a slight delay (depending on the sensor device specification). If we take into account the definition of Internet of Things – which is an environment in which objects, animals or people are equipped with unique identifiers with ability to transfer data using internet network without a person-person or person-computer interaction (Gluhak, 2011), the issues of animal tracking and data collection can be looked as a data transfer issue within IoT. The methods in this type of data collection can be further separated into two groups:

- Wired wildlife data collection
- Wireless wildlife data collection

Data collection realized with wired connection is quite complicated in forest setting, and can be used only in specific scenarios.

Wireless data collection is universally the most common when tracking wildlife. It is mainly limited by the energy requirements for the sensors to operate and transfer data (duration and cost of batteries). Because the devices cannot be too heavy (it would hinder the animals) the main method to reduce energy requirement is to avoid continuous real-time connection in favour of transferring the data in chunks at specified time intervals.

Wireless data transfer in wildlife tracking can be divided into several categories:

- Transfer on UHF / VHF frequencies (Ultra High Frequency / Very High Frequency)
- Transfer using current wireless technologies, for instance GSM (Groupe Special Mobile)
- Transfer using IoT specific networks – low power wide area networks (LPWA)

The UHF / VHF methods have range limits, which are few dozen metres in VHF and several kilometres with technologies using UHF. The main advantage of this type of solution is the relatively low cost for the devices and the transfer itself.

Transfer using GSM networks is realized as a SMS (short message services) or using data transfer services such as GPRS (General Packet Radio Service), EDGE (Enhanced Data rates for GSM Evolution), LTE (Long Term Evolution) and others. The limiting factor for using GSM networks is often the absence of signal coverage which is usually prevalent in heavily wooded areas which are the main wildlife habitat. The coverage can be expanded but the financial costs of that are very steep. Other methods involve utilizing satellite phones, but those are very expensive and costly to maintain, not to mention their energy requirements. The data blocks transferred through GSM or satellite are usually in range of several MB.

Last option for transferring small volume of data is utilizing LPWA networks. These networks are capable to cover several square kilometres areas using only one base station and the scale of usage can be easily expanded. Few of the most common LPWA technologies are LoRa Wan or SigFox. These networks are currently being deployed and field tested and hold a great potential not only in wildlife monitoring but in IoT in general.

Table 1 Characteristics of different wireless networks

parameters / network	**UHF/VHF**	**GSM/satellite phone**	**LWPA**
Transfer speed	slow	fast	slow
Energy consumption	medium	high	low
Volume of data	small	big	small
Prevalent form of usage	collars	camera traps	collars

Conclusion

The behavior of cloven hoof animals is very diverse and there aren't any universal solutions how to deal with the issue and prevent crop damages. The key factors that contribute towards varying levels of crop damage are linked to nearby landscape profile (fields, forests, meadows), the population of game in the area and the food sources provided naturally and by the farmers (maize, rape and other crops on the fields versus oaks and beeches in the forest). It is therefore necessary to look for tools to determine the specifics in given area, track animals in that setting and then propose solution to negate crop damage.

Based on analyses it can be stated that the most suitable technology for transferring small volumes of data (from animal collars) seems to be the newly developed LPWA networks. For transferring larger data, like pictures from camera traps, it is best to use GSM or satellite phone based technology. The technological background established by Department of Information Technology allows researchers to utilize and field test all the necessary tools and devices to conduct the research and propose crop damage preventive measures.

Currently the only way to reduce crop damages from cloven hoofed animals is to utilize complex measures primarily based on local behavioral patterns (preference of food sources for instance) in conjuncture with established agro-technical solutions. These can include creating good conditions for hunting to decrease the game population or utilizing diversion fodders and scent repellents.

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