Compare Param Discretization with PDFs

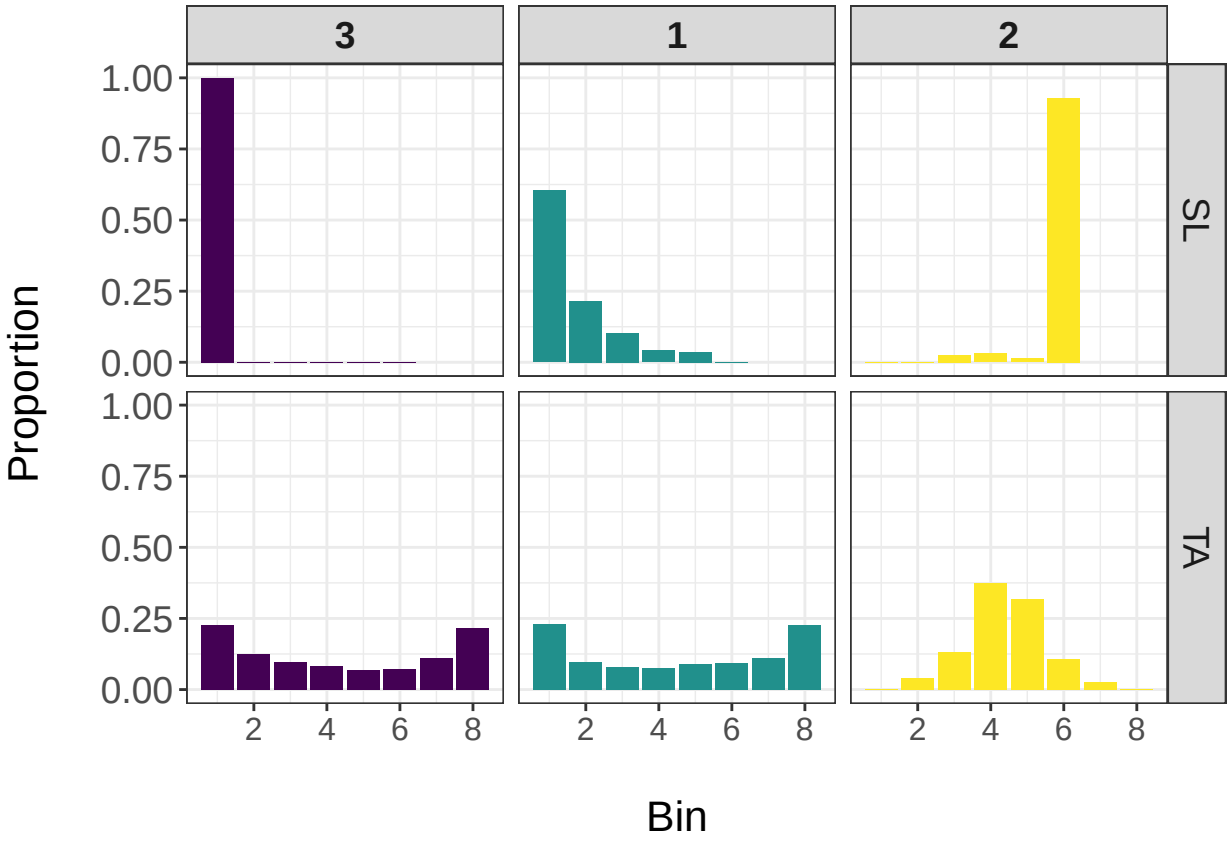
Josh Cullen

21 February 2020

Background

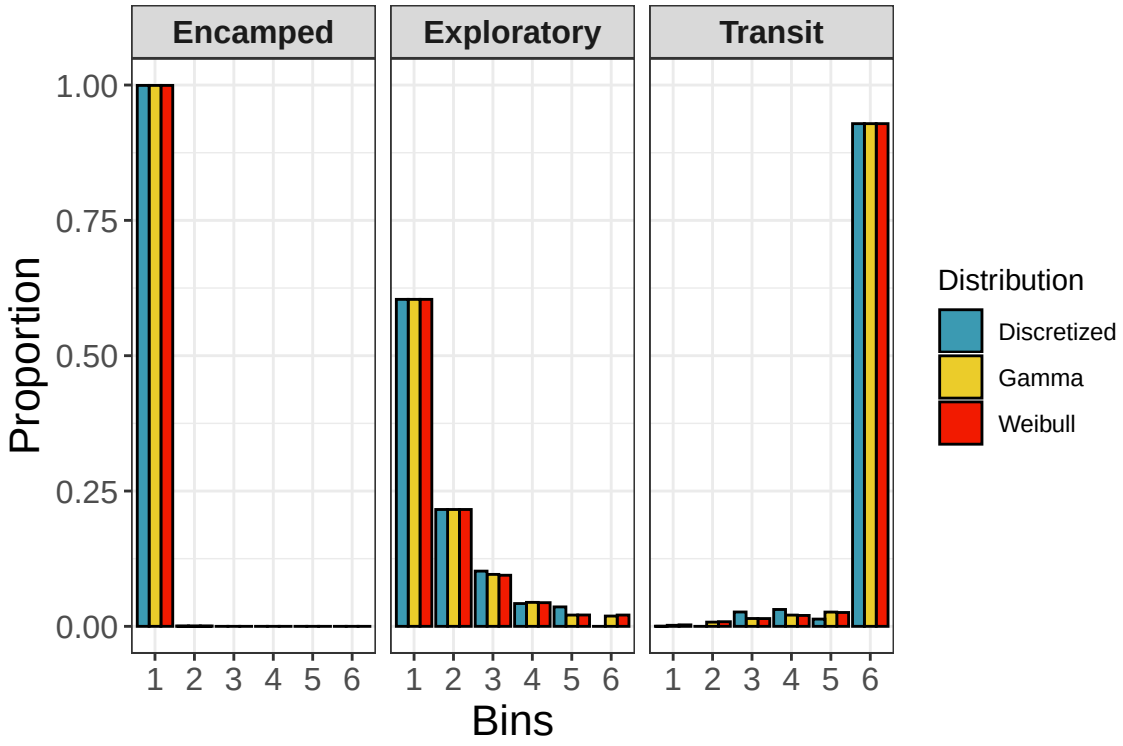
Due to the comments and concerns we've received about the use of discretized movement parameters (SL and TA) in our behavior estimation model, this document will determine whether our method characterizes distribution shapes not possible through the use of tpyical probability density functions (PDFs) used for SL (gamma, Weibull) and TA (von Mises, wrapped Cauchy). This is demonstrated for empirical snail kite data originally tagged at Lake Toho.

