Somatosensory Cortical Database

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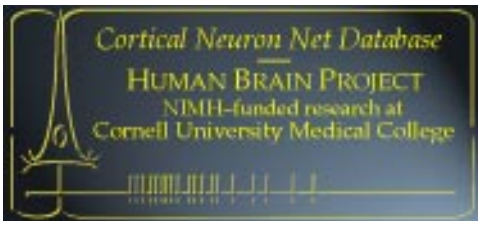
HUMAN BRAIN PROJECT NIMH-funded research at
Weill Medical College of Cornell University

...formerly Cornell University Medical College



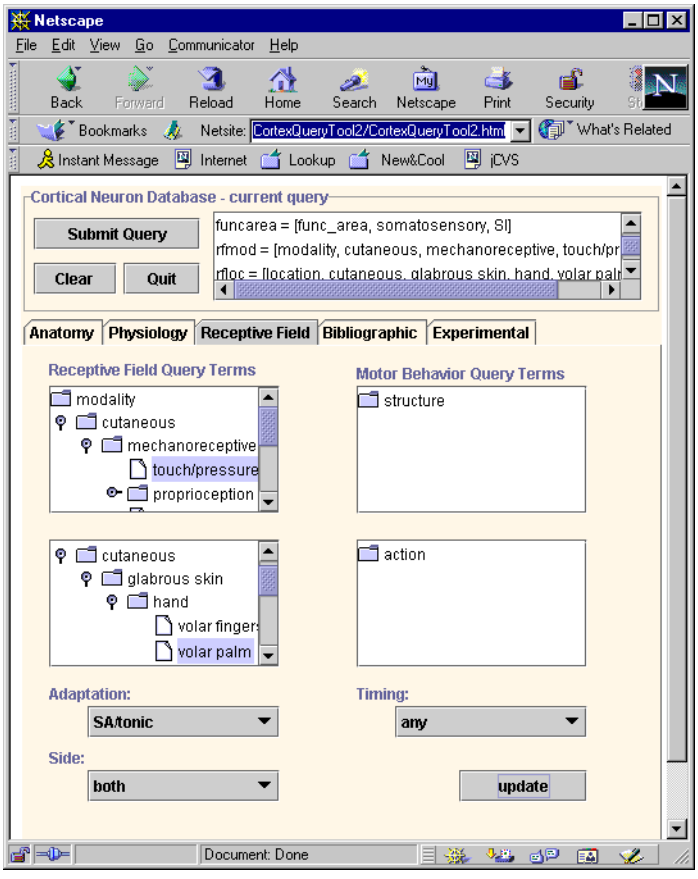
We are developing a Web-accessible database of electrophysiological traces and text information describing cortical neurons and their characteristic responses to somatosensory and other stimuli. When complete, the database will be a free and open resource for author-submitted data. The project continues to benefit from the input of several consultants in the somatosensory and other communities, but we now ask for comments from the wider group attending this Symposium.

Please review this document, which introduces our database, the tools by which users can query the database and view datasets, and the underlying Common Data Model, designed as well to serve the needs of interoperability between disparate neuroscience data resources throughout the international Human Brain Project and beyond.

The database has been designed for:
- Free and open access to the neuroscience community
- Availability on all computer platforms via Java and Web protocols
- Selection of data and use of methods intuitive to neurophysiologists
- Dynamic views of data (such as variable sweep) as well as delivery of actual datasets
- Search by metadata descriptions
- Reliance on collaborators to test tools and provide data
- Scalability to all neurophysiology

We ask for your input as to how well we have met these goals. Much of this information is available on the project's principal Web site, `http://cortex.med.cornell.edu`

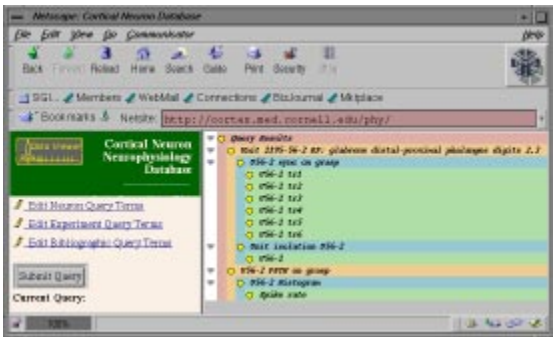
This document begins with snapshots of the tools used to access the database and to display data: our Java QueryTool and DataViewer, showing as well what kinds of data are available and how they are organized. The data model is described, then our selection of metadata used to specify datasets and to distinguish them from others, enabling meaningful search.

