Cloven-hoofed animals spatial activity evaluation methods in Doupov Mountains in the Czech Republic

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Anotace

Řešení projektu „Sběr a interpretace pozičních dat"je zaměřeno na využití pozičních dat (informace o pohybujícím se objektu) pro vědeckovýzkumnou a pedagogickou činnost v různých oblastech (životní prostředí, logistika apod.). Záměrem je vytvořit a v reálných podmínkách ověřit universální model pro sběr a následnou prezentaci dat získaných o sledovaném objektu prostřednictvím GPS (Global Positioning System).

V článku jsou popsány možné způsoby zpracování a vizualizace dat o pohybech jelena siky v Doupovských horách, které slouží k vyhodnocení jeho prostorové aktivity. Datovou základnu pro analýzu a zpracování tvoří rozsáhlé soubory dat získané na základě spolupráce Fakulty lesnické a dřevařské ČZU v Praze s Vojenskými lesy a statky ČR, s.p.

Klíčová slova

Telemetrické sledování, GPS, GSM, jelen sika (Cervus nippon), polygon, quick hull, heat map.

Abstract

The focus of the project „Collection and interpretation of positional data" is placed on the use of positional data (or the information about a moving object) in the scientific research and educational activities in various fields such as environmental science, logistics, spatial data infrastructure, information management, and others. The objective of this effort is to create an universal model for collection and presentation of moving objects data retrieved through GPS (Global Positioning System), and to verify the model in practice.

Several different approaches to process and visualize data about sika deer (Cervus nippon) spatial movements in Doupov Mountains are described in the paper. The data base is represented with large data files created through the cooperation of the Faculty of Forestry and Wood Sciences at the Czech University of Life Sciences in Prague and the Military Forests and Estates of the Czech Republic, a state-owned enterprise.

Pieces of knowledge introduced in this paper resulted from solution of an institutional research intention. Internal grant agency of the Faculty of Economics and Management, Czech University of Life Sciences in Prague, grant no. 20121043, „Sběr a interpretace pozičních dat".

The results of the cloven-hoofed animals spatial activity evaluation methods will be available for Research Program titled "Economy of the Czech Agriculture Resources and Their Efficient Use within the Framework of the Multifunctional Agri-food Systems" of the Czech Ministry of Education, Youth and Sports number VZ MSM 6046070906.

Key words

Telemetric observation, GPS, GSM, sika deer (Cervus nippon), polygon, quickhull, heat map.

Introduction

Due to the growing amount of damages caused by cloven-hoofed animals in forests and agricultural places and due to rise of new species such as sika deer (Cervus nippon), there is a need to inspect spatial activities of cloven-hoofed animals. The information about daily and seasonal movements of different species of cloven-hoofed mammals is a vital part of complex knowledge of their biology. Without knowing the spatial activity of these species, there is rarely any estimation of the evolution of their numbers owing to local migration in the given season of the year. Especially, the continuous growth of the area of sika deer presence in the Czech Republic (Anděra, Červený, 2010), the knowledge in biology, ecology and home ranges of sika deer populations is very insufficient in spite of the influence on the local red deer (Cervus elaphus) population. However, the information about sika deer from its original areas are very well known (Igota et al. 2004, Takatsuki 2009).

The first, the oldest and obviously the most used way of identification of cloven-hoofed animals is by fitting of caught animals with an ear tag. The data that are retrieved comes from random observations, repeated captures of animals, or occasional shooting of marked individuals. Therefore, it is needed to mark a large number of animals so that "there is a chance to get some information back". The second most used method is a telemetric observation. The accuracy of the method is dependent on the number of observations and the method is quite time consuming (Klitsch, Holešinský, 2012). The third, and currently the fast developing method is to label the animal with a GPS collar (Global Positioning System) (Löttker 2010). The collar stores positional data and transmits it through GSM (Global System for Mobile Communications) for processing without a physical presence in the terrain. The data are stored in tabular form, and provide date, time (UTC), geocentric coordinates (ECEF), latitude and longitude according to the WGS 84, and satellite spatial reference system used for location calculation. In the collar, there is a sensor of mortality, activity data recording and automatic release mechanism when the collar is damaged.

