Kyffin Williams: Digital Analysis of Paintings

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1 Project Summary

Sir John "Kyffin" Williams was a landscape painter from Wales who's work was predominantly based in Wales and Patagonia. His work, and associated metadata collected by Gareth Lloyd Roderick and the National Library of Wales, allows for some interesting analysis; particularly that of temporal or geological data for a given painting.

Temporal analysis will be the focus of this project as it allows for a diverse range of techniques; from statistical analysis of RGB values of the paintings to looking at the length and style of paintbrush strokes. The ultimate aim of this being to accurately place the year of a given painting which has no metadata collected.

2 Background

There are many papers which look into the digital or computerized analysis of paintings, many of these focus on the authentication of paintings by a given artist. Many others go into the analysis of (brush) stroke detection or classification of the painting tool used to make strokes.

The idea of classifying the year of a piece of art has been researched before, however it seems to focus around the method of printing the work, or providing a very general answer for old pieces of work.

The AUTHENTIC project [1] deals with the computerized authentication of paintings and defines a useful method for analysing the brush strokes of Vincent Van Gogh.

3 Goals and Objectives

3.1 Analysis Goals

3.1.1 Statistical Analysis

The first goal for the analysis section of the Kyffin Williams Project is to statistical analyse colour space values of the pixels of an image. Typically taking the mean and standard deviation over a whole painting.

The two colour spaces this project will typically focus upon is RGB (Red, Green, Blue) and HSV (Hue, Saturation, Value) colour spaces. The project may explore other colour spaces further into the project.

After basic statistical analysis, the next step is to create histograms for each image in both colour spaces and use these to analyse the values these contain.

3.1.2 Distance Measures

Part of the analysis will need to include a way of measuring the distance of two outputs from the associated technique; for points in space distance measures such as Manhattan Distance (Figure 1) or Euclidean Distance (Figure 2). For more complex forms, such as histograms, specialised distance measures will be needed.

3.1.3 Brushstroke Analysis

After these techniques are implemented there is a lot of space to develop new techniques specific to both painting analysis and to Kyffin Williams. One very interesting technique is to analyse the brush strokes the artist made on the painting. It is clear from looking at his work that he dramatically reduces the number of brush strokes he makes as time goes on.

According to the AUTHENTIC project "The digital extraction of brushstrokes proceeds in two steps: (I) contour enhancement, and (II) quantification of brushstroke shape" [1]. They perform contour enhancement by applying a circular filter to the image, this filter picks out the characteristic parallel contours of brushstrokes. For the works of Kyffin Williams this may not work as well as he typically used a pallet knife to paint with, instead of a regular paintbrush.

Once these contours are enhanced you can then fill a closed area for each brushstroke, reduce this to a thin line and finally fit some form of polynomial function to this line. Again, for the Kyffin Williams project the third part of this may not be applicable as the AUTHENTIC project specialises in ensuring the authenticity of a painting and does so by verifying that the brushstrokes in one painting match the style of Van Gogh. Even looking at the number of visible brushstrokes in Kyffin Williams' work may be enough to classify a painting.

3.2 Machine Learning Goals

The Machine Learning (ML) module is designed to classify analysed paintings to the training examples in order to get the approximate year the were created.

Machine Learning on it's own is a large and complex field, so the techniques used here may be simple to ensure the project completes on deadline.

3.2.1 K-Nearest Neighbour Classification

The simplest solution to the classification problem is to take the nearest neighbour of a given, analysed, painting and set the year of the new example to the one of the existing example. This is highly dependant on the type of analysis, noise in the training examples, etc.

It is, however, very simple to implement (see Figure 3), with simple modification one can easily change 1-Nearest Neighbour to K-Nearest Neighbour (see Figure 4) and approach with different values for K to give a potentially more accurate answer. K-Nearest Neighbour also has options for interpreting the result, by taking the modal result or a mean of all the results.

4 Current Progress

4.1 Technical Challenges

4.2 Outline Design

4.3 Implementation Options and Choices

4.3.1 Computer Vision & Image Processing Library Decision

Aside from directly reading pixel values using built-in language features or a simple image or graphics library, there are a variety of computer vision and image processing libraries. Each of which have numerous functions to manipulate and process images.

OpenCV (Open Source Computer Vision (`http://opencv.org/`) is one of the more popular choices for Computer Vision libraries, boasting C, C++, Python and Java interfaces for several of the common platforms, including mobile devices. OpenCV leverages multicore processing and optimized C/C++ code to be able to handle real-time systems.

FIJI (FIJI Is Just ImageJ) (`http://fiji.sc/`) is Java-based image processing package, is akin to a distribution, packaging ImageJ, Java3D and a lot of other useful features to provide a coherent user interface for the packaged image libraries.

IVT (Integrating Vision Toolkit (`http://ivt.sourceforge.net/`) aims to provide an easy to use, stand-alone C++ computer vision tool kit. It's features include camera interfaces and fast implementations of computer vision techniques as well as mathematical data structures and functions.

$$d = \sum_{x=0}^{X} |a_x - b_x|$$

X: All dimensions present in both a and b.
a: The first point.
b: The second point.

Figure 1: Manhattan Distance

$$d = \sqrt{\sum_{x=0}^{X} (a_x - b_x)^2}$$

X: All dimensions present in both a and b.
a: The first point.
b: The second point.

Figure 2: Euclidean Distance

$bestDistance \leftarrow \infty$
for $x = 1 \rightarrow X$ **do**
  if $distance(a, x) < bestDistance$ **then**
    $bestDistance \leftarrow distance(a, x)$
  end if
end for

Where:
a is the example to classify.
X is the list of all training examples.

Figure 3: 1-Nearest Neighbour

$kBest \leftarrow []$
for $x = 1 \rightarrow X$ **do**
  $cur \leftarrow distance(a, x)$
  for $k = 1 \rightarrow K$ **do**
    if $cur < kBest[k]$ **then**
      $temp \leftarrow kBest[k]$
      $kBest[k] \leftarrow cur$
      $cur \leftarrow temp$
    end if
  end for
end for

Where:
a is the example to classify.
X is the list of all training examples. K is the number of nearest neighbours to check.

Figure 4: K-Nearest Neighbour

5 Project Planning

5.1 Process Model

5.2 Weekly Plan for the Project

5.3 Demonstration Plan

Annotated Bibliography

[1] I. E. Berezhnoy, E. O. Postma, and H. J. van den Herik. Authentic: Computerized brush-stroke analysis. In *Multimedia and Expo, 2005. ICME 2005. IEEE International Conference on*, pages 1586–1588. IEEE, July 2005.

Library	License	Language Support	Platform Support	Installation	Usage
OpenCV	BSD	C, C++, Python, Java	Windows, Mac, Linux, Android, iOS	Medium	Easy - Fair.
FIJI	GPL Individual per plug-in	Java	?	Easy - Fair	Medium
IVT	Modified BSD	C++	Windows, Mac, Linux	Medium	Medium

Table 1: Details of Computer Vision Libraries

Library	Image Filtering	Transformations	Histograms	Structural Analysis
OpenCV	✓	✓	✓	✓
FIJI				
IVT				

Table 2: Features of Computer Vision Libraries