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# 2024 NYC Neuromodulation Conference

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Main sessions and events: August 1-3, 2024

Pre-Conference Workshops: Wednesday, July 31, 2024

Satellite Symposia: Sunday, August 4, 2024

## BRIDGING THE GAP: INTEGRATING DEEP BRAIN STIMULATION IMAGING AND CLINICAL DATA IN A UNIFIED DATA MANAGEMENT SYSTEM

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## Synopsis (533 of 800 characters)

We present a novel data management system tailored for Deep Brain Stimulation (DBS) research. It addresses challenges in heterogeneous data collection and management during the patient journey and subsequent data analyses. The system integrates an Electronic Data Capture platform (REDCap), a relational database (SQLite), and a brain imaging file structure standard (BIDS), facilitating efficient data capture, storage, and analysis. The system demonstrates improved data quality, organization, analysis, and collaboration potential.

## Background

DBS research faces challenges in managing the heterogeneous types of data generated during the patient's journey. Pre-operative planning, surgical implantation and post-operative follow-ups result in the generation of massive collections of patient data, ranging from demographic information, to clinical evaluations and medical images ((1–3)). On top of this, DBS files processing and analysis in research institutes is a further source of data. An additional challenge is posed by the data collection process: DBS implantation protocols can vary among medical centers and data is usually recorded on paper or spreadsheets ((4,5)). The lack of data standardization and organization hinders its secure transfer to research institutes and subsequent accessibility and retrieval for further analyses. Therefore, we propose a novel data collection and management approach tailored to DBS workflows and pipelines. Our framework leverages REDCap ((6)), a secure web-based platform, for clinical data capture in hospital settings and the Brain Imaging Data Structure (BIDS) ((7)) to standardize brain imaging files naming and folder structure. However, REDCap does not support image files and BIDS is limited when it comes to integrating clinical metadata such as clinical scores. Thus, to overcome these limitations, clinical data and references to imaging files are stored in a relational SQLite database, acting as unified interface to the diverse DBS data types.

## Methods

A user-centered design approach was employed to define system requirements. The system caters to two primary user groups: clinicians and researchers. Use-cases for clinicians consist in data entry, edit and export, while the main use-case for researchers is DBS group analysis which in turn involves data retrieval, processing and results saving. To fulfill the clinician's requirements we used REDCap, where customized REDCap forms were designed to best capture data originating from diverse sites. Clinicians can enter patient-related metadata, including demographic information, medication and neurological assessments in the forms through REDCap's user-friendly interface. All entered data is automatically stored on the REDCap server and inserted in the SQLite database through a self-developed tool (REDCap2SQLite (<https://github.com/IM2Neuroing/REDCap2SQLite>)). Medical image data from the neurosurgical planning station (Elements, Brainlab Munich, Germany) is stored and transmitted in anonymized DICOMDIR format. To prepare the data for analysis and store it in its BIDS format, a Python script extracts the DICOMDIR data, converts it into Neuroimaging Informatics Technology Initiative (NIFTI) format and stores the files following the BIDS standard. Image references are then created in the SQLite database. The database was modelled according to a patient-centric, DBS-specific schema. This streamlined approach facilitates BIDS-compliant data storage analysis, and management (see Figure 1).

*Figure 1: Overview of the components of the data collection and management framework.*

## Results

The system caters to the needs of both clinicians and researchers engaged in DBS studies. To validate our proposed data management system, we gathered and scrutinized data from two reputable medical institutions: the University Hospitals of Basel and Clermont-Ferrand. We established distinct REDCap projects for each institution, maintaining uniformity while permitting certain adaptations. Collaborating physicians filled out these forms. Furthermore, they identified research-relevant images and plans from the neurosurgical planning stations (Elements, Brainlab Munich, Germany) and exported them. After physicians collected the data and transferred image data, our system effortlessly integrated the information into the database. Our framework currently captures data for 107 patients, averaging 35 images/labels per patient, and offers several advantages. The patient-centric SQLite database, with 28 tables, 230 fields, and 33 relationships, enables comprehensive storage, retrieval, and querying of metadata. The efficiency and power of our system is indeed outstanding when leading group-specific analyses. The primary objective of these analyses is to leverage data from several patients to derive reliable insights into phenomena such as the efficacy of DBS. This involves an initial delineation of demographic and clinical attributes within the designated patient cohort, followed by meticulous selection and extraction of pertinent information. Different data types need to be handled and merged in various processing steps. For instance, patient's brain imaging data, transformed to a common anatomical space, is combined with electrode models and clinical parameters (e.g., stimulation configurations) to conduct electrical field simulations. The streamlined retrieval, handling, and storage capabilities provided by our system significantly speed up all the steps outlined above.

## Discussion (1163 of 1600)

Efficient data capture and management are pivotal for the progression of DBS research. Therefore, in this work we presented a robust data management system based on the integration of an Electronic Data Capture platform, a relational database, and a medical file structure standard. These components were made interoperable through self-developed tool (REDCap2SQLite) and customized Python scripts, and their combination allowed us to overcome the limitations arising when using them singularly. Such a system has the potential to yield substantial improvements in data quality, organization, analysis, and collaboration among medical and scientific institutions. Although systems with similar functions have been introduced in the neuroscience field ((8,9)), this is the first framework developed specifically for integration in DBS pipelines. It enables researchers to leverage both standardized imaging data and detailed patient information for group analysis, by interfacing with a single, comprehensive system.

This enhanced data management framework facilitates deeper and more efficient DBS research, potentially leading to improved clinical decision-making and patient outcomes.

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Figure

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