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TRACKING OF SICK INDIVIDUALS OF RED LIST THREATENED SPECIES BY MEANS OF UAV

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Abstract—*In the given paper, it was proposed the algorithm for tracking sick individuals of threatened species on the base of thermogram post-processing.*

Index Terms—Threatened Species of Red List; infrared thermography; image processing; object tracking; UAV.

I. INTRODUCTION

The global scale of a problem of preservation of rare species of animals is defined by awareness of importance of preservation of biological diversity as guarantee of sustainable development of all countries of the world.

According to Zoological society of London, from 1970 the number of wild animals on the planet was reduced approximately by 25-30%. From them land for 25%, marine animals - for 28%, river – for 29%. Annually the person destroys about 1% of all animals.

In programs of preservation of the threatened species ways of their preservation in their live environment are with highest priority as only in such environment full and long-term preservation of live organisms and continuation of their natural evolution are possible.

At preservation of populations their number and a genetic variety is essential. However an important indicator of a state of populations is also health of separate individuals in population since at strong deterioration in health, the number of populations and their genetic variety some time still can remain invariable or even grow.

Temperature is a very good indicator of health, as changes of just a few degrees on skin (cutaneous or superficial) can be used as an indicator of possible illness. The result can be presented as false-color image called a thermogram.

The basis of preservation control of a numerical and specific variety of animals is monitoring of a state of their populations and the habitat.

At essential decrease in the spent funds for involvement of the piloted aircraft, tasks of protection of rare populations and species of fauna being under the threat of disappearance, monitoring of their state can be assigned to means of unmanned aerial vehicles (UAVs).

For the obtaining the qualitative thermographic representation of subjects for monitoring and the environment which have thermal radiation, thermovision system is entered in structure of onboard systems of UAV.

A series of high-quality pictures of objects of monitoring and elements of their living environment in the visible range with a binding to geographical coordinates, become result of such work.

The objective of this work is processing of the thermograms received by means of the UAV, identification of sick individuals with the subsequent their tracking and information transfer about their location.

II. PROBLEM STATEMENT

Motion of the object can be complex and there can be many real time processing requirements for tracking. Tracking is not a trivial task given the non-deterministic nature of the subjects, their motion, and the image capture process itself.

The objective of video tracking is to associate target objects in consecutive video frames. We have to detect and track the object moving independently to the background.

The main goal of this project is to track the detected sick individual in every frame or to predict the position of individual if it disappeared from the area of camera view. There is both camera motion and object motion in the movie.

The desired output is a video in which the sick individual is marked in every frame of the video. It is to be noted that the individual should not be occluded neither partially nor fully in any frame of the video sequence.

III. PROBLEM ANALYSIS

Infrared thermography (IRT) is a science dedicated to the acquisition and processing of thermal information from non-contact measurement devices

The main approach to detection in thermal infrared has historically been thresholding, so called hotspot detection. Thermal cameras were expensive, had low resolution and interesting objects typically appeared as points (a few pixels, or even subpixels) in the image. In addition, typical objects of interest were those that are warmer than the background because they generate kinetic energy in order to move (e.g. airborne and ground vehicles). Thresholding combined with post-processing (e.g. merging and splitting of blobs) is an efficient detection technique in the case of high background/object contrast.

Regarding object tracking in thermal infrared imagery, there are two common beliefs. The first is that it is all about tracking warm objects against cold backgrounds, so called hotspot tracking. This assumption is valid for certain applications only, e.g., tracking aircrafts against a cold sky, but for most other applications the situation is more complex.

The second common belief is that tracking in thermal infrared is identical to tracking in grayscale visual imagery. Consequently, a good tracker for visual imagery should also be a good tracker for thermal infrared.

There are numerous approaches for object tracking[1]. These methods differ from each other depending on the object representation which is suitable for tracking, image features that should be used, the way, in which the motion, appearance, and shape of the object are modeled.

Point Tracking. Objects detected in consecutive frames are represented by points, and the association of the points is based on the previous object state which can include object position and motion. Recognition can be done relatively simple, by thresholding, from identification of these points.

Kalman filtering. Kalman filter is based on Optimal Recursive Data Processing Algorithm [2]. It calculates estimations of past, present, and even future states, and it can do the same even when the precise nature of the modeled system is unknown. The filter estimates the process state at some time and then obtains feedback in the form of noisy measurements [3].

