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Real time video analysis for behavioral studies of animals

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Abstract

The automatized real time analysis of videos offer advantages in comparison to traditional animal observation methods like rather simple to implement 24 hours a day observation and avoiding the subjectivity of human observers. Observation over long time like months and years are easily possible and require only little administrative efforts. But dependent on the observation target various technical obstacles have to be solved. Within the project “Animal Perception of Seismic Phenomena” various techniques were used and are described here. Starting with the calculation of overall activity over sub scence activity calculation to object detection and tracking by color codes. For each method it will be discussed how to optimize the observation conditions and what and what not can be expected from the results. The focus is on techniques which require little technical resources and can be used with low energy systems which can be operated more easily outdoors.

Key words : animal, behavuoral, earthquake, disaster, video

Background

Definitions

Real time: Processing of an input video stream with only a very tiny delay (less than 1s). Topology: Topology means the spatial relation of objects (the animals) to each other. Video: Stream of images with constant time interval (independent of the actual time interval and resolution) Video Analysis: The automatic extraction of information from the video stream.

Project

Before an animal monitoring project can be successfully implemented a number of questions have to be answered, like:

Basic questions

- What is the target of the project?
- Time frame of the project?
- What should be monitored?
  - Size of animals
  - Environment (aquatic yes/no; lightning)
  - Distance to the observed animals, what resolution is required?
  - Video source: Color, gray scale or thermal infrared (might depend when and what is observed)?
  - Single animals, group of animals, have single animals to be distinguished?

The better the task is defined, the faster and more successfully the campaign will be implemented.

Conditions

In the same way the conditions of the observation should be analyzed:

- What kind of power supply is available and how stable is it?
- How often is it possible to check the installation?
- What work force do I have, what is there educational background?
- Can artificial lightning during night or other low light situations be used?
- What budget is available – a standard USB camera might be available for some USD, certain thermal infrared cameras are in the range of many thousands USD
- Is it possible to store the video for later analysis (this text is assuming that it is not possible, maybe short

sequences or sample images for testing and training)

The software is the "brain" of the observation system and from it, it depends what is possible. On the other side to develop software a lot of resources, expertise and time is required. So it should be checked first what solutions are on the market (commercial software or from the scientific community) and if these solutions do what is required for the project.

In general commercial applications often have less options for configuration but are more stable whereas software developed for research handles more "exotic" conditions, is less stable, very specific and documentation is often not professional / not existing. This is a simple matter of fact as testing and documentation are two time consuming and resource intensive tasks which are not possible within a research project – so most of these applications are tested only for a very specific work flow.

In case non standard operations are required which can not be found within an existing application, in might be useful to have a closer look on the OpenCV library, which provides a quite complete function set.

Observation environment

One basic question is, if we can we control the observation environment (like in a lab experiment)? The more we control the easier is the observation but we have to be aware that every change of the environment influence the animals and we might not be able to monitor anymore what we want to monitor. Questions which should be answered are:

- Cameras are optical sensors which required light for operation. In dim light conditions, is it ok to work with artificial lightning?
- The more the background differs from the color of the observed animals they more easy and reliable is the observation. What type of background can be provided, is it homogeneous? Are there any moving objects (like trees move by wind)?
- Is it possible to tag the animals? (unique identifier)
- Number of animals, is it known, constant or variable?
- Size of animals – is it constant or variable (growth, especially in long term observations)?

Techiques

Overall Activity monitoring, Sub Scene Activity monitoring, Object recognition and tracking.

Overal Activity Monitoring

This is the most simple method of analysing the movement of animals. Nevertheless if it fits to the situation, it can be useful and because of the simplicity avoids problems which more complicated methods will encounter.

Situation

Of interest is the sum of position changes of all animals or the animal. Their position or single animals are not of interest. There are no other movements or it is possible to filter them.

Definition

The amount of images pixel which show a difference in coloring (or brightness) between two images made at time 0 and time 1 (of the same position) are evaluated.

What can be done, what do the result tell us

Average speed of animals can be calculated from the amount of pixel changed in a time interval – this is especially possible if the animals move only 2 dimensional (eg on the floor of their cage) and there are no perspective effects.

Limitations

This technique is sensitive to movements in the background (eg. leaves moved by wind, reflections of a water surface). If the disturbance can be clearly defined and removed by filtering before the analysis it is still possible to use it. In optimal conditions this method can deliver details which are not inferior to an animal mounted accelerometer (1 axis).

Sub Scene Activity Monitoring

Situation

Of interest is the sum of position changes within user defined subregions of the video scene. The position of a single specific animal is not of interest.

