Semi-automatic Identification of Retinotopic Visual Areas

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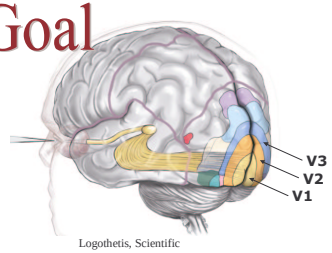
The Goal

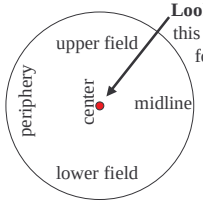
Identify retinotopic visual areas in human cortex with functional MRI



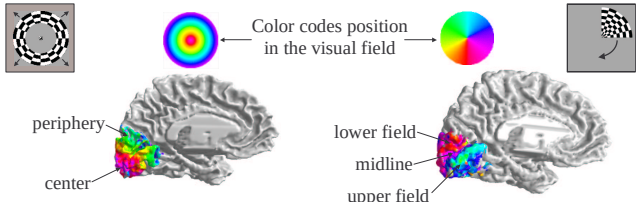
Logothetis, Scientific American, 1999

Retinotopy in Visual Cortex

Visual Field: optically mapped to retina



- In visual cortex, the retina's map is preserved in several distinct 'visual areas'
- We measure activity in visual cortex with functional MR
- By stimulating different regions of the visual field in sequence, we can visualize the retinotopic maps on cortex

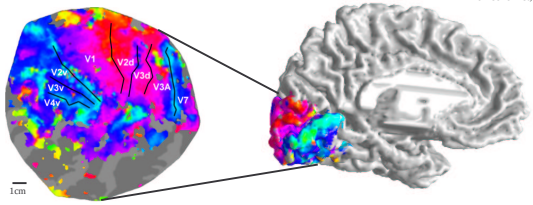


Note: right visual field activates left hemisphere only

Cortical Flattening

Flatten cortical sheet to better visualize data (see poster # 12)

The Economist, January 27, 2001



The Problem

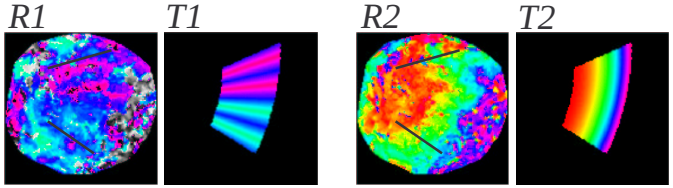
Visual areas have been identified by subjective inspection of functional flat map data- prone to **error** and **bias**.

The Solution

1. Model the expected pattern of activity with a 'template' image
2. Fit the template to the measured data
3. Visual areas derived from template

1. Create templates

The user draws two lines on the measured data (the reference images, *R1* and *R2*) to create the initial templates (*T1* and *T2*).



2. Warp templates to fit measured data

The templates (*T1*, *T2*) are simultaneously elastically deformed to fit the measured data (*R1*, *R2*) by minimizing both the difference between *T1* & *R1* and between *T2* & *R2* (the *Error*), as well as the strain energy (the *Strain*) of the deformation field (*u*,*v*).

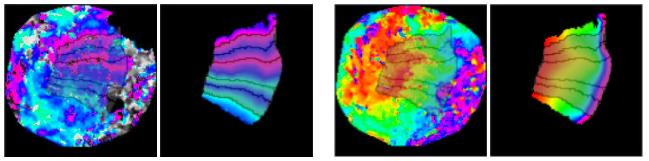
$$Error(u,v) = T1(x+u, y+v) - R1 + T2(x+u, y+v) - R2$$

$$Strain(u,v) = \int \frac{\lambda}{2}(u_x + v_y)^2 + \mu\left(u_x^2 + v_y^2 + \frac{1}{2}(u_y + v_x)^2\right) d(x,y)$$

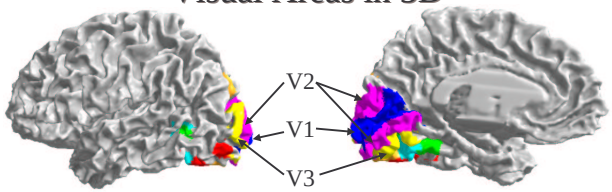
(Where λ and μ are constants which determine the elasticity properties.)

Results

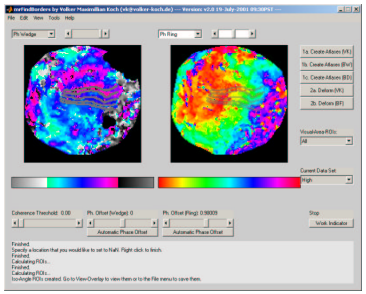
Deformed atlases & visual area overlays



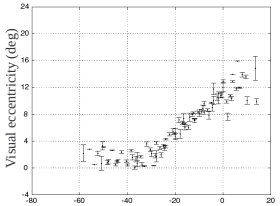
Visual Areas in 3D



Cortical Magnification computed from objectively-defined iso-angle lines



The retinotopic maps are distorted. The central visual field is over-represented. We can measure this 'cortical magnification'.



References

- Fischer, B. and Modersitzki, J. (1999) **Fast Inversion of Matrices Arising in Image Processing.** *Numerical Algorithms, 22*; 1-11.
- Wandell, B.A., Chial, S. and Backus, B. (2000) **Visualization and Measurement of the Cortical Surface.** *Journal of Cognitive Neuroscience, 12 (5)*; 739-52.
- Wandell, B.A. (1999) **Computational Neuroimaging of Human Visual Cortex.** *Annual Review of Neuroscience, 10 (22).*