A video data base system for studying animal behavior

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A Video Data Base System for Studying Animal Behavior[1,2]

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ABSTRACT: Classification of farm animal behavior is based on oral or written descriptions of the activity in which the animal is engaged. The quantification of animal behavior for research requires that individuals recognize and code the behavior of the animal under study. The classification of these behaviors can be subjective and may differ among observers. Illustrated guides to animal behavior do not convey the motion associated with most behaviors. Video-based guides offer a method of quantifying behaviors with real-time demonstrations of the components that make up a behavior. An animal behavior encyclopedia has been developed to allow searching and viewing of defined (video-recorded) behaviors on the Internet. This video data base is being developed to initiate a system that automatically extracts animal motion information from an input animal activity video clip using a multiobject tracking and reasoning system. Eventually, the extracted information will be analyzed and described using standard animal behavior definitions (the behavior encyclopedia). The intended applications of the behavior encyclopedia and video tracking system are 1) an accessible data base for defining and illustrating behaviors for both research and teaching and 2) to further automate the collection of animal behavior data.

Key Words: Animal Behavior, Video Recordings, Cattle, Pigs

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Introduction

The study of animal behavior is important to livestock management and veterinary medicine, and to answer basic ethological questions. Behavior data acquisition, summary, and analysis are usually very time-consuming. Time-lapse video techniques have been successfully used to facilitate the documentation of animal behaviors with many species of livestock. Although some programs exist for helping the observer with the summarization, the whole video annotation process remains manual and suffers from several problems. First, documentation of behavior can be tedious. Even with the help of some of the newer software (McGlone et al., 1985; Noldus Information Technology, 1995), the person must still decide on the classification of each behavior. Because of this, the second problem is that of an added component of subjectivity or bias when various individuals classify behaviors.

Behavior Encyclopedia

Within the field of applied animal ethology and, in particular, the study of farm animal behavior, ethologists differ about what actions constitute a given behavior. This leads to a lack of consistency in comparing studies of animal behavior. Typically, at the beginning of a behavior experiment, an ethogram is developed for the species under study. Even though many dictionaries are available to assist with this process, behavior is extremely dynamic and difficult to capture using only written information and still photographs found in animal behavior textbooks. Therefore, it is important, as computer and video technology has progressed, to make definitions of animal behavior more dynamic.

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[3]Mention of a trade name, proprietary product, or vendor does not constitute a guarantee or warranty of the product by USDA or imply its approval to the exclusion of other products or vendors that may also be suitable.

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To assist with this process, a behavior encyclopedia has been developed that is available on the Internet and should therefore be useful as an adjunct to animal behavior courses or for use by other individuals interested in animal behavior. The video encyclopedia will then serve as a basis for development of a computerized animal behavior annotation system.

Source of Definitions and Video Clips

The primary source of written definitions is from Hurnik et al. (1995). Dr. Hurnik and Iowa State University Press were most generous in allowing us to use these definitions as a basis for the behavior encyclopedia. Because a complete encyclopedia of animal behavior is a major undertaking, we have begun with a limited number of animals, mainly cattle and pigs. The number of species and behaviors will undoubtedly grow exponentially. Depending on the interest of viewers, this project could expand to include laboratory, zoo, and companion animal species. The initial video clips were kindly provided by Dr. Jack Albright (1993) as raw footage from his videotape "Normal and Abnormal Behaviors in Domestic Livestock used for Research."

Regional project NCR 131 (animal behavior) has agreed to review the definitions and video for selection in the encyclopedia as well as assist in supplying video clips. The NCR 131 project has representation from a majority of the research scientists in applied ethology within the United States. Each behavior in the encyclopedia has a comment form attached so that anyone that visits the site can offer an opinion or can suggest changes in the encyclopedia (either definitions or video clips). We anticipate much controversy regarding the selection of behaviors and definitions but believe that this is the only democratic process that can be used for such a behavior encyclopedia. Visitors at the site will also be encouraged to provide additional definitions of video clips of particular behaviors. The NCR 131 group will provide the final review for all comments. Recommendations by the NCR 131 group for changing or adding definitions to the encyclopedia will be completed by ARS Livestock Behavior Research personnel. We are currently able to use any format of VHS tapes (PAL/NTSC) and NTSC S-VHS tapes.

System Requirements and User Notes

The video files in the behavior encyclopedia are in MPEG format. We recommend a Pentium, PowerMac, or equivalent system to view the files in the data base. A minimum of 16 megabytes of RAM should be present in the system. A direct, high-speed connection to the Internet is also recommended. An ISDN or greater speed connection is suggested to those who browse the video section of the data base. A section on system requirements and user notes is available at the site or directly at http://www.ansc.purdue.edu/USDA-LBRU/vdb/vsysreq.htm. All video has been captured at 30 frames per second (fps). Playback should therefore be at this rate. If your system is not able to playback MPEG files at this rate, it should be noted that the behavior that is being viewed will not appear the same as it did in reality. An attempt has been made to keep the video clips used for each entry as short as possible because video files tend to be very large. File size is given beside each behavior.

