Visual Saliency Detection for 3D Models

[redacted]

Title – *Understanding the elements that formulate visual saliency detection methods for 3D models and their effective implementations in modelling the human visual system.*

Abstract –

A Context/Background

The ability of the human visual system is remarkably fast and reliable at attending to salient regions of an environment. However, visual saliency detection has been an on-going challenge in modelling this intellectual behaviour within the field of computer vision due to its dependence upon methods of reliability and accuracy. It acknowledges the subjective perceptual qualities that make individual objects stand out distinctly through modelling and alternative techniques whilst facilitating limited perceptual and cognitive resources on the pertinent visual input. Thus its efforts are incorporated to model the mechanism of the human visual system in three dimensional environments.

B Aims

This study aims to explore the various mechanisms, computational models and experimentation techniques of visual saliency as such approaches utilize certain elements to model the human visual attention. We will identify performance and limitations of key features of which saliency detection methods impose in order to identify strengths, weaknesses and any potential areas for improvement through the analysis and evaluation of the various results obtained throughout the implementation.

C Method

The methods shall analyze the foundations of which visual saliency methods are built upon to provide improved knowledge on their effective implementations. The applied bottom-up approach will receive various images of 3D scenes to compute into resulting saliency maps for further justification and experimentation. Current methods of visual saliency mostly depend upon cues (such as colour, texture, orientation, etc.) whilst ignoring additional information which is vital to the human cognitive system such as depth and so on which will be explored. Such methods are undertaken by the user through the navigation on an operational user-interface.

D Proposed Solution

A bottom-up approach for the visual saliency detection of 3D models will be designed. It permits users to input an image of a 3D coloured scene to be transformed into a saliency map based upon the chosen characteristics of the implementation. The implementation itself will be written in Python with the outcome being presented on a basic GUI (Graphical User Interface). Information and images will be collected from the internet and no questionnaires or interviews are done throughout the process. Additional solutions will be extracted with regards to data analysis and testing, along with visualizations of such data to indicate the effectiveness of the implementation.

Keywords – Visual saliency detection, saliency maps, GUI (Graphics User Interface), Python 2.7, bottom-up approach, feature integration, depth, revision framework, simulation, data analysis.

I. INTRODUCTION

A. *Visual saliency for 3D object detection*

The human attention is attracted to visually salient regions and such object detection has been easily solvable by humans but elevates difficulty for machines. Therefore, the assembly of a technical system that can mimic the human visual attention is a crucial criteria within the field of computer visions, with the inclusion of machines handling large amounts of perceptual input. This concept leads to visual saliency detection which strives to model the mechanism of the human visual attention as certain objects within an environment are more noticeable in comparison to its surrounding scenario. It benefits various applications ranging from object recognition and tracking, to graphical image manipulation and more. Though its integration is beneficial in numerous way, it can still encompass computational complexity limitations that results in low real-time performance and affecting the quality of the outcome.

Excessive computational complexities tend to arise on machines from the simultaneous identification of salient regions within a visual field (Tsotsos, 1991). The mechanisms of visual attention are incorporated to allocate an order of operations to limit any complexity in object recognition as individual salient regions are highlighted for visual analysis before moving onto the next salient region. The identification of the corresponding salient regions are based around the inclusion of chosen characteristics that such saliency approaches utilize within their computation. Such saliency at a particular location is determined by how different it is from its surrounding in terms of colour, orientation, depth and more (Koch and Ullman, 1985, p. 221). The chosen characteristics can influence the efficiency and effectiveness of the computed method in terms of the performance speed and the end-result that is obtained.

Visual saliency is mainly classified under distinct terms known as a Top-down approach where it is detected through the utilization of visual knowledge and depends upon the effective incorporation of task-specified saliency detection, such as human activities for scene detection and tracking. However, an alternative approach known as Bottom-up is generally preferred as training is not necessary due to its reliability upon a Feature Integration Theory (Koch and Ullman, *Human Neurobiology,* 1985). It acts as a pre-processing step to aid in the computational processing by prioritizing the search environment for object recognition and detection tasks, similar to the models by *Itti et al.* for rapid scene analysis (*IEEE Transactions PAMI, 20(11), 1998*). Therefore, the focus will revolve around bottom-up approaches as they are identified to aggregate general features such as colour, texture, shape and additional elements which include intensity and orientation.

