# Project Statement and Plan

## Project Statement

During my summer internship at Sony I worked on visualisations of transformations between colour spaces to build an understanding of both colour theory and the transformations themselves. I was using WebGL, a web-based adaptation of the widely used 3D rendering language, OpenGL. My project doesn't follow the same path as the work I did at Sony but it uses the knowledge of colour and proficiency in technologies that I gained.

My project is a web-based, 3D colour histogram of images, developed using the WebGL and Three.js JavaScript libraries (mrdoob, 2015). Classic 2D luminosity histograms graph light intensities against the number of pixels with said luminosity; colour histograms work under the same principles but have three plots, one for each colour channel. 2D Colour histograms are usually applied to 3D colour spaces such as RGB or HSV; choosing which colour space to use in my project will be a trade-off between simplicity and accurate colour representation. Traditional colour histograms are used to check the exposure in an image but don't allow inspection of individual colours, something that is possible with a 3D histogram. A 3D colour histogram is a cube with each axis representing a colour channel. The space inside the cube is divided into bins and pixels are put into the bins in a process called colour quantization. The size of these bins is represented by the size of a 3D shape such as a sphere, which is coloured according to the colour it represents.

My application, inspired by Javior Villarroal's online colour histogram (Villarroal), will allow the user to upload an image and view it's 3D colour histogram. What brought my attention to Villarroal's histogram were five of the stock images that showed the same photo but with the saturation, lightness, etc. changed. This gave me the idea of using a 3D colour histogram as a tool in image processing; my project will allow the user to make alterations to an image's colour and observe the changes in the colour histogram. In order to affect these changes I must choose a method of colour alteration; the two that I have experience with are ASC CDL and Lift/Gamma/Gain.

If my colour histogram is successful I will expand it to being a tool of image editing itself. Rather than selecting an area of an image spatially and applying changes to the isolated area a histogram could be used to select the colours that are to be altered: this approach would be quicker than selecting spatially and allow greater control over effects such as mood and temperature. In addition, colour histograms are often bi-modal because the background and foreground contain different colour sets, it should therefore be possible to separate the foreground and background of an image using a colour histogram.

My project will be browser-based and written mostly in Javascript. For the renderings I will use the WebGL JavaScript library and an additional library called Three.js which wraps up the otherwise complicated WebGL functionality into something that is easier to use and understand. A small amount of code will be written in Open GLSL, a language based on C that runs in tandem with WebGL to do matrix and vector operations on the GPU.

## Risk Assessment

My project can be divided into milestones: generating a 3D colour histogram of a stock image; generating a 3D colour histogram of an image uploaded by the user; allowing the user to alter the colours of an image; allowing the user to select regions of the image by colour using the histogram and edit those selections independently.

With the experience that I gained at Sony I believe that the first milestone, a 3D colour histogram of an image, is easily achievable and this shall be the minimum viable product for my project. Allowing the user to upload an image and then edit it is more challenging but the progress made already with a prototype has given me the confidence to expect that this goal will be achieved. The final milestone, allowing the user to isolate and edit areas of an image, is ambitious; I do not expect to complete this goal however if the previous goals are met I will aim to have a prototype for this functionality.

## Ethical Considerations

There are no ethical considerations to be made for my project: I do not intend to gather or use any personal data in my project and it will have no direct effect on the physical or mental wellbeing of any living thing.

## Literature Review Plan

### WebGL/Three.js

(Learning WebGL, 2010) : A WebGL tutorial that demonstrates how bloated the code is, which is the reason for using the Three.js library.

(mrdoob, 2015) : The homepage for the WebGL Javascript library, Three.js. I will be using this for all of my renderings.

(Javi Fontan, 2015) : An in browser Open GLSL compiler and some example programs. I will be using GLSL in tandem with WebGL in order to run some of the graphics on the GPU.

(three.js) : The Three.js documentation for the ShaderMaterial, which is used to run GLSL code in tandem with WebGL.

