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Activity Monitoring System

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Musculoskeletal Soft Tissue Laboratory Fall 2018 Semester Report: Activity Monitoring System

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This report is a summary of my work in Dr. Spencer Lake's Musculoskeletal Soft Tissue Laboratory during the semester of Fall 2018. The project I pursued this semester was the creation and implementation of an in vivo cage monitoring system for rodents. With this tacking system, we are able to track position and velocity with time of a rodent in a 2x2ft arena. These measurements will give us an indication of degree of activity during free cage activity following bandage removal.

This report will be broken up into two sections. The first section will briefly discuss the construction of the activity monitoring arena. The second section will discuss data acquisition settings and how these settings were determined.

Constructing the Arena

The activity monitoring arena's base was constructed using four 2x8'' pieces of wood fastened together to create four walls. On top of the base sits a 0.25" thick red acrylic sheet lit from behind by a red fluorescent light bulb. The animal walks on the top of the acrylic sheet and is contained via four black acrylic sheets glued together to form a bottomless box. The results when filming with a Canon VIXIA HF R800 camcorder from directly above, is a distinct light-dark contrast between the arena floor and the animal shown in fig. 1 below. This contrast makes gray-scale thresholding easier and more reliable.

Figure 1: A rodent stands on top of the backlit red acrylic sheet to create a silhouette effect. This light-dark difference makes gray-scale thresholding easier and more reliable.

Software and Data Analysis

After recording the animal's activity for one hour, the video file is processed using EthoVisionXT. Animal centroid location is measured at a frequency of 30 Hz. An excel file is exported from EthoVisionXT with the x and y position of the centroid of the animal; measurements spaced 0.0333 seconds apart. An image of animal detection and centroid location can be seen in fig. 2 below.

Figure 2: A single frame of animal detection (yellow) and centroid location (red dot)

It was found that the sampling frequency used to process a given video effects the measured total distance the animal has moved. I will elaborate more on this fact in the following section. To correct for this affect of sampling frequency, a MATLAB code is used to analyze the exported data.

The MATLAB code stores the centroid of the animal at its initial position immediately when the trial begins. The distance between this stored x-y value (the reference position) and each subsequent x-y measurement is calculated. If this distance is greater than 2.5 cm, the distance is added to the total distance travelled within the trial, and the x-y position of the animal at the later of the two times is defined as the new reference position. The process repeats, comparing subsequent measurements to the new x-y reference position. This has been named the "minimum distance travelled filter."

Justification for Data Analysis Methods

As mentioned in the previous section, while experimenting with data acquisition settings, it was found that the sampling frequency affects the total distance travelled. The higher the sampling frequency, the further the animal travels according the EthoVision. A graphical representation of this phenomenon can be seen in fig. 3 below.

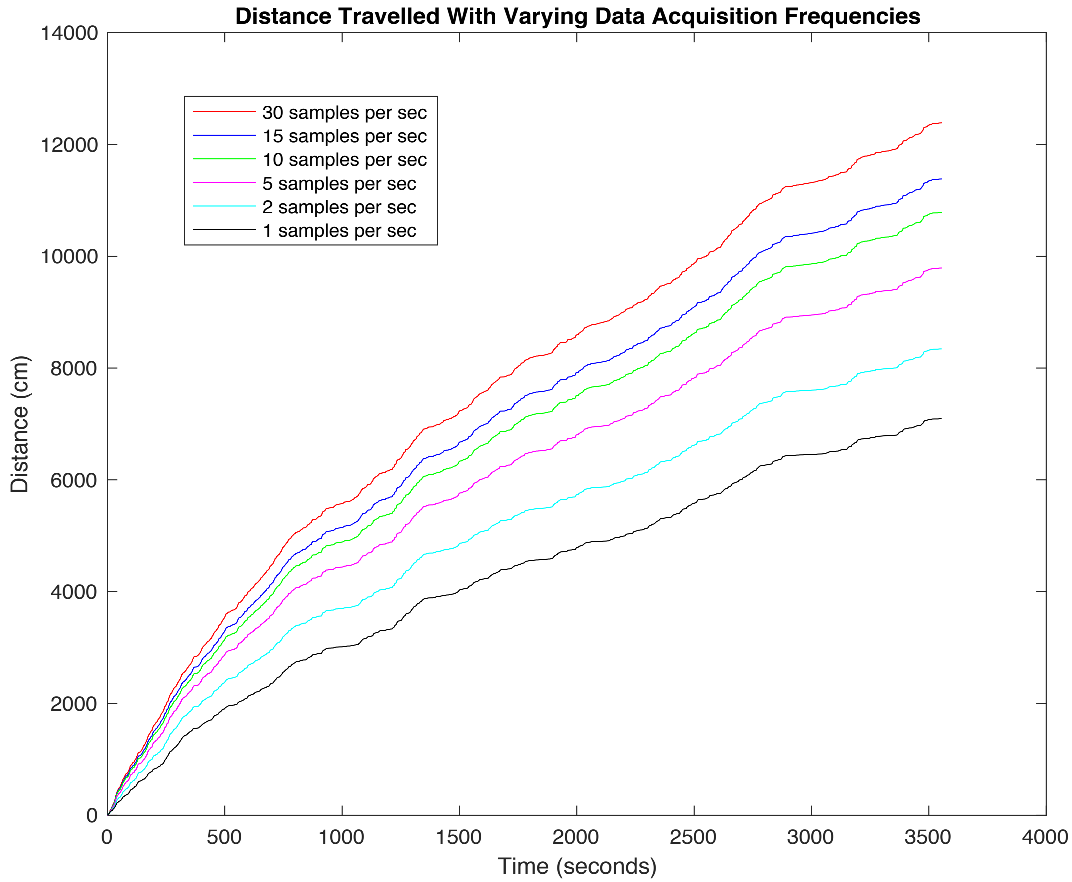

Figure 3: As sampling rate increases, the animal's measured distance travelled increases as well. Notice the overall shape of the curves is the same, but higher sampling rates yield further distances travelled.

It is believed that the reason sampling rate effects distance travelled is because when sampling rate increases, small sways of the animal's body and shifts of weight cause the centroid to move, which is in turn recorded as a movement. The faster the sampling rate, the greater the effect of these small sways have on the total distance travelled. It is important to note that these shift of the centroid happen without the animal ever taking a step.

To correct for these unwanted shifts of the centroid, the "minimum distance travelled filter" is used to eliminate noise. We want to record movement of the animal, which for our application includes locomotion, so we want to make sure we capture any steps taken, but ignore any random shifts in weight. The minimum distance of 2.5 cm was determined by observing a video clip that has the animal stationary and qualitatively seeing how far EthoVision claims the animal has moved during that stationary period. Also, from previous data, we know that the smallest step size of an injured animal with an asymmetric gait is roughly 3 cm. By using 2.5 cm as the minimum distance travelled, we are sure to pick up on any steps taken by the rodent, but we ignore the insignificant body weight shifts and jitters. The filter essentially only records movements of the animal that require the animal to take a step.

Conclusion

This semester I constructed an activity monitoring arena and determined the appropriate data acquisition settings. Videos are recorded and processed at 30 frames per seconds and a "minimum distance travelled filter" is used to eliminate any motion that does not require the animal to take a step. The filter does capture any movements that do require a step, so we will be able to determine an average degree of activity during the animal's session of free cage activity.