Visual saliency detection is not only determined by those confined set of features as different methods may propose additional characteristics to provide different sources of vital information. Methods were proposed based upon frequency tunes to compute a pixel's saliency as a colour difference from the average image colour (by Achanta, Hemami, Estrada in 2009). Additionally, other methods are available based upon a contrast comparison among the pixels using a luminance cue illustrating the approaches that visual saliency can endorse.

The exploitation of such features will be explored and how their incorporation affects the performance of the computation process in comparison to the low-level features. Depth is an individual cue that determines salient regions and has played a signification role due to the evolution of the human visual system in three dimensional environments (3D). Its implementation provides an additional channel for the retrieval of objects and scene layout through object segmentation and detection which delivers a more informative saliency map as it salvages 3D layout information and shape features. The exploration of this feature will provide a different perspective to the functionality of visual saliency detection as it exploits the layers of a 3D environment and limits the capture of unnecessary background information.

B. Project Purpose

The computational modelling of visual saliency ranges as a broad subject in mimicking the intellectual behavior of detecting salient regions within a 3D environment. The proposed solution will revolve around the presentation of information and data based upon traditional methods of incorporating features that formulate the foundations of visual saliency detection for 3D models. Though it will overview methods of computation, the main focus will be to identify the individual characteristics that such methods comprise of for further analysis.

The illustration of various visual saliency methods would have been the obvious approach, but further justification is highly valuable through the effective demonstration of features that such methods integrate. The similarities, difference and potential areas of improvement will be discovered throughout the process. In addition, the utilization of such features and implementation methods must be comprehended in order to understand their efficiency and whether they provide a sense of reliability and accuracy towards the obtained results.

The extracted elements are exploited in fabricating a saliency map that highlights object detection within a scene depending upon the specific elements. Moreover the inclusion of multiple elements may influence the computation results obtained as further analytical data are interpreted. The presented saliency map will identify the salient regions of 3D models based upon characteristics of interest. Its delivery will act as a general framework of the 3D model to pinpoint possible locations of the required object or show locations with high chances of containing the object being searched for. The map accentuates objects that are separated from the background through depth layers and modifications and various testing will be executed to convey a selection of different visual saliency maps.

Though saliency maps remain as the dominant reflection of the implemented approach, the inclusion of additional tests will provide further results in relation to the computation process and speed of the visual saliency method to allocate strengths, weaknesses and potential improvements. The solution will offer opportunities for exploration of my interpretations of visual saliency detection of 3D models and the knowledge I congregated so far to experiment upon existing methods in an attempt to analyze their characteristics for additional evaluation.

C. Stakeholders and Project Relevance

The study of visual saliency detection is conducted for providing data for future studies based upon object detection, whilst contributing to a broader understanding of computational methods and techniques for ensuring the efficient recognition of salient regions within a 3D environment. This implies to all those involved in different areas of expertise such as signal processing, computer vision, machine learning, image cropping and so on. Such a broad range of real-life applications illustrates the importance of visual saliency detection within society. Though the conclusion can be generalized and extrapolated to many forms of visual saliency, this particular study will only focus upon the method and characteristics in which they integrate. The functional tool produced will be used for personal experiment and evaluation of the implemented features and no exterior stakeholders are used within the experimentation.

D. Deliverables

D.1 Basic

- Implementation of a revision framework to provide information about the simulation.
- Implementation of an outline of a user-friendly interface to interact with the simulation.
- Implementation of a basic framework used for the simulation to compute.
- Implementation of a basic visual display of the computed simulation result.

D.2 Intermediate

- Collation of additional data from the simulation and visualising the obtained results.
- Conducting an in-depth analysis to identify strengths and weaknesses of the simulation.
- Expansion of the simulation to ensure its application is fully operational and that its computation will allow a variety of results to be retrieved.
- Expansion of the user-interface to ensure its operational and functions as intended.

D.3 Advanced

- Integrating improvements into the simulation and verifying its efficient modifications.
- Conducting an in-depth comparison analysis with regards to the included alterations.
- Implementing some complexity and additional features towards the user interface.
- Exploration of additional characteristics (e.g: depth) that tolerate in a 3D environment.

E. Development Lifecycle Approach

Planning and the distribution of workload have a tendency to be the main constraint among implementation of complex propositions, consequently raising concerns on timing. Such boundaries will be overcome through the layout of descriptive project proposals that define the tasks to be carried out to ensure the methods are executed efficiently and effectively. The inclusion of a plan improves organization and reduces the risk of change from occurring throughout the implementation to ensure that all the stated aims are met, rather than changing the course of the deliverables. However, the necessity for flexibility within a proposal is still imperative for any essential changes that are mandatory to be achieved throughout the implementation with the addition of contingencies put in place for major points of risk.

II. Design

A. Requirements (Functional and Non-Functional)

	Requirement	*Priority*
FR 1	**The user should be able to use the provided user-interface to construct the saliency maps from the implemented visual saliency detection approaches.**	**High**
FR 1.1	The simulation should provide the corresponding saliency map depending upon the selected approach (or even the characteristics such as colour, shape, etc.)	High
FR 1.2	The user should have the ability to view the various worked solution whether may refer to the saliency maps or additional analysis data of the implementation.	High
FR 1.3	The navigation of the user-interface should be kept minimalistic to prevent the need for much unnecessary data input and to aid in the ease of use for the users.	Medium
FR 1.4	The generated user-interface should have some complexity and professiona lism and so should be seen in the form of a written -based on graphical user interface.	Medium
FR 1.5	The user should have access to the produced saliency maps as jpg images that are saved within a local folder for any future analysis among the results.	Low

FR 2	**The user should be able to be aware of only the essential aspects of the visual saliency approach with respect to its functionality and features.**	**High**
FR 2.1	The user should have no access to any of the code (or able to edit code) to prevent distribution to the performance and functionality of the implementation.	High
FR 2.2	The user should have access to a revision section where information regarding the implementation, functionality, characteristics, guidance is provided.	Medium
FR 2.3	The user should be able to run from a single python file or from the incorporation of an .exe file that runs the program and brings forth an interface.	Medium
FR 3	**The outcome of the implemented visual saliency approach should be readily available and clear for examination and extra evaluation.**	**High**
FR 3.1	The user should have access to some form of computation speed or any similar outcome that outlines the performance and effectiveness of the implementation.	High
FR 3.2	The user should have access to various saliency maps which are the standard result obtained in visualizing the impact that the implementation has among 3D scenes.	High
FR 3.3	The user should have access to some form of additional data that may be analyzed to identify strengths, weaknesses and potential improvements.	High
NFR 1	The functionality of the implementation should run efficiently with no evident impact upon its performance when producing the various visual saliency maps.	High
NFR 2	The characteristics and features implemented to compute visual saliency detection should be made clear of their intended applications.	High
NFR 3	The visual design and structure of the set of outcomes should be kept simple as most of focus should revolve around perfecting the implemented simulation.	Medium
NFR 4	The user interface of the implementation should be user-friendly with easy guidance for the user to establish how to run and receive the outcomes.	Medium
NFR 5	The runtime of the simulation should be kept minimal to prevent any delays and to ensure efficiency when computing the saliency maps.	Medium

B. Hardware and Software Requirements

The visual saliency detection implementation is a code-based application to be conducted in the python programming language with no additional server side scripting necessary for the simulation to compute. Hardware requirements were kept minimal as the focus should be upon ensuring the simulation is operational and fulfills the necessary functional requirements. Therefore, the program will be run on a basic windows 8 computer with 64-bit operating system that contains the python version 2.7. Software requirements may differ depending on the situation at the time of implementation as new ideas may arise in relation to the applied approach. The visual aspect of the simulation will function due to the inclusion of additional modules into the python shell for the saliency maps to be generated as an outcome such as the Python Imaging Library (PIL) or even the OpenCV module for loading coloured images. Aside from the use of imported images from google and the establishment of multiple python files to execute the computation, no additional resources will be necessary to support this implementation unless new ideas come to mind later on. The program will function on a local system and requires no access to exterior hosts or online media support.

For the purpose of this study, I felt as though python imposes a sense of ease and comfort in order to produce an effective piece of work that runs efficiently. In addition, my experience towards python is far greater than other programming languages which influenced my decision towards choosing this particular one as the basis for my work. I will ensure the integration of my work are bound within this programming language only in order to prevent unnecessary differentiation and problems from occurring later if multiple languages are used.

C. External Components

The coding of the implementation will be prepared using the knowledge assembled from reading numerous sources of information and articles with aid from external code segments that may be extracted and implemented depending upon their relevance and usefulness towards the project. References to the articles, sources and extracted code will be at the end of the Design Report. The table below will illustrate some of the vital components, tool kits and python modules that I have located through the internet which can potentially be exploited within the course of the implementation. Additional components which are not listed within the table below may still be used later on as new components are discovered and the majority of the included components are related in some way to image processing.

Component	*Usage*
Python Imaging Library 1.1.7 for Python 2.7	It allows the addition of image processing capabilities to the python interpreter. The library is useful as it supports numerous file formats and provides powerful image processing and graphics capabilities.
OpenCV in python	OpenCV will be of use to both the user interface and implementin g the simulation. It aids in feature detection and provides image processing functions along with various graphics capabilities too.
Image Module	This module has similarities to the PIL module as it enables the functions for loading images from files and creating new one in addition to various others with relevance to image processing.

D. Implementation Structure and Layout

Maintaining and standardising the implementation is important to ensure that both its operations are functional whilst also having the most appropriate structure to the layout that the code is presented in. The effective execution of a program in python tends to require the need of multiple python files where each file establishes various tasks. However, having a central main file that extracts the functionalities from the numerous files is beneficial. The majority of the code will be confined within the python 2.7 programming language. The incorporation of a .exe file would be beneficial in preventing the need to open numerous python shells to run the program whilst also improving the professionalism of the project.

The layout of the visual saliency detection implementation will follow the concept of previous computational models used to operate such a function. Its structure should have the ability to produce a saliency map whilst following the main two interacting stages necessary:

- The first stage is the pre-attentive extraction of the visual features among the spatial maps, where each individual map is an indication of a different characteristic such as colour, shape, orientation and so on. This extraction requires speed and the ability to function in parallel. Such features are computed using additional functions such as linear filter and center-surround structures.
- The second stage is the focal attention of the salient regions and the automatic shifting mechanism which tends to be a slow process that functions in sequential order. The most conspicuous image location should be selected, along with a mechanism that will generate automatic shifts to the next location.

It is difficult to clarify the exact representation of how my code will be expressed. However, following such concepts of implementation will give a general idea of what is expected from the structure of my code and the different aspects that need to be distributed among its layout.

E. *Saliency Maps - Information*

Saliency maps are the most practical approach of providing evidence for the corresponding implementation as they represent a topographically arranged map for indicating visual saliency of a 3D environment. However, a particular difficulty that should be overcome through the creation of saliency maps, is the perception of information overload. Such a problem can be maintained through the process of selective attention which is the precise selection and ordering of specific features of the map.