First, lets take a look at the histograms of step lengths and turning angles for the top three behaviors identified by the LDA model:



Step Length

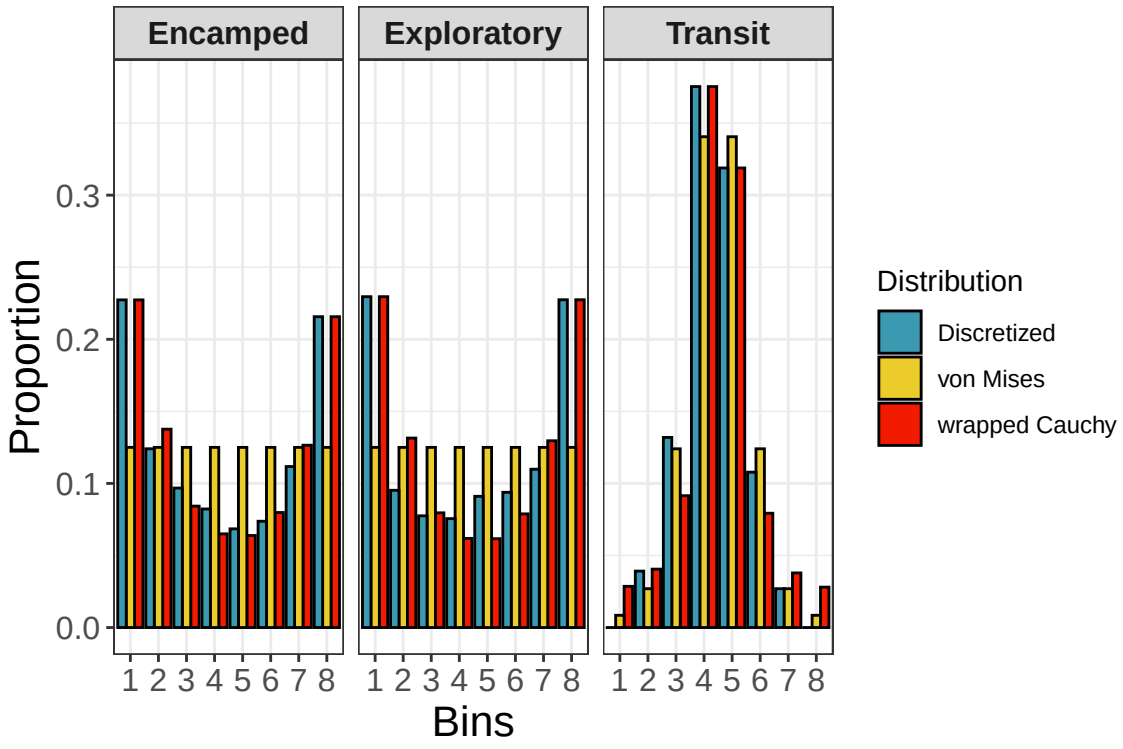
Focusing first on SL, I will use the `optim` function to determine the best parameter values to use within a gamma or Weibull distribution and see how well these PDFs fit the distributions generated by our model. Below is a figure demonstrating how well the gamma and Weibull distributions compare:



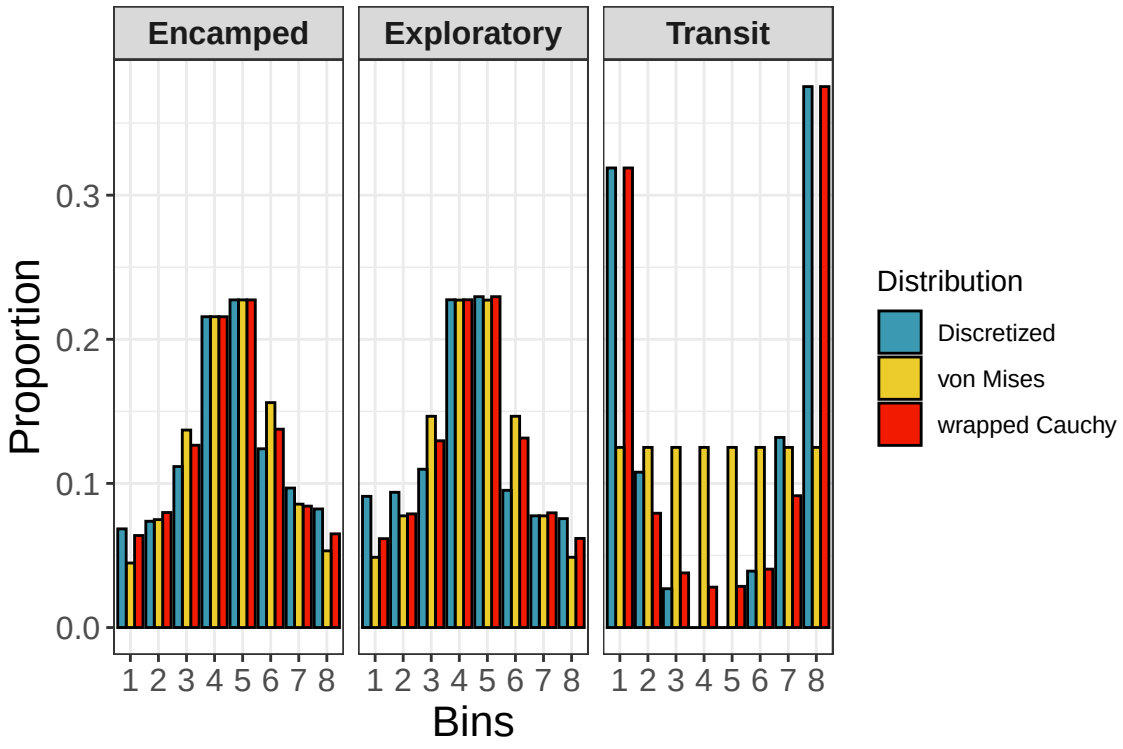
Both gamma and Weibull distributions appear to fit the discretized distribution from our Bayesian model well for all three behaviors. Now, lets see how the parametric distributions fare against the turning angle distributions generated by our model.

Turning Angle

The same method used to determine the best parameter values for SL (based on maximum likelihood) was also used for TA.



The wrapped Cauchy distribution matched our discretized distribution quite closely for each of the three behaviors. Although the von Mises distribution was able to fit the discretized shape of the 'Transit' behavior relatively well, it performed poorly for the 'Encamped' and 'Exploratory' behaviors. This resulted in a uniform distribution instead of a shape where most of the probability mass was in the first and last bins ($-\pi/\pi$) with a large drop in probability towards angles closer to 0 radians (bins 4 and 5). To determine if these results were driven by the shape of the peak (one single peak in the middle vs a peak at each limit), the probability masses were centered at π rather than at zero and then reanalayzed.



In this example it appears that the von Mises has trouble with the "Transit" behavior as opposed to the other two, indicating that it can't properly fit distributions where probability mass is at the edges rather than in the middle. However, the wrapped Cauchy distribution again performs well compared to the distribution generated from our model.

Conclusions

Based on this snail kite dataset, success in using parametric PDFs to estimate behavioral states within hidden Markov models may only perform well if using certain distributions. For SL, it appears that both the gamma and Weibull were capable of matching the distributions generated from our discretized SL movement parameters. However, only the wrapped Cauchy distribution was able to successfully match the TA distributions generated from our model. Although there may be other reasons why discretization of SL and TA may be useful when analyzing telemtry data, it appears that a large difference in distribution shape is not the case when using either a gamma or Weibull distribution for SL and a wrapped Cauchy distribution for TA.