Kyffin Williams: Digital Analysis of Paintings

Final Report for CS39440 Major Project

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Acknowledgements

To Llyod, Hannah and the Cooper's Arms for setting the scene for this crazy project.

To Jade, Kate, Yarrow and Sam for being great friends in times of need.

To Kyffin Williams himself, for being such an interesting artist.

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Finally, though she already been mentioned, to Hannah who has been everything a student could want in a supervisor and a lot more. For the crazy ideas and piles of reading material. And for getting me to cite Rolf Harris.

Abstract

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Chapter 1

Background & Objectives

1.1 Sir John "Kyffin" Williams

Sir John "Kyffin" Williams (1918-2006) was a Welsh painter and printmaker, widely regarded as the defining artist of Wales during the 20th century [4]. He was advised to take up art by a doctor after failing a British Army medical examination because of an 'abnormality' (epilepsy) as something which would not tax his brain.

He studied at the Slade School of Fine Art and taught art in Highgate School, after which he retired to Anglesey until he died in 2006 after a long battle with cancer.

His most characteristic pictures are of Welsh landscapes, painted with thick layers of oil paint applied with a palette knife [2]. Most of his paintings are highly textural; to the point of being 3-dimensional.

As his life progressed Kyffin's 'abnormality' grew steadily worse, especially when exposed to bright light. As a result most of his paintings are of overcast Welsh landscapes and tend to become visibly darker over time [6]. By eye it is generally quite easy to approximate the time period in which a painting was created.

In 1969 he won a scholarship to study and paint in Y Wladfa; the Welsh settlement in Patagonia. This period of his life is very obvious from his paintings as there is a complete contrast in colour between Patagonian and Welsh landscapes.

1.2 Interdisciplinary work with the National Library of Wales

This project was initially suggested through a conversation between Hannah Dee and Gareth "Llyod" Roderick about image processing and art. Llyod is a PhD student at the National Library of Wales (NLW) researching (TODO: Find out what Llyod's thesis title is). Their initial idea was to be able to geolocate a Kyffin painting on a map to build up a geographical representation of Kyffin's work.

Hannah started to create a prototype for performing geographical analysis, this proved to be a difficult task and one which is still being researched.

However, the nature of Kyffin's illness and painting style allows for a second form of analysis: temporal. As previously stated it is fairly easy to judge by eye a good approximation of the period in which a Kyffin painting was created. It should, therefore, follow that this process can be performed digitally.

When I started this project I was given a "database" (in reality this was just a spreadsheet) Llyod had produced, containing information of Kyffin Williams' paintings, including: title, year,

category (landscape, portrait, etc.), canvas size and a few additional details which aren't so relevant to the project.

The first meeting held was between Llyod, Hannah and I, in which we discussed the current state of the project, what our aims for the project were and what form of help Llyod could provide to us. As one of the objectives of this project is to, eventually, get a paper published, the relevant details of the process we would need to go through if we wanted to do so.

The second meeting was between Hannah, Llyod, Lorna (Llyod's supervisor) and I. Again we discussed the state of the project. Llyod had also produced a better version of his "database" to be more machine readable and succinct. A lot of information came from this meeting;

- The "cut-off" point between early and late is around 1973.
- The size of the canvas might be a useful data point to use in classification, as Kyffin sold more paintings he would have had the money available for larger canvases and the paint for said canvas.
- It is a little dubious as to whether some dates can be trusted. One painting owned by the NLW was stated to be his last painting, but Lorna believes it was painted much earlier and claimed to be his last to improve the sale price.
- Llyod may have found date markings on some paintings. These again may not be accurate, but may prove to increase the sample size.
- It should be easy to provide a "no later than" estimate for each painting from the art historians.
- Paul (?) should be able to produce some exemplars for us as a ground truth.
- Llyod may be able to find more paintings in the hands of private collectors to increase the sample size.
- Llyod had been playing around with ImageJ to do some basic graph plotting. This might be useful to look at further to expand my own work.

There were also more detailed discussions about publications, particularly in a digital humanities journal.

1.2.1 Continuation of the Kyffin Project

There are several projects that could continue on from the Kyffin Project.

One was to use the Learning/Teaching development fund to produce a web-based front-end for of some of my analysis.

