Peterson Barney Data

Purpose

Especially Fig. 8 from this paper has become famous. In this notebook we try to recreate this plot, but also allow for slightly different implementation of statistics and visualization.

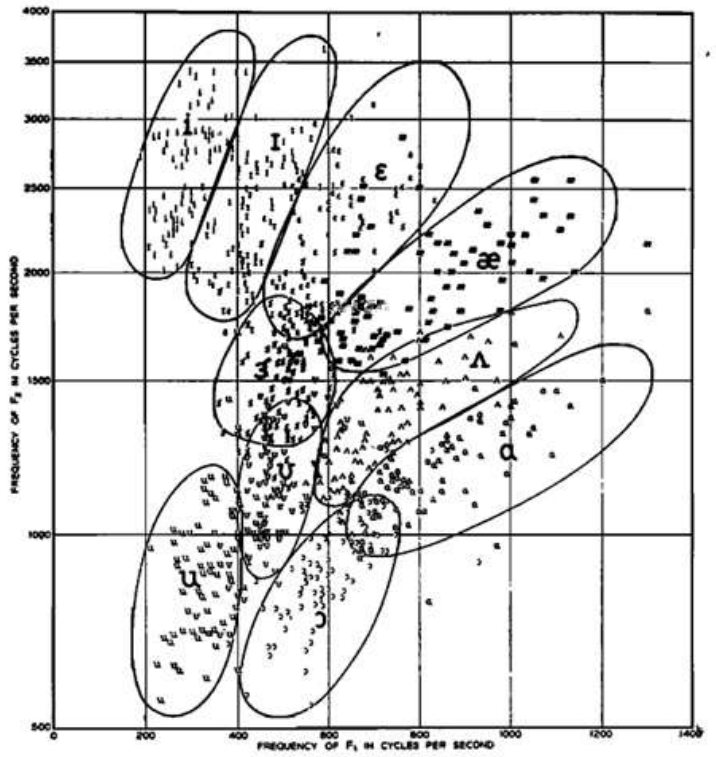


FIG. 8. Frequency of second formant *versus* frequency of first formant for ten vowels by 76 speakers.

Frequency Transformation to be applied to F2 and F3

In the Peterson Barney paper F1 is shown on a linear scale and F2 on a warped frequency scale. Details on the warping are not given in the paper. Most likely an early version of the 'mel-scale' was used. Here we use the mel scale as implemented in HTK which is a reasonable match. We apply the transformation both to F2 and F3 before computing averages or plotting. The axis labels is in Hz for easy interpretation. Below set SCALE to 'HTK' for this transformation; set it to 'LINEAR' for maintaining linear frequency. In summary we found that for these experiments the differences are quite limited.

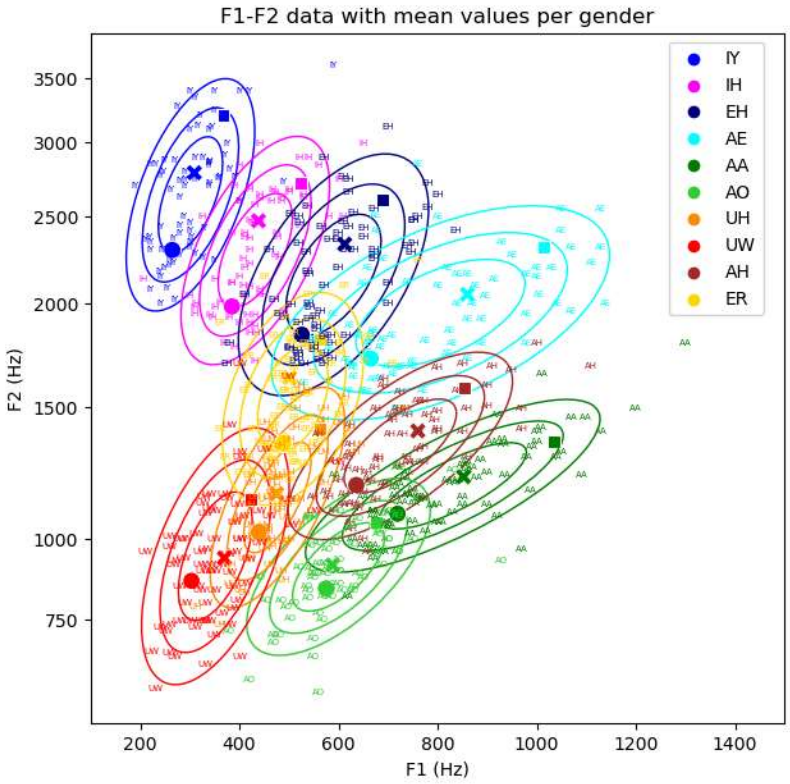
Compute average Formant Values

The computations are done gender independent and gender dependent The 'F2t' and 'F3t' values contain the averages computed in the transform domain. The 'F2' and 'F3' values are 'F2t' and 'F3t' reconverted to Hz

Gaussian Modeling and Confidence Ellipses

Gaussian modeling is a standard and intuitive approach for scatter data as observed in the Peterson Barney data.
We show the data with a number of confidence ellipses; values selected are 1.0, 1.5 and 2.0. The Gaussian model may not be perfect, but it does a more than decent job. The 2*sigma contours are a sensible approximation of the region wherein Formants of a specific vowel are expected to appear.
Small variants are made of this plot: just the confidence ellipses, the mean values added to them and the mean values per gender added to the plots. The latter shows considerable variation between male and female values (due to vocal tract length differences) and it also draws our attention to the underlying bimodal distribution of the data.

Out[11]:



Kernel Density Estimates

It is clear that our Gaussian Density estimates of the Formant distributions don't match well with the per formant 'regions' drawn in the paper We may assume that these were drawn by hand and inspired by a motivation to come up with maximally non overlapping F1-F2 regions Here we use Kernel Density plots that are more suitable to model data that is not Gaussian. We played a bit with the control parameters and this is the best we could come up with. For some regions, like 'IY' and 'IH' the results are quite good. However the same parameters don't seem to work well for e.g. the 'AE' region . Also the overlap of the 'UW' vs 'UH' and 'AA' vs 'AO' is significantly larger than in the PB plots, which hints as a bias in the human interpretation of the results in the PB paper.

Out[12]: