

Neurotech Club Resources Project Ideas

BciPy	API
Brainflow	API
EEG Pong	Example project (deprecated) - Play pong with your mind (based on mental commands)
P300 BCI	Example project - Control a keyboard with your mind (based on oddball stimulus)
OpenBCI example projects	Great place to see what others have done in the past. Lots of project examples with open source code.
NTX Project Examples	Example projects granted by NTX, also a great place like openBCI
Visual Database	Database containing EEG data corresponding to visual stimuli

Databases (needs to be linked and organized)

There isn't a widely recognized public database that directly associates specific EEG data with individual commands or words being thought, mainly because decoding such precise information from EEG signals is extremely challenging and varies significantly from person to person. However, there are some datasets and resources that may be of interest for related research:

- 1. OpenBCI Datasets:** OpenBCI provides a platform for EEG research and has some datasets available. While these might not be directly associated with specific commands, they could be a good starting point for learning how to process and interpret EEG data.
- 2. PhysioNet:** This is a resource for complex physiological signals, including EEG data. Some of the EEG datasets here are annotated with specific tasks or stimuli that participants were exposed to, which could be a starting point for studying EEG responses to cognitive tasks.

3. **BCI Competition Datasets:** These datasets are from various BCI (Brain-Computer Interface) competitions and include EEG data associated with specific tasks like motor imagery, which can be somewhat related to command-like thoughts.
4. **Kaggle:** Occasionally, Kaggle hosts datasets and competitions related to EEG data. While not always focused on thought commands, you might find useful datasets that could be adapted for your research.
5. **NeuroTechX:** This community provides access to various neurotechnology resources, including EEG datasets. They sometimes have datasets that might be close to what you are looking for.
6. **EEGmmidb:** This database contains EEG data recorded while participants performed motor and imagery tasks. While it's not about specific words, motor imagery is a common focus in BCI research, and this could be a relevant dataset.

For your specific interest in EEG data associated with thought commands, you might need to conduct your own experiments. This would involve collecting EEG data while participants think of specific words or commands and then developing a machine learning model to identify patterns associated with those thoughts. This approach would likely require custom data collection due to the personalized nature of EEG signals.

Websites

Brain-Computer Interface Wiki (bciwiki.org)	Great place to start with lots of comprehensive information about labs, companies, and technologies.
Deep-Learning-for-BCI/README.md at master · xiangzhang1015/Deep-Learning-for-BCI · GitHub	An in-depth explanation of all the important aspects of a deep learning EEG BCI project.

Podcasts

Neural implant podcast	Podcast where people in the industry working at neurotech startups talk about their work.
Stimulating brains	

Research Labs

School	PI	Research
--------	----	----------

UPITT-RNEL	Debbie Harrington - debbie.harrington@pitt.edu	Electrode arrays that decode neural signals and use that to control prosthetics, trying to get sensory feedback to work.
CALTECH	Richard Andersen - andersen@vis.caltech.edu	Decoding motor signals for prosthetics.
UMICH	Jane Huggins - janeh@umich.edu	Using EEG BCIs to help quadriplegics use technology
CWRU	Dustin Tyler - dustin.tyler@case.edu	Sensory prosthetics and spinal cord stimulation - haptic sensation

Companies

Company	Description
Category:Companies - Brain Computer Interface Wiki (bcwiki.org)	Source to explore companies.
Ceregate	Software for sensory stimulation.
Blackrock	neurotech giant: builds devices and other neurotech hardware.
Synchron	stentrode BCI (BCI in the blood vessels) for quadriplegic control of technology.
Neuralink	Elon Musk's company: electrode arrays in the gray matter of the brain for quadriplegic control of technology.
Hanisongreen	neurotech recruitment for companies (Helps companies recruit talent).
Newronika	BCI and DBS for movement and sensory restoration.

FES Center Cleveland	Functional electrical stimulation center in Cleveland.
--------------------------------------	--

Books

Hands on machine learning with scikit-learn, keras and tensorflow	
Livewired - David Eagleman	Discusses neuroplasticity, how the brain can make meaning from various inputs or output vehicles. Important to understand sensory substitution, addition and enhancement when interfacing with the brain.