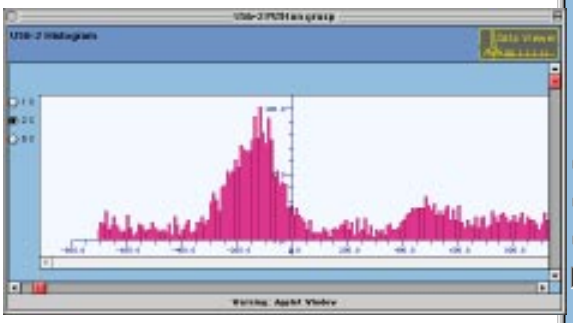


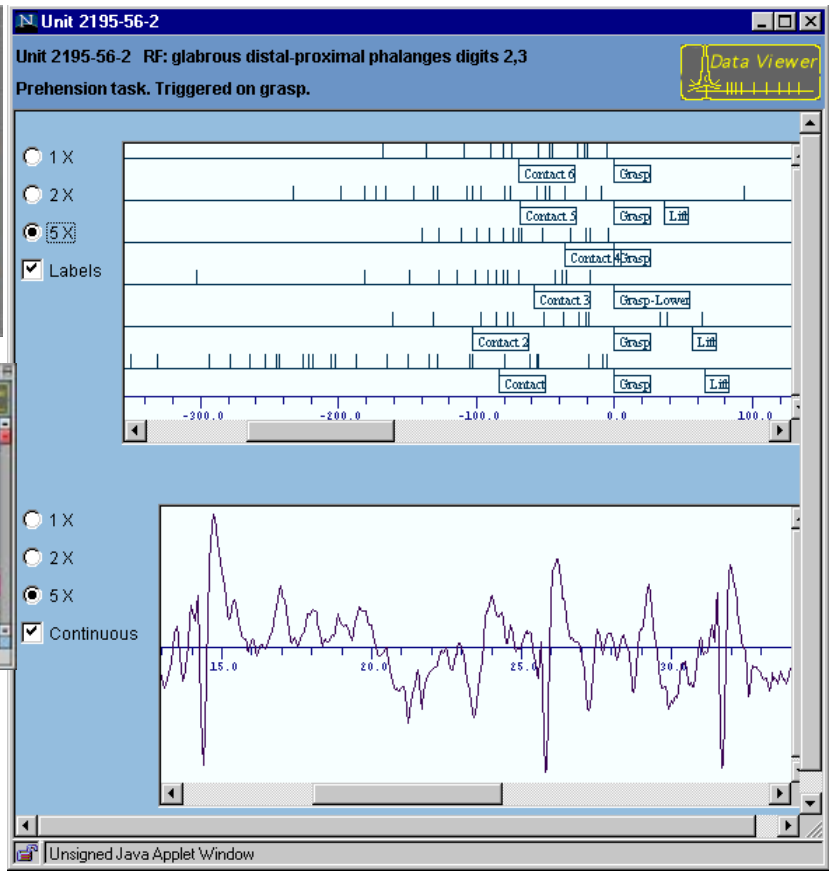
Database QueryTool and DataViewer

Somatosensory data are selected by building queries that select search terms from controlled vocabulary describing neuronal and dataset properties. These metadata are common to both submitters and requestors. The figure on the right shows a query screen from our Java multiplatform QueryTool, specifying receptive field modality and location. The result of a previous entry, selecting area S I, can be seen as the total query is assembled in the upper text box. Here, the QueryTool was running under WindowsNT; performance is identical on any Java-enabled platform.

