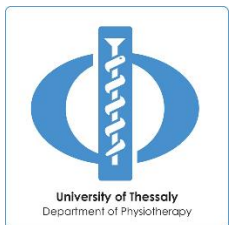




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Copyright

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Application General Information

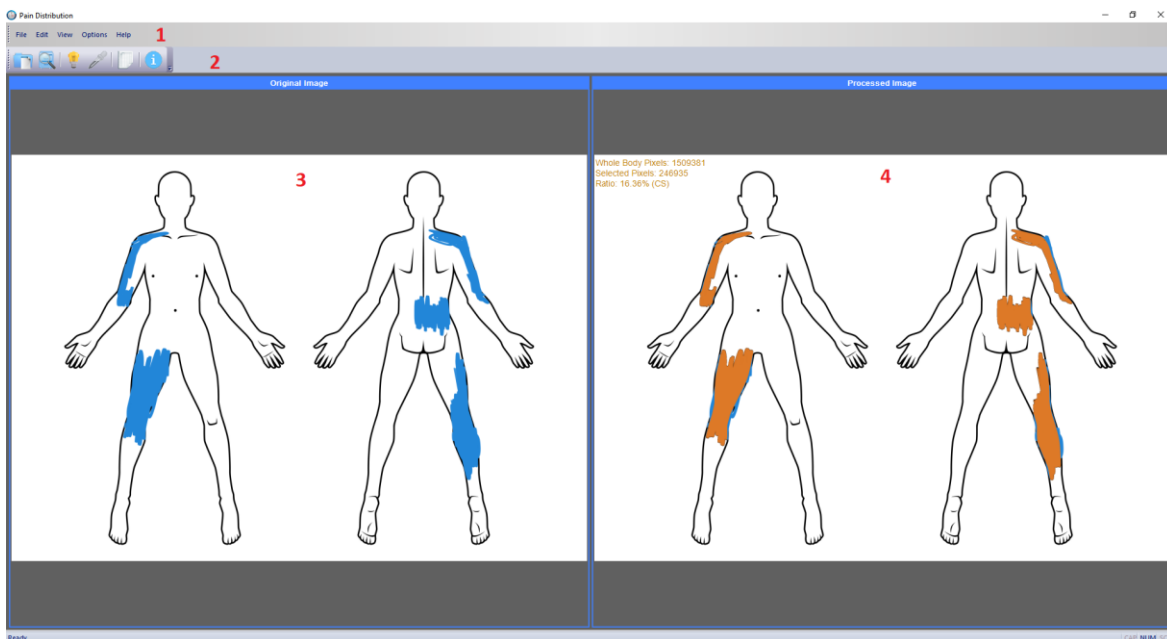
Pain Distribution is an application that automatically calculates the number of the pixels the patient has chosen and therefore quantifies the pain extent, provides the frequency distribution from a group of images, and has the option to select the threshold over which the patient is considered with central sensitization (CS). Additionally, it delivers results and statistics for both every image and the frequency distribution, providing mean values, standard deviations, and CS indicators, as well as the ability to export them in *.txt file format for further analysis.

Installation

Windows Users: Download the application, run the installer and follow the instructions.

MacOS Users : The application is tested and runs without problems in MacOS by using the [WhineHQ emulator](#).

