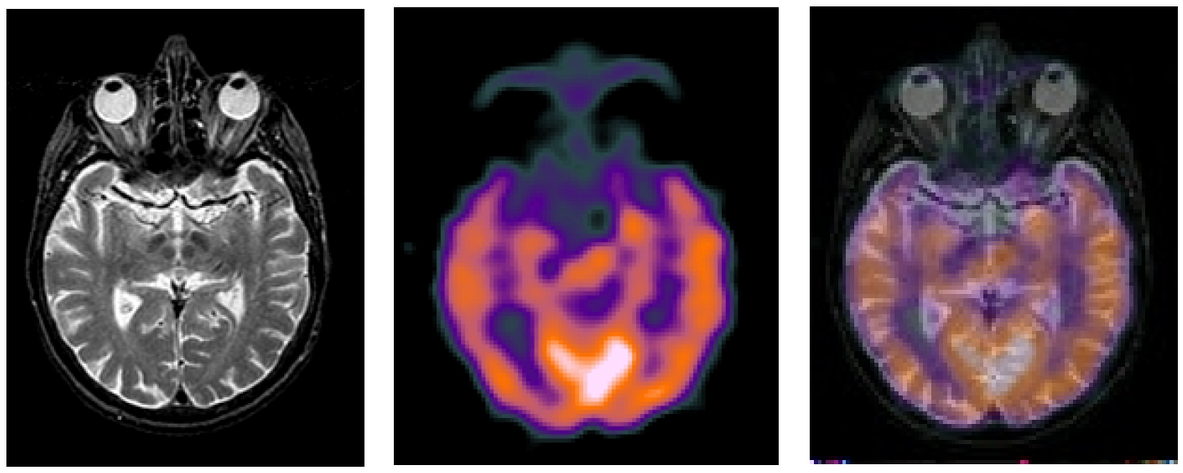
Registration: Essential to Medical Imaging

Registration is the process of geometrically aligning images using translations and rotations. Registering images accurately over different imaging modalities (MRI, CT, PET, SPECT, etc.) is an important aspect of medical image processing. There is complementary information found in each type of image. Diagnosis, computer guided surgery, and brain functional analysis are all benefited by using multiple imaging modalities. A tumor in the brain may best be outlined in an MRI, but the surgeon uses CT images to guide the operation. Having the ability to transfer the coordinates of the tumor from the MR image to the CT image becomes a necessity due to this.



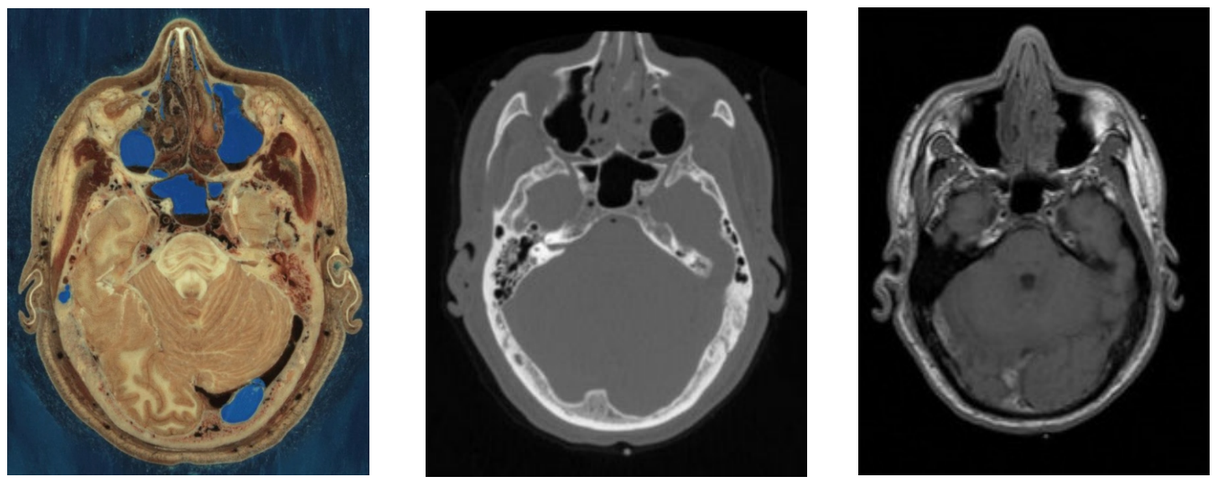
(a) (b) (c)

Figure 1: (a) transverse MR image of the brain. (b) SPECT image of the same slice of the brain showing cerebral blood flow. (c) registered MR and SPECT images combining functional and anatomical information

THE VISIBLE HUMAN PROJECT®

Data Used to Test the Registration Algorithm

The Visible Human Project is part of the National Library of Medicine's 1986 long-range plan to create complete, anatomically detailed, three-dimensional representations of the male and female human body. It consists of CT, MRI and cryosection images of the male and female anatomies taken at 1 mm and .33 mm intervals respectively. The long term goal of the project is to link this database of anatomical knowledge with physiological knowledge.