Current approaches to spatial data evaluation are most frequently based on data transformation into some proprietary geographic information software (GIS) (Halbich, Vostrovský 2012), (Klitsch, Holešinský, 2012) where the data processing is conducted. The size of local regions of animals is settled by the method Kernel Home Range. However, GIS is not used for data presentation.

There are three places where the method of animal observation via GPS and GSM can be found in the Czech Republic. The first, a common Czech-German project for observations of deer, roe deer and Eurasian lynx in national parks Bavaria Forest and Bohemian Forest (Telemetry team, 2012). In the beginning of 2012, the project has been stopped in the Czech Republic and only the German part has been operating. The second place is a national park Bohemian Switzerland where the red deer is observed (Klitsch, Holešinský, 2012). Since 2009, there is a telemetric observation of sika deer in Doupov Mountains and since 2010 the observation has been extended to red deer (Macháček et al., 2012). The research is done in the Hradiště area that is located on the military training ground.

The area is maintained by the state-owned company Military Forests and Estates of the Czech Republic, Karlovy Vary division. Hradiště area is of 35,435 hectares and represents one of the most consistent area in the Czech Republic.

Figure 1. Sika deer with GPS collar.

The data collected with cooperation of Military Forests and Estates of the Czech Republic and the Faculty of Forest and Wooden Sciences at the Czech University of Life Sciences by observations in the region of Doupov Mountains were used as a fundamental data base for analysis and design of on-line evaluation and presentation of spatial activities of cloven-hoofed animals.

Material and methods

The main objective of proposed solution is to visualize collected spatial data that were retrieved by observation of cloven-hoofed animals and to enable their use for scientific research and pedagogical purposes and to popularize research results. As a result an application available on-line through WWW was developed. Main projected functions of the application are such as:

- Display mode: public and personalized access
- Projection of animal position in given period (time period and daytime)
- Visualization of home range and motion path in given time period
- Calculation of home range and length of motion path in given time period
- Display of additional textual information about position (such as temperature, or altitude)

Based on introductory analysis the positional data were obtained by observation of cloven-hoofed animals and then stored in MySQL 5 database server. Next, the data were cleared of erroneous figures. Web application was run on Apache web server. The application core was programmed in web programming language PHP 5 (Hypertext Preprocessor) with the use of Nette Framework 2.

Figure 2. Layout of functions in application window.

The visualization of information about movements was done by means of Google Maps from Google Inc. The communication with Google Maps was maintained through Google Maps JavaScript API V3. The visualization was created with JavaScript framework JQuery.

Users can access the data through common web browsers, and further effort will be put on development of mobile access.

The web interface has basic menu and two other main functions: selection part where the parameters of data selection could be set, and output part where search results are presented – both in visual and statistic way (see the Figure 2). Combination of both functions in the selection part enables us to watch the presence of animals in different time periods and life conditions.

Description of selection part of application:

1 — Deer selection: one or more animals could be selected.

2 — Type of presentation: can be displayed as points of presence, motion path and home range in the form of polygon or motion heat map.

3 — Time period: can be selected as last day, week, month or year, or as a particular period within dates. In both cases the daytime can be specified.

Description of output part of application:

4 — Display of selection in Google Maps where each animal is depicted with different colour - see the colour scheme in „Deer selection“ (1).

5 — Statistic of selected figures – there is the information about the number of points of presence, the length of motion path and size of home range within the selected time period.

6 — Information about all animals – period of observation, total number of measured positions within a time period.

Display of points of presence

The default display of deer position is as points of presence that represent particular positions of animals. By clicking on points other information can be obtained such as time of measurement, temperature and coordinates. GPS collar records the position each thirty minutes. If the data are of a good quality, especially the measured figures are accurate as to the number of located satellites they are stored in the database. The data in database are then requested with selections.

The position data are two dimensional and they are processed by JavaScript code with connection to Google Maps API.