The User Interface



1. The Menu
2. The Toolbar
3. The original image
4. The processed image

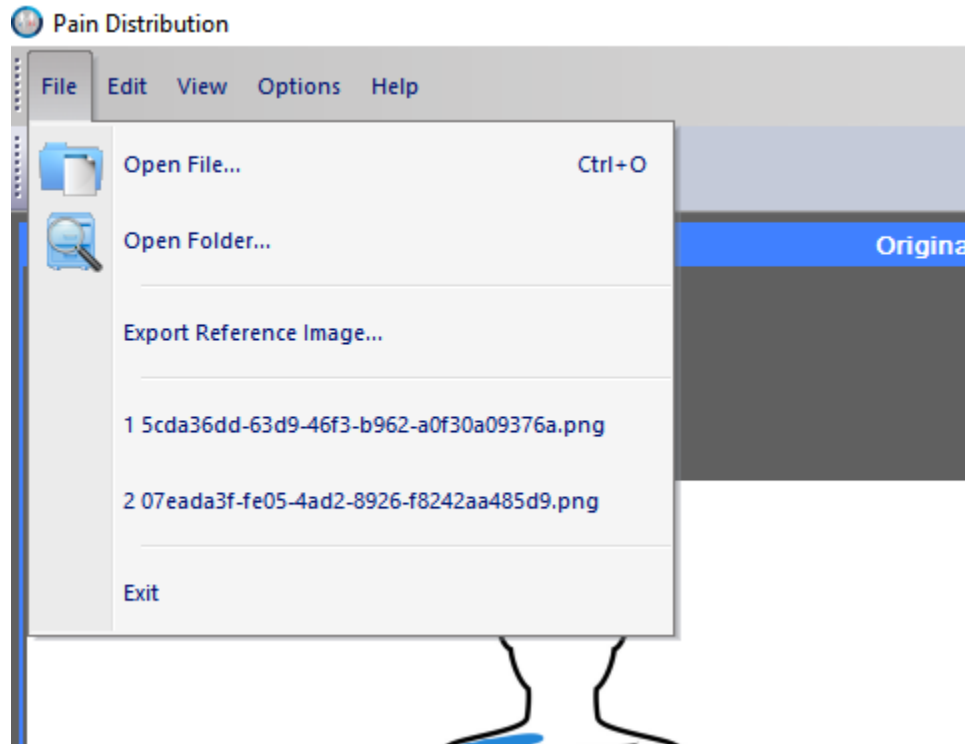
Note: At the 1.1.0 version of the software the “Compare two files”  Compare two files **has been added in File Menu as well as on the toolbar.**



1. The Menu

The menu bar contains all the commands of the program. Specifically:

The File (contains **Important Reading!**)



- **Open File...** : Opens and process one image.
- **Open Folder...** : Opens a folder with images and process all of them at once.
- **Export Reference Image** : Exports the reference image used as template by the application.

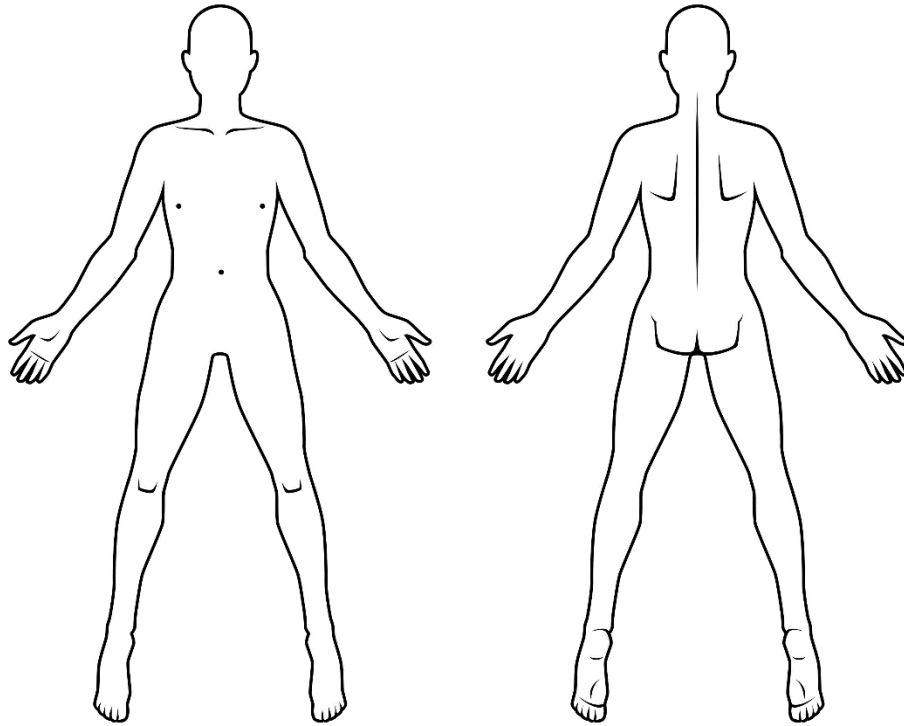
Important Reading: The Pain Distribution application, in order to automate its calculations, uses a standard reference image (template) and no other image should be used by the users.

Go File>Export Reference Image and save the template (Reference.png) on your disk. Transfer the template image on your tablet and use it with your sketching application of choice (there are plenty of them online given for free). After the patients have sketched the pain areas on the reference image with a color pen (with any color other than black or-obviously- white), transfer the images from the tablet to your Pain Distribution application for processing.

