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Classifying California Horn Shark Behavior Using Semi-Supervised Hidden Markov Models

Data on the movement and body position of California horn sharks was collected through the use of accelerometers in both a lab setting and in Santa Catalina Island, California, USA. Accelerometer data from horn sharks in a lab environment can be partially labelled using video timestamps as corresponding to a type of behavior such as resting, swimming, or feeding. As such, we are then able to develop models to classify horn shark behaviors from accelerometer data in a semi-supervised manner where we leverage the labelled data to produce better classifications. The models can then be applied to classify the behaviors of horn sharks from accelerometer data gathered in the field, which is helpful as it is difficult to monitor the sharks in nature.

We focus on development of semi-supervised hidden Markov models (HMMs) as they assume that the movement data is a result of the horn shark exhibiting one of several behavioral states, and allow for integration of partially labelled data. For the response variables, different combinations of static and dynamic acceleration data are used and modeled with a first-order autoregressive structure. The model's parameters are estimated using maximum likelihood estimation. We use both the Viterbi and forward-backward algorithm for state-decoding to find the optimal sequence of behaviors predicted by the model, which is compared to the actual behavior labels to estimate the accuracy of the semi-supervised HMM. Along with the semi-supervised HMM, we also explore a fully unsupervised setting for behavioral classification of horn shark behavior.