With regard to the response time of the system and different internet connection speed of users, the maximum number of displayed points was limited to 1500. If the limit is exhausted, which could be caused by selection of longer time period or by selection of multiple animals, the points that are over the limit are omitted. In detail, each point at position x is processed with modulo function (that produces the remainder of division of two numbers) such as: number of record MOD each record at position x is equal or not equal (it depends on how many records are over limit) to 0. In final turn, there are displayed up to 1500 records picked up equally

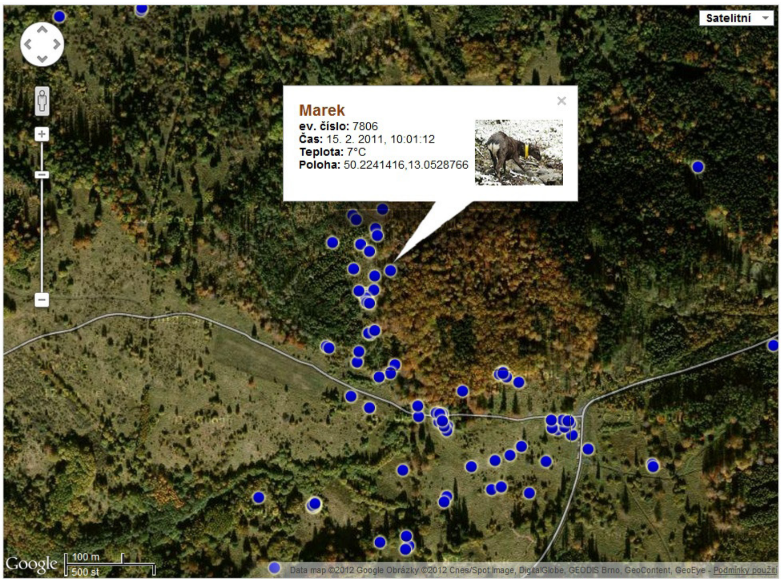

Figure 3. Display of points of presence.

from the series of points.

Theoretical number of recorded positions is 1440, respectively 1488 per month, but in practice, the number of stored positions is approximately a half of it due to the clearance of data. The information about the number of stored positions is displayed in the right bottom corner (see 6).

Motion path

Next function is to display the motion path of selected animal. There are lines connecting the individual point of presence forming so-called PolyLines which are projected through Google Maps API. In the middle of each line, there is an arrow presenting the direction of motion of the object. The start of path is depicted with letter Z and the end of path is depicted with letter K. The coordinates of arrows are calculated as an expected value of two neighbouring coordinates according to the formula (it is the same for both width and length):

$$LATITUDE = L2 - \frac{L2 - L1}{2}$$

L1 – first point latitude

L2 – second point latitude

The angle of correct projection of direction is counted with function arctg, respectively atan2() which is a PHP function.

Minimal passed distance is calculated according to the formula:

$$\$a = \sin\left(\frac{\$dlat}{2}\right)^2 + \cos(\$lat2) * \cos(\$lat2) * \sin\left(\frac{\$dlng}{2}\right)^2$$

$$distance = 2 * \mathrm{atan2}\left(\sqrt{\$a}, \sqrt{1 - \$a}\right)$$

$dlat and *$dlng* – variance between two neighbouring coordinates

$lat1 and *$lat2* – coordinates of latitude,

atan2 – PHP function that gives arctg of two variables.

The value is multiplied by the semi-diameter of Earth (6372,797 km) to get the total distance. Results are available in the application window „Statistisc of selected figures“ (5).

Size of home range – the polygon

One of the most important parameter in observation of spatial activity of cloven-hoofed animals is a definition of home range. The quickhull algorithm (Barber et al. 1996) was utilized for the calculation.

The quickhull algorithm is based on divide and conquer approach (Li and Klette, 2011). The convex hull is constructed of two parts, the upper part called upper hull and the lower part called lower hull.

Upper hull is above the join of two points *q1*; *q3* MBR with extreme coordinates *x, q1 = min(xi), q3 = max(xi),* lower hull is under the join of *q1; q3.*

