Tracking System for the Kihansi Spray Toad

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Abstract

To support the conservation efforts of the Kihansi spray toad, we introduce (1) a tracking system designed specifically for the small, cold blooded Kihansi spray toad, and (2) automated behavioral observations of the toad. Currently, the tracking system combines motion detection using depth and RGB color information, and object detection using a YOLO v3, which uses a convolutional neural network architecture. The outputs of the tracking system consist of movement paths and heat maps of movement densities in an area, which can assist in the study the toad's behavior.

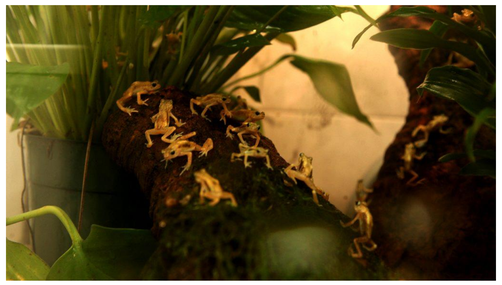

Figure 1: A group of Kihansi spray toads.

Background

The Kihansi spray toad, *Nectophrynoides asperginis*, is a small toad endemic to a small area at the base of the Kihansi River waterfall in Tanzania. In May 2009, the International Union for Conservation of Nature declared the Kihansi spray toad extinct in the wild, largely due to the construction of the Kihansi Dam in 1999. Conservation efforts over the last 2 decades have allowed for the reintroduction of the Kihansi spray toad into the wild.

Figure 2: The tanks in which the Kihansi spray toads are held.

Methodology

Video

- The Intel RealSense SR300 camera is positioned approximately 1 inch away from a single terrarium at the Bronx Zoo (see Figure 2).
- The video stream consists of depth and color streams shot at 30 FPS at a 640x480 resolution.

Figure 3: The video streams of the Intel RealSense SR300 camera.

Object Detection

- The YOLO v3 model was used to recognize and predict a bounding box around each toad.
- The neural network was trained with 1000 images of toads from the video. Each image consisted of one toad pasted to a background image with no other toads in it.
- The collection of images had a diversity of toad body configuration and levels of obscurity.

Motion Detection

- Toads identified from movement information, and then validated using color correlation.
- To obtain movement information in the form of contours from the depth stream, a foreground mask is generated using a Gaussian Mixture based background subtraction model (KadewTraKuPong and Bowden[2]) as implemented by OpenCV.
- Only contours that are within a valid size threshold are considered so as to minimize erroneous identifications caused by noise
- The dynamic lighting conditions that the toads are exposed to are accounted for by converting images to HSV (hue, saturation, value) format.
- RGB frames are converted to HSV format with brightness set to a constant value so that light levels will not influence color correlation.
- Color correlation is then performed using a color template of a toad that is selected manually. To determine significant correlation, we used the mean squared difference.

Results

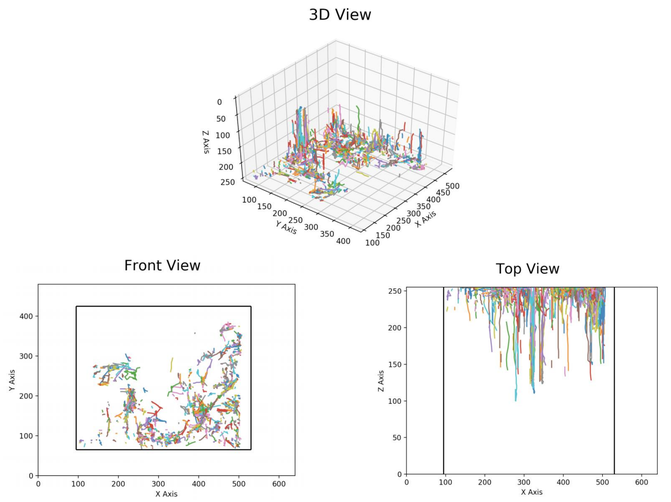

Figure 4: Tracks generated over the course of the same 1 hour interval, with each track represented as a separate line in space.

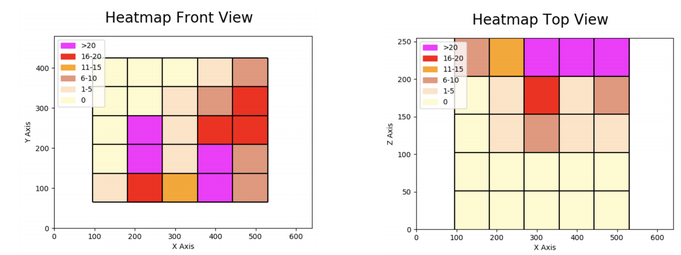

Figure 5: Heatmaps generated for the same 15 minute interval.

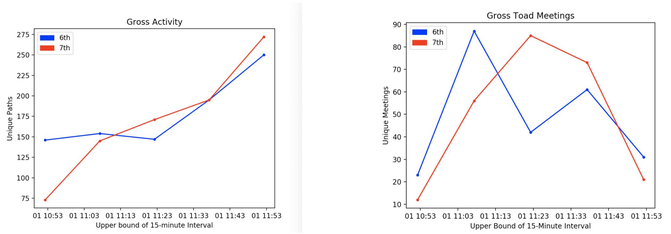

Figure 6: The gross activity (left) and gross meeting (right) graphs for tracks generated during the same 1 hour and 15 minute period compared over 2 separate days.

Behavioral Analysis

- All tracks are output to their own unique files which are further processed to generate behavioral analytics for biologists. While it is possible for there to occasionally be erroneous track identifications, the errors are expected to occur at a consistent rate, and thus overall trends in data should still be accurate to make deductions upon.
- General activity trends over the course of multiple hours or days are shown in the form of gross activity graphs with 15-minute intervals. As each track has a timestamp associated with each recorded coordinate, it is trivial to count the number of unique tracks present at any desired interval. To better compare gross activity trends over the course of a day, graphs of separate days are overlaid with each line segment representing a different day.
- One possible measurement that can be made from the track data to illustrate or investigate toad behavioral trends are toad meetings. The gross number of unique meetings is calculated by checking how many times 2 tracks are within a constant distance of one another at the same time. Examples of the gross activity and meeting graphs are shown in Figure 6.

References

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[2] KaewTraKulPong P., Bowden R. (2002) An Improved Adaptive Background Mixture Model for Real-time Tracking with Shadow Detection. In: Remagnino P., Jones G.A., Paragios N., Regazzoni C.S. (eds) Video-Based Surveillance Systems. Springer, Boston, MA

[3] LEE, S & Zippel, Kc & RAMOS, L & SEARLE, J. (2006). Captive-breeding programme for the Kihansi spray toad Nectophrynoides asperginis at the Wildlife Conservation Society, Bronx, New York. International Zoo Yearbook. 40. 241 - 253. 10.1111/j.1748-1090.2006.00241.x.

[4] Tian, Yicong & Dehghan, Afshin & Shah, Mubarak. (2018). On Detection, Data Association and Segmentation for Multi-target Tracking. IEEE Transactions on Pattern Analysis and Machine Intelligence. PP. 1-1. 10.1109/TPAMI.2018.2849374.