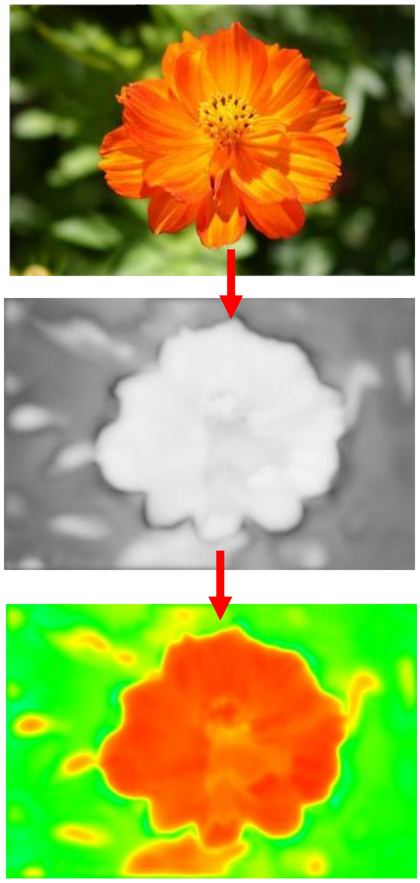


Figure 1: This illustrates how saliency maps may be represented from an original image and how a distinct object is extracted and highlighted in comparison to its surrounding environment. Different maps are made depending upon the style in terms of the colour, intensity, brightness and other features used to illustrate the various salient regions.

Processing high loads of information at a particular time can restrain the processing speed and subsequently increase computational costs. Precision is mandatory in determining the information that is to be discarded and those that are to be processed for detecting salient regions. Therefore, prioritization will be an established technique to aid in arranging the features, with the most relevant being processed initially in order to process different parts of the 3D environment. Bearing in mind that the implementation is based upon a bottom-up approach, the proposition of combining these elected features for detecting the salient regions can be combined into a single saliency map which has been the most appropriate approach since stated by Christof Koch and Simon Ullman in 1985. The map integrates the normalized information from each individual feature map into a single measure of conspicuity.

Some difficulty may arise when allocating the appropriate features to contribute and so focusing upon bottom-up approaches will benefit the distinguishing of such factors as the focus will be based upon instantaneous sensory input such as shape, colour, texture and so on. Such an approach will prevent the need to observe the internal state which may include the goals, past history and experiences of the implemented detection method.

These maps also deemed to be the most fitting source of data to provide evidence of visual saliency of which users can take into account for further evaluation. A collection of various saliency maps will be provided to allow analysis amongst them in identifying their effective interpretations and if improvements could be integrated to improve individual maps. Different maps have their own perception of object detection, so observing this analysis from as many possible perspectives is beneficial.

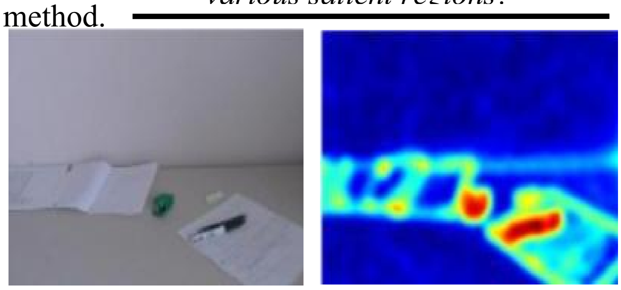


Figure 2: Saliency maps may illustrate the detection of numerous objects within a scene as oppose to singular ones. The different detected objects may be highlighted in different colours depending upon the detection order relating to the integrated approach.

F. Saliency Maps - Construction

The construction of saliency maps are inclined to follow a central architecture based on the idea presented by Itti, Kock and Neibur, IEEE PAMI, 1998. It illustrates how we encode for the local conspicuity within a 3D environment in order to rapidly break down a complex scenario to rapidly identify the individual locations to be examined. Functions are followed to attend to those individual areas in order of decreasing saliency. Inspirations of analysing such a visual system has been influenced by the behavior and the neuronal architecture of the primate visual system from early ages and throughout time. The following model indicates the aspects incorporated into generating a saliency map to represent the salient regions of a 3D environment. This model will be used as a reference to reflect back to during my project.