The creation of the reference image (template) was a complicated task: had to be in HD (many pixels), the front and back figure areas being of the same size, had to provide easy recognizable

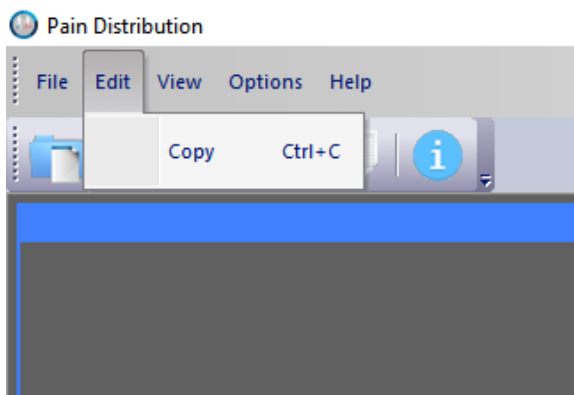


body parts, had to deliver most of the body areas for sketching, had to be genderless, and many other complicated technical demands (see *Application Errors, page 12*).



The above is the reference image and it was created by the professional Illustrator [Thodoris Tibilis](#).

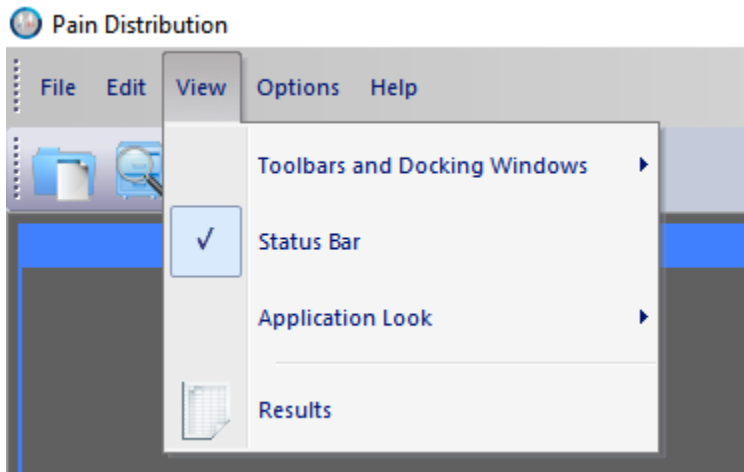
The Edit



Go Edit>**Copy** to copy the Processed Image on your clipboard for transferring. Should the user needs both images, original and processed, can use PrntScr and crop the area of interest by using a windows build-in app like Paint.

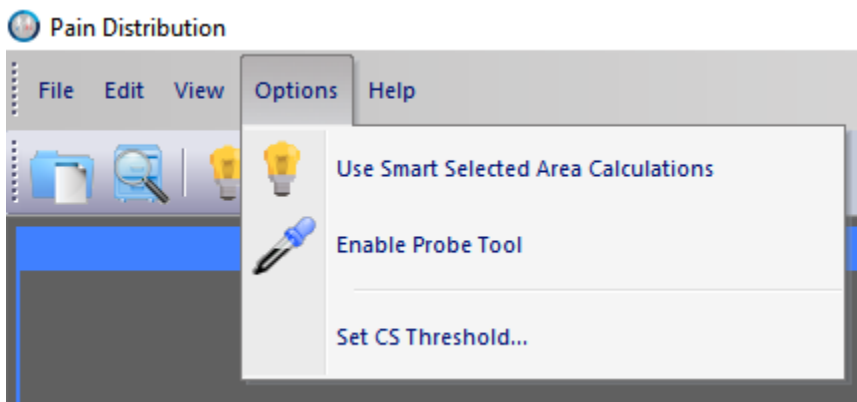


The View



- **Toolbars and Docking Windows** : Use Standard or Customize the docking of the application's Toolbars.
- **Status Bar** : Use or not a Status Bar at the bottom of the application.
- **Application Look** : Change how the application looks according to your taste.
- **Results** : Delivers the processing results. As it is necessary to explain how the application works first, the Results are discussed latter (*see page 9*).

