ACSE-5 project 2 Edge enhancement for supporting the interpretation of X-Ray scans

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Description

Code was originally intended to read bmp format images directly (without an specialist library), which was then extended to DICOM images by conversion to bmp through the DMCTK library. Once loaded various filters have been made which combine to give a range of possible effects such as an edge enhancement filter which is intended to help the analysis of X-ray scans by discerning complex bone/tissue structures, spotting micro-fractures and sharpening details.

Code Features

Use of a pure virtual function allows a command line interface where a single pointer to the virtual function can be filled with any of its children. This allows for only one image instance to be created but of different types (bmp or dcm). Both 24 and 8 bit depth bmp files are compatible by using a single index function which uses the files header information to choose where to index (Almost all BMP and DICOM images come in these two depths). This means no other functions need be changed based on the file depth.

User Interface

The UI here is based on a command line interface allowing ease of use with no background in the code structure. A map is used to enumerate the text based options and a switch-case allows actions to be performed. Of course it falls to the user to carry out these methods in a sensible manner.

Robustness

Several checks are implemented on the users input to prevent mistakes causing the program to crash. For example, getline is used so that spaces don't enter multiple commands and un-recognised commands are ignored (the user is prompted again). The some issues come from the user entering the wrong commands, providing valid but non-existent file name or not having the DCMTK[2] pack installed.

Filters

Laplacian filter

The main filters used are variants of the Laplacian filter which convolving our image analogous to taking the second derivative with an explicit spatially central method. We apply it to each pixel and store the new value in intermediate storage to avoid propagation of these changes, which is then re-scaled to fit the into a uint_8 vairable (i.e. 0-255 RGB-colour range).

Two algorithms were implemented, the first being a bi-directional filter which sharpens the divide between pixel intensities in the two perpendicular directions. It is fast to run, but ignores edges in the diagonal directions. The second being the omni-directional variant which can provide better sharpening, but of course requires more computation.

Grey-scaling

The Laplacian filters are best applied to a grey image. Two methods are implemented National Television System Committee[1] and spectral averaging, each of which dictate the weighing applied to each colour channel when averaged to a single intensity value which each color value is set to. NTSC weightings are recommended[1], however in cases where an image has less of a particular color taking the equal-weighted average of each color may provide a greater intensity variance resulting in better edge detection when passed through the Laplacian filter.

Other

A pure black and white filter is also present where pixels below a supplied threshold are made white and the rest black. There is also a color inversion filter, where every pixel is replaced with its opposite color.

DICOM compatibility

The conversion to and from the DICOM format to BMP is provided by the DCMTK[2] pre-compiled binaries and DLLs included in the repository, namely the dcm2pnm and img2dcm applications. These are run from within the C++ code base upon user prompting.

Further work

Possible expansions on this program include:

- Conversion from DICOM format to various other file-types and back
- More filters for better edge-enhancement, such as Sobel filters[3] or adaptive threshold algorithms
- Fixing the potential memory leak issues present as a consequence of the command line based input system
- Improving the robustness of the code from the previously mentioned issues

References

[1] Bruce Justin Lindbloom - 07/02/2019 - RGB Working Space Information - http://www.brucelindbloom.com/index.html?WorkingSpaceInfo.html

[2] DMCTK - 07/02/2019 dicom.offis.de - https://dcmtk.org/

[3] Sobel, Irwin. (2014). An Isotropic 3x3 Image Gradient Operator. Presentation at Stanford A.I. Project 1968.