### Colour Spaces

(Wikipedia, 2015) : The Wikipedia page for the CIE-XYZ Colour Space; includes an overview and important formulae. CIE-XYZ is often used as a common colour space when translating so I may have to use it if I do any colour space transformations.

(Wikipedia, 2015) : The Wikipedia page for the CIE-L*a*b* Colour Space; includes an overview and conversion formulae between CIE-XYZ and CIE-L*a*b* space, which will be important if I choose to use the CIE-L*a*b* colour for my histogram.

(Cruse, 2015) : A webpage with an introduction into the CIE-L*a*b* colour space. It is useful for an overall understanding of the colour space.

(BartoszKP, 2015) : An answer to a Stack Overflow question that defines the limits of the CIE-L*a*b* colour space, something that can be quite ambiguous at times.

(Juckett, 2010) : A webpage with conversions between RGB colour spaces; includes information on white points, gamma correction curves, and transformation matrices. This will be very helpful if I have to do any colour space transformations.

(Wikipedia, 2015) : The Wikipedia page for the Rec.709 colour space, the colour space used by most displays. In particular the luma coefficients and conversion formulae to linear form (i.e. the reverse gamma function) are useful. While useful for my work at Sony, it may have limited use in my project.

(Irotek, 2014) : A webpage with conversion formulae between colour spaces, in particular from CIE-XYZ to CIE-L*a*b*. This will be very useful if I choose to represent colours in any colour space other than RGB and require transformations.

(Selan, 2012) : A Cinematic Colour white paper. I haven't read it all yet but it focuses on how colour spaces are used in cinema. It will be useful to read if I need to do any colour space transformations.

## ASC CDL

(Wikipedia, 2015) : The Wikipedia page on ASC CDL, which is one of the methods by which an image's colour can be altered. It includes correction formulae which will be useful when I have to add colour controls to my project.

(Nikolai, 2013) : An introduction to ASC CDL. In particular is has good visualisations of the effects of slope, offset, and power. Probably the best resource for an overall understanding of what ASC CDL is and how it's used.

(Xat/KeyerNode) : Conversion formulae between CDL and Lift/Gamma/Gain, the two methods of colour alteration that I am currently considering to use in my project.

(Tarlier, 2009) : A comparison of lift/gamma/gain and ASC CDL. It will be useful when I come to choose between the two.

## Colour Histograms

(Villarroal) : The online 3D colour histogram that inspired my project.

(Wikipedia, 2015) : The Wikipedia page on colour histograms; it includes an explanation of what colour histograms are, what they're used for, how to create one, and what their drawbacks are.

(Rockwell, 2006) : An explanation of what colour histograms are and how to use them. While aimed primarily at photographers it still has some useful background information.

(Cambridge in Colour, 2015) : A detailed comparison of luminance and colour histograms. It is mostly irrelevant as it's aimed at identifying over-exposure rather than individual colours: it does however have some good toys to view the R, G, & B components of an image.

(Meskaldji, 2009) : An article on colour quantization. It includes useful definitions of colour histograms, comparisons of RGB and HSV, and an explanation of colour quantization. While

written in the context of an image search tool the information is still largely relevant to my project.

(Barthel, 2007) : An implementation of a 3D colour histogram written in Java.

(Third Ave Design) : An online implementation of a 3D colour histogram that also allows the user to upload an image; worth inspecting to see how they achieve this.

