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CSG6224 Special Topic 1  
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Sleep Monitor Project

Technical Documentation

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# 1.0 Project Methodology

The software is designed to semi automate the analysis of sleep images by detecting points where the sleep position has changed and allowing the user to classify each sleep position and add comments to any frame in the image series.

The method used to determine sleep position changes is called “frame difference” and works by summing the values of the pixels in two consecutive images and calculating the difference between these two values. If the value is greater than the threshold value set by the user, the software marks this position as a sleep position change. The chart including frame difference (blue line), threshold (red line), sleep segment markers (orange lines), and playback position (green line) is shown in Appendix 3 – Sleep Monitor Main Window.

Best results are obtained when using depth images for frame differencing. Infrared images provide a clearer image to allow the sleep researcher to gather information about the sleep position, and for this reason the software loads two series of images and enables the sleep researcher to toggle the display between the two.

Once the analysis is complete, the software exports the analysis to a CSV file. A sample is included in Appendix 4 – Output.csv.

# 2.0 Development Tools

The application is built on the Microsoft .NET Framework 4.5.2 using the C# language and is a 64 bit application. C# is a popular development language because it inherits many of the best features of C++ and Microsoft Visual Basic, but has cleaner syntax and is easier to use (Sharp, 2007). The GUI is developed using WinForms as this platform was the most efficient option for building a desktop application. The IDE used was Visual Studio Enterprise, however none of the features exclusive to this version were used and the project is also compatible with Visual Studio Community and Visual Studio Professional.

# 3.0 Libraries

## 3.1 OpenCV 3.10

OpenCV is an open source computer vision and machine learning software library written in C++ and originally developed by Intel (“OpenCV About,” 2016). OpenCV has bindings for C++, Java, Python and Matlab. OpenCV is used by the Sleep Monitor Project to calculate the sum of the pixel values for each image, and for simple image processing such as x axis flipping of the image before it is displayed in the picture box.

OpenCV is licenced under the 3 clause BSD licence (see Appendix 1 – OpenCV Licence) which exempts the copyright owners from any liability arising from use of the software and allows it to be used by the Sleep Monitor Project without any conditions other than the requirement for distributions of the project in either source code or binary form to be accompanied by this licence.

## 3.2 EmguCV 3.10

EmguCV is a .NET wrapper for OpenCV which allows its functions to be accessed using .NET compatible languages such as C#, VB, VC++, and IronPython (“EmguCV Wiki,” 2016).

EmguCV is licenced under a dual licence system (see Appendix 1 – EmguCV Licence). If an open source licence is used then the project must also be licenced as open source and shared with the open source community. If EmguCV is to be used to derive commercial advantage then a commercial licence must be used and the code does not need to be shared with the open source community (“EmguCV Licencing”, 2016). A commercial licence for EmguCV costs US$199 for a single developer (“EmguCV Commercial Licence Purchase”, 2016).

# 4.0 Configuring the Development Environment

## 4.1 Development Platform

The steps below are from the EmguCV download and installation instructions (“EmguCV Download and Installation,” 2016) and are to be performed on an x64 compatible PC running Windows 7 or later with the following software installed:

|  |  |
| --- | --- |
| Name | Source |
| Visual Studio 2015 (Community, Professional, or Enterprise) | <https://www.visualstudio.com/en-us/downloads/download-visual-studio-vs.aspx> |
| EmguCV Version 3.1 For Windows | [https://sourceforge.net/projects/emgucv/files/emgucv /3.1.0/libemgucv-windesktop-3.1.0.2282.exe/download](https://sourceforge.net/projects/emgucv/files/emgucv/3.1.0/libemgucv-windesktop-3.1.0.2282.exe/download) |
| CMake | <https://cmake.org/download/> |

## 4.2 Compiling OpenCV

Download and extract the OpenCV source code from:

<http://sourceforge.net/projects/opencvlibrary/files/opencv-win/3.1.0/opencv-3.1.0.exe/download>

The steps below assume that the OpenCV source files are extracted to the folder C:/Users/Cameron/Downloads/opencv

Open CMake and configure as per the screenshot below, then click the “Configure” button at the bottom of the screen.



As per the screenshow below, expand the “Build” node and ensure that the only lines containing “opencv” that are ticked are “opencv\_core” and “opencv\_imgproc”. Then click the “Generate” button at the bottom of the screen.