Just below on the left, the QueryTool returns lists of *experiments* meeting search criteria, organized into *views* (analogous to figure panels), each of which displays a linked set of *traces* on a common horizontal axis. The DataViewer can present time series (right) and histogram (lower left) data from many sources and techniques. Data are delivered to the user, enabling views of data to be dynamic, with and other parameters under user control.







These Java-based multiplatform tools are shown running on Silicon Graphics and Macintosh (above), and Microsoft Windows (right).

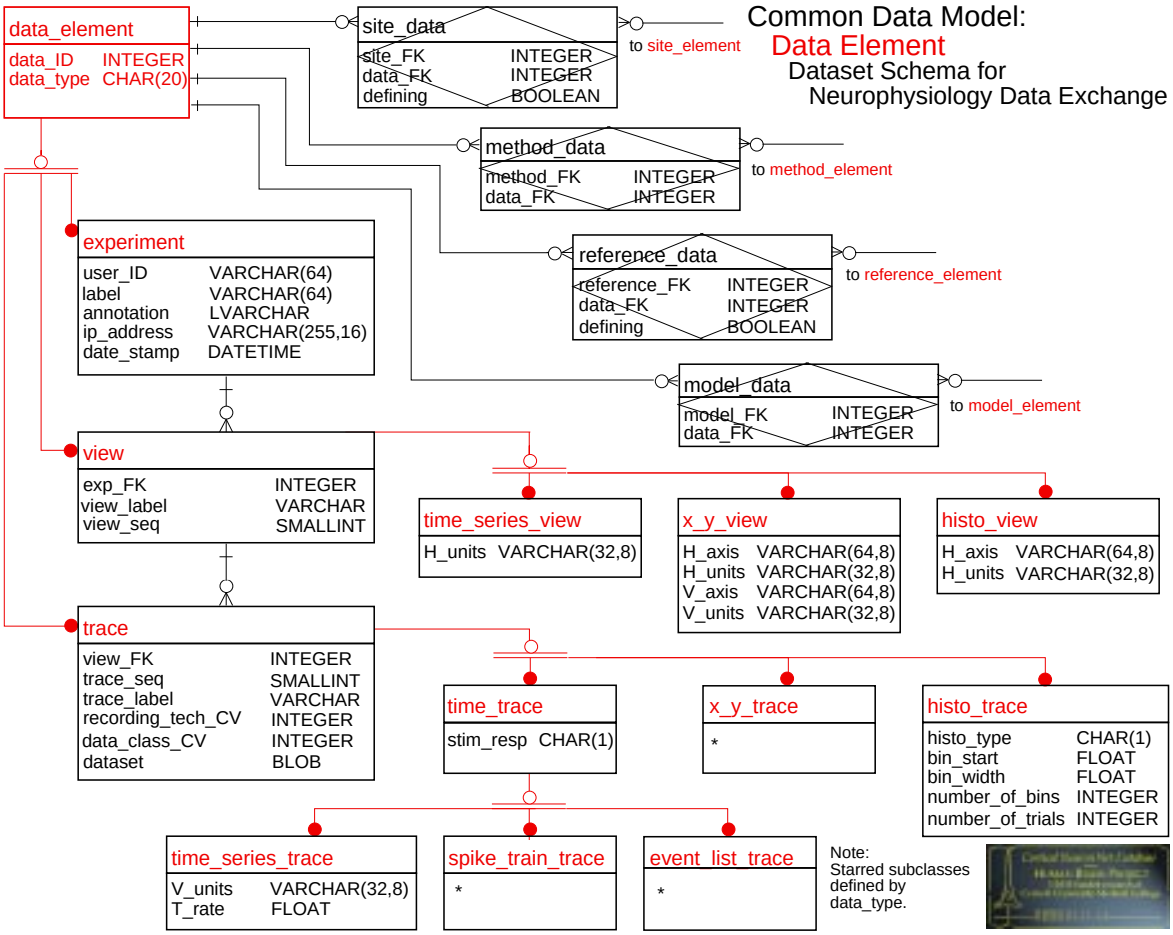
Database Contents and Common Data Model

Somatosensory neurophysiologists who acquire or analyze cortical data should review the data model to evaluate the utility of our selection of time-series (both continuously-sampled and time-stamped), histogram, and bivariate data types, the ways we group and organize data into experiments, views, and traces, and the metadata attributes we have chosen to describe and specify data.