Using the Behavior Encyclopedia

Users interested in accessing the behavior encyclopedia can find it at http://www.ansc.purdue.edu/USDA-LBRU/VBD/vdb/video.htm. When you have reached the Livestock Behavior Video Database Home Page you will be asked to "Please input a query," at which time you should type in the word "video" and click on "submit the form." Next you will see the definitions, their source, and a small box with a picture of a pig (animal icon). When you find the definition you wish to view, click on the animal icon, and you can view the behavior. One example video can be seen on the ASAS Web site at http://www.asas.uiuc.edu/abs/1998/f06915s.mpg.

Video Annotation and Object Tracking

Computerized tracking of animal behavior has been based on the early work of movement notation (for a review, see Eshkol and Waxhmann, 1958; Fentress, 1976). The fundamentals of such a system are that animals relate to their environment both spatially and temporally (Fentress, 1992). As Fentress (1992) and Golani and Fentress (1985) point out, such computer-assisted behavior annotation systems facilitate quantitative studies on how patterns of normal and abnormal behavior are structured.

A current animal behavior recording and annotation system involves a CCD video camera that records animal behavior in real-time or, eventually in a time-lapse mode, according to the requirements of the study. Through the graphic user interface (**GUI**), a user can input a piece of animal behavior video data, initiate the annotation process, and the system then tracks multiple animal contours and deduces and summarizes the behaviors. The information used to "read" or annotate the video clips is based on the video encyclopedia. After the video is annotated, this serves as an index for additional video queries, based on information contained in the annotation.

The GUI in a video data base plays a crucial role in the overall usability. It facilitates the access to the data base, including video data insertion, query specification, and data presentation. In our system, the GUI is designed to have the following functions: 1) display a summary of a given video clip; 2) play all or

part of the given video clip; 3) initialize the annotation process; 4) input other information that cannot be directly obtained from the video clip (i.e., observer's name or date); 5) review the annotation and make corrections; and 6) query the video clip based on additional information, such as date, key word, or description of the behavior.

Video Data Modeling and Animal Tracking

In our system, a video model similar to the stratification model proposed and extended by Thomas et al. (1991) and Weiss et al. (1994) is being used. The basic idea is not to segment the video data (as with segmentation-based models; Swanberg et al., 1993) but to build a hierarchical annotation structure on top of the raw video data. In this type of system, each annotation is related to a piece of logical video segment determined by its starting frame number and ending frame number. The logical video segments can overlap each other in time using this system. For additional information on the video annotation model, see Jiang and Dailey (1996) and Jiang et al. (1996).

With our animal behavior data base system, animals can be tracked over time. We are not the first to propose animal tracking over time, but, to date, the following complications have arisen: 1) it is difficult to track multiple objects at the same time; 2) relatively precise object contours in each frame are currently very important; 3) animals exhibit nonrigid contours (i.e., their contours change constantly, and it is possible that only part of the object moves at a time); 4) animal motion is abrupt and not smooth, making motion prediction difficult; 5) animals may be in close contact, which makes it difficult to track and individually identify an animal; and 6) backgrounds (animal environments) are not homogeneous and often have strong edges that confound other tracking systems.

Snakes

In our system currently under development, the active contour model is used to identify animal contours and to track animals over time. Active contours are also referred to as "snakes" and are energy-minimization splines, which are used in computer vision to find certain image features, such as edges and contours (Kass et al., 1987). A complete mathematical description of the snakes used in our system can be found in Jiang and Dailey (1996). Snakes offer several advantages for our specific applications, including flexibility (i.e., the actual energy minimization equation can be determined for different purposes) and efficiency (i.e., no dependence on distinction between the background and the animal), and they are robust because contour tracking is usually more powerful than point tracking.

One of the greatest advantages of the snake model is that it combines contour finding and tracking rather than treating them as two separate steps. This contour tracking of animals is based on the assumption that displacement between two consecutive video frames is small. The basic idea is to use the converged solution of the previous frame as the initial snake of the current frame. Even though several approaches, such as Kalman filtering, affine transformation, and motion-based analysis (Bascle et al., 1994) have been proposed to predict the position of the snake for the next frame, we chose not to do so because of the unpredictable nature of animal motion. An example of animal tracking can be found at http://www.asas.uiuc.edu/abs/1998/pig2-20-.mpg. In this example, the pig is tracked for 200 video frames, and the results are shown at an interval of every five frames for the purpose of clarity in the figure. Using this system, certain behaviors can be deduced from their position relative to other animals and to landmarks in the environment (i.e., feeder, waterer). In this way, behaviors such as eating and drinking can be identified. It should be pointed out that not all behaviors can be recognized by this system, but the videotapes can also be viewed directly. Other object tracking techniques, such as template matching, are currently being investigated; one example can be seen at http://www.asas.uiuc.edu/abs/1998/p.mpg.

Implications

We have described a video encyclopedia and a new application for its use, namely, as an animal behavior video data base system for the automatic measurement of behavior from video tape. Even though the system and the encyclopedia are currently at an early stage of development, the initial results have been promising. We have placed the encyclopedia on the Internet and are continuing to study how the use of "snakes" can track the contour of animals. Even though automatic tracking will never completely replace human observation of animal behavior, it may yield important information about normal and abnormal patterns of behavior in specific environments. In parallel with the automatic annotation and object tracking system, the behavior encyclopedia can be used in teaching and in research.

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