The Options (contains **Important Reading!**)



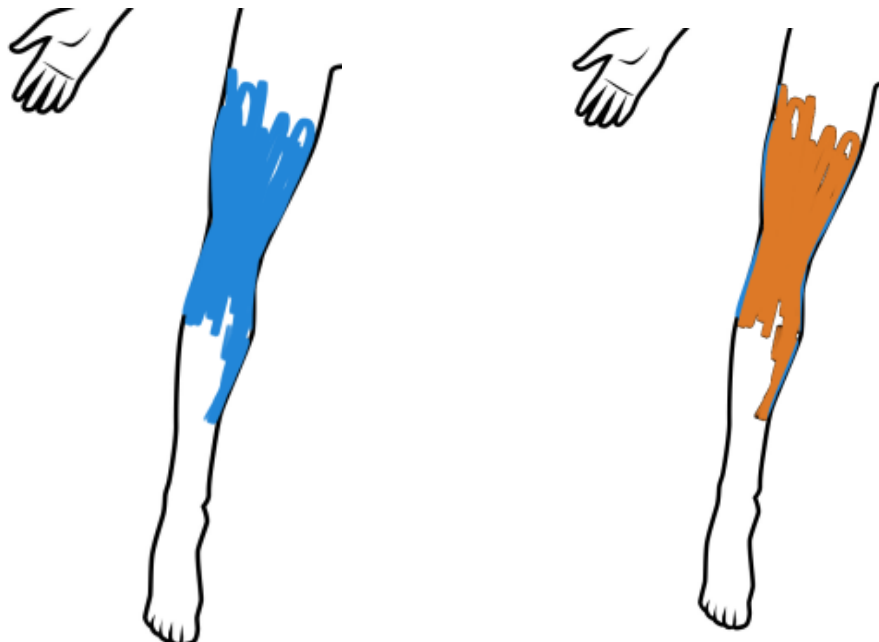
- **Use Smart Selected Area Calculations** : The Pain Distribution application has calculated the number of the pixels of the whole-body areas and compares this number with the number of the pixels the patient has chosen with the color pen. Then, it creates a processed image at the right side of the original one (*see User Interface 3 and 4 at page 2*).



By default, the application excludes all the colored pixels selected by the patients that happened to exceed the boundaries of the body chart and uses for the calculations only the ones that are inside the body-chart areas. In order to provide visual inspection and proof, the pixels used by the application for the calculations are showed in the Processed Image by the complementary of the color used by the patients, while the pixels not included in the calculations are left in their original color, as it is shown below.

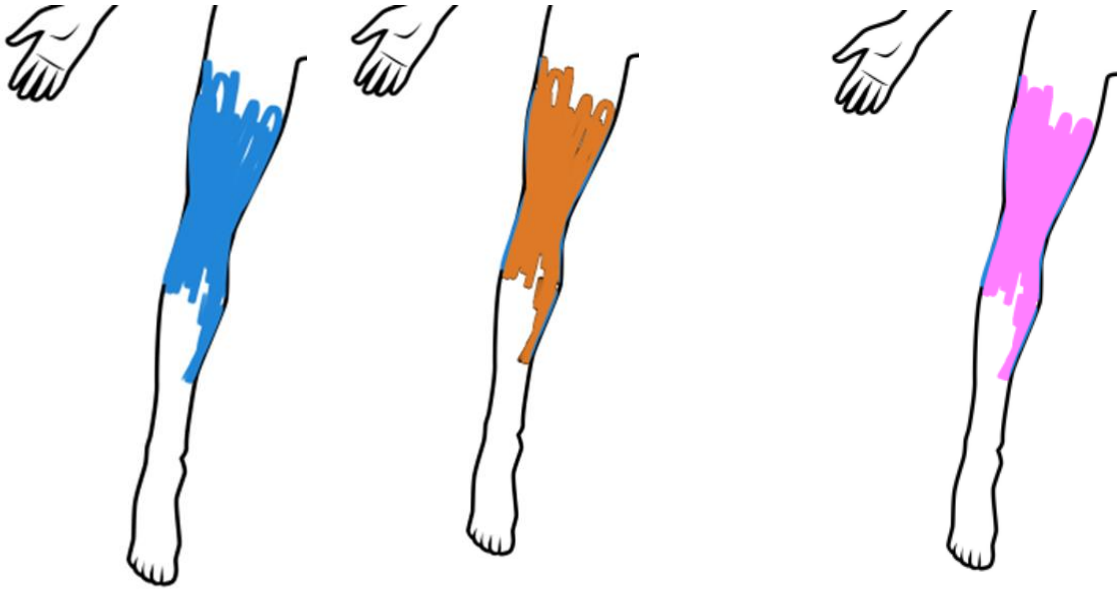


Occasionally, some patients leave uncolored some areas that we are sure they intended to be colored, like these small white areas inside the colored areas shown below. Notice that in the processed image at the right, these white areas inside the colored selected areas are not included in the calculations.