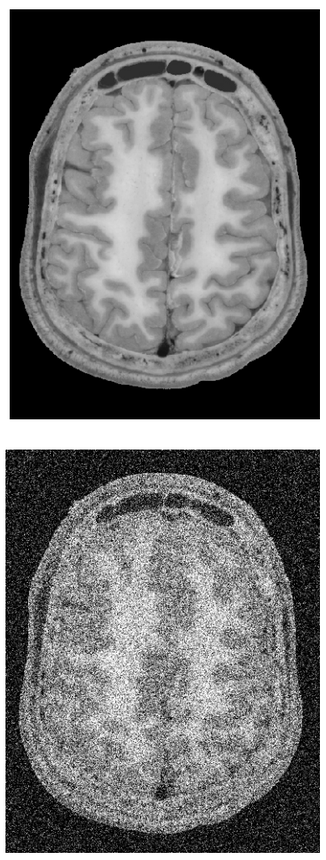


(a) (b) (c)

Figure 2: (a) cryosection image of brain. (b) computed tomography image (c) magnetic resonance image

Registration using the Hilbert-Schmidt Estimator

The special orthogonal group SO(n) = $\{A \quad R^{n\ n} \mid AA^T = I, \det(A)=1\}$ corresponds to rotations in R^n. By using the Hilbert-Schmidt norm given by $\|A\|_{HS} = \sqrt{\sum_{i,j\ 1}^{n} a_{i,j}^{2}}$, a mean squared criterion can be defined on SO(n). The norm becomes 4-4cos(theta) in SO(2) where theta is the angle between orientations of an image. The Hilbert-Schmidt estimate (HSE) is defined to be a minimum mean squared error estimator on SO(n). By associating an element of SO(n) with each rotation of an image, the correct orientation of a 2D or 3D image can be found. This approach was originally used for automatic target recognition.



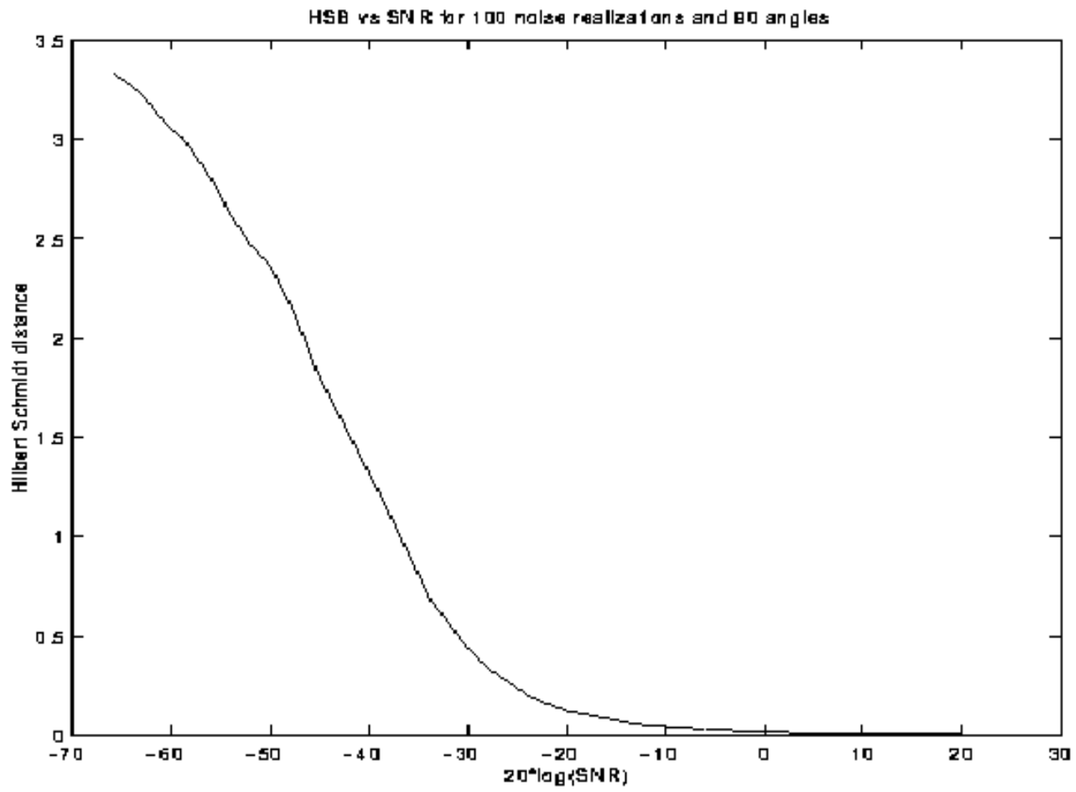


Figure 3: The two images are a transverse slice of the brain. The first without any noise added. The second one has a SNR(dB) of 0. The plot is the bound of the estimator versus the signal to noise ratio of the image.