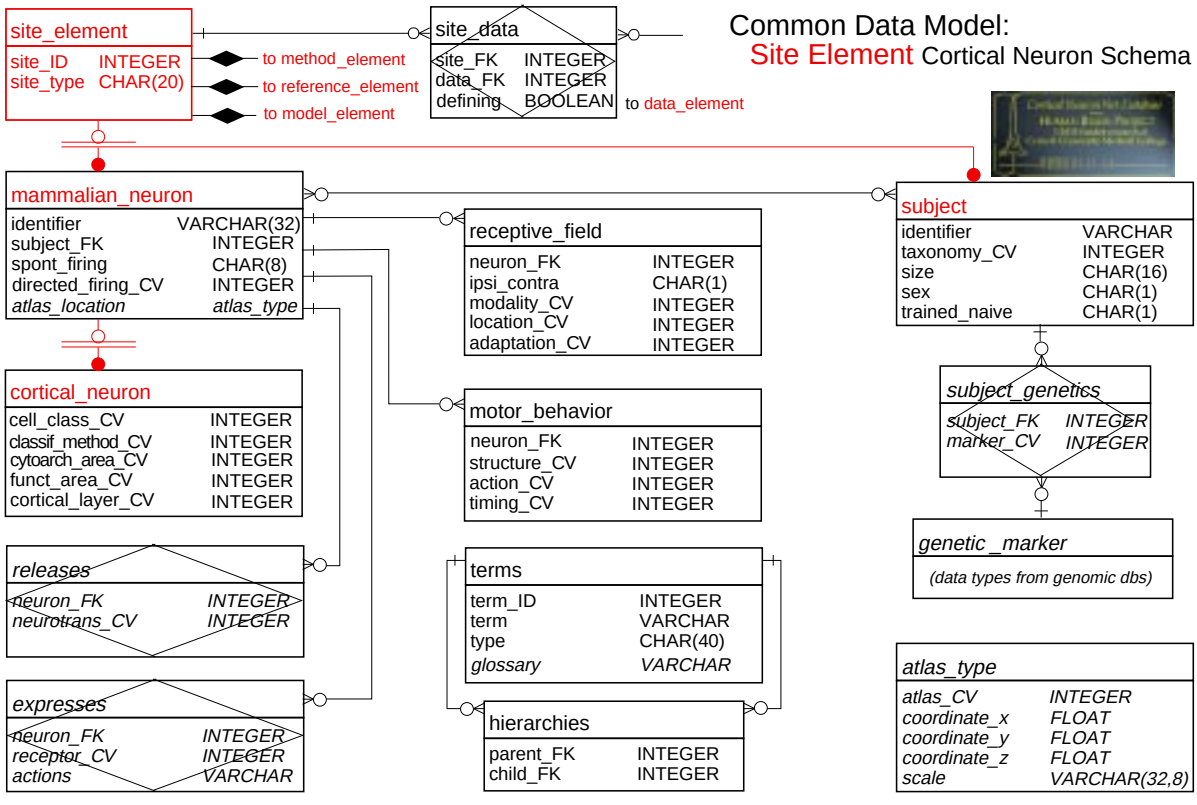
The data model is a subset of our Common Data Model for neuroscience and biophysical data archiving and exchange. Every component of the Common Data Model is a member of one of five superclasses that together span the complex domain of contemporary neurophysiology: defining data and datasets, recording sites and other anatomy, methods and protocols, models, and references. The evolving model is designed to become as well an open extensible standard for describing and sharing data models, metadata, and dataset formats of a wide range of neuroscience data resources: a standard enabling neuroscience data exchange.