Above each hull line *a;b* we look for the farest

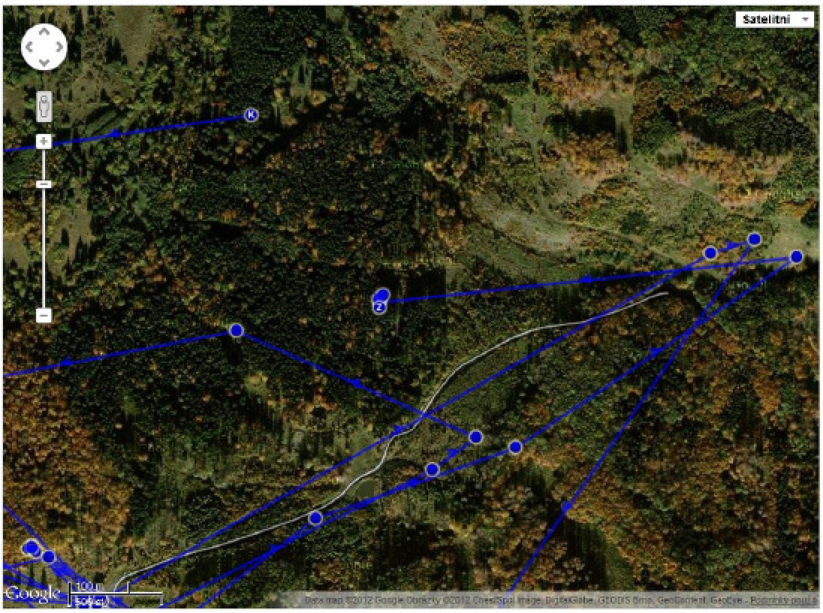

Figure 4. Display of path motion.

point *c* lying right to the line that will become a new point joining the convex hull where each line that was found is disintegrated into two new lines.

Both parts of convex hull are processed separately, and resulting convex hull is a compilation of both parts. When creating a convex hull the algorithm does not operate with all points in the input set, but only with points that are near to convex hull. Despite the quadratic evaluation of the worst case, the good speed of algorithm is ensured by that.

The algorithm utilizes a couple of recursive calls of procedure Quickhull for both newly formed lines *ac, cb* out of original line *ab* (Bayer, 2012).

The size of the polygon (according to the quickhull) where the object was moving is calculated with the

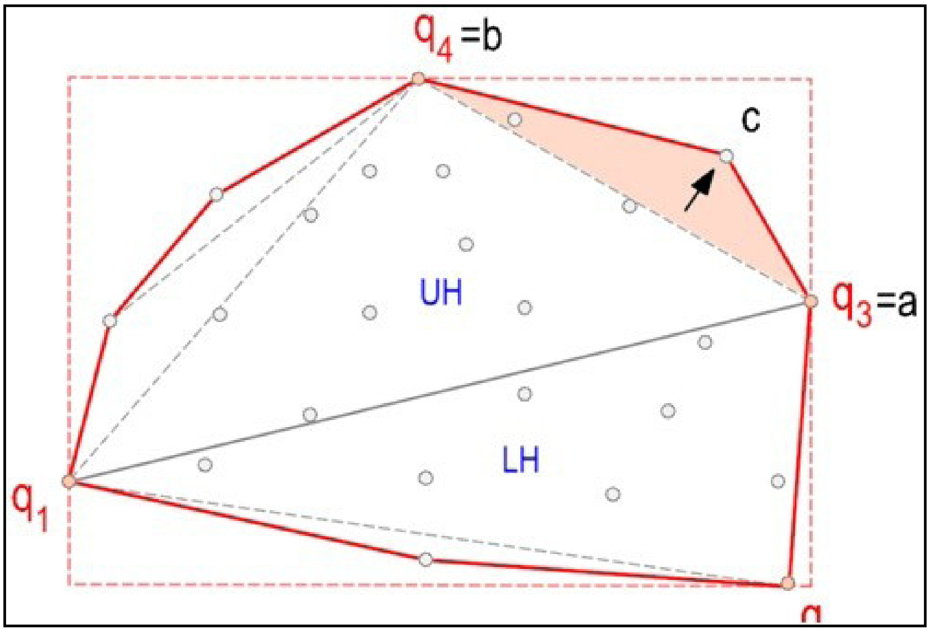

Figure 5. Quick hull construction (Bayer 2012)..

Figure 6. Display of home areas in form of polygons (quick hull).

function Geometry for Google Maps API.

Density of occurance in home range – heat map

The presence of an animal in its home range is not uniform. The heat maps were used to present graphically the points of presence with various density of occurrance (Wilkinson, 2008). The whole interest area is divided into matrices in which points are gradually added. When a new datapoint is added to the heat map's store, the store is checking if there is an index for the new data point, if not, it creates one and then checks whether there is a new maximum or not. If there is a new maximum count, the store initiates a global redraw by cleaning the heat map and then redrawing each data point.