By selecting the “Use Smart Selected Area Calculations” option these areas are covered with color and take part in the calculations, as it is shown below.



Original Image
option

Processed without “Use Smart
Selected Area Calculations” option

Processed with “Use Smart
Selected Area Calculations”

Notice that when the Use Smart Selected Area Calculations option is chosen, the color of the calculated area changes to pink. Therefore, users are advised to avoid using the pink color on the pen. However, although the instruction of avoiding black or white pen color is strict, for the pink color is not: the processed image may not be visually correct, but all the calculations will be done in a valid way.

Important Reading:



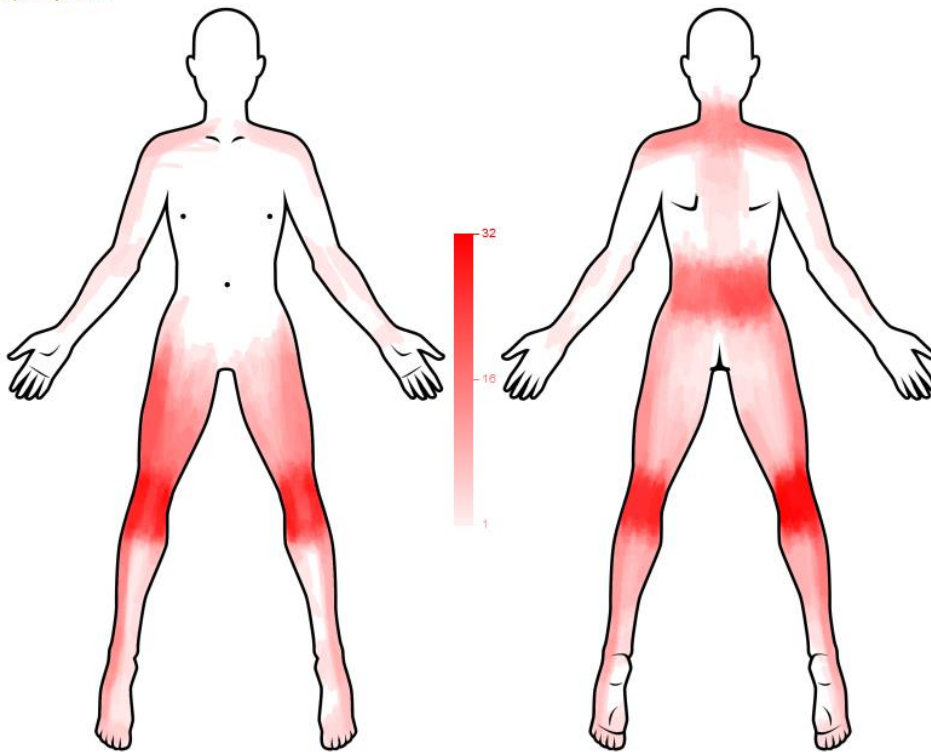
There will be cases where the patients intentionally leave an area uncolored, like in the example on the left. In these cases, the Use Smart Selected Area Calculations option should not be used.

Users are advised to inspect all the images before they use this option in order to avoid erroneous calculations.

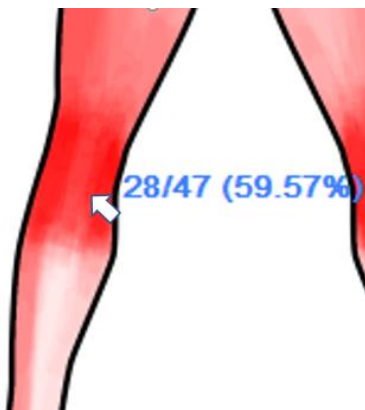


- **Enable Probe Tool** : This tool provides the Frequency Distribution image, like below.