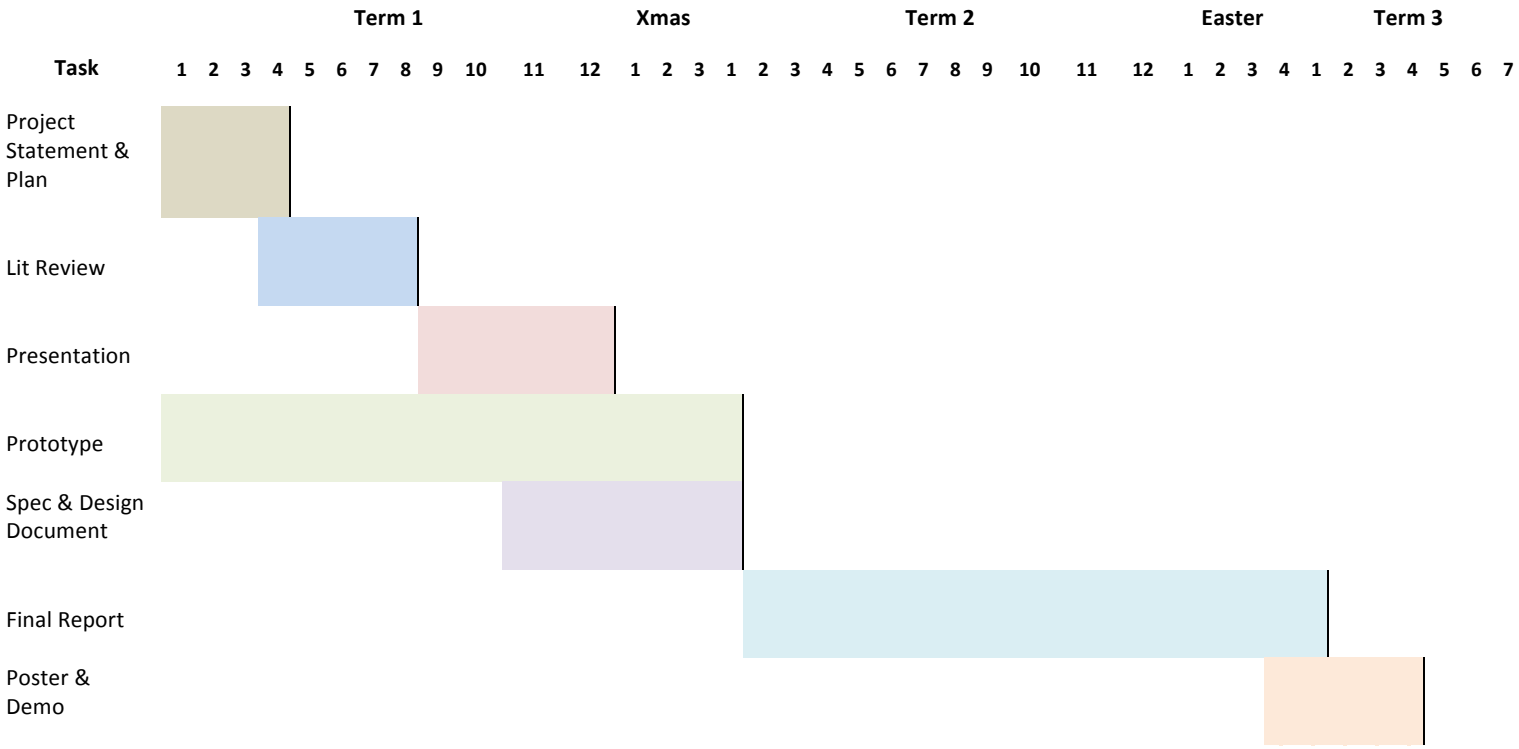
(Caballero) : A real-time (video) 3D colour histogram. It appears to use Three.js and has alternative colour spaces, including HSV. This will be very useful when deciding what colour space to use.

### Literature Review Plan

Most of my initial research from Sony was into colour spaces and transformations; now however I have changed tack and am looking into colour histograms. The resources and literature gathered on colour spaces are still useful for an overall understanding of colour and will applicable if I have to perform any transformations, for example if I choose to use the HSV or CIE-L*a*b* colour spaces in my histogram. The resources gathered on colour histograms will take precedence over those regarding colour spaces in my literature review as they relate directly to my project.

Research into ASC CDL and WebGL/Three.js are as relevant to my project as they were at Sony because they are tools applicable in both situations. I will continue my research into these areas and they will be given their fair share of attention in my literature review.

## Time Plan



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