In order to get a comprehensible display of home range, the treshold of maximum values display could be set. In our case the treshold value was set to 2. On the same way, the radius of drawn points was set to 15 pixels. The opacity of the heat map was set to 60 %. In the beginning, there is only monochromatic painting that is then repainted with colours. Red colour represents the highest rate of occurrance, yello is lower, while turqouise and blue represent the lowest occurrance of an animal.

Conclusions

There is an on-line access to sika deer observation data in Doupov mountains at the address http://jeleni.agris.cz. The observed deers are monitored with GPS collars that transmitt location data through GSM. The data are purified and stored into the database.

The above mentioned application enables to select data and project them into the map. It could be selected by animals and by time period. Results can be presented in various forms: points of presence, motion path and home ranges depicted as a polygon in the map (quickhull) or as a heat map that represent the density of occurrance. The size

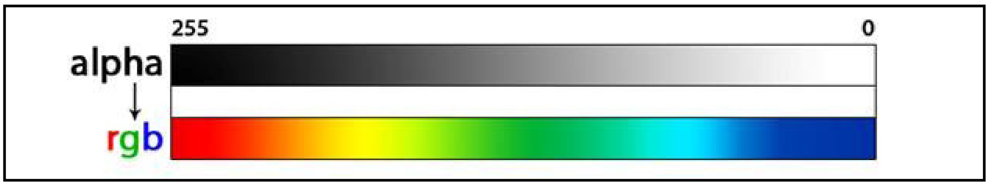

Figure 7. Colour spectrum of density of occurrance as heat maps.

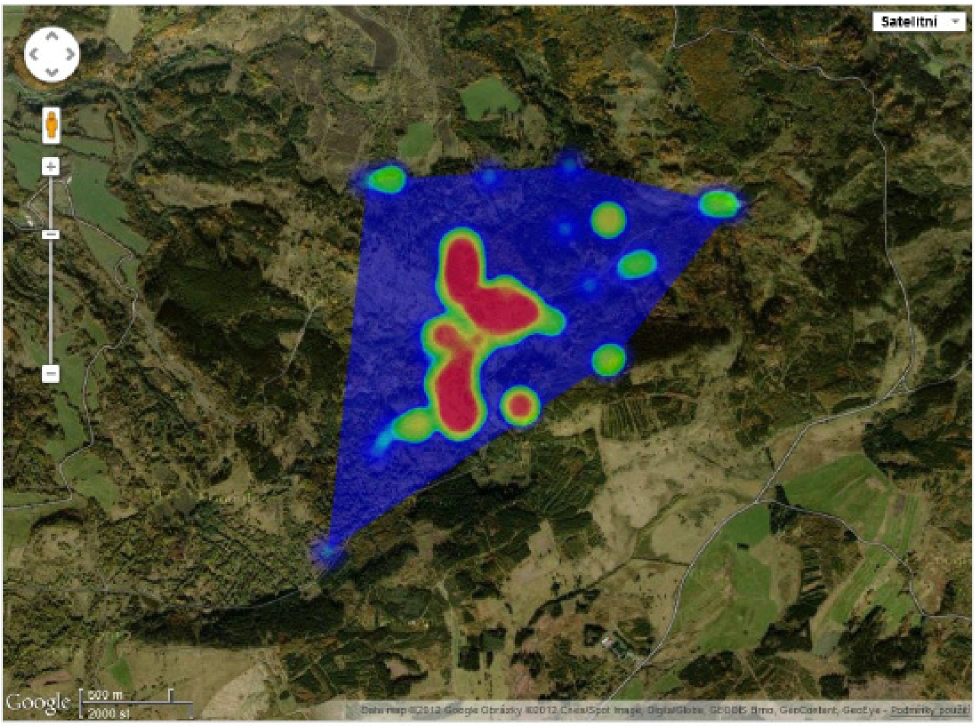

Figure 8. Display of home areas as heat maps.

of polygon and the length of path are summarized with basic statistic characteristics.

The application is designed for employment of retrieved data of deer observation in scientific research and pedagogical activities. Several functions of application will be publicly released to foster the promotion of scientific research in this field.

Other planned activities tend to enable real-time deer observation data collection and their publication on mobile devices.

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