Processing of DRAM Device Variables

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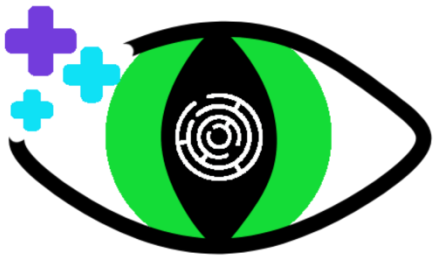


This document explains in detail the tables where the collected information is recorded and the processing of the variables stored in the database after the functional tests with the DRAM device. On GitHub, there is a CSV and SQL file with 4 tables, which are explained below.

Table 1 - User Registration

The first table corresponds to the users registered in the database for individual rehabilitation with the device. It has an "**ID**" column that represents the unique identification of the user. It also has a "**Users**" column that represents the username of the individual who wishes to undergo therapy. Finally, in the "**Password**" column, the password associated with the username is stored, which allows access to the graphical interface and the ability to carry out rehabilitation through therapy sessions.

Table 2 - Check & Errors

This second table stores the unique identification as a foreign key in the "**ID**" column. Additionally, the "**Distancia**" column stores the user's distance from the device in millimeters to ensure data fidelity when collected during therapy. The "**Nivel**" column records the level at which the user performed the therapy, allowing for analysis of ocular rehabilitation across different levels.

To analyze the various times in which the user managed to complete the zones of a level and observe progress through certain areas of the maze, a series of checkpoints were established across all levels. Two of these are "**Tiempo_CHKP_1**" and "**Tiempo_CHKP_2**", which store

time values in nanoseconds. The “**Tiempo_total**” column represents the sum of these times until the user completes the maze level.

To track the errors made by the user, it was proposed that users should not touch the maze walls; otherwise, the error count would increment by one, with these errors stored in the “**Errores**” field. To distinguish these therapy times from other therapies completed or canceled by the same user, the “**Num_Sesiones**” field was used, enabling traceability of sessions performed by a single individual. Finally, the previously mentioned maze zones are added to indicate in which zone the user finished at any level, allowing an understanding of whether the user found the maze level easy or challenging.

With the mentioned data, linear regression was performed using the fields “**Errores**” or “**Tiempo_total**” against the “**Num_Sesiones**” field. Two regressions were conducted to observe the trend of errors and total time against the number of sessions completed by the user. To perform this type of regression, it is necessary for the user to have completed at least one full week of rehabilitation sessions (8 days).