On the next page, we present the two excerpts of our data model most relevant to cortical neurophysiology. The first—Data Element—defines dataset classes and wrappers used in the somatosensory database, each characterized by metadata. The second—Site Element—presents the methods and classes of descriptive terms the database project uses to define cortical neurons.

Are the data types adequate for data you produce or wish to see displayed? (We are adding imaging datatypes such as fMRI and PET to our model.) Does our selection of attributes and relations characterizing cortical neurons provide sufficient specificity for your use?



In the Entity-Relationship diagrams used to describe Data Element (above) and Site Element (below) each rectangle is a database table defining an element of our data model by means of values of the attributes listed below each table title. Attributes ending in _CV have controlled vocabulary values.



Controlled Vocabulary for Specification and Search

In order to facilitate description, specification, and selection of datasets, permissible values of many of the attributes listed on the previous page and ending in _CV are specified by a controlled-vocabulary hierarchical metadata schema. These trees of descriptive terms characterizing somatosensory neurons, datasets, and methodology are shared by data submitters and requestors, thereby facilitating directed searches. In our menu-based implementation of such hierarchies, terms may be selected at any level of specificity using the point-and-click interface shown on the first page, with the search algorithm ensuring appropriate recognition across levels. (Some attributes allow free text).

As for the data model, we invite comments and review from prospective users. Do the top-level choices of each hierarchy span the needed range adequately? Is each term is the most appropriate in common use? Note that we can easily expand each tree by adding more specific elements under those already shown without disabling searches on prior entries.

Receptive field modality:

- cutaneous
  - mechanoreceptive
    - touch/pressure
    - proprioception
      - joint
      - muscle
    - vibration
    - polymodal
  - nociceptive
    - noxious_mechanical
    - noxious_heat
    - noxious_cold
    - chemical
    - polymodal
  - thermal
    - warm
    - cold
- deep somatic
  - muscle
  - joint

Receptive field adaptation:

- RA/phasic
- SA/tonic
- mixed phasic-tonic

Cortical neuron cell class:

- pyramidal
- nonpyramidal
  - stellate
  - basket
  - Golgi II
  - double bouquet
  - chandelier

Cortical neuron classification method:

- electrophysiology
- morphology/histology
- location
- multiple

Receptive field location:

- cutaneous
  - glabrous skin
    - hand
      - volar fingers
      - volar palm
    - foot
      - plantar toe
      - sole
    - mouth
      - lips
      - tongue
      - intraoral
    - cornea
  - hairy skin
    - hand
      - dorsal fingers
      - hand dorsum
    - arm
    - foot
    - leg
    - trunk
    - scalp+neck
    - face
      - ophthalmic+cheeks
      - perioral+jaw
  - tooth+nail
  - vibrissae
- deep somatic
  - hand
    - fingers
    - wrist
  - arm
    - elbow
    - shoulder
  - foot
    - toes
    - ankle
  - leg
    - knee
    - hip
  - trunk/vertebrae/neck
  - head
    - jaw
    - tongue
    - extraocular muscles
    - scalp
    - pinnae
- deep visceral

Cortical neuron functional area:

- somatosensory
  - SI
  - SII
  - insular/retroinsular
  - postauditory/lg/ld
  - posterior parietal
- motor
  - MI
  - MI
  - SMA/preSMA
  - cingulate
  - MEF
  - PMd
  - PMv
  - FEF
- preF/preM/orbitoF
- visual/multi
  - V1
  - V2
  - V3
  - V3a
  - V4
  - VP
  - MT
  - temporal
  - parietal
    - MST
    - LIP
    - VIP
    - AIP
- auditory
  - AI
  - RL/CM/lateral
- speech/language
  - Broca's
  - Wernicke's
- olfactory
  - piriform
  - periamygdaloid
- gustatory
- hippocampal
  - CA1
  - CA3
  - dentate
  - subiculum
- entorhinal ctx
- amygdala/periamygda ctx