Research Articles

This next section is an AI generated, fairly comprehensive list of most of the skills that make up the BCI industry. It provides resources that you can use to learn the skills and if you are motivated to, I recommend that you use ChatGPT and the resources it provides to explore these concepts at a deeper level. Happy learning:)

Technical Skills

Skill Area	Specific Skills	Resources
Neuroscience	Understanding neural anatomy and physiology, Knowledge of neural signaling and synaptic mechanisms.	KhanAcademy:Nervous System ,Neuroscience Online Textbook,OpenStax:Anatomy and Physiology

Signal Processing	Proficiency in techniques for filtering, analyzing, and interpreting neural signals, Familiarity with Fourier transforms, wavelet transforms, and other signal processing methods.	MNE-Python Documentation, Digital Signal Processing by Richard Lyons , SciPy Signal Processing, W3C Digital Signal Processing
Machine Learning	Experience with machine learning algorithms for pattern recognition and signal decoding, Knowledge of supervised, unsupervised, and reinforcement learning techniques.	Coursera: Machine Learning by Andrew Ng (Audit for free) , Hands-On Machine Learning with Scikit-Learn, Keras, and TensorFlow (Free PDF available), Google Machine Learning Crash Course
Programming	Proficiency in programming languages like Python, MATLAB, or C++, Experience with neural network libraries such as TensorFlow or PyTorch.	Python Programming Tutorials , MATLAB Online Documentation, TensorFlow Tutorials, PyTorch Documentation, GitHub: Awesome Python Resources
Data Analysis	Skills in statistical analysis and data visualization, Proficiency with tools like R, pandas, NumPy, and visualization libraries like Matplotlib or Seaborn.	Python for Data Analysis by WesMcKinney(Open Access),Pandas Documentation,Matplotlib Tutorials, Seaborn Tutorial, DataCamp:FreeData Analysis with Python Course

Scientific Skills

Skill Area	Specific Skills	Resources
Research Methodology	Ability to design experiments, formulate hypotheses, and conduct rigorous scientific research, Experience with both in vivo and in vitro experimental techniques.	Coursera: Research Methods (Free Audit) , ScienceDirect: Research Methodology , MIT OpenCourseWare: Introduction to Experimental Biology
Electrophysiology	Expertise in recording neural activity using techniques like EEG, MEG, ECoG, or single-unit recordings, Experience with microelectrode arrays and neural interface devices.	Frontiers in Neuroscience: Electrophysiology, OpenBCI Community Resources, Neuromatch Academy: Computational Neuroscience Course
Neural Modeling	Knowledge of computational models of neural activity, Experience with simulating neural circuits and understanding their behavior.	Computational Neuroscience Online Course(Free) , Neuron SimulationEnvironment (NEURON), Brian2:A Simulator for Spiking Neural

		Networks
--	--	--------------------------

Practical Skills

Skill Area	Specific Skills	Resources
Hardware and Electronics	Understanding of electronics and hardware used in neural prosthetics, Experience with microcontrollers, sensors, and signal acquisition systems.	Adafruit Learning System, Arduino Tutorials, EEVblog: Electronics Engineering Video Blog , SparkFun Electronics Tutorials
Prototyping and Fabrication	Skills in prototyping and developing neural interface devices, Experience with 3D printing, circuit design, and PCB fabrication.	Instructables: 3D Printing Projects, KiCad PCB Design Tutorials, Ultimaker: 3D Printing for Beginners, All3DP: Free 3D Printing Software
Collaboration and Communication	Ability to work effectively in multidisciplinary teams, Strong communication skills for presenting research findings and writing scientific papers.	Coursera: Teamwork Skills (Free Audit) , Scientific Writing by Stanford University (Free Access) , Nature Masterclasses: Effective Collaboration

Steps for Writing Encoding and Decoding Algorithms

Step	Topics	Skills/Focus Areas	Resources
Step 1: Basics of Programming	Programming Fundamentals: Learn a programming language commonly used in neuroscience and machine learning (e.g., Python, MATLAB). Focus on understanding basic programming concepts such as variables, data types, control structures (loops, conditionals), functions, and error handling.	Data Structures and Algorithms: Study fundamental data structures (arrays, linked lists, stacks, queues, trees, graphs). Learn basic algorithms (sorting, searching, traversal).	Python.org: Beginner's Guide , MIT OpenCourseWare: Introduction to Algorithms, Learn X in Y Minutes (Python)
Step 2: Advanced Programming Concepts	Object-Oriented Programming (OOP): Understand OOP principles: encapsulation, inheritance, polymorphism, and abstraction. Practice implementing classes and objects in your chosen programming language.	Data Handling and Analysis: Learn how to handle large datasets efficiently. Familiarize yourself with libraries for data manipulation and analysis (e.g., NumPy, pandas in Python).	W3Schools: Python OOP, Coursera: Data Manipulation with Python (Free Audit) , Automate the Boring Stuff with Python (Free eBook)