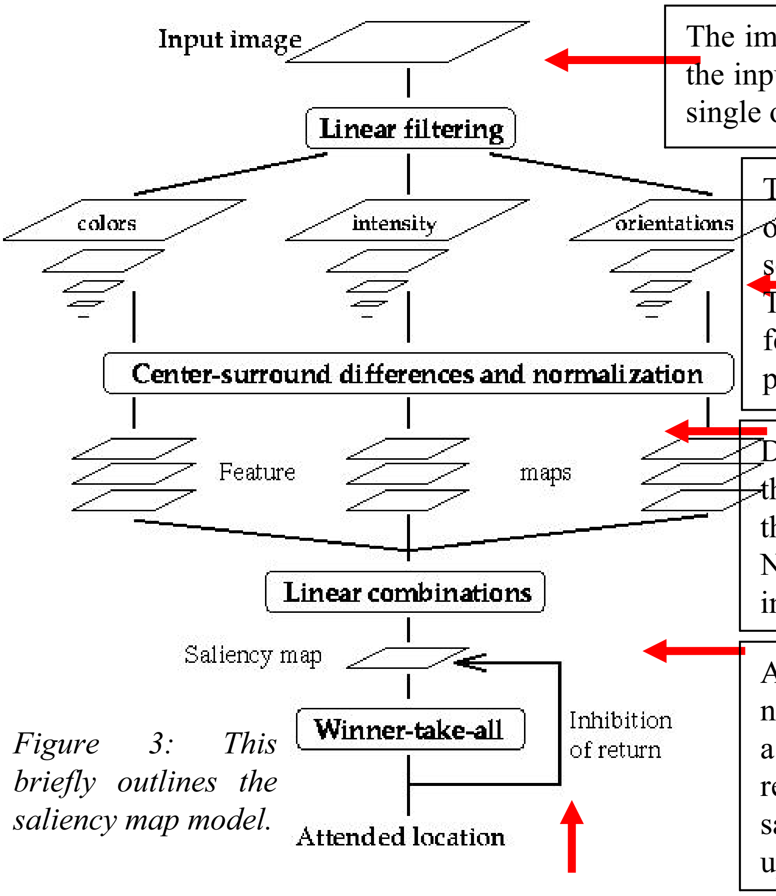


Figure 3: This briefly outlines the saliency map model.

The image of the 3D environment is used as the input. It may range from an image with a single object or even some with complexity.

This is the visual pre-processing stage of determining salient regions of a scene using individual characteristics. These are incorporated in the set of feature maps that are computed in parallel for separate representations.

Determining contrast and normalizing the values of the map is essential once the visual pre-processing is complete. Normalized information is integrated into a single measure of conspicuity.

A linear combination is performed by normalizing the conspicuity maps into a final input for the saliency map to be returned as the outcome. The way the saliency map is perceived will depend upon how the approach is structured.

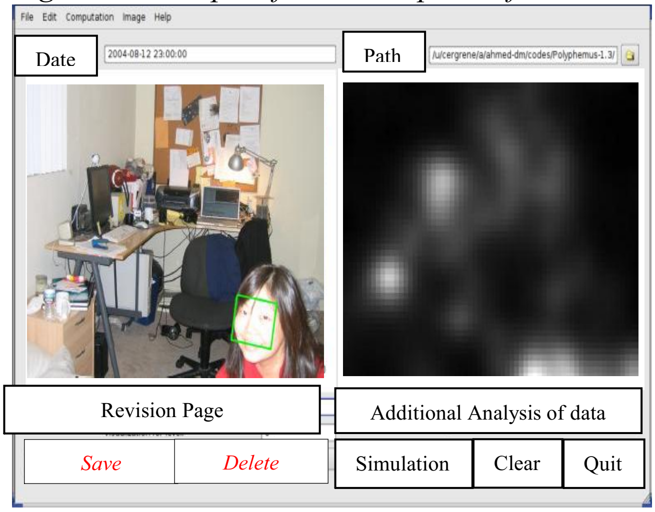
The 'winner-take-all' step is the implementation of the selection process which revolves around a single rule that is the conspicuity of the location. Proximity rules are also incorporated. The selection process functions by moving onto the next most conspicuous location automatically.

