# EMPE - Application Documentation

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## Introduction

\*\*EMPE\*\* is a desktop application created as alternative software for the *\*Embodying Math&Physics Education\** project.

It is used for real-time acquisition, visualisation and analysis of data from EMPE Lidar distance sensors. The programme has been designed for educational applications, enabling precise physical experiments to be carried out, such as measuring free fall.

The application communicates with the sensors via serial ports, cable, or Bluetooth   
and offers a rich set of tools for interacting with data.

## Main Features

- \*\*Support for two sensors\*\*:   
Ability to work with one or two EMPE Lidar sensors simultaneously, with dynamic mode switching.

- \*\*Live data visualisation\*\*:   
Presentation of real-time readings on an interactive graph.

- \*\*Advanced chart customisation\*\*:   
The user can modify, among other things, line thickness, axis unit range, enable smoothing (moving average) and automatic chart scrolling.

- \*\*Dynamic themes\*\*:

The interface automatically adapts to the light or dark theme of the operating system for a comfortable working experience.

- \*\*Multilingualism\*\*:

support for Polish and English, with the option to change languages while the application is running.

- \*\*Time interval measurement (optically triggered stopwatches)\*\*:   
A dedicated window for measuring the time between detected "events" (changes in the distance of the measured object), with adjustable sensitivity of the optical gate threshold.

- \*\*Data recording\*\*:

Possibility to export collected measurement data and time intervals to files in `.csv` format for further analysis.

- \*\*Developer tools\*\*:   
Hidden debug menu (accessible with the shortcut `Ctrl+0`) displaying raw data from ports and global time.

**## User Manual**

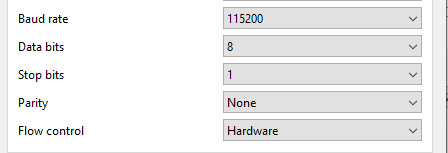
1. \*\*Start-up\*\*:   
After launching the application, the main window will appear.

2. \*\*Port configuration\*\*:

- Go to `☰ Menu` -> `Port Settings`.

- In the new window, select the appropriate COM ports for your sensors. You can refresh the list of available ports by clicking `Refresh`.

- Configure the transmission parameters (speed, data bits, etc.) or leave the default values.  
Receiving data:



3. \*\*Selecting the operating mode\*\*:

- In the main window, select the `Use two COM ports` box if two sensors are connected and used simultaneously. Otherwise, do not select it.

4. \*\*Starting the measurement\*\*:

- Press the `Start` button in the main window or on the graph to start collecting data. The button will change its name to `Stop`.

5. \*\*Observation and analysis\*\*:

- Open the graph window (☰ Menu -> Graph) to visualise the data.

- Open the stopwatch window (☰ Menu -> Stopwatches) to measure drop times.

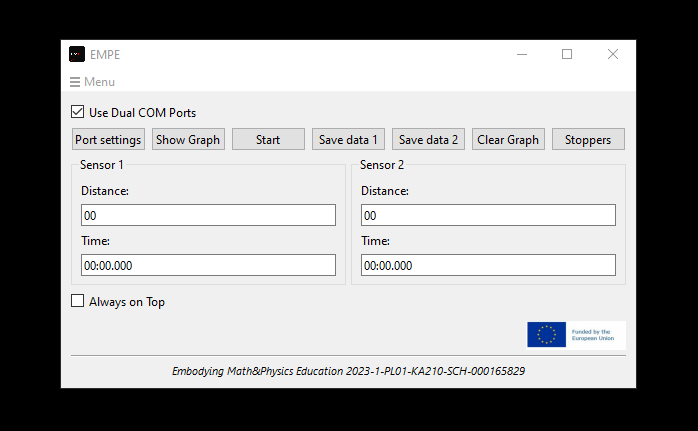
6. \*\*Finish and save\*\*:

- Press `Stop` to end the measurement.

- Use the `Save data 1` / `Save data 2` buttons in the main window or `Save result` in the stopwatch window to export the data to `.csv` files.

## Description of Window Functions

### Main Window



The application control centre.

