MIXING TIME DETERMINATION - Using Colorimetric Method

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Introduction

This program was developed to determine the global mixing time of a reactor, with a colorimetric method. It will analyze an experimental video and return the mixing time.

We developed this program to characterize our bioreactor. We were looking for a global measurement method, due to a colorimetric one.

The program essentially converts the experiment video into frames and analyzes the color change in four areas on the video (explanation in the topic “Select the Areas”), chosen by the user. It will find the frame that the experiment starts and, from there, analyzes, in this first version, the green component of the RGB color space and determines the mixing time.

Why does the program analyze only the green component of the RGB? On this first version, we prepared to analyze a color change from colorless to magenta. This change mainly affects the green component of the RGB (Red, Green, Blue) color space.

Graphical User Interface (GUI)

When the user presses the **“Start Program” button**, a new window will appear named “Data Filling”. There are 5 parameters that the user needs to fill in:

1. **Click on “Search” button** and select the experiment video.
2. Enter **the name of the folder** where the frames will be saved.
3. If you will use it for the first time or want to change the 4 areas selected previously, **select the check button** to select the areas.
4. If you want to discard a final part of the video, enter the **time value (seconds)** you want to remove. Otherwise enter **0**.
5. Enter the **name of the worksheet** where the results will be saved.

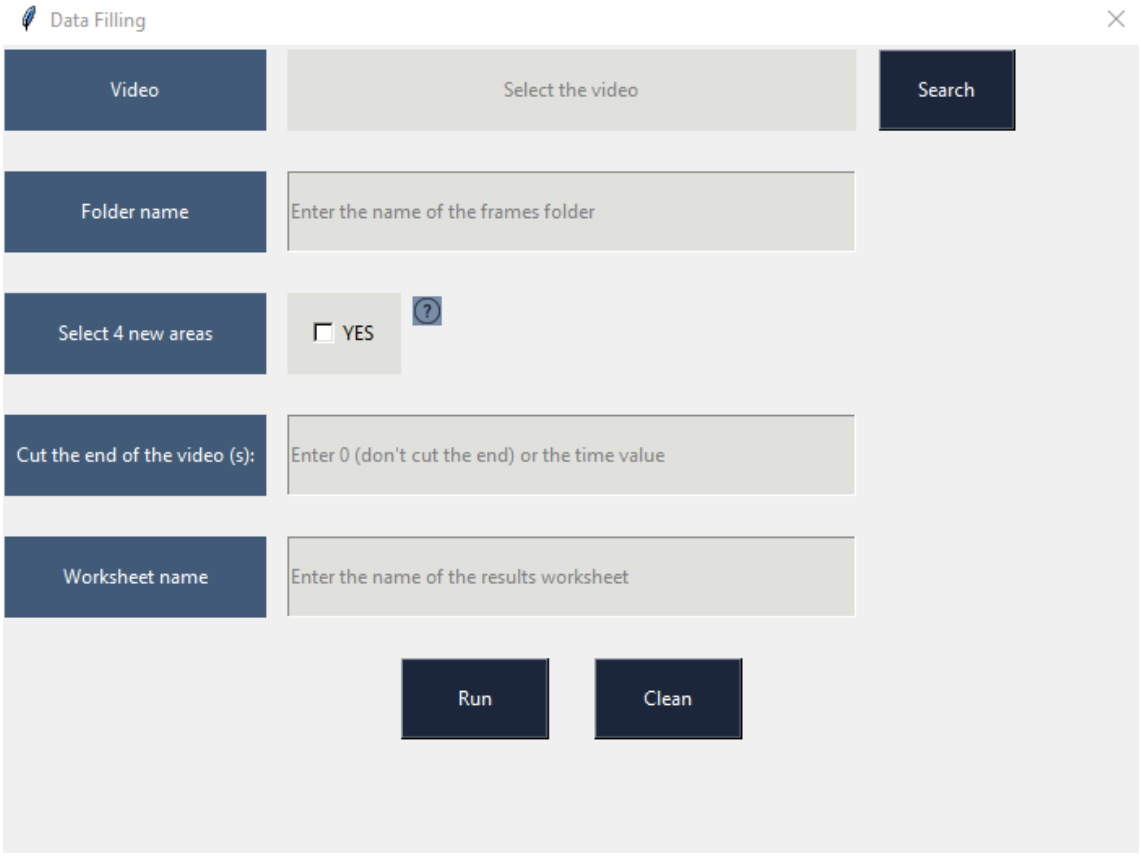

Figure 1 – Data Filling window

After filling in all data, press **"Run" button** to start the program (a message box will appear asking to confirm). "Data Filling" window will close, and a new one will appear, listing what the program is doing, step-by-step. When a step has been completed, "OK" is writing in front of it.