Particle filtering. The particle filtering generates all the models for one variable (initial state, noise covariance, number of particles etc.) before moving to the next variable. This algorithm has an advantage when variables are generated dynamically and there can be unboundedly numerous variables. This algorithm usually uses contours, color features and texture mapping [4]. It also consists of fundamentally two phases: prediction and update as same as Kalman Filtering.

Multiple Hypothesis Tracking (MHT). It is an iterative algorithm, several frames have been observed for better tracking outcomes [5]. Iteration begins with a set of existing track hypotheses. Each hypothesis is a crew of disconnected tracks. For each hypothesis, a prediction of object's position in the succeeding frame is made. The predictions are then compared by calculating a distance measure. MHT is capable of tracking multiple object, handles occlusions and calculation of optimal solutions [5].

Kernel Based Tracking. Kernel tracking is usually performed by locating the moving object, which is represented by an embryonic object region, from one frame to the next. The object motion is usually in the form of parametric motion such as translation, conformal, affine, etc. But one of the restrictions is that some part of the objects may be left outside of the defined shape while portions of the background may exist inside. This can be detected in rigid and non-rigid objects.

Simple Template Matching. Template matching is a method of examining the Region of Interest (ROI) in the video sequences. In template matching, a reference image is verified with the frame that is separated from the video. Tracking can be performed for single object in the video and overlapping of object is done partially. Template Matching is a technique for finding small parts of an image that matches, or are equivalent model with an image (template) in each frame [6].

Mean shift method. The mean-shift algorithm is an efficient approach to tracking objects whose appearance is defined by histograms. Image characteristics of the objects like appearance, color etc., are selected to express object firstly, then matching is executed constantly in sequence images. Mean-shift tracking tries to find out the area of a video frame that is locally most similar to a previously initialized model [7]. To characterize the target, color histogram is chosen.

Contour Tracking. Contour tracking methods, iteratively progress a primary contour in the previous frame to its new position in the current frame. This contour progress requires a certain amount of the object in the current frame overlying with the object region in the previous frame [8].

IV. PROBLEMS SOLUTION

The suggested algorithm can be presented in the following steps:

1. infrared thermal images acquisition;
2. the first stage begins with fast screening procedure to hypothesize only the location of the sick individual in the image. To enhance the detection rate, a thermal-based thresholding technique is employed in the snapshot process.;
3. at the moment when the sick individual is detected, the UAV begins tracking with the help of Kalman filtering until stop signal is received from operator. At the same time the tracking individual location information is sent to the base station.

Thermal image can be captured by sensing the radiation emitted from objects under different environment conditions, both day and night. As long as the thermal property of a foreground object is slightly different from their surroundings, this object will appear at a contrast from the environment. Thus, thermal image can provide useful information which is not available in visual image, in particular of surveillance and monitoring proposes [9].

In a thermal image, an area with the hottest temperature is usually represented by the brightest color.

Image segmentation is one of the challenging tasks in image analysis. The purpose of segmentation is to subdivide an image into its constituent regions or objects. Rather than working in a colored thermal image, we apply the advantage of using a grayscale conversion of thermal image, since the sick individual is still recognizable at grayscale image.

Thresholding technique has been widely used in various image segmentations because of its simplicity and easy to implement. In examining the thermal state of sick individuals, thresholding technique has become a very useful method for separating the warm region from its background. The possible thermal anomalies in the health state can be detected by filtering the image using a certain threshold value. If the original image is $I(x,y)$, the thresholded image $G(x,y)$ is defined as

$$G(x,y)=\begin{cases}1\text{ if } I(x,y)>T,\\ 0\text{ if } I(x,y)\le T,\end{cases} \quad (1)$$

where T is the threshold value. The segmentation result is in the binary image form where 1 represents the target object or region and 0 represent for background image.

A Kalman filter is an optimal estimator. That means, the filter infers parameters of interest from indirect, inaccurate and uncertain observations. It is recursive so that new measurements can be processed as they arrive.

The Kalman Filter algorithm belongs to the state space approach class of tracking algorithms. It solves the tracking problem based on the state space equation and the measurement equation. So object tracking with Kalman Filter divides to two steps: prediction equation and correction equation. In this paper Kalman Filter perform the task of tracking by prediction of possible position of sick individuals and updating the bounding box if the predicted position and actual detection do not coincide in each frame of the sequence. It has been suggested that the changes in speed of the individual is up to some limitation, in other words, the acceleration of the target is not very high.

The first phase of each iteration of the Kalman filter is the prediction stage, in which the algorithm gives both predictions of the object's state vector and an estimate of how reliable the prediction is [10].

