A (Sort of) New Image Data Format Standard: NIfTI-1

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- **NIfTI** = Neuroimaging Informatics Technology Initiative
  - NIH-sponsored working group to promote interoperability of functional neuroimaging software tools
- **DFWG** = Data Format Working Group within NIfTI to deal with ***data*** interoperability
  - e.g., make it easier to interchange image (etc.) data between analysis packages
- Near-term efforts: extend ANALYZE™-7.5 file format (.hdr/.img file pairs) to add features the DFWG agreed were highly desirable for FMRI analysis = **the NIfTI-1 format**
  - New features fit into unused/little-used ANALYZE fields

Current Status

- DFWG has approved NIfTI-1 format
- Major software packages (AFNI, BrainVoyager, FSL, SPM) agree to *read* NIfTI-1 files by **July 31, 2004** and to be able to *write* them by **Dec 31, 2004**
- NIfTI-1 specification is in the form of a very heavily commented C header file, laying out the fields and their interpretations:

http://nifti.nimh.nih.gov/dfwg/

Outline of New Features

- ***Two*** affine coordinate definitions relating voxel index (i,j,k) to spatial location (x,y,z)
  - One orthogonal transform (6 parameters), indicating orientation and location of data in scanner coordinates
    - Orthogonal matrix is specified by a *quaternion*
  - One general affine transform (12 parameters), to indicate mapping to a "normalized" space
- Codes to indicate spatial normalization type
  - e.g., MNI, Talairach-Tournoux
- Codes to indicate units of spatio-temporal dimensions
  - e.g., mm, microns; seconds, milliseconds
- Codes to indicate spatio-temporal slice ordering for FMRI
  - Frequency, phase, and slice encoding axes
    - for 2D spiral, set freq=phase=0 and slice=1,2, or 3
  - Duration of slice acquisition (e.g., for clustered acquisition sequences with "silent" intervals, duration may be less than **pixdim[4]/dim[slice]**)
  - Interleaving of slice acquisition can be specified
    - Zero padding slices on edges can be allowed for
- "Complete" set of 8–128 bit data type codes
  - Signed and unsigned integer types; RGB byte triples
  - Floating point and complex types
- Standardized way to store vector-valued datasets
  - e.g., a matrix or a vector at each point in the grid
- Affine data scaling: **true value = α·(data value) + β**
- Codes and parameters to indicate data "meaning"
  - e.g., values are a *t*-statistic with 27.3 degrees of freedom
  - 21 codes supplied for various parametric distributions
    - Parameters can be global for entire dataset or different for each voxel
  - Also, codes to indicate if multiple values at each voxel (**dim[5]**) are a vector, matrix, etc.
- "Magic" string to indicate if header is NIfTI-1 compliant
- Single or dual file storage
  - **.hdr/.img** file pairs, as in ANALYZE
  - **.nii** file, which is header followed by data in one file
    - Can be useful for Web links to data and results

Mark Jenkinson of the FMRIB/Oxford also contributed mightily to NIfTI-1

Other Resources at Web Site

- FAQ list (e.g., "*What is a quaternion?*")
- Web message board for discussion and questions related to NIfTI issues
- A long-winded rationale for the choices made in developing this format:
  - Compatibility with ANALYZE-7.5 format
  - Coordinate systems
  - "Why not just use DICOM, anyway?"
- Sample C functions for reading and writing NIfTI-1 files
  - e.g., conversion of rotation matrix to/from quaternion
  - Matlab functions "will be available" (Ashburner)
- C library for 21 parametric distributions:
  - Compute CDF (*p*, given statistic) and inverse CDF (statistic, given *p*) for 21 distributions
    - correlation coefficient, central *t*, central *F*, *N*(0,1) [z-score], central χ^2, central Beta, binomial, Gamma, Poisson, $N(\mu,\sigma^2)$ [normal], noncentral *F*, noncentral χ^2, Logistic, Laplace, Uniform, noncentral *t*, Weibull, χ, inverse Gaussian, Extreme value type I, *p*-value

Future NIfTI Efforts

- Create a standardized way for users to add customized fields to the NIfTI-1 header ("NIfTI-1.5")
  - So far, agreement within the DFWG is elusive:
    - XML? or Binary? or Simple Text ("name = string")?
    - "Ratified" extensions with agreed-upon meanings?
    - Just wait for NIfTI-2?
- Develop a hierarchical vocabulary ("namespace" or "ontology") for describing FMRI metadata
  - Including analysis information, such as the linear model and statistical assumptions
  - Use this vocabulary to specify how a new NIfTI-2 format will be laid out and should include
  - NIfTI-2 may not be a format, but rather a meta-format