Maximum Frequency: 32/47



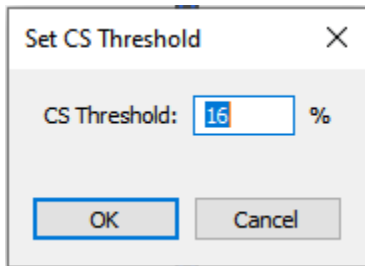
In order to use this tool, a folder of images should be selected (*see Open Folder, page 3*). The Frequency Distribution image explains the frequencies in a color bar, while at the top left informs the user about the Maximum Frequency. By placing the mouse cursor on the colored area, frequency information of that specific point is provided, like below.



This information comes in a form of $x/y (z\%)$, where x stands for the number of images that have been colored at the selected point, y stands for the total number of images and z stands for the percentage of the x over y .



- **Set CS Threshold...** : Prior to any calculation, the user should select the threshold over which the patient is considered with CS. When this option is selected, a dialog box like below appears.



The application uses a dummy number of 16%, but the user should use the number recommended from the bibliography or the scientific research papers, or he could simply use his own number to test an idea.

The Help

Delivers information about the contributors, the copyright, provides contact information and opens the present application guide.

2. The Toolbar

The toolbar provides shortcut buttons for the most useful commands of the program, as it is shown below.



The above icons, from left to right, stands for Open File, Open Folder, Use Smart Selected Area Calculations (*see page 5*), Enable Probe Tool (*see page 8*), Results and the “About the Application”.

The Results

The results are shown either by selecting the above toolbar icon or from the Menu bar, by selecting View>Results. When selected, the following dialog box appears:



Results (CS Threshold = 16 %) ✕

#	Filename	Ratio (%)	CS
1	0d845169-0f1f-4087-94f9-94d1c992014d.png	10.55	false
2	120b17b5-1970-41a6-ab7a-6d26adee5bc3.png	10.87	false
3	14095482-680e-4bec-a26e-557418aa42b6.png	7.01	false
4	145f0cf5-fe93-4b45-86af-6a5e3974b0a3.png	8.70	false
5	200d4adc-946d-46bc-a6e8-f326b0dc98ae.png	13.97	false
6	260d6efc-5122-4e91-9ffb-fcdb04a9e11e.png	8.87	false
7	2dbe0481-c502-4bde-b2ea-af3c14f4814f.png	12.46	false
8	338e8f85-414a-4d9a-add3-ce62727bb5be.png	16.36	true
9	34ef7403-9bfd-4b0e-a32c-a3efad73e46b.png	11.63	false
10	415b5735-94d7-4124-8387-a695582fe38c.png	15.71	false
11	4f31e523-130c-418a-8776-5ae32f396131.png	1.41	false
12	511ac922-adf0-4ea1-ada6-dcca6368de5b.png	19.15	true

CS Threshold = 16 %
Total number of pictures = 47
Number of pictures with CS = 6 (12.77%)

Mean picture ratio = 11.05
Mean picture with CS ratio = 19.98
Mean picture without CS ratio = 9.74

SD picture ratio = 4.06
SD picture with CS ratio = 4.28
SD picture without CS ratio = 3.17

Frequency distribution of the whole picture set = 32/47
Frequency distribution of the CS picture set = 6/6
Frequency distribution of the non CS picture set = 27/41

At the top, information about the CS Threshold chosen by the user (*see page 9*) is provided. All the following calculations use this CS Threshold.

Next, is a table with four columns: the first is the number of the image, the second is the image name, the third is the Ratio (%) of the colored area in relation to the total body area (frontal + back), and the fourth column is the CS indicator (true or false) according the chosen CS Threshold. Notice that the CS incidence is colored red.

Below that table, more detailed information is given about the mean ratio (with SDs) of the whole image set, the CS image set and the non-CS image set.

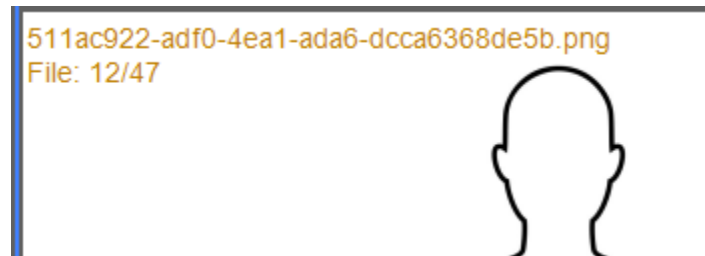
The Frequency Distribution numbers deliver information about how many images have common colored areas in the whole image set, in the CS image set, or in the non-CS image set.

