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HEARLab™ ACA: Software Architecture Overview

SAD0001

Software Architecture Overview

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1 INTRODUCTION

1.1 Purpose

This document outlines the software architecture for the HEARLab™ ACA software. It also details each of the subsystem and its components in the overall architecture, as well as address risk control requirements.

1.2 Scope

This document outlines the software architecture design in accordance with the software requirements, details each of the subsystem components, as well as addresses how the software manages risk factors. This document does not specify implementation details of each of the subsystem components.

1.3 Glossary of Terms

ACA	Acronym for Aided Cortical Assessment
EP	Electrode Processor; a hardware component of the HEARLab™ system used for the acquisition of signals from electrodes
HEARLab™ System	A device that can be used to assist in hearing assessment. It comprises of a customized set of electronic hardware that can be configured and controlled by software running on a PC.
SC	Stimulus Controller; the main hardware component of the HEARLab™ system used for stimulus presentation and monitoring
Client	Adult or child whose hearing is assessed using HEARLab™ ACA
User	Trained clinician who will be using the software to perform an hearing assessment

1.4 References

- [1] RS0002 HEARLab Product Requirement Specification
- [2] SRS0001 Software Requirement Specification for HEARLab™ ACA

2 ARCHITECTURE OVERVIEW

2.1 Objectives of the software architecture design

HEARLab™ ACA is the first of audiological test suites to be made available with the HEARLab™ system. The purpose of the software module is to provide a simple, efficient and accurate means for audiologists to assess a person's hearing using cortical auditory-evoked potentials. Since ACA is the first software module to be released, thus may set the model for development of future software modules, the main objectives of the ACA software architecture are:

- Maintainability
- Extendibility
- Manageability

The architecture of the software will be presented in the following views:

- Use case view
- Logical view
- Design view

3 ARCHITECTURE GOALS AND CONSTRAINTS

The architecture is constrained by the following:

- Device requirements as specified in the SRS [1]
- Software functional requirements as specified in the SRS [1]
- Interface requirements as specified in the SRS [1]

4 USE CASE VIEW

4.1 Introduction

The major use cases of the application that are architecturally significant are:

- User performing a hearing assessment on a client

- User retrieving assessment records

4.2 Use Case 1: User performs hearing assessment

Primary Actor: User

Preconditions: GUI is displayed, hardware connected to PC correctly, transducers have been calibrated and connected

Success Guarantee (Post conditions): Acoustic stimuli presented at the correct level, GUI displays acquired responses and analysis results

Main Success Scenario:

1. User selects a client to be assessed
2. User specifies the test configuration (stimuli presentation pathway, stimuli to be presented, presentation level)
3. User checks the skin-electrode impedance and is satisfactory
4. User starts the test
5. Acoustic stimuli are presented
6. GUI displays acquired responses and analysis results, such as averaged responses and statistical analysis results
7. Test is stopped automatically once stop criteria has been reached, or user chooses to stop the test
8. User saves the assessment record
9. GUI displays message to confirm that the record has been successfully saved

Extensions:

1a.. System is unable to access database

1. Display error message indicating system is unable to access database
2. Exit use case

5a. No audible acoustic sounds

1. User needs to restart both hardware and application
2. Exit use case

6a. GUI does not display results

1. User needs to restart both hardware and application

2. Exit use case

8a.. System is unable to access database

1. Display error message indicating system is unable to access database
2. Exit use case

4.3 Use Case 2: User views client's hearing assessment

Primary Actor: User

Preconditions: GUI is displayed

Success Guarantee (Post conditions): Client's assessment results displayed correctly on the GUI

Main Success Scenario:

1. User selects a client to be viewed
2. User selects the assessment record to be retrieved
3. GUI displays acquired responses and analysis results, such as averaged responses and statistical analysis results

Extensions:

1a.. System is unable to access database

1. Display error message indicating system is unable to access database
2. Exit use case

3a. User wants to print results

1. User selects to print the test report
2. User selects the printer
3. Go back to step 3. of main success scenario.

5 LOGICAL VIEW

5.1 Introduction

The logical view of the HEARLab™ ACA software is comprised of five main packages:

- User interface
- Hardware interface

- Audio I/O interface
- Database interface and
- Signal handling and processing.