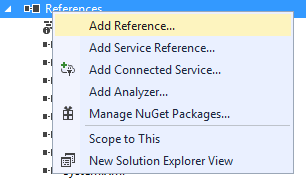
Next, open the file C:/Users/Cameron/Downloads/opencv/build/OpenCV.sln with Visual Studio and build the project.

Once the project has finished compiling, the files opencv\_core310d.dll and opencv\_imgproc310d.dll will be in the folder C:\Users\Cameron\Downloads\opencv\build\bin\Debug. Copy these files to a safe location and the folder C:\Users\Cameron\Downloads\opencv can now be deleted.

## 4.3 Integrating OpenCV and EmguCV with Visual Studio

Create a new project in Visual Studio.

In the solution explorer section, right click on the References section, select Add Reference and add the reference: C:\Emgu\emgucv-windesktop 3.1.0.2282-2\bin\Emgu.CV.World.dll



Right click on the project and select “Add”, then “Existing item



Add the DLL file C:\Emgu\emgucv-windesktop 3.1.0.2282-2\bin\x64\cvextern.dll, and then complete this step again to add the two DLL files created in part 3.2 above.

Finally, add the following two lines to any files that will be using OpenCV and those files will be able to access the OpenCV functions:

using Emgu.CV;

using Emgu.CV.Structure;

# 5.0 Program Structure

## 5.1 Sleep Monitor Main Window (Form1.cs, Form3.cs, and Form4.cs)

The Sleep Monitor main windows is initiated by launching Form1.cs when the program starts. A screenshot of the main window is shown in Appendix 3 – Sleep Monitor Main Window. An explanation of each section of the code and its purpose is outlined in the table below:

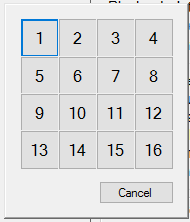
|  |  |
| --- | --- |
| Section | Purpose |
| Constructor | Initiates the form when it is first loaded. Clears the GUI, and chart and sets the waitTime variable which determines the playback speed to the value in App.config. |
| Timer | The timer is used to update the image displayed to provide playback of the image series. When a region on the chart is clicked, the behaviour of the timer is modified so that either the threshold line, or playback position is modified depending on the region clicked. |
| GUI | Updates the the regions of the form below when a new image is loaded, when the chart is modified, and when the form is reset to its initial state:   * 2. Picture box * 5. Details |
| Chart | Provides functionality relating to the chart including the following:   * Initialize the chart * Plot pixel differences (blue line) * Plot threshold line (red line) * Plot playback line (green line) * Plot and unplot segmentation (orange lines) * Get chart X and Y values when chart is clicked * Calculate pixel differences (and clean pixel differences if this setting is enabled in the preferences) |
| Tool strip menu item methods | Methods to provide functionality for:   * 1. Tool strip menu items |

|  |  |
| --- | --- |
| Tool strip menu item actions | Triggered when tool strip menu items are clicked and call methods above. The methods are separate from the actions to allow the methods to also be called by keyboard shortcuts. |
| Button methods | Methods to provide functionality for:   * 3. Transport controls * 7. Segment controls |
| Button actions | Triggered when buttons are clicked and call methods above. The methods are separate from the actions to allow the methods to also be called by keyboard shortcuts. |
| Keyboard shortcuts | Provides functionality for keyboard shortcuts in:   * 3. Transport controls * 7. Segment controls |
| Tool tips | Provides tool tips for the buttons in:   * 3. Transport controls * 7. Segment controls |
| Textbox | Saves the contents of the text box in region 6 before loading new text when the displayed image changes. |

Form3 (shown below) is used to provide feedback to the user and is shown concurrently while the program is parsing the image files and calculating the pixel differences. It closes automatically once processing is complete.



Form5 (shown below) is opened when the user clicks “Categorise sleep segment” in the segment controls. It is closed once the user makes a selection.



## 5.2 Management Class (Management.cs)

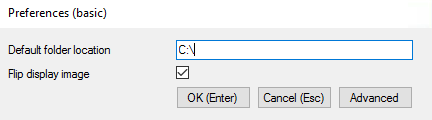
The Management class is comprised of two sections. The first section contains global variables to store information used by different methods inside the forms.