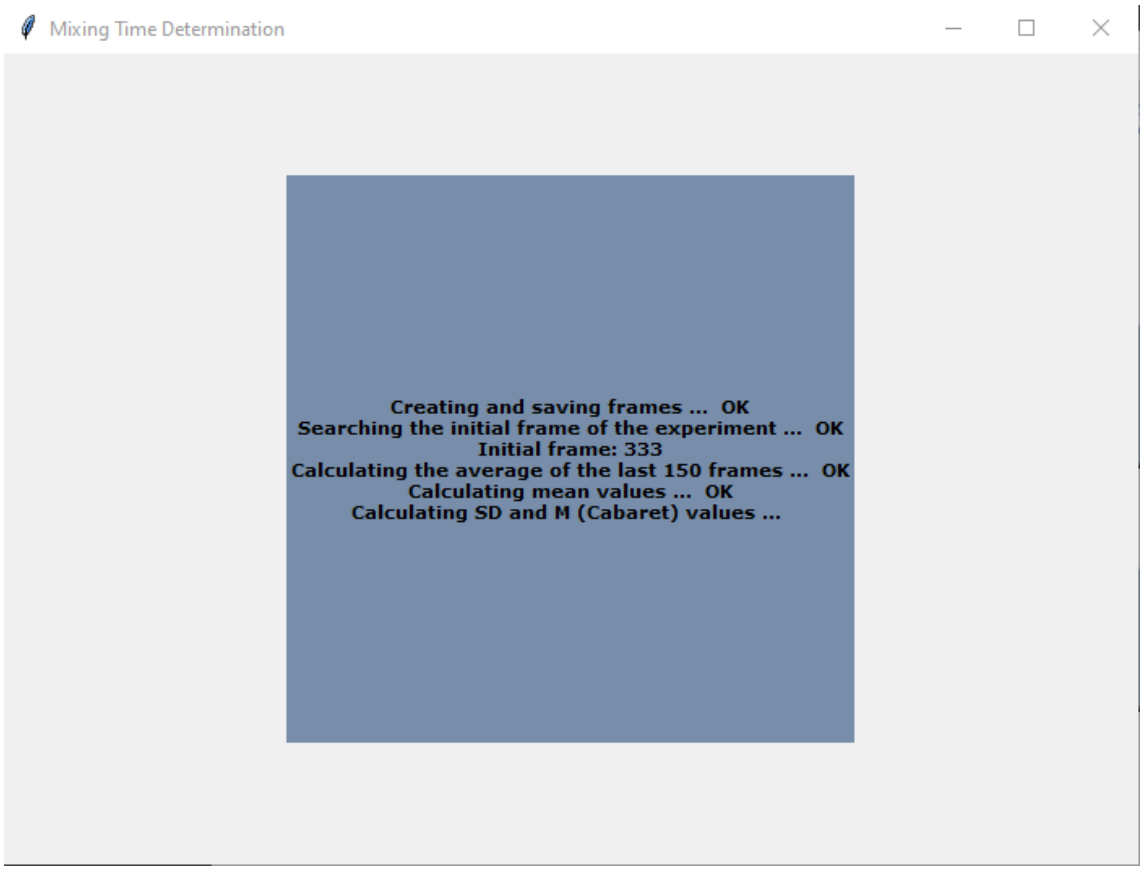

Figure 2 – Window with the steps of the program.

Program steps and how we used it are described below.

Experiment Video

This program was tested with a video recorded with a 30 frame per second (fps) camera. Keep in mind that the higher fps, the slower the program processing takes.

The user selects the video that wants to analyze. It will be converted to multiple images, depending on the fps: 30 fps video generates 30 images per second of video.

Select the Areas

This initial version of the program requires the user to select 4 areas of the analyzed equipment.