At the bottom right of the dialog box, the user can export the above information in a *.txt file for any further processing in the Microsoft Excel or any statistical software.



3. The Original Image

The original image is the image that comes from the tablet and is colored by the patient. At the top left the image name and number are given.



To scroll between images, use the left-right keyboard arrows or the mouse wheel.

4. The Processed Image

The processed image comes in two forms: a) the processed original image, and b) the frequency distribution image.

- A. The Processed original image always shows the results of the original image being on the left side of the application. At the top left, information about the whole-body pixels, the selected (colored) pixels, the ratio between them, and a possible CS indicator (according to the Threshold chosen by the user) is given.

Whole Body Pixels: 1517036
Selected Pixels: 248146
Ratio: 16.36% (CS)



- B. The Frequency Distribution image is shown when the Probe Tool is enabled (*see page 8*) and provides information about the Maximum Frequency at the top left.



Maximum Frequency: 32/47



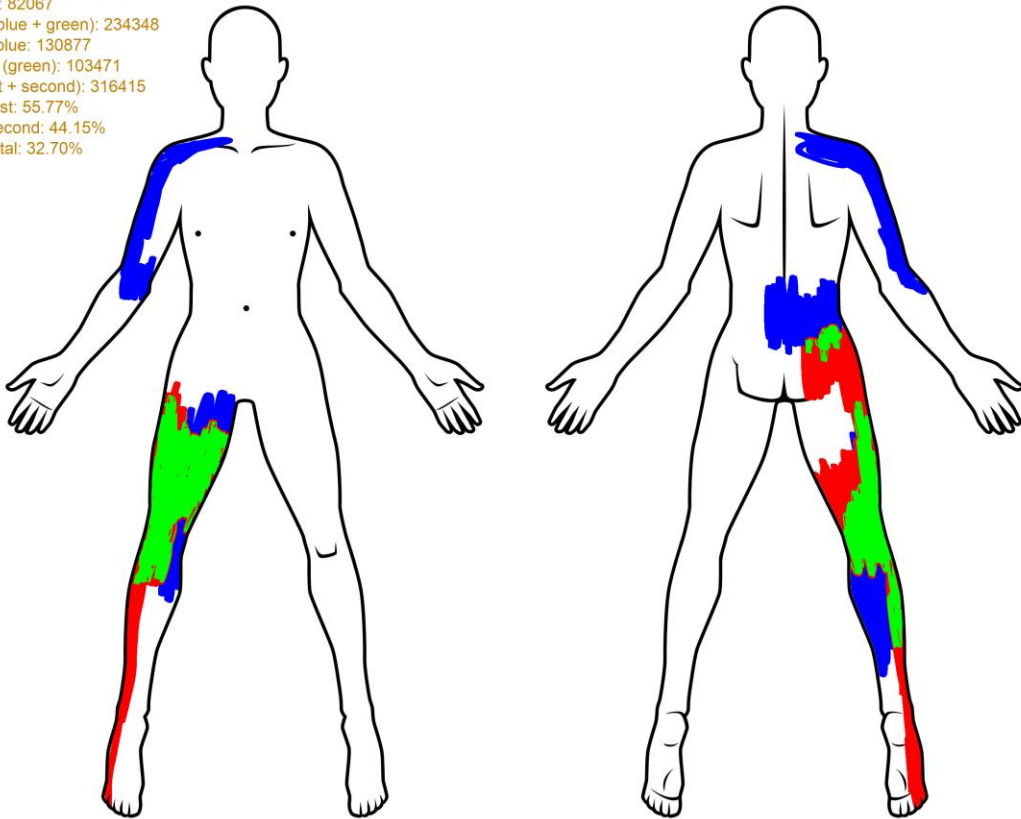
5. File Comparison (in 1.1.0 version of the Software)



In order to fulfill “Reliability Test” needs of the scientific community, the new

tool has been added at 1.1.0 version of the software. The tool provides information (in pixels and percentages) regarding the common and uncommon drawn areas between any two images, as it is shown below:

first total (red + green): 185538
first only (red): 82067
second total (blue + green): 234348
second only (blue): 130877
common area (green): 103471
total area (first + second): 316415
common vs first: 55.77%
common vs second: 44.15%
common vs total: 32.70%





Application Errors

All possible sources of application errors have been investigated thoroughly, and specifically:

1. Validity

- The calculations are valid: the application measures exactly what the patient has colored, and only inside the body shape.
- Validity errors coming from any discrepancies between the area the patient colors as painful and the true painful area are not considered as application's errors.

