1100 Brain Image Analysis and Atlas Construction

**Figure 17.14**: Cortical averaging. The average cortical surface for a group of subjects (N=9, Alzheimer’s patients) is shown as a graphically rendered surface model. If sulcal position vectors are averaged without aligning the intervening gyral patterns (top), sulcal features are not reinforced across subjects, and a smooth average cortex is produced. By matching gyral patterns across subjects before averaging, a crisper average cortex is produced (bottom row). Sulcal features that consistently occur across all subjects appear in their average geometric configuration. (For a color version of this Figure see Plate 36 in the color section of this book.)

### 17.8.2 Average brain templates

Maps that deform individual cortical patterns into a group average shape can also assist in generating a brain template with the mean shape for a group. In a recent approach [32–34], high-dimensional transformations were used to create a mean image template for a group of patients with Alzheimer’s disease, whose anatomy is not well accommodated by existing brain atlases or imaging templates.

To make a mean image template for a group, several approaches are possible [23, 31–34, 38–40, 64, 73, 145, 146]. If scans are mutually aligned using only a linear transformation (Fig. 17.17), the resulting average brain is blurred in the more variable anatomical regions, and cortical features are washed away. The resulting average brain also tends to exceed the average dimensions of the component brain images. By averaging geometric and intensity features separately [23, 32–34, 82, 147, 148], a template can be made with the mean intensity and geometry for a patient population. To illustrate this, we generated an initial image template for a group of Alzheimer’s patients by (1) using automated linear transformations [67] to align the MRI data with a randomly selected image, (2) intensity-averaging the aligned scans, and then (3) recursively re-registering the scans to the resulting average affine image. The resulting average image was adjusted to have