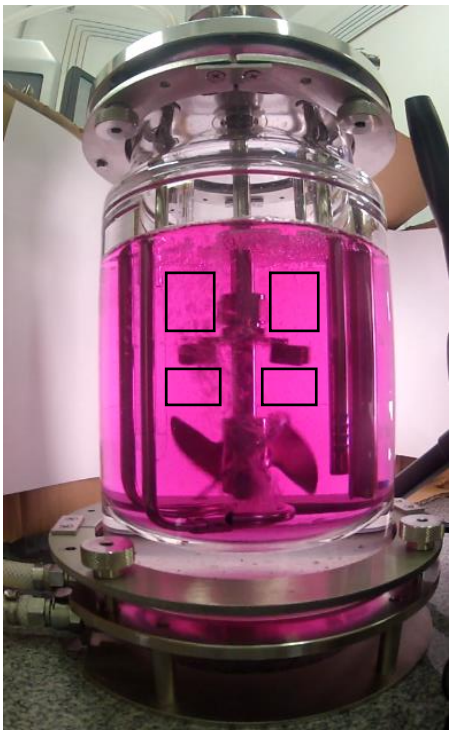

Figure 3 – Example of geometry used to limit the four areas.

An important detail is that the user must first select the area where the tracer was injected. That is necessary to find the initial frame of the experiment.

The first frame of the selected video will appear with a title "Select four areas (Press Space to confirm the selection):". First select the tracer injection area and press Space bar, then select three more areas, which one press Space to confirm.

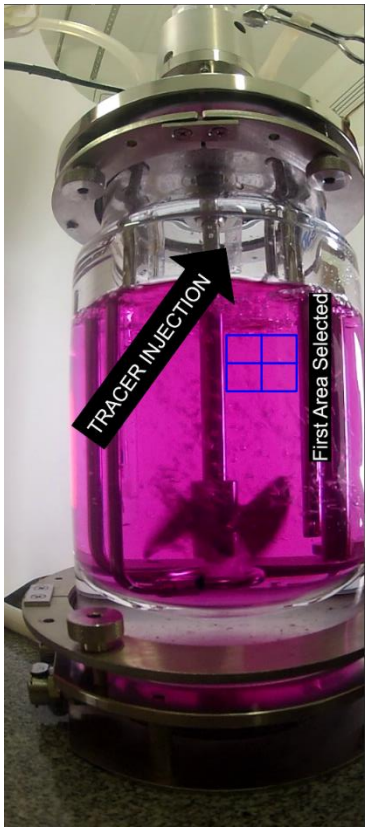

Figure 4 – Example of first area selected.

Automatic Initial Frame Locator

Once the areas have been selected, the program will find the start experiment frame. The frame number, according to the frame folder, will appear on the steps of the program window.

Color Change Analysis

To analyze the pixels on the areas and determine the mixing time, the program uses three methods to evaluate the color change per image: **Mean green values; Standard deviation values; M value (Cabaret *et al.*, 2007)**

Results: Mixing Time, Graphs and Worksheet

Each color change analysis method results in a mixing time (showed in the program steps window).

