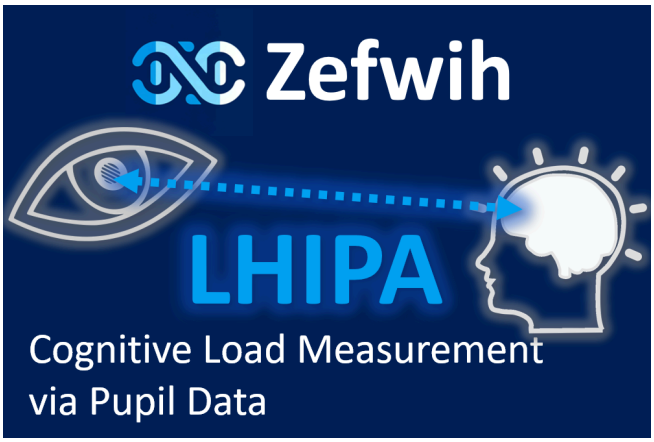
LHIPA - Low-High Index of Pupillary Activity and Mental Load Calculator



Unity Asset Documentation

v1.0

Introduction

The **LHIPA (Low-High Index of Pupillary Activity)** is a cognitive workload metric based on fluctuations in pupil diameter. It is widely used in cognitive science, human-computer interaction, and psychology to assess mental effort in real-time or post-processed data analysis.

What is LHIPA?

LHIPA is computed by analyzing high-frequency changes in pupil diameter using **Symlet16-Wavelet transformation**. It is independent of sampling rate and provides a standardized measure of cognitive load.

A **higher LHIPA value** indicates increased cognitive demand, while a **lower value** suggests minimal effort or distraction.

- **Example Values:**
  - 0.05 = Low cognitive load
  - 0.25 = High cognitive load

Scientific Background

For more details on LHIPA, refer to:

Duchowski, A. T., et al. "**The Low/High Index of Pupillary Activity (LHIPA): A Psychophysiological Measure of Cognitive Workload**". CHI Conference on Human Factors in Computing Systems, 2020.

Asset Key Features

✅ **Plug & Play:** Drag the script into your Unity scene and call the LHIPA function with pupil diameter data—computation happens automatically!
✅ **Cross-platform:** Works on **desktop, mobile, and VR** applications.
✅ **Live & recorded data:** Supports **real-time LHIPA computation** and post-analysis of **pre-recorded eye-tracking data**.
✅ **Configurable settings**
✅ **Well-documented & example scenes:** Includes **two demo scenes** showcasing LHIPA integration.

Technical Details

How LHIPA is Calculated

LHIPA is computed by analyzing the **power of high-frequency bands** in the pupil signal using a **Symlet16-Wavelet transformation**. This method detects changes in pupil size associated with mental workload.

What's Included in the Asset?

- **LHIPA Calculation Script** – The core script for computing LHIPA.
  2 Example Scenes:
  - **Eye Tracking Simulator:** Simulates real-time LHIPA computation.
  - **LHIPA Testing Scene:** Allows testing with recorded pupil diameter data.
- **2 Prefabs:**
  - **Eye Tracking Simulator UI** – Example UI for live data processing.
  - **LHIPA Tester UI** – UI for analyzing recorded data.
- **Example pupil diameter data** in `pupil_diameter_signals.json`.

Technical Requirements

- Unity **2020.1 or newer**
- **TextMeshPro** (required for UI elements)
- **Newtonsoft.Json** required for reading and writing recorded json data.

You can install both of the packages in the Unity Package Manager (*Window -> Package Manager -> TextMesh Pro* and *Window -> Package Manager -> Newtonsoft.Json for Unity*)

Usage

LHIPA.cs is the main script and *CalculateLHIPA()* the main method you need to calculate a LHIPA value. Just call *CalculateLHIPA()* with an array of pupil diameters and provide the recording time in seconds and get the LHIPA value. The method can be called **in real-time** (with a running eye tracker) or **retrospectively** (using recorded data).

CalculateLHIPA() Method Inputs

- float[] pupilDat: Array of pupil diameters in mm (min. length: 256)
- float durationInSeconds: Time between first and last data point
- float modMaxCorrectionThreshold: Threshold for modulus maxima correction
- bool debugLog: Enable detailed logging in Unity Console

CalculateLHIPA() Method Output

- float LHIPA: Value between 0 and 1 representing cognitive load

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Scripts & Methods

1. LHIPA.cs

Description

This is the **core script** for calculating the **Low-to-High Index of Pupillary Activity (LHIPA)** based on a **pupil diameter signal**. (See above)

modMaxCorrectionThreshold Details

This threshold is used to **eliminate noise** in modulus maxima values that arise from rounding errors.

Best correction values:

- `0.01 - 0.1` recommended
- Higher values may reduce noise but affect sensitivity

Example regression results:

Threshold	R^2	F-Value	β	α
0.0	0.31	43.08	0.14	0.043
0.05	0.056	5.86	0.096	0.065
0.1	0.049	5.06	0.097	0.065

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2. LHIPATester.cs

Description

A testing class to compute LHIPA values for **recorded data or simulated input arrays**. Further examples, how to use *CalculateLHIPA()* are in the Start()-Method.

Public Variables

- public float durationInSeconds: Duration of the data sample
- public float modMaxCorrectionThreshold: Correction threshold for LHIPA
- public string inputFilePath: Path to recorded eye-tracking data
- public string outputFilePath: Path for LHIPA result logs
- public bool consoleLog: Enable logging in Unity console
- public float[] eyeDiametersExampleArray: Example pupil diameter data

Public Methods

TestLHIPAAndLog(bool useInputFile)

Computes LHIPA for test data and logs results.

Parameter:
useInputFile: If true, uses recorded data; if false, generates test arrays

Returns:
public string: Path to logfile with LHIPA values

GenerateTestArrays()

Generates 100 sample pupil diameter arrays for testing.

Returns:
List<float[]>: List of float arrays</returns>

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3. EyeTrackSimulation.cs

Description

Simulates eye-tracking data to test LHIPA calculations in Unity. *CalculateLHIPA()* is called live every *calculationInterval* seconds. Can be used as an example, how to work with a real eye tracker.

Public Variables

- float baselineDiameter: Average pupil diameter
- float simulationSwitchInterval: Time between high/low pupil sizes
- float samplingRate: Simulated eye tracker sampling rate
- bool startWithScene: Auto-start simulation
- float calculationInterval: LHIPA calculation interval
- float modMaxCorrectionThreshold: Correction threshold
- bool showDetailedCalculationLog: Enable debug logging
- float currentLHIPAValue: Stores latest LHIPA value

Public Methods

StartSimulation()

Starts eye-tracking simulation and the live calculation.

StopSimulation()

Stops eye-tracking simulation and the live calculation.

GetPupilDiameterFromEyeTracker()

Returns:
float: Random pupil diameter

Additional Components

UI Scripts

Handle example **UI interactions** with canvas (button clicks, text field inputs, displaying the results) in the provided prefabs and scenes.

SharpWave (Wavelet Library)

Modified sharpWave implementation with Symlet16 and updated decompose()-methods. Based on sharpWave by graetz23: https://github.com/graetz23/sharpWave under MIT License: https://github.com/graetz23/sharpWave/blob/master/LICENSE

Can be replaced with other wavelet implementations if needed.

Contact

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