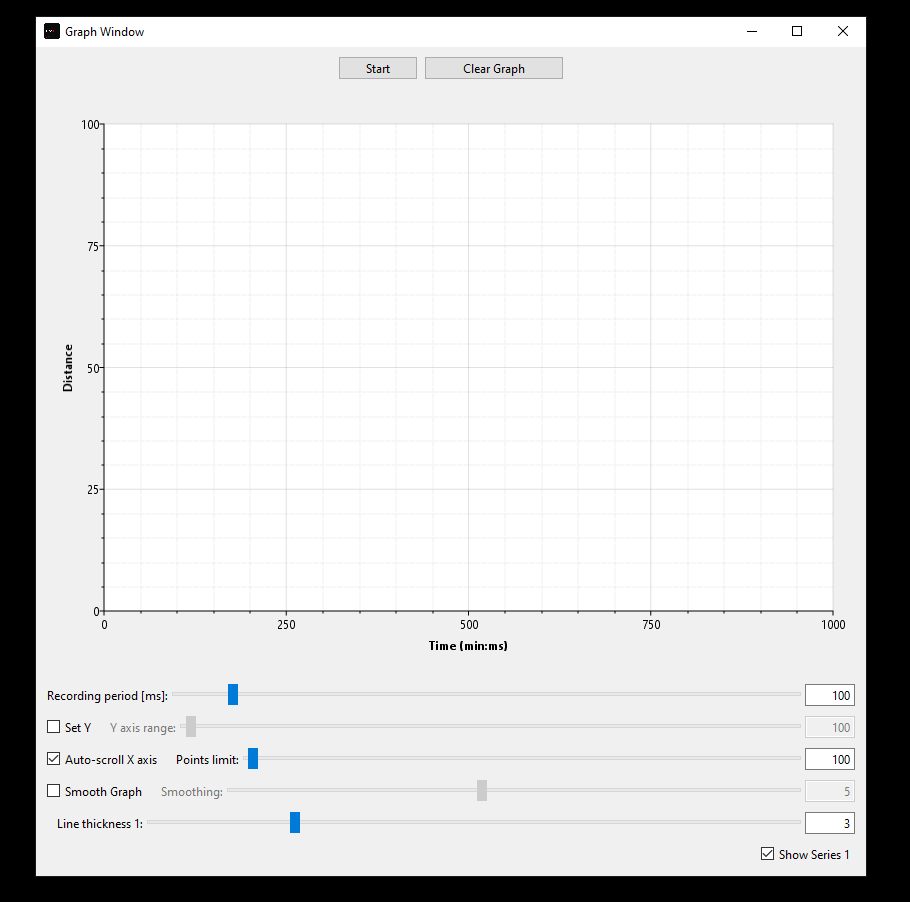
- \*\*Displays\*\*:   
Show the latest distance and time readings for each sensor.

- \*\*Buttons\*\*:   
Allow you to start/stop measurement, save data, and open other windows.

- \*\*COM mode switch\*\*:   
Allows you to choose whether the application should listen on one or two ports. One or two distance sensors simultaneously.

- \*\*Always on top\*\*:   
Keeps the application window on top of other windows.

### Graph Window



- \*\*Graph\*\*: Dynamically plots distance as a function of time.

- \*\*Controls\*\*: `Start`/`Stop` and `Clear graph` buttons.

- \*\*Customisation\*\*:

- `Y-axis range`: Manual or automatic scaling of the Y-axis.

- `Automatic X-axis scrolling`: Enables/disables chart scrolling and allows you to set a limit on the number of points displayed.

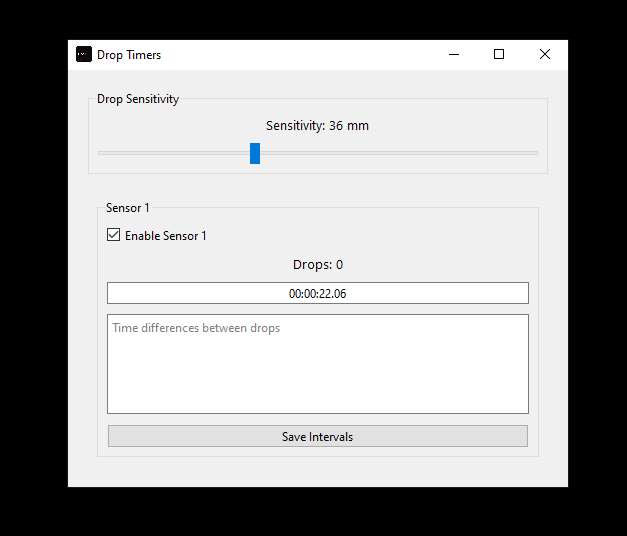
- `Smooth graph`: Activates a moving average algorithm to reduce noise.

- `Line thickness`: Allows you to adjust the thickness of both data series.

- `Show series`: Allows you to temporarily hide one of the data series when using two lidars simultaneously.

### Stopwatch window

The stopwatch starts when you press the start button on the main window. It is an optical gate that counts the elapsed time after exceeding a set distance threshold.



A tool for analysing events.

- \*\*Distance threshold\*\*: A slider that determines how much change in distance (in mm) is recorded as an "event".

- \*\*Counters\*\*: Count the number of events detected by the optical gate for each sensor.

