Automatically determining active investigation in rodents using contour analysis

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Introduction

The ability to automate the tracking and annotation of laboratory assays offers many possibilities for more quantitative and meaningful statistics, and could help achieve much higher levels of accuracy and constancy compared to that typically achieved across different staff and laboratories [1]. Recent advances in improving the robustness of tracking rodents using computer vision techniques [2] have lead to encouraging results, even for multiple targets. Determining, and labelling, the actions of the subject animals under observation (as for example in [3]) can provide enriched data for further analysis, and enables the potential to ultimately link behaviour back to genetic and other experimental factors.

However, one of biggest problems in handling video data of rodents is the variation with which they can deform and change direction. Correctly determining the orientation of the animal is critical to understanding their interactions with the environment and each other. In this work we address this problem by using an intrinsic description provided only by the outline of the rodent.

Method

Our approach is based on analysis of the curvature of the extracted rodent contour. We use the robust, scale invariant approach described by [4] to produce a *curvegram* profile along the perimeter. By automatically compensating for the relative complexities between different scales and shapes of contours as they change over time, the curvegram presents a unique signature in which regions of high curvature can be clearly differentiated as extrema (peaks). By taking the derivative of this profile and recording the zero crossings the number and location of these peaks can be identified.

In our data, the single most detectable peak corresponds to the tip of the tail – as seen in Figure 1. Conversely, we assume the next largest peak to represent the head, or close to it. Additional peaks are often associated with the bending of the tail where it joins the body. In the case of the entire body turning around a larger number of peaks are generated, which can be used to determine this event.

Results

We generated a test sequence of 1200 frames from the top-down video of a subject animal in a plus maze. Contour data was extracted by a simple background subtraction and thresh-holding method, with additional morphological closing and cleaning. The sequence was then annotated by hand to record the location of the tail and head tip in every frame. We then ran our method over each contour frame and recorded the distance from our estimated positions – as shown in Figure 2. In addition, by recording the number of occurrences when the number of peaks in the contour exceeded four we were able to clearly distinguish the 3 incidents of the mouse turning. This is also indicated in the figure by the error in the head position at around frames 200, 750 and 1200.

Conclusions

In this work we have investigated the possibility of determining orientation from rodent contour data by considering the curvegram profile. This is robust to the appearance of additional limbs and foreshortening of the body, and is particularly able to locate the tail tip with reasonable accuracy. Further enhancements could consider other features of the contour, and using this to derive meaningful labels for the individual actions (e.g. “going forwards”, “looking right”, “rearing up”, etc).

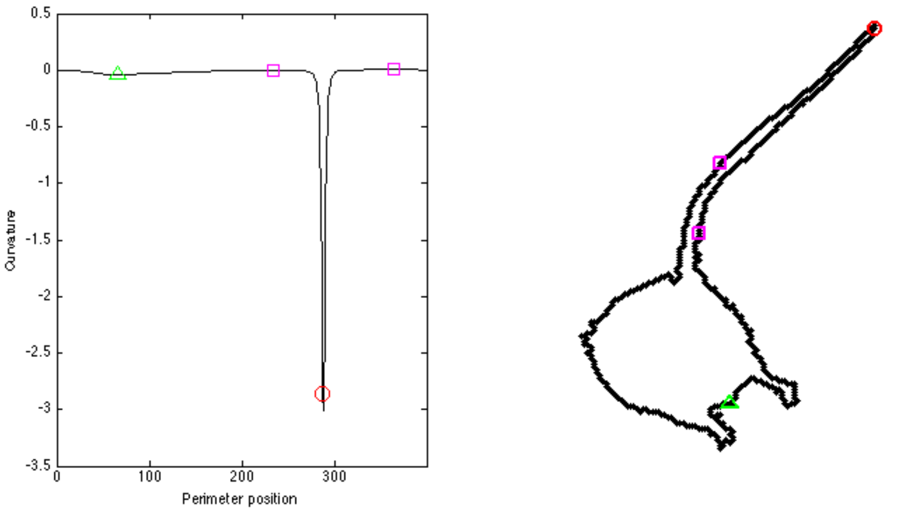

Figure 1. *Mouse extracted curvegrams and detected peak positions for tail tip (red circle), nose (green triangle), plus inner and outer bend of tail (magenta squares). Notice how the technique ignores the fore-paws.*

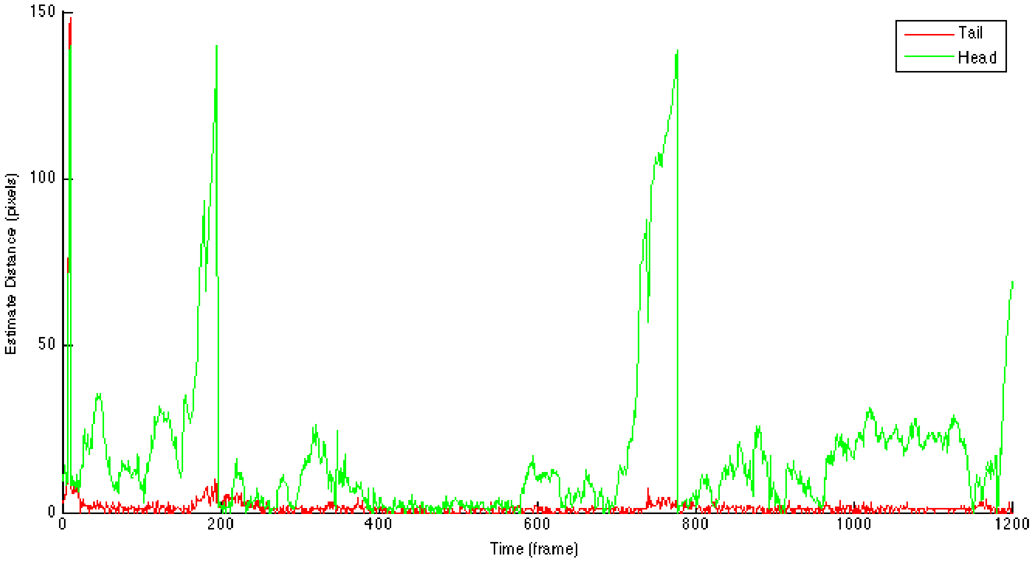

Figure 2. *Distance from estimated head and tail position from indicated location in every frame. Notice initial confusion at frame number 12 when the tail is trapped beneath the rodent.*

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References

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