Definition

The amount of images pixel which show a difference in coloring (or brightness) within a subregion between two images made at time 0 and time 1 are evaluated.

What can be done, what do the result tell us

We are interested in the activity of a group of animals (except we monitor just one animal) and want to know where there is little of a lot of activity. (Do the animals group? Do they swim only close to the surface?) The location of the animals (but not a single one) on the recorded images matters for us. Average speed of animals can be calculated from the amount of pixel changed in a time interval – this is especially possible if the animals move only two dimensional (eg on the floor of their cage).

Limitations

This technique is sensitive to moving background (eg. leaves moved by wind, reflections of a water surface). If the disturbance can be clearly defined and removed by filtering before the analysis it is still possible to use it.

Object Recogniyion and Tracking

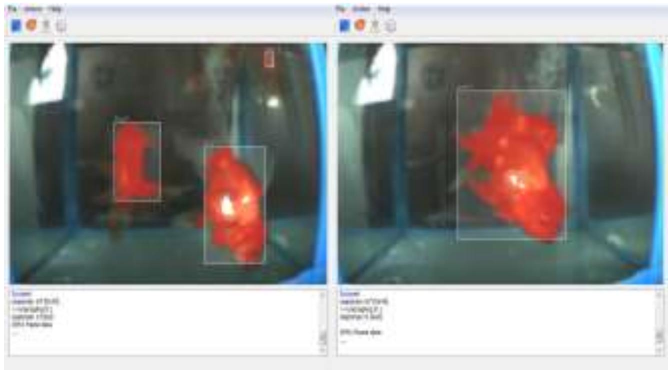
Object recognition for our purposes means that we can identify a single animal and follow its position. In this way we can learn a lot more about the animal behavior. We can identify times of sleep/resting, running, even we can see if a certain animal likes to group with other animals.

This is the most advanced method but:

- How can we identify a single animal, do they have individual properties that we can use?
- Is tagging possible? (The animals get unique identifiers, like plates with color code)
- Unlikely: the animals have unique colors, shapes, sizes (shapes and sizes are anyway no good tags as the change with distance and orientation)

The problem is that because of movement, visibility, position to each other not all animals can be identified properly. So we have to work with a lot of assumptions in the case that the animals have not unique identifiers (which is the most common situation if we make observations of wildlife).

In many cases – especially if the monitoring is over a longer time – the animals will be mixed up and we have no more information about path, speed, individual behavior so the “Sub Scene Activity” monitoring might deliver the same results with less powerful (= energy consuming) hardware.



Identified animals using a color sensitive detection algorithm: As long as the animals are not too close, they can be counted and evaluated without problem. Are they too close (right picture) the algorithm will only see one bigger object. If they increase the distance again, it is not possible to tell which animal is which (size might be a function of distance).

What the computer is seeing (top left: input video image; top right: objects as seen by identification of color values).
right: a simple color tag to help unique identification.

Equipment

Computer
Notebook computers offer the most possibilities and integrate battery and display. They can be programmed using the most common standard tools and require so less specific knowledge. They might be interesting souvenirs for by – passers and use quite a lot of energy.

INTEL/AMD based single board computers are still easy to program can use Windows or Linux and can still use the most widespread software.

Single board computers like Raspberry (Linux based) have much less computation power (equal to a smartphone) – smaller software pool but still libraries like OpenCV are available. Energy consumption for a system with 1 camera ~3-3.5W. We can analyze 5-10 images a second with a resolution of 320x240 pixel.

Microcontrollers have very limited memory and only larger ones might be used for very low resolution video analysis (80x60 pixel) – still it depends on the task. The use of course much less energy as well < 1W. The easy to learn Arduino environment seems to be too limited and considerable learning time (if not employing a specialized person) has to be considered!

Cameras
CCTV
These cameras come often in weatherproofed casing and night enabled (using infrared LEDs for lighting which is invisible for most animals). The image quality is often very bad and the video has to be converted to digital. The software delivered with it will be most likely not very useful for the project.

USB cameras
Cheap and offer a digital output. Some have the reputation to be very light sensitive but for night observations additional lighting will be necessary.

Software (video analysis libraries)
OpenCV
This is the most frequently solution, works on INTEL/AMD and ARM (Raspberry) based computers. It is a very huge library and therefore requires some learning. It can be used with Python (calling its C/C++ functions) or directly using C/C++.

OpenIMAJ
This seems to be a very interesting library as well and should be checked. The disadvantage: It is Java (the programming language, not the island) based and might be no option for weaker hardware.

Especially simple video analysis functions can be written without a problem if a programmer is available. This should be just an option if function libraries like OpenCV are not available.

General advice
All in all the development is very fast, so it is recommended to check the actual state when starting a project.