Figure 1. Linear Regression

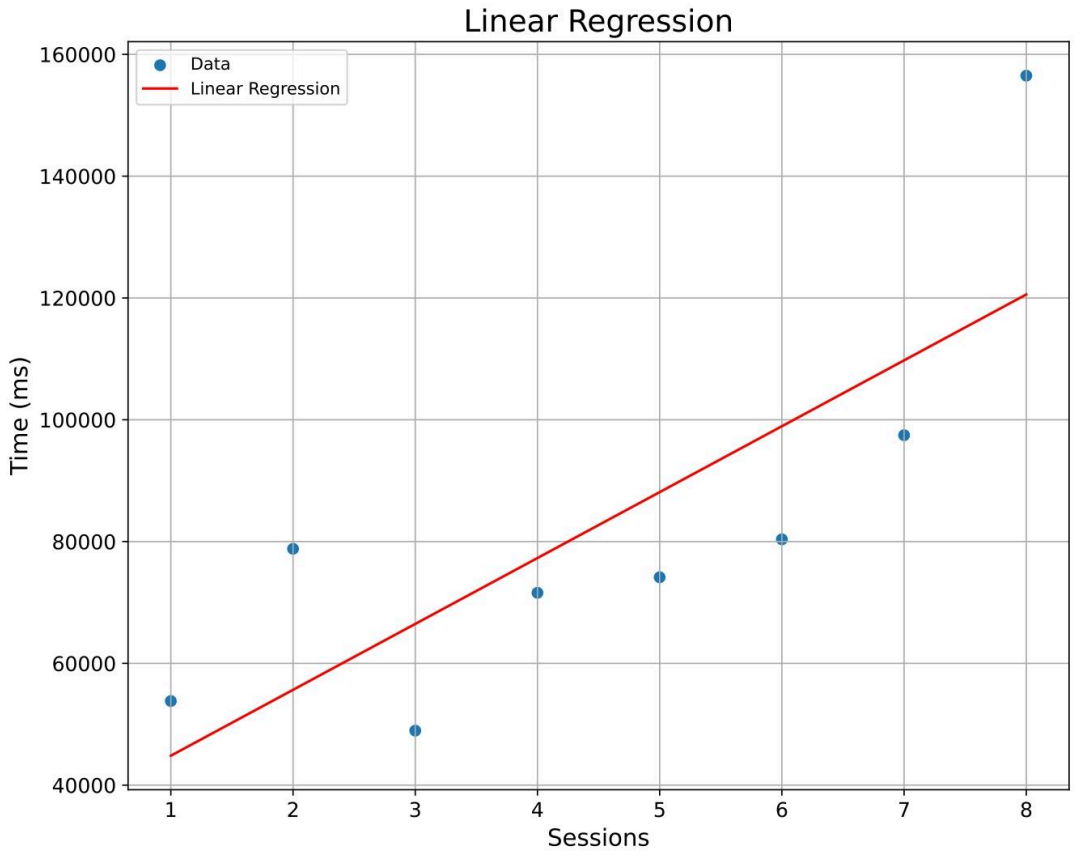


Table 3 - Displacements

The third table stores the records of ocular displacement performed by users during rehabilitation therapies. This is the most important table, as it allows for various analyses of lateral and anteroposterior eye movements in each of its operating modes: right monocular, left monocular, and binocular.

This table consists of a "**Fecha**" field to locate the records by date and time (YYYY/MM/DD), enabling an exhaustive search of ocular displacements. The unique identifier "**ID**" serves as a foreign key to relate the data to the user performing the therapy. The fields "**DireOjos_H**" and "**DireOjos_V**" record the ocular direction used by the user to navigate the maze, using characters to indicate whether the pupils are deviating to the right, left, up, down, or remaining centered. To record the (x, y) coordinates of the pupils during ocular displacement, the fields "**Iris_Der**" for the right eye and "**Iris_Izq**" for the left eye are used. Additionally, the fields "**Mov_Lateral_D**" and "**Mov_Lateral_I**" record the lateral movements of the right and left eyes in pixels (px) in the monocular mode of the therapy. The field "**Mov_Lateral_Bin**" records the lateral movement of both eyes in binocular mode, also in pixels (px). Similarly, anteroposterior movement is recorded depending on the mode of operation using the fields "**Mov_Anteroposterior_D**", "**Mov_Anteroposterior_I**" and "**Mov_Anteroposterior_Bin**" all in pixels (px). Lastly, the "**Modo_Operación**" field records the selected mode of operation, as the user can choose to perform the therapy for the left eye, right eye, or both eyes.

The values of lateral and anteroposterior movements are also represented through ellipse graphs. To create these graphs, the central points (h, g) were first calculated. This requires finding the maximum and minimum values of the "x" axis (lateral movement) and the "y" axis (anteroposterior movement) of the eye, which are subsequently used in the following equations:

$$h = \frac{X_{Min} + X_{Max}}{2} \quad g = \frac{Y_{Min} + Y_{Max}}{2}$$

To find the lateral and vertical limits of the ellipse (a^2 and b^2, respectively), the following formulas are used:

$$a^2 = \left(\frac{X_{Max} - X_{Min}}{2}\right)^2 \quad b^2 = \left(\frac{Y_{Max} - Y_{Min}}{2}\right)^2$$

Finally, to find the values that make up the ellipse, three numerical sequences of 11 components are generated. These sequences represent the *y* values of the ellipse, the *x* values on the right side of the ellipse, and the *x* values on the left side of the ellipse. To determine the *y* values, the

first value in the sequence is the maximum anteroposterior value, and the remaining 10 values are calculated using the following mathematical formula:

$$\sum_{n=1}^{11} y[n-1] - \frac{(y_{Max} - y_{Min})}{10}$$

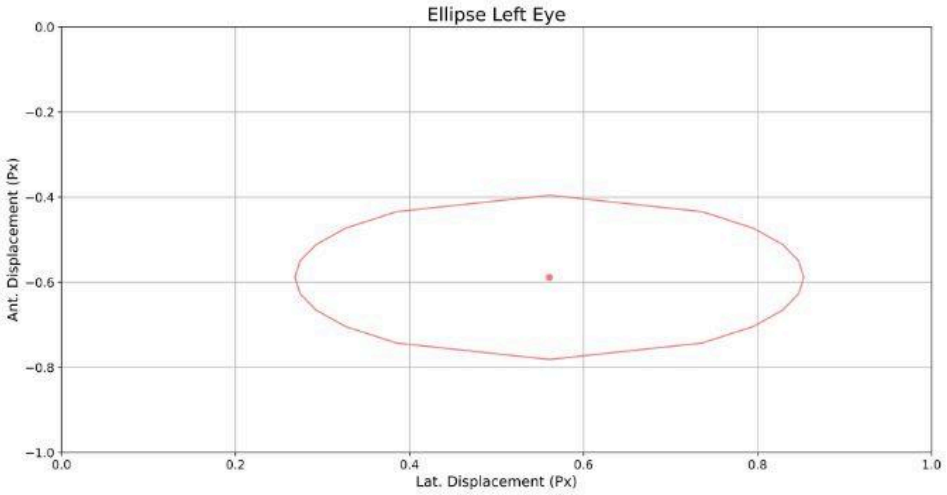
Then, to find the *x* values on both the right and left sides of the ellipse, the initial and final values of the 11-number sequence are set to the previously calculated value of "h." The remaining values are obtained using the following mathematical formula:

$$\text{x\_der} = \sum_{n=1}^{10} = -\sqrt{1 - \frac{(y[n]-g)^2}{b^2} * a^2} + h$$

$$\text{x\_izqr} = \sum_{n=1}^{10} = \sqrt{1 - \frac{(y[n]-g)^2}{b^2} * a^2} + h$$

Finally, the data obtained from these three sequences are plotted, resulting in an ellipse as shown in **Figure 2**. These ellipses can represent the movements of the right eye, the left eye, and also depict binocular vision during the rehabilitation process.

Figure 2 - Ellipse



Additionally, to better observe the differences in displacements, **boxplots** are created using the variables "**Mov_Lateral_D**", "**Mov_Lateral_I**" and "**Mov_Lateral_Bin**" for the lateral displacement of the eyes in pixels (px), depending on the selected therapy. For the

anteroposterior movement, the variables “**Mov_Anteroposterior_D**,” “**Mov_Anteroposterior_I**,” and “**Mov_Anteroposterior_Bin**” are used. These boxplots allow for an in-depth analysis of the user's rehabilitation progress over the course of the therapy sessions.

Figure 3 - Boxplot

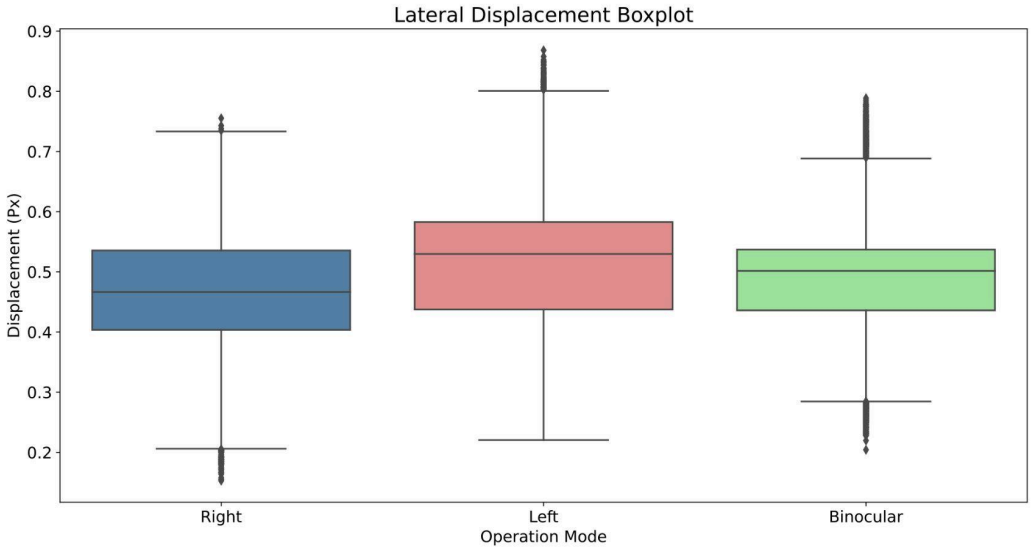


Table 4 - Time & Errors

In this final table, time and error data for a complete rehabilitation session are collected, recording the total times and errors obtained in each of the five mazes or those the user was able to complete. First, the unique identifier “**ID**” is used as a foreign key to relate these results to each user. The “**Fecha_Inicial**” field records the date and initial time of the therapy session, while “**Fecha_Final**” records the date and final time when the session ended. This allows tracking of the time elapsed during the various sessions performed by the user. To distinguish between sessions, the “**Sesiones**” field uses an ascending count to indicate the session number. The total time in nanoseconds is recorded using the fields "**Tiempo1**", "**Tiempo2**", "**Tiempo3**", "**Tiempo4**" and "**Tiempo5**". Similarly, errors in each completed level are recorded using the fields "**Error1**", "**Error2**", "**Error3**", "**Error4**" and "**Error5**" with each field corresponding to a specific level, as indicated by the ascending numbering. Finally, the fields "**Error_total**" and "**Tiempo_total**" represent the cumulative calculation of total errors and total time in nanoseconds for a complete session.