Cortical neuron layer:

- surface
- intracortical
  - supragranular/I-III
  - granular/IV
  - infragranular/V-VI
- white matter

Cortical neuron cytoarchitectonic area:

- 1
- 2
- 3a
- 3b
- . . .
- 47

(each numbered area and some subareas included)

Recording technique:

- extracellular
  - single electrode
  - multielectrode array
- intracellular
  - voltage-clamp
- patch clamp
  - cell-attached
  - o-o
  - i-o
- whole-cell
- macroelectrode
  - nerve cuff
  - field/surface
    - scalp
    - cortical
- optical
  - neuro-intrinsic
  - neuro-via-dye
  - light intensity
- MEG
  - radial
  - planar
- mechanical
  - pressure
  - force
  - displacement
    - translation
    - rotation
    - radial
  - sound intensity
- thermal

Trace data class:

- AP
  - single
  - train
  - multiunit
- PSP
  - single
  - train
  - summed
- channel currents
- other cell potentials/currents
- slow waves
  - evoked potentials
  - EEG
- ion concentration
- muscle
  - EMG
  - force/tension
- nonmuscle behavior
- stimulus
- I-V curves
- f-V curves
- other bivariate
- channel histogram
  - amplitude
  - duration
- spike histogram
  - PSTH
  - ISI
  - instantaneous freq
- autocorrelogram
- cross-correlogram

Subject taxonomy:

- human
- nonhuman primate
  - monkey
    - Macaca/macaque
    - Cebus/capuchin
    - Saimiri/squirrel
    - Aotus/owl
    - Papio/baboon
  - Galago
- cat
- rodent
  - rat
  - mouse
    - knockout/chimera
- rabbit
- other mammal

Motor behavior structure:

- hand
  - fingers
  - wrist/palm
- arm
  - elbow
  - shoulder
- foot
  - toes
  - plantar foot/heel/ankle
- leg/limbs
  - knee
  - hip
- eyes/extraocular muscles
- head/neck
  - jaw
  - tongue
  - pinnae
  - scalp
  - larynx/pharynx
  - cervical vertebrae
- trunk
  - diaphragm/intracostals
  - viscera
  - cardiac
  - cardiovascular
  - GI
  - reproductive

Motor behavior timing:

- planning/anticipation
- premotor
- pattern generation/rhythmic
- initiation/ballistic
- maintenance/tracking
- termination
- suppression

Motor behavior action:

- hand/arm
  - flex/extend
  - pronate/supinate
  - abduct/adduct
  - manipulate
    - reach/point/press
    - track
    - grasp
    - palpate
    - translate/rotate/push-pull
    - reject
- leg/limbs/foot
  - flex/extend
  - pronate/supinate
  - abduct/adduct
  - locomote
    - rotate
    - step
    - swim
- eyes/extraocular muscles
  - fixate
  - saccade
  - smooth pursuit
  - vergence
  - nystagmus
- head/neck
  - flex/extend
  - rotate
  - feeding/mouth/jaw
    - lick
    - bite/grasp
    - chew
    - swallow
    - secrete
  - orient
  - whisk
  - vocalize
- trunk
  - inspire/expire
  - sympathetic
  - parasympathetic
  - GI motility
  - reproductive

Somatosensory Cortical Database Questionnaire

We are most interested in comments from the somatosensory community.
Please detach this page and return to Esther Gardner at this meeting
or e-mail comments to: dan@aplysia.med.cornell.edu

Your name: _____

1. Would the somatosensory cortical database be of use to you? Does our selection of data types include data you wish to see displayed, or would additional types be of interest?

2. Would you be willing to deposit relevant electrophysiological data in the database, perhaps at the time that related findings are submitted or accepted for publication? ...are published? Are the data types adequate for data you produce?

3. Does our selection of attributes and relations characterizing cortical neurons provide sufficient specificity for your use?

4. Do the top-level choices of each hierarchy span the needed range adequately? Is each term is the most appropriate in common use?