- \*\*Stoppers\*\*: Measure the total duration of the measurement session.

- \*\*Interval log\*\*: Displays the time elapsed between successive events.

- \*\*Results log\*\*: Exports the recorded intervals to a `.csv` file.

### Port Settings

Configuration of the connection to the sensors.

- \*\*Port selection\*\*: List of available COM ports.

- \*\*Transmission parameters\*\*: Baud rate, data bits, stop bits, parity, flow control.

- \*\*Port information\*\*: Displays detailed data about connected devices.

### Debug Menu

Available under the shortcut `Ctrl+0`.

- \*\*Global time\*\*: Displays the common, largest time from both sensors.

- \*\*Raw data\*\*: Shows unprocessed data frames received from serial ports, which is useful for diagnosing communication problems.

- \*\*Data generator\*\*: The `Start Fake Data` button allows you to test the application without connected sensors.

## Technologies

- \*\*Language\*\*: C++20

- \*\*Framework\*\*: Qt 6 (modules: Core, Gui, Widgets, SerialPort, Charts, LinguistTools)

- \*\*Build system\*\*: CMake

## Project Compilation

To compile the project, you need a C++20 compiler, CMake, and the Qt 6 library installed.

1. Clone the repository.

2. Create a directory for build files (e.g. `build`).

3. Run CMake to generate the project:

```bash

cmake -B build -S .

```

4. Compile the project:

```bash

cmake --build build

```

## Glossary

| Term (Polish) | Term (English) | Description |

| :--- | :--- | :--- |

| \*\*COM Port\*\* | \*\*COM Port\*\* | A serial communication port used to connect the computer to the Lidar sensors. |

| \*\*Dual COM Mode\*\* | \*\*Dual COM Mode\*\* | An application mode where data is read simultaneously from two sensors connected to two different COM ports. |

| \*\*Raw Data\*\* | \*\*Raw Data\*\* | Unprocessed data frames (e.g., `YY100T5000E`) received directly from the sensors before being interpreted. Available in the Debug Menu. / The unprocessed data frames (e.g., `YY100T5000E`) received directly from the sensors before being parsed. Available in the Debug Menu. |

| \*\*Stoppers / Drop Timers\*\* | \*\*Stoppers / Drop Timers\*\* | A feature and a window used to measure time intervals between detected "drops". / A feature and a window used to measure time intervals between detected "drops". |

| \*\*Distance threshold\*\* | \*\* Thresold \*\* | A configurable threshold (in millimetres) in the Stoppers window that defines how large the change in distance must be to be considered a "drop". / A configurable threshold (in millimetres) in the Stoppers window that defines how large the change in distance must be to be considered a "drop". |

| \*\*Intervals\*\* | \*\*Intervals\*\* | The time elapsed between two consecutive registered events. This data can be saved to a `.csv` file. / The time elapsed between two consecutive registered drops. This data can be saved to a `.csv` file. |

| \*\*Graph Smoothing\*\* | \*\*Graph Smoothing\*\* | An algorithm (moving average) applied to the graph data to reduce noise and show a smoother trend line. |

| \*\*Fake Data Generator\*\*| \*\*Fake Data Generator\*\*| A tool in the Debug Menu that simulates sensor data, allowing for application testing without physical hardware. / A tool in the Debug Menu that simulates sensor data, allowing for application testing without physical hardware. |

| \*\*Auto-scroll\*\* | \*\*Auto-scroll\*\* | A graph feature that automatically shifts the time axis to the left as new data arrives, keeping the latest measurements in view. / A graph feature that automatically shifts the time axis to the left as new data arrives, keeping the latest measurements in view. |

| \*\*Points Limit\*\* | | In auto-scroll mode, this setting determines the maximum number of data points displayed on the graph at one time. |

| \*\*Relative/Absolute Time\*\*| \*\*Relative/Absolute Time\*\*| A graph setting. Absolute time is the total time since the sensor started. Relative time is the time since the current measurement session began (starts from zero). / A graph setting. Absolute time is the total time since the sensor started. Relative time is the time since the current measurement session began (starts from zero). |

| \*\*Baud Rate\*\* | \*\*Baud Rate\*\* | The speed of data transmission over the serial port, measured in bits per second. It must match the sensor's settings. / The speed of data transmission over the serial port, measured in bits per second. It must match the sensor's settings. |

| \*\*Flow Control\*\* | \*\*Flow Control\*\* | A mechanism in serial communication to prevent the sender from overwhelming the receiver's buffer. |

## Licence

This programme is free software; you may redistribute it and/or modify it under the terms of the \*\*GNU General Public Licence, Version 3\*\* of this Licence or (at your option) any later version.