5.1.1 User interface

The user interface package contains classes that define the means by which users can specify test configurations, perform assessments and view results. It should also contain classes that allow specialized users to perform calibration of the hardware transducers.

5.1.2 Hardware interface

The hardware interface package should contain functions / classes to allow for setting up the HEARLab™ SC and EP accordingly.

5.1.3 Audio I/O interface

The audio I/O interface package should contain functions / classes to enable acoustic signal playback and recording.

5.1.4 Database interface

The database interface package should contain functions / classes to enable storage / retrieval of data to / from the database.

5.1.5 Signal handling and processing

The signal handling and processing package is the main package of the architecture. It should handle all processing for presenting acoustic stimuli, analyzing acquired cortical responses, and perform statistical analysis on acquired cortical responses.

6 DESIGN VIEW

6.1 Introduction

The Design Views briefly outlines what each of the system components are responsible for.

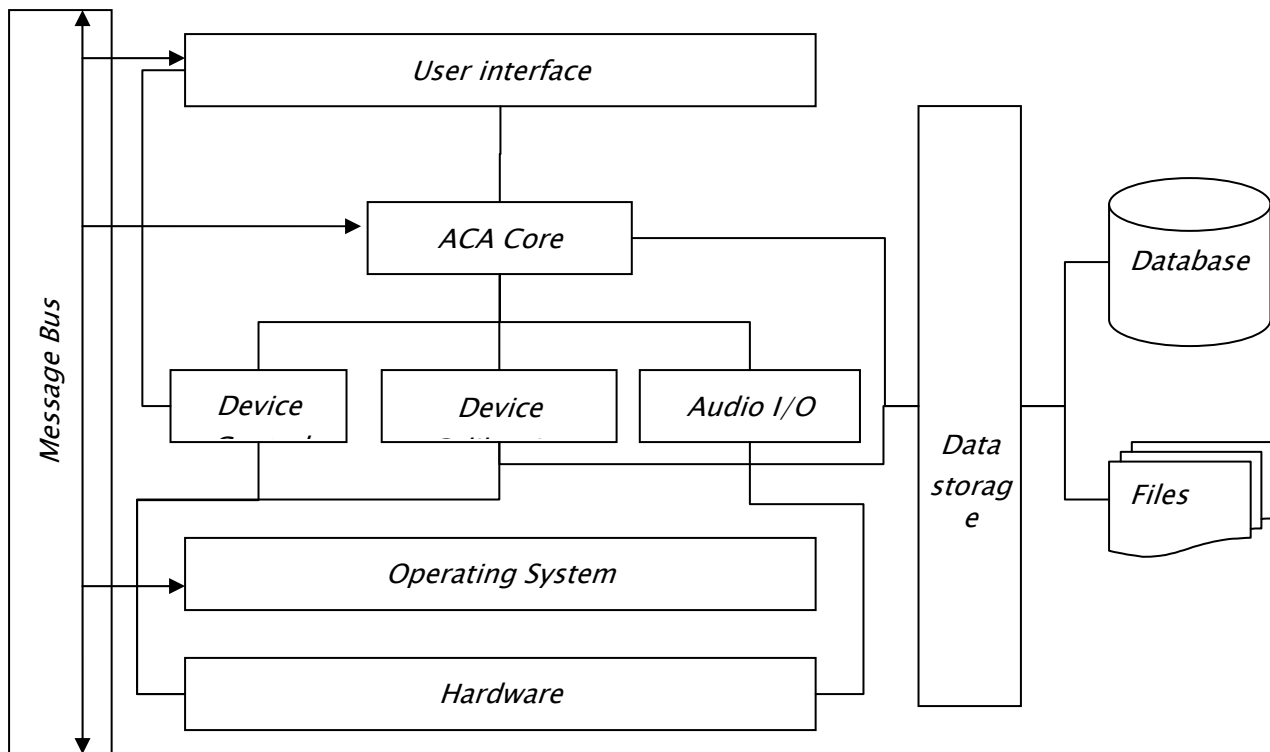


Figure 1. Overview of ACA software architecture design.

