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

Richard Boyne, Hitesh Kumar

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1 Description

Here we developed the code so that we could read in DICOM images, convert them to BMP, manipulate them and the convert back to DICOM. The edge enhancement filter is intended to help the analysis and interpretation of X-ray scans, helping to discern complex bone/tissue structures, spotting micro-fractures more easily and sharpening the details via abstractions.

2 The filters

2.1 Laplacian filter

The main filters we use are the two common variants of the Laplacian filter (analogous to taking the second derivative with an explicit, centred in space method), and convolving our image with this. We apply it to each pixel and store the new value in temporary, intermediate storage to avoid simulating the propagation of the changes induced by this, and then re-scale all pixels to fit the new information into the 0-255 range, valid as intensity values for RGB-coloured images.

The first variant is the bi-directional filter which sharpens the divide between pixel intensities in the two off-diagonal directions, faster to run and theoretically can provide sharper distinctions between edges but primarily in the two directions, and may have poor results otherwise:

0	-1	0
-1	4	-1
0	-1	0

And the second being the omni-directional variant which solves the issue the previous variant has and can provide better sharpening, but of course requires more computation.

-1	-1	-1
-1	8	-1
-1	-1	-1

2.2 Grey-scaling and colour inversion

To complement the Laplacian filters, pixel operations are provided to convert a 3-colour channel, 24 bit depth BMP to a single channel BMP file (with the same depth) (grey-scaling) or to simply take the modulo inverse (255− pixel colour) of each colour channel and numerically invert the colour channels.

With grey-scaling, we provide two methods, each of which simply dictate the weighing applied to each colour channel when averaged to a single intensity value: NTSC-standard weighting, and spectral averaging. NTSC standard weightings are recommended [1], however in some cases taking the equal-weighted average of each channel (spectral averaging) may provide a greater variance in intensities resulting in better edge detection when the range of blues in the image is limited relative to the reds and greens.

3 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 dcmj2pnm and img2dcm applications. These are run from within the C++ code base upon user prompting. A automated setup batch-commands file is provided that creates a text file with the absolute path to these files, preventing any missing file issues or manual setup.

4 User interface

The UI here is optimised for instant ease of use, requiring no background in what filters and capabilities this code base has, presenting all the options to the user at run time via the command prompt. 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...

5 Further work

Given more time and perhaps funding (we can include words like blockchain and machine learning in our proposal) we would pursue the following possibilities:

- 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

6 References

[1]: Mathworks - 07/02/2019 - converting RGB to greyscale - https://uk.mathworks.com/matlabcentral/answers/99136-how-do-i-convert-my-rgb-image-to-grayscale-without-using-the-image-processing-toolbox
[2]: DMCTK - 07/02/2019 -dicom.offis.de - https://dcmtk.org/ [3]: Sobel filtering - 00/02/2019 - Sobel operator - Wikipedia - https://en.wikipedia.org/wiki/Sobel$_o$*perator*