The second section contains a number of methods used to provide functionality to the Sleep Monitor main window. The main functionality provided is listed below:

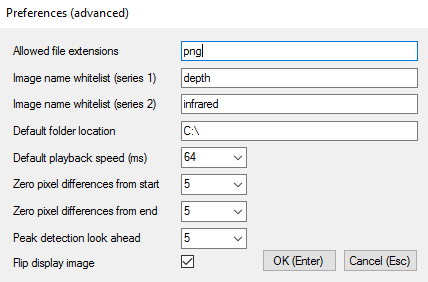
* Calculate pixel values for an image
* Express a file size in human readable form
* Provide a folder dialogue to specify a folder
* Get the contents of a folder and filter according to the settings
* Translate an image counter number to a sleep segment number
* Calculate timestamps relating to a sleep segment number
* Export to CSV

## 5.3 Preferences (Form6.cs and Form2.cs)

When the user clicks the tool strip menu item Edit -> Preferences or the keyboard shortcut F8 is pressed Form6 is opened which shows basic preferences and is shown in the screenshot below:



When the advanced button is clicked the advanced preferences window is opened which contains the two preferences shown in the basic window as well as others:



The functions of the different preference items are outlined in the table below:

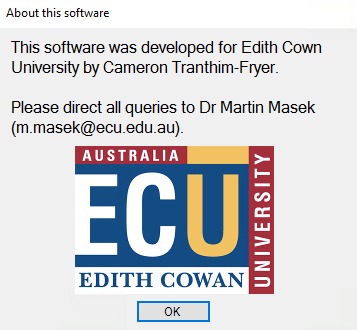
|  |  |  |  |
| --- | --- | --- | --- |
| Preference | Basic | Type | Functionality |
| Allowed file extensions | No | Free text | List of file extensions allowed when new images are loaded into program. Must have at least one entry. Default is “png”. |
| Image name whitelist (series 1) | No | Free text | Whitelist term for images to be loaded into series 1 which is series used to calculate pixel differences displayed in chart. If field is blank then all images in input folder will be attempted to be loaded. Default is “depth”. |
| Image name whitelist (series 2) | No | Free text | Whitelist term for images to be loaded into series 2 which provides alternative display images. If field is blank then alternative display images will be unavailable. Default is “infrared”. |
| Default folder location | Yes | Free text | Default location opened when loading new images into program. Default is “C:\”. |
| Default playback speed (ms) | No | Combo box | Allows the user to set the default playback speed. Default is 64. Range is 2 – 1024. |
| Zero pixel differences from start | No | Combo box | Zeros out pixel differences by number of frames at start of series to avoid spikes relating to set up which affect scale on chart. Default is 5. Range is 0 – 9. |
| Zero pixel differences from end | No | Combo box | Zeros out pixel differences by number of frames at end of series to avoid spikes relating to shut down which affect scale on chart. Default is 5. Range is 0 – 9. |
| Peak detection look ahead | No | Combo box | Number of frames to look ahead when pixel difference exceeding threshold is detected. Avoids having multiple consecutive segment markers relating to a single movement. Maximum value in look ahead range is taken as segment point. Default is 5. Range is 0 – 9. |
| Flip display image | Yes | Check box | Flips image on x axis before displaying in image box. Default is checked. |

When either of the preference windows are opened, the preferences saved in App.config are loaded into the form.

When OK is clicked in either the basic or advanced preference windows, the fields that have free input, such as allowed file extensions, are parsed before saving. Parsing involves removing duplicates regardless of case, removing whitespace, and detecting invalid input. If invalid input is detected a warning window is displayed and the user is returned to the preferences window to make changes before trying to save again. Preferences are saved in App.config which allows them to persist between usage sessions. If cancel is selected none of the changes are saved.

## 5.4 About This Software (Form5.cs)

This a basic form that is triggered by clicking on the tool strip menu item Help -> About. The purpose of this form is to provide the user with basic information about the software and is shown in the screenshot below:



## 5.5 Help

When the user clicks the tool strip menu item Help -> View Help, or presses the keyboard shortcut F1, the file help.pdf located in the same folder as sleep.monitor.exe is opened using the default Windows application for opening PDF files. This allows the user to browse information about how to use the software.

# References

EmguCV Commercial Licence Purchase (2016). Retrieved from <http://www.emgu.com/wiki/index.php/Commercial_License_Purchase>

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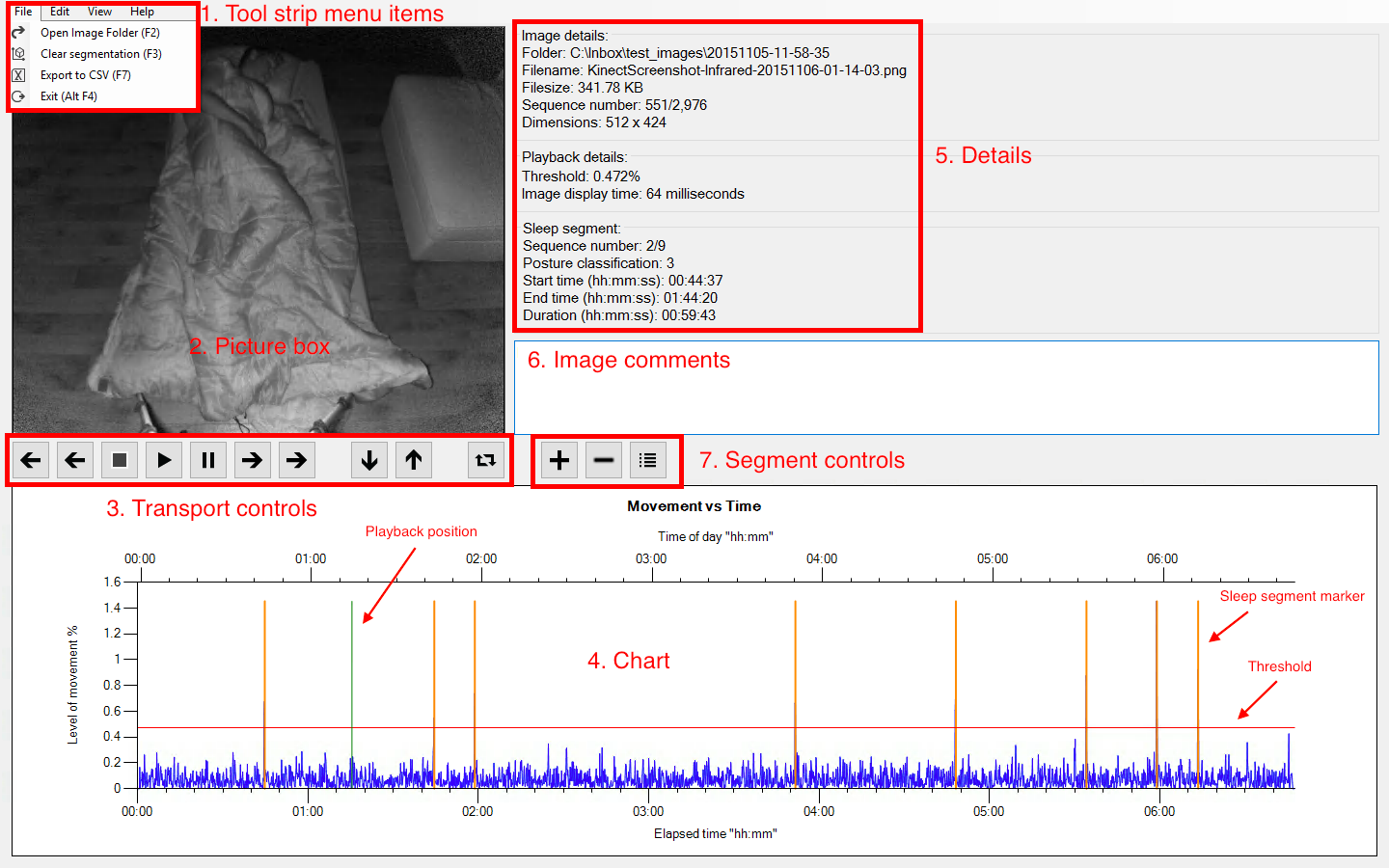
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# Appendix 3 – Sleep Monitor Main Window



# Appendix 4 – Output.csv

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Client: |  |  |  | |  | | |  | | | | |  | |  | |  | |  | |
| Generated: 16-05-2016 04:45:04 | | | |  | |  | | | |  | |  | |  | |  | |  | | | |
| Folder: C:\Inbox\test\_images\20151105-11-58-35 | | | |  | |  | | | |  | |  | |  | |  | |  | | | |
| Threshold value: 0.5218% | | | |  | |  | | | |  | |  | |  | |  | |  | | | |
| Total sleep time: 06:47:28 | | | |  | |  | | | |  | |  | |  | |  | |  | | | |
| Images in series: 2976 | | | |  | |  | | | |  | |  | |  | |  | |  | | | |
| \*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\* | | | | | | | | |  | | |  | |  | |  | |  | | | |
| Image # | Segment # | Image Name | Comment | | Side | | | SSL | | | | | Position | | Segment Duration | | Time (relative) | | Time (absolute) | |
| 1 | 1 | KinectScreenshot-Depth-20151105-23-58-45.png | | | | |  |  | | | 1 | | | 44.6 minutes | | 0:00:00 | | 5/11/2015 23:58 | | | |
| 327 | 2 | KinectScreenshot-Depth-20151106-00-43-22.png | | | | |  |  | | | 2 | | | 59.7 minutes | | 0:44:37 | | 6/11/2015 0:43 | | | |
| 763 | 3 | KinectScreenshot-Depth-20151106-01-43-05.png | | | | |  |  | | | 3 | | | 14.2 minutes | | 1:44:20 | | 6/11/2015 1:43 | | | |
| 867 | 4 | KinectScreenshot-Depth-20151106-01-57-19.png | | | | |  |  | | | 4 | | | 112.9 minutes | | 1:58:34 | | 6/11/2015 1:57 | | | |
| 1097 | 4 | KinectScreenshot-Depth-20151106-02-28-51.png | Random comment | | | | |  | | | | |  | |  | | 2:30:06 | | 6/11/2015 2:28 | |
| 1691 | 5 | KinectScreenshot-Depth-20151106-03-50-13.png | | | | |  |  | | | 0 | | | 56.5 minutes | | 3:51:28 | | 6/11/2015 3:50 | |
| 2104 | 6 | KinectScreenshot-Depth-20151106-04-46-44.png | | | | |  |  | | | 0 | | | 46 minutes | | 4:47:59 | | 6/11/2015 4:46 | |
| 2440 | 7 | KinectScreenshot-Depth-20151106-05-32-45.png | | | | |  |  | | | 0 | | | 24.8 minutes | | 5:34:00 | | 6/11/2015 5:32 | |
| 2621 | 8 | KinectScreenshot-Depth-20151106-05-57-32.png | | | | |  |  | | | 0 | | | 14.5 minutes | | 5:58:47 | | 6/11/2015 5:57 | |
| 2727 | 9 | KinectScreenshot-Depth-20151106-06-12-03.png | | | | |  |  | | | 0 | | | 34.2 minutes | | 6:13:18 | | 6/11/2015 6:12 | |
| \*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\* | | | | | | | | |  | | |  | |  | |  | |  | |

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Sleep Position | Total Duration | % of Total | # Occurrences | Average Duration | |
| 0 | 176 minutes | 43.2 | 5 | 35.2 minutes | |
| 1 | 44.6 minutes | 10.9 | 1 | 44.6 minutes | |
| 2 | 59.7 minutes | 14.7 | 1 | 59.7 minutes | |
| 3 | 14.2 minutes | 3.5 | 1 | 14.2 minutes | |
| 4 | 112.9 minutes | 27.7 | 1 | 112.9 minutes | |
| 5 | 0 minutes | 0 | 0 | 0 minutes |  |
| 6 | 0 minutes | 0 | 0 | 0 minutes |  |
| 7 | 0 minutes | 0 | 0 | 0 minutes |  |
| 8 | 0 minutes | 0 | 0 | 0 minutes |  |
| 9 | 0 minutes | 0 | 0 | 0 minutes |  |
| 10 | 0 minutes | 0 | 0 | 0 minutes |  |
| 11 | 0 minutes | 0 | 0 | 0 minutes |  |
| 12 | 0 minutes | 0 | 0 | 0 minutes |  |
| 13 | 0 minutes | 0 | 0 | 0 minutes |  |
| 14 | 0 minutes | 0 | 0 | 0 minutes |  |
| 15 | 0 minutes | 0 | 0 | 0 minutes |  |
| 16 | 0 minutes | 0 | 0 | 0 minutes |  |