Another venture was to look into PhD funding to build up a 3D map of some of Kyffin's paintings and being able to display it (perhaps via HTML5 and WebGL) so they can explore the painting digitally how it is meant to be in real life.

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Appendix A

3rd Party Libraries and Tools

1.1 Python 2.7

1.1.1 setuptools

`http://pypi.python.org/pypi/setuptools`

1.1.2 scipy

`http://www.scipy.org/` [7]

1.1.3 numpy

`http://www.numpy.org/` [7]

1.1.4 matplotlib

`http://matplotlib.org/`

1.1.5 liac-arff

`https://github.com/renatopp/liac-arff`

1.2 OpenCV

`http://opencv.org/` [1]

1.2.1 OpenCV Python

`http://opencv.willowgarage.com/wiki/PythonInterface` [1]

1.3 Weka 3

`http://www.cs.waikato.ac.nz/ml/weka/` [5]

1.4 git

1.4.1 github

Appendix B

Equations

2.1 Statistical Equations

2.1.1 Mean

$$\mu = \frac{1}{N}\sum_{i=1}^{N} x_i \tag{1}$$

2.1.2 Standard Deviation

$$\sigma = \sqrt{\frac{1}{N}\sum_{i=1}^{N}(x_i - \mu)^2} \tag{2}$$

2.1.3 Pearson's product-moment coefficient

$$\rho_{X,Y} = \frac{\operatorname{cov}(X,Y)}{\sigma_X \sigma_Y} = \frac{E[(X - \mu_X)(Y - \mu_Y)]}{\sigma_X \sigma_Y} \tag{3}$$

2.2 Distance Equations

2.2.1 Manhattan Distance

$$d_1(\mathbf{p}, \mathbf{q}) = \|\mathbf{p} - \mathbf{q}\|_1 = \sum_{i=0}^{n} |p_i - q_i| \tag{4}$$

2.2.2 Euclidean Distance

$$d_1(\mathbf{p}, \mathbf{q}) = \sqrt{\sum_{i=0}^{n}(q_i - p_i)^2} \tag{5}$$

2.3 Filter Equations

2.3.1 Gradient Direction

$$\theta = \operatorname{atan2}\left(\frac{\delta f}{\delta x}, \frac{\delta f}{\delta y}\right) \tag{6}$$

2.3.2 Discrete Derivative Masks

$$\begin{bmatrix} -1 & 0 & 1 \end{bmatrix} \begin{bmatrix} -1 \\ 0 \\ 1 \end{bmatrix} \tag{7}$$

2.3.3 Gabor Filter

$$g(x, y; \lambda, \theta, \psi, \sigma, \gamma) = \exp\left(-\frac{x'^2 + \gamma^2 y'^2}{2\sigma^2}\right) \cos\left(2\pi \frac{x'}{\lambda} + \psi\right) \tag{8}$$

where:

$$x' = x\cos\theta + y\sin\theta$$
$$y' = x\sin\theta + y\cos\theta$$

Appendix C

Code Samples

3.1 Gabor Filter Example Implementation

Listing C.1: Example implementation of a Gabor Filter in MATLAB from wikipedia [3]

```
function gb=gabor_fn(sigma,theta,lambda,psi,gamma)

sigma_x = sigma;
sigma_y = sigma/gamma;

% Bounding box
nstds = 3;
xmax = max(abs(nstds*sigma_x*cos(theta)),abs(nstds*sigma_y*sin(
    theta)));
xmax = ceil(max(1,xmax));
ymax = max(abs(nstds*sigma_x*sin(theta)),abs(nstds*sigma_y*cos(
    theta)));
ymax = ceil(max(1,ymax));
xmin = -xmax; ymin = -ymax;
[x,y] = meshgrid(xmin:xmax,ymin:ymax);

% Rotation
x_theta=x*cos(theta)+y*sin(theta);
y_theta=-x*sin(theta)+y*cos(theta);

gb= exp(-.5*(x_theta.^2/sigma_x^2+y_theta.^2/sigma_y^2)).*cos(2*
    pi/lambda*x_theta+psi);
```