Figure 1 shows a simplified overview of the ACA software architecture. Details of each of the components are specified in the subsequent subsections.

6.2 Device Control

The Device Control component shall be responsible for handling commands for setting up the HEARLab™ hardware, such as the Stimulus Controller (SC) and the Electrode Processor (EP). It shall also implement a function / algorithm to ensure the signal output level does not exceed the hardware saturation limits. As such, the main functions of this component will be:

- Detect and initialize HEARLab™ devices
- Provide an interface for other components in the architecture for setting up HEARLab™ devices

- Ensure signal output level does not exceed hardware saturation limits

6.3 Audio I/O

The Audio I/O component shall handle all the audio input and output and provide an interface for other components in the architecture. The main functions of this component will be:

- Handle audio signal playback, whether from files or database
- Handle audio signal recording
- Generate audio signals such as pure tones and warble tones

6.4 Device Calibration

The Device Calibration component shall handle the calibration process for each of the output transducers connected to the HEARLab™ SC. Calibration ensures accurate output levels of stimuli presented to the client. The main functions of this component are:

- Handle process of free field loudspeaker calibration and ensure acoustic environment is satisfactory for presentation of free field stimuli at the maximum presentation level of 75 dB SPL
- Handle process of microphone calibration and ensure microphone's sensitivity is as per factory specification
- Handle process of insert earphone calibration and ensure insert earphone's frequency response is within acceptable limits as stated in the Software Requirements Specification document [1].
- Handle process of bone conductor calibration and ensure bone conductor's frequency response is within acceptable limits as stated in the Software Requirements Specification document [1].
- Store calibration results in the database and allow user to export results as a separate file.

6.5 ACA Core

The ACA Core component shall have three subcomponents: the ACA Configuration component, the ACA Impedance component and the ACA Signal Processing component.

6.5.1 ACA Configuration

The ACA configuration component shall handle, in conjunction with user input, the configuration for each hearing test. The parameters that shall be handled by this component include:

- Identification of the acoustic stimuli to be presented
- The output level at which the stimuli are to be presented
- The signal output pathway used to present the stimuli (free field, insert earphone or bone conductor)

This component shall also utilize the interface provided by the Device Control component to set up the hardware appropriately for the signal output pathway as well as the signal output level. It shall also store the configuration settings in the database as appropriate.

6.5.2 ACA Impedance Check

The ACA Impedance Check component shall, in conjunction with the user interface, allow user to check the quality of the connection of the scalp electrodes to the Client's head.

6.5.3 ACA Signal Processing

The ACA Signal Processing component shall have the following functions:

- Organize the template for presenting the acoustic stimuli in a pseudo-random manner
- Using the signals recorded from the Audio I/O component, identify the stimulus onset and extract the corresponding cortical response
- Determine quality of the extracted response and accept / reject it as appropriate
- Perform averaging of all accepted cortical responses to each presented stimulus
- Perform ongoing statistical analysis on accepted responses
- Pass on acquired data and analysis results to the user interface for display

6.6 Data Storage

The Data Storage component shall provide the database interface for storing and retrieving the following data:

- User information
- HEARLab™ system information
- Client information
- Assessment records
- Calibration records
- Test settings

6.7 User interface

The User Interface component shall provide the means for obtaining user input for ACA test configurations and for displaying the recorded cortical responses as well as subsequent analysis for the user to see. It shall only provide the user with options that are within safety limits, e.g. not allowing users to select presentation levels exceeding 110 dB HL.

6.8 Message Bus

The Message Bus is the component by which different components can communicate with each other, and makes use of the Windows® messaging system.