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REAL-TIME SOFTWARE FOR FUNCTIONAL MAPPING OF ELOQUENT CORTEX USING ELECTROCORTICOGRAPHY

R. Prueckl[1], C. Kapeller[1], C. Potes[2], M. Korostenskaja[3], G. Schalk[2], Ki H. Lee[3], C. Guger[1]

[1]g.tec Guger Techologies OG, Schiedlberg, Austria
[2]Wadsworth Center, Albany, NY, USA
[3]Florida Hospital for Children, Orlando, FL, USA

prueckl@gtec.at

Abstract: *In this work, we present and validate a software package for functional mapping of eloquent cortex using task-related changes in gamma activity recorded from subdural electrocorticography electrodes prior to resective brain surgery. The software is designed for use by non-experts in addition to traditional mapping procedures such as electrical cortical stimulation (ECS) mapping.*

Keywords: *Functional Mapping, Electrocorticography, Epilepsy, Electrical Cortical Stimulation, Gamma Activity*

Introduction

Epilepsy is a disorder of the brain that impairs the quality of life of people by the effects of seizures or medication. For some of the patients, who are resistant to antiepileptic medication, surgical resection of the seizure focus can reduce or even cure epilepsy. Prior to the resection, the identification of eloquent cortex is important in order to minimize the possibility of functional deficits [1]. This has been done using several different approaches. Amongst them the most common is ECS [2]. While ECS is effective, it also has substantial problems [3]. We designed and validated a clinical product based on published methods [4] that is reliable and easy to use as a tool for cross-checking or narrowing down the sites of interest. The system analyzes data acquired from ECoG electrodes for task-related changes in the gamma band (i.e., between 60 and 170 Hz).

System Architecture

On the hardware side of the system, a synchronized array of high resolution multi-channel biosignal amplifiers (g.USBamp, g.tec Guger Technologies OG, Austria) is connected to the electrodes implanted in the brain of the patient. The amplifiers digitize the signals and transfer them to the recording computer. This computer has two screens, one for the patient that displays instructions for the tasks, the other for the operator, displaying the mapping results. See Fig. 1.

The Montage Creator is used to create a schematic picture of the implanted electrodes. For this purpose, the software comes with a library of electrode grid shapes. The program then generates a list pointing out how to connect the

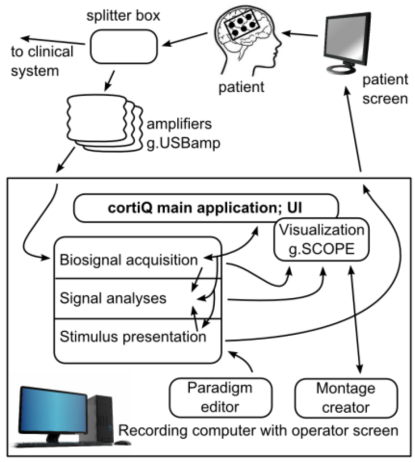

Figure 1: Hard- and software architecture of the cortiQ system.

grids to the amplifier. The Paradigm Editor is there for efficient editing of the tasks the patient should accomplish. The contents of the tasks can be designed using images, audio files, text, or tactile stimulation. Also referencing can be influenced, e.g., tasks vs. baseline or task x vs. task y. The Main Application provides the operator with a structured way of conducting the experiment with little need for input. After selecting the montage, raw data channels can be checked for data quality. Here, exclusion of noisy channels and re-assignment of ground and reference electrodes is possible. Then, the paradigm is selected and started. In real time, the results of the mapping are displayed according to the montage for each individual task and electrode as circles with different diameters. Additionally, the magnitude of the response is displayed.
Signal acquisition, signal processing, and stimulus presentation run as sub-processes in the background, and analyze the data according to methods that build on those described in [5].

System Validation

Two epilepsy patients from Florida Hospital for Children (Orlando, FL, USA) participated in the experiments. They underwent surgery to place subdural ECoG electrode grids over different brain regions. Eloquent cortex of the patients was identified using ECS. The patients gave informed consent through a protocol reviewed and approved by the review board of the Florida Hospital for

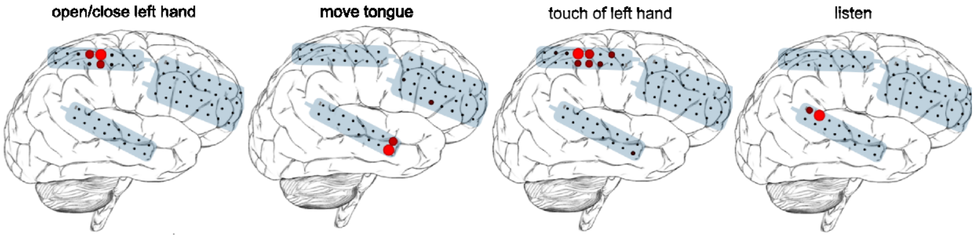

Figure 2: Topographical result maps of patient 1 as displayed on the operator screen.

Children.
After the preparation, the electrode montages and the paradigm, data were collected with the g.USBamp amplifiers at the bedside of the patients and processed by the cortiQ software in real time, gradually building the result in form of topographical brain maps that shows the task-related differences in activity (see Fig. 2).
The patients went through 3 repetitions of a paradigm which contained four tasks: open/close the left hand (task 1), move the tongue (task 2), feel the touch which is applied to the palm of the left hand (task 3), listen to a story (task 4). Each task had a length of 15 seconds with 15 seconds relaxation baseline in between.

Results

The outcome of the software is compared to the results of ECS mapping. Specifically, we counted the sites that were assigned to a particular function/area in the ECS procedure and checked whether the significant result values of the cortiQ software were at the same or at the next neighbor locations. Task 4 was not checked with ECS, so it was excluded from analyses. For both patients the error rates for tasks 1 to 3 reveal no false negative detections and the grand average of false positive identifications is 1.24 %.

Discussion

We demonstrated a clinical hardware and software system for cortical functional mapping of the eloquent cortex to be used prior to resective surgeries in epilepsy patients. Based on methods from previous research [4, 5], the results of the software are in the close neighborhood to locations determined by the well-established ECS procedure. While ECS has been applied regularly over the past decades, it has some important drawbacks. We expect that cortiQ software should provide distinct benefits to mapping of eloquent cortex. Most importantly, the results from cortiQ mapping may be used to optimize subsequent ECS mapping.

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