In order to predict the next position, we will need to compute our tracking individual motion model. Our detector is imperfect so there is noise in object locations, generally called measurement noise. So, the task has narrowed down to the next position incorporating only following parameters:

1. process equation;
2. measurement equation.

In mathematical terms, the previously described steps can be presented with the help of the following pair of equations:

1. Process equation

$$x_{k+1}=F_{k+1,k}x_k+w_k \quad (2)$$

where $F_{k+1,k}$ is the transition matrix taking the state x_k from time k to time $k+1$. The process noise w_k is assumed to be additive, white, and Gaussian, with zero mean and with covariance matrix defined by

$$E\left[w_n w_k^{\mathrm{T}}\right]=\begin{cases}Q_k & \text{for } n=k,\\ 0 & \text{for } n\ne k,\end{cases} \quad (3)$$

where the superscript T denotes matrix transposition. The dimension of the state space is denoted by M .

2. Measurement equation

$$y_k=H_k x_k+v_k \quad (4)$$

where y_k is the observable at time k and H_k is the measurement matrix. The measurement noise v_k is assumed to be additive, white, and Gaussian, with zero mean and with covariance matrix defined by

$$E\left[v_n v_k^{\mathrm{T}}\right]=\begin{cases}R_k \text{ for } n=k,\\ 0 \text{ for } n\ne k,\end{cases} \quad (5)$$

Moreover, the measurement noise v_k is uncorrelated with the process noise w_k. The dimension of the measurement space is denoted by N.

V. RESULTS

The above presented algorithm was performed in the following way. Firstly, thresholding was implemented was infrared thermal images in order to detect the presence of sick individual. It then performs morphological operations on the resulting binary mask to remove noisy pixels. After that the holes in the remaining blobs are filled. The results for segmenting the original infrared image based on the before mentioned methods are represented in Fig. 1 [11].

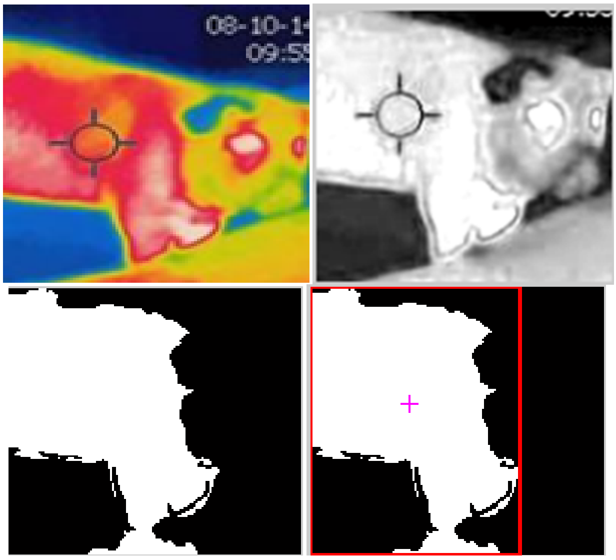

Fig. 1. The results of infrared image processing

After the image processing is completed, the Kalman filter is used to predict the centroid of each track in the current frame. The bounding box accordingly is updated as well.

The tracking was performed on the suggestion that the supervised individuals move in linear direction with the approximately constant speed.

The results of our tracking investigation are shown on Fig. 2.

VI. CONCLUSION

In this work, we suggest to use an algorithm that uses thresholding for infrared image processing. We estimate the health state of supervised individuals. We then use Kalman filtering for tracking to predict the future possible individual location until the operator stop signal is received. Our algorithm seems to perform well for most of the as shown in results.

In this paper, it was developed approach which allows detecting sick individuals of threatened species with high accuracy.

Fig. 2. The results of tracking algorithm implementation

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В. М. Синєглазов, В. Ю. Деркач. Відстеження хворих особин видів, занесених до «Червоної Книги», засобами БПЛА

Запропоновано алгоритм відстеження хворих особин видів, занесених до «Червоної Книги», на основі подальшої обробки інформації, отриманої з термограм.

Ключові слова: види, занесені до «Червоної Книги»; інфрачервона термографія; обробка зображень; відстеження об'єктів.

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В. М. Синеглазов, В. Ю. Деркач. Отслеживание больных особей видов, занесенных в «Красную Книгу», средствами

Предложен алгоритм отслеживания больных особей видов, занесённых в «Красную Книгу», на основе последующей обработки информации, полученной из термограмм.

Ключевые слова: виды; занесенные в «Красную Книгу»; инфракрасная термография; обработка изображений; слежение за объектами.

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