Tongue Surface Extraction From Ultrasound Images: Error due to Left-to-Right Measurement Direction

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May, 2000

This project was motivated by the knowledge that the MuTongue program measures tongue curves unidirectionally using B-splines. We were concerned that some shape bias might be introduced into the measurements.

Data Source.

We have coronal tongue data which consist of the same curves measured from left to right and from right to left. The measured curves were produced by the MuTongue program. The dataset names are symm.arr and asymm.arr, corresponding to one speaker with roughly symmetric contours and a second speaker with very asymmetric contours. They are S-plus data arrays with dimensions (2,5,2,100), and with dimnames as follows:

```
> dimnames(asymm.arr)
[[1]]:
[1] "x" "y"

[[2]]:
[1] "lae"  "lah"  "le"  "se"  "siy"

[[3]]:
[1] "left"  "right"

[[4]]:
character

> dimnames(symm.arr)
[[1]]:
[1] "x" "y"

[[2]]:
[1] "la"  "le"  "li"  "lo"  "luh"

[[3]]:
[1] "left"  "right"

[[4]]:
character(0)
```

There are 100 (x,y) pairs for each of five sounds. In dimension 3, the “left” indicates the data measured from left to right; the “right” indicates the data measured from right to left.

Goal.

We wish to find out how close the two curves, the "left" and the "right", corresponding to each sound are. To do this, we use simple plotting first and then use some S-plus functions to see how close these curves can be overlaid pairwise after shifting in the x-direction. The process is illustrated in the following figures, one for each sound and speaker.

First, we plot the two curves separately, the "left" and the "right" corresponding to each sound and put them on the first and second panels.

Second, we use the S-plus function matplot to get an overlaid plot of the two curves, the "left" and the "right" in the third panel without any translation in the x-direction.

Finally, we use the two Splus functions AvCurv and OvrLay, which were written by Dr. Slud, to find the x-shift and y-shift such that the graphical overlay is as good as possible. Then we plot the two curves, the "left" and the "right" in the fourth panel after the optimum translation in the x-direction.

Conclusion.

The x-shifts and y-shifts are small enough, so we can say that the graphical overlay of the curves measured from left to right and from right to left is very good. The table below displays the final x-shifts and y-shifts for each sound and speaker in mm.

For asymm.arr data:

Sound	X-shift	Y-shift
lae	0.7697711	-0.2868479
lah	-0.6868401	0.00403474
le	0.1799541	0.05148419
se	-1.190984	0.4673678
siy	0.3292543	-0.2226182

For symm.arr data:

Sound	X-shift	Y-shift
la	-0.3204195	0.1518682
le	1.2706570	-0.3734324
li	-0.03574041	-0.2888516
lo	0.2291189	-0.04628302
luh	-0.6813191	0.0548418