3.2 OpenCV Histogram Example Code

Listing C.2: Example Histogram calculation and displaying code from OpenCV [1].

```
# Taken from: http://opencv.willowgarage.com/documentation/
    python/imgproc_histograms.html#calchist
```

```
# Calculating and displaying 2D Hue-Saturation histogram of a
    color image

import sys
import cv

def hs_histogram(src):
    # Convert to HSV
    hsv = cv.CreateImage(cv.GetSize(src), 8, 3)
    cv.CvtColor(src, hsv, cv.CV_BGR2HSV)

    # Extract the H and S planes
    h_plane = cv.CreateMat(src.rows, src.cols, cv.CV_8UC1)
    s_plane = cv.CreateMat(src.rows, src.cols, cv.CV_8UC1)
    cv.Split(hsv, h_plane, s_plane, None, None)
    planes = [h_plane, s_plane]

    h_bins = 30
    s_bins = 32
    hist_size = [h_bins, s_bins]
    # hue varies from 0 (~0 deg red) to 180 (~360 deg red again
       */
    h_ranges = [0, 180]
    # saturation varies from 0 (black-gray-white) to
    # 255 (pure spectrum color)
    s_ranges = [0, 255]
    ranges = [h_ranges, s_ranges]
    scale = 10
    hist = cv.CreateHist([h_bins, s_bins], cv.CV_HIST_ARRAY,
       ranges, 1)
    cv.CalcHist([cv.GetImage(i) for i in planes], hist)
    (_, max_value, _, _) = cv.GetMinMaxHistValue(hist)

    hist_img = cv.CreateImage((h_bins*scale, s_bins*scale), 8,
       3)

    for h in range(h_bins):
        for s in range(s_bins):
            bin_val = cv.QueryHistValue_2D(hist, h, s)
            intensity = cv.Round(bin_val * 255 / max_value)
            cv.Rectangle(hist_img,
                         (h*scale, s*scale),
                         ((h+1)*scale - 1, (s+1)*scale - 1),
                         cv.RGB(intensity, intensity, intensity)
                            ,
                         cv.CV_FILLED)
    return hist_img
```

```
if __name__ == '__main__':
    src = cv.LoadImageM(sys.argv[1])
    cv.NamedWindow("Source", 1)
    cv.ShowImage("Source", src)

    cv.NamedWindow("H-S Histogram", 1)
    cv.ShowImage("H-S Histogram", hs_histogram(src))

    cv.WaitKey(0)
```

Annotated Bibliography

[1] G. Bradski, "The OpenCV Library," *Dr. Dobb's Journal of Software Tools*, 2000.

Used Python (http://opencv.willowgarage.com/documentation/python) and C++ (http://opencv.willowgarage.com/documentation) documentation for library reference and some learning on image processing/computer vision. Used since 11 October 2012.

[2] I. Chilvers, J. Glaves-Smith, and I. Chilvers, *A dictionary of modern and contemporary art*. Oxford University Press, 2009. [Online]. Available: http://www.worldcat.org/isbn/0199239665 0199239665.

[3] W. Contributors, "Gabor filter," Online, Oct. 2012. [Online]. Available: http://en.wikipedia.org/w/index.php?title=Gabor_filter&oldid=517342109

[4] J. Davies and A. Gymreig, *The Welsh Academy encyclopaedia of Wales*. University of Wales Press, 2008, pp. 957–958. [Online]. Available: http://www.worldcat.org/isbn/9780708319536 9780708319536.

[5] M. Hall, E. Frank, G. Holmes, B. Pfahringer, P. Reutemann, and I. H. Witten, "The WEKA data mining software: an update," *SIGKDD Explor. Newsl.*, vol. 11, no. 1, pp. 10–18, Nov. 2009. [Online]. Available: http://dx.doi.org/10.1145/1656274.1656278

Citation for the Weka data mining software. Weka is a Java based tool which can be used to run a lot of classifiers to a dataset, making it a very useful tool to apply to the Kyffin Williams project. Weka allows the application of complex machine learning techniques without having to spend a lot of time learning, understand and implementing said techniques.

[6] R. Harris, "How Rolf learnt to paint like Sir Kyffin Williams," BBC Broadcast, Feb. 2011. [Online]. Available: http://www.bbc.co.uk/programmes/p00f6nyt

A video on the BBC by Rolf Harris about some of Kyffin Williams' life and about his interesting style of painting.

[7] E. Jones, T. Oliphant, P. Peterson, *et al.*, "SciPy: Open source scientific tools for Python," 2001.