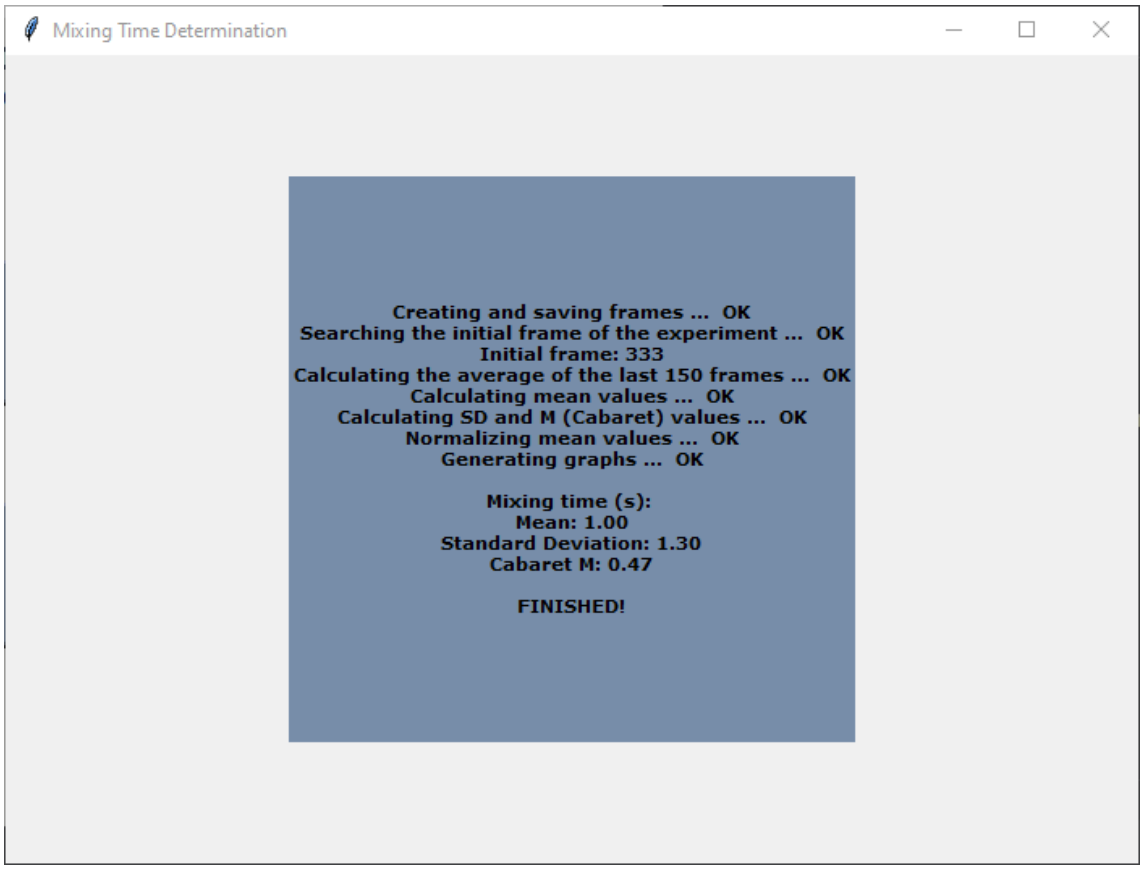

Figure 5 – Final steps of the program window.

The program shows two graphs by method: first one is the results by area (top graph) and second the normalized results (bottom graph).

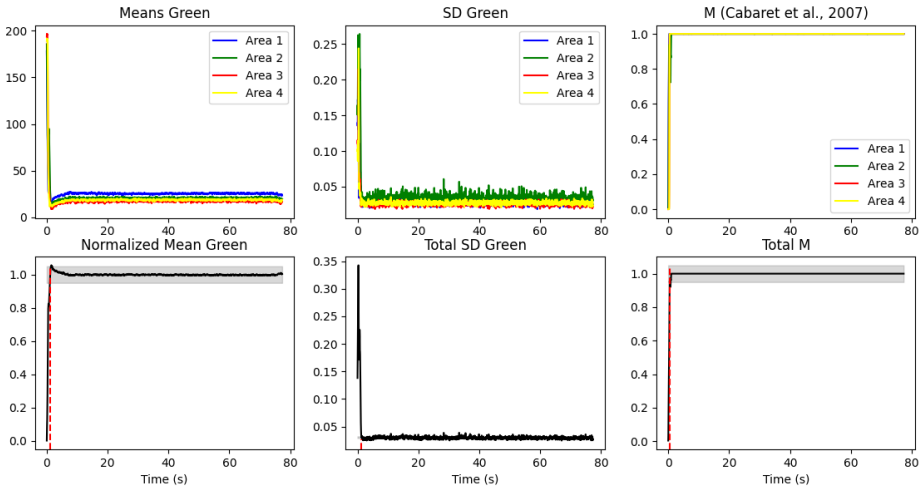

Figure 6 – Graphs of the results.

The program saves all the results (mixing time included) in a worksheet, with a title typed by the user on Data Filling window.

NOTE: This is the first version. Updates will be released.

Reference:

CABARET, F. *et al*. Mixing Time Analysis Using Colorimetric Methods and Image Processing. **Industrial & Engineering Chemistry Research**, v. 46, n. 14, p. 5032–5042, jul. 2007.