2. Reliability

- The application is reliable, as it uses the same code methods in any repeated calculation.

3. Reference image errors

- The frontal and back side of the image have the same number of pixels: 758518 each side.

ROI	Voxels	Min Value	Max Value	Mean Value	Std. Deviation	Area (cm ²)	Volume (cm ³)
1	758518	162.00	162.00	162.00	0.00	7585.1800	379.2590
2	758518	162.00	162.00	162.00	0.00	7585.1800	379.2590

- The reference image has been drawn without antialiasing, meaning that they have as less gray tones as possible, and therefore the boundaries of the body shape are recognized without significant errors coming from a gray color area (error of a few pixels on an 1,5m pixels image).
- All the inside-the-body black lines help the patient to recognize his pain areas but have been excluded from the calculations, meaning that even if the patient colors the black line of the scapula, for example, this area is included in the calculations.

Some researches (or clinicians) may want the reference image to follow the rule of nines for burn. Although this issue cannot be considered as an error, the examination of the reference image provided the following results:

- A. Upper extremity: $78253\text{pixels}/1517036\text{pixels} = 5.16\%$. The Frontal Upper Extremity area over the total body area should be 4.5%. Difference 0.7%.

Frame	Voxels	Min Value	Max Value	Mean Value	Std. Deviation	Area (cm ²)	Volume (cm ³)
1	78253	162.00	162.00	162.00	0.00	782.5300	39.1265

- B. Torso: $250803\text{pixels}/1517036\text{pixels} = 16.5\%$. The frontal torso area over the total body area should be 18%. Difference 1.5%.



Frame	Voxels	Min Value	Max Value	Mean Value	Std. Deviation	Area (cm ²)	Volume (cm ³)
1	250803	162.00	162.00	162.00	0.00	2508.0300	125.4015

C. Lower Extremity: $157704\text{pixels}/1517036\text{pixels} = 10.4\%$. The frontal lower extremity area over the total body area should be 9%. Difference 1.4%.

Frame	Voxels	Min Value	Max Value	Mean Value	Std. Deviation	Area (cm ²)	Volume (cm ³)
1	157704	162.00	162.00	162.00	0.00	1577.0400	78.8520

D. Head: $48409\text{pixels}/1517036\text{pixels} = 3.2\%$. Head and neck together should be 4.5%, and neck is considered 0.5%. Therefore, we have a difference of 0.8%.

Frame	Voxels	Min Value	Max Value	Mean Value	Std. Deviation	Area (cm ²)	Volume (cm ³)
1	48409	162.00	162.00	162.00	0.00	484.0900	24.2045

Summarizing the above results, there is a mean of 1.1% (SE 0.2%, range 0.7%-1.5%) difference on each body side, and double [mean 2.2% (SE 0.4%, range 1.4%-3%)] for the whole body (as we have the same frontal and back number of pixels).

The maximum difference of 3% that exists between the sketched body shape and the rule of nines for burn is small; this difference can be considered as an error coming from the points defining the lines that set the boundary between each body part, and therefore, we believe that the reference image follows the aforementioned rule.

License

The Pain Distribution application and its reference image are free for any use by mentioning the contributors. In case of use in research/academic, citing the following paper which regards the application would be highly appreciated:

Kanellopoulos A K, Kanellopoulos E K, Dimitriadis Z, Strimpakos N S, Koufogianni A, Kellari A A, Poulis I A, (2021) Novel Software for Pain Drawing Analysis. Cureus 13(12): e.20422. doi:10.7759/cureus.20422

[\[https://www.cureus.com/articles/77401-novel-software-for-pain-drawing-analysis#!/\]](https://www.cureus.com/articles/77401-novel-software-for-pain-drawing-analysis#!/)



Contact Information

For any bugs, suggestions, questions or other information please contact:

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Please, on the email subject, write: Pain Distribution Application