Step 3: Mathematical Foundations	Linear Algebra: Study vectors, matrices, and operations on them. Understand eigenvalues and eigenvectors.	Probability and Statistics: Learn basic probability theory, random variables, probability distributions, and statistical inference. Calculus: Review differential and integral calculus, focusing on functions, derivatives, and integrals.	Khan Academy: Linear Algebra , Khan Academy: Probability and Statistics , MIT OpenCourseWare: Single Variable Calculus
-------------------------------------	---	---	--

Step 4: Signal Processing	Digital Signal Processing (DSP): Understand the basics of signals and systems. Learn about Fourier transforms, filtering, and signal reconstruction.	Time-Series Analysis: Study methods for analyzing sequential data, including autoregressive models and spectral analysis.	Coursera: Digital Signal Processing (Free Audit) , Time Series Analysis in Python
Step 5: Machine Learning and Neural Networks	Introduction to Machine Learning: Learn the basic concepts of supervised and unsupervised learning. Study algorithms like linear regression, logistic regression, decision trees, k-means clustering, and support vector machines.	Deep Learning: Understand the architecture and training of neural networks. Learn about convolutional neural networks (CNNs) and recurrent neural networks (RNNs). Familiarize yourself with deep learning frameworks like TensorFlow and PyTorch.	Deep Learning Specialization by Andrew Ng (Coursera - Free Audit) , Scikit-learn Documentation, Google AI Blog
Step 6: Neuroscience Specific Topics	Computational Neuroscience: Study the principles of neural coding and information processing in the brain. Learn about models of neurons and networks, spike trains, and neural dynamics.	Brain-Computer Interface (BCI) Technologies: Understand the basics of BCI systems and the types of neural signals used. Learn about different types of implanted microelectrodes and their data characteristics.	Coursera: Computational Neuroscience (Free Audit) , Nature: Brain-Computer Interfaces , NeuroTechX: Resources for Neurotechnology
Step 7: Practical Implementation	Feature Extraction: Learn techniques for extracting meaningful features from neural data, such as spike sorting and local field potential (LFP) analysis.	Pattern Recognition and Classification: Implement algorithms for decoding neural signals, such as support vector machines, hidden Markov models, and neural network classifiers. Real-Time Processing: Study techniques for processing and analyzing neural data in real-time. Learn about the software and hardware	Feature Extraction Techniques in Signal Processing, Real-Time BCI Development Guide , NeuroTechX: Brain-Computer Interface Resources

		requirements for implementing real-time BCI systems.	
Step 8: Advanced Topics and Research	Advanced Machine Learning Techniques: Explore advanced topics like reinforcement learning, generative adversarial networks (GANs), and transfer learning.	Cutting-Edge Research: Keep up with the latest research in neural decoding and BCI by reading scientific papers and attending conferences.	OpenAI's Spinning Up in Deep Reinforcement Learning , Google Research Papers, ArXiv.org for AI and Machine Learning
Step 9: Projects and Practical Experience	Implement Projects: Work on projects that involve decoding neural data to solidify your understanding and gain practical experience.	Collaborate with neuroscience labs or participate in BCI competitions. Internships and Research Opportunities: Seek internships or research opportunities in companies or academic institutions specializing in neural interfaces and BCI.	Kaggle: EEG Brainwave Dataset, NeuroTechX: Student Clubs and Competitions, IEEE Brain Data Bank

Project Examples for Application

Project Title	Description	Resources
BCI Speller System	Develop a BCI system that allows users to spell words using brain signals.	OpenBCI Speller Project
EEG-Based Emotion Recognition	Build a system that classifies emotions based on EEG data.	EEG Emotion Recognition with Keras
Real-Time Neurofeedback Game	Create a game that uses real-time EEG data to provide neurofeedback.	Neurofeedback with OpenBCI
Brain-Controlled Robot	Design a robot that can be controlled using brain signals.	Brain-Controlled Robot Using OpenBCI
Motor Imagery-Based BCI for Prosthetic Control	Develop a BCI that uses motor imagery to control a prosthetic device.	Motor Imagery BCI Tutorial
EEG Signal Classification with Deep Learning	Implement a deep learning model to classify EEG signals for different mental tasks.	Deep Learning for EEG Classification