The set of features selected for the recognition of salient regions should only be a moderate burden upon the system and its computational resources to prevent substantial impact upon the ability to perform and detect. The saliency map will combine the information gathered from each individual feature map into a single global measure. The points of a location within a feature map will correspond to a single unit within the saliency map. Therefore the saliency is determined at a particular region through the level of differentiation among that location in comparison to its surrounding environment. Though the above model mainly focuses upon the creation of saliency maps based upon low-level features, the inclusion of alternatives will still be investigated for incorporation once the foremost characteristics have been interpreted.

G. User Interface

A program with significant performance power has little value if its reflecting user interface does not meet the necessary standards. The user interface is the main interaction amongst a human and a machine where the main operations and controls of the machine are available from the users end. It may range from a basic written-based user interface to a more complex implementation of a GUI (graphics user interface). Though my project is mainly centered upon code and the implementation aspects of visual saliency detection, I felt as though it is equally important to establish a user interface to display and navigate through the necessities of the program. The requirements of my user interface will be clarified in detail with relation to its functional and aesthetic quality, in addition to the various approaches it may undertake.

Figure 4: Example of what is expected from the GUI.



This example provides some indication of the expected user-interface as it should include a contrast of buttons for achieving the individual tasks and also provide any evidence of the outcome (this may be the saliency maps or specific data requested by the user through the user interface). Simplicity should be achieved in terms of the aesthetics and functional demands required by the user to prevent any confusion when navigating throughout the interface. However, some complexity should be maintained to enhance the user interface with a more professional appeal. The GUI facilities numerous elements which range from the availability of icons, buttons, scroll bars, menu options, commands, files and other useful aspects towards the simulation.

The integration of a GUI will take advantage of the computer's graphics capability in an attempt to provide a more professional and user-friendly approach towards navigating and operating the implemented simulation. This computer environment will simplify the interaction with the computer whilst lowering the required skill level to operate its facilities and ensuring higher efficiency and productivity. However, the user interface I intend to use should not fluctuate my main focus from implementing the necessities of the simulation.

Time is a crucial factor and so it is imperative to ensure the implementation is complete within the time scale specified. Therefore, another approach for the interface must be planned if time is too short in implementing a GUI. Thus, my alternative user interface will be written-based, where the user fills in the necessary information in the python shell and navigates through the given information to perform particular tasks. This approach is time efficient but is not as equally as effective and professional when being compared to a GUI.

H. Revision Page

The revision page is a feature accessible through the user interface that comprises of several subheadings in order to illustrate the functionality and operations of the implementation. It should take into consideration that the user may have no past knowledge of visual saliency and so should written in a level that is somewhat easily understandable. The revision page will be a local pop-up rather than requiring access to the internet. This feature seemed appropriate to include as a program is hard to understand without some brief introduction.

I. Additional Outcomes

Aside from the interpretation of saliency maps, there is other sources of information that may be extracted from these implementations and analysed to obtain a better understanding of visual saliency detection. However, visualisation is a limited outcome as saliency maps are the only distinct representation of identifying the salient regions. Therefore, the focus will move towards other analytical data which may have relevance towards the implementation.

The constraint upon computational resources and speed are two crucial elements that should be taken into consideration and so further evaluation will be undertaken to provide data with respect to the computational processing of the implementation. Representation of such data can be made available through additional features present on the user-interface in which the user can select their preference of information to observe. Since visualisation is always the most critical attribute of any program, then graphs can be integrated with the results to allow comparison of differentiation and similarities among sets of results. Though observations provide sufficient evidence, there is always some trait missing which can be refined through the clarification of the presented data. Any form of outcome produced will always be accessible for viewing by the user through the user-interface.

J. Improvements

So far most of the information discussed relates to implementing an approach based upon existing knowledge from past computational-models of visual saliency. However, it is vital to exemplify my own perception of visual saliency and how I may integrate my own knowledge to the implemented approach in order to improve both its functionality and efficiency. Hence there is a link among the additional outcomes (data) retrieved and analysed and the areas that will be identified for potential improvement. The concept of improvement allows additional investigation of strengths and weaknesses of the visual saliency detection method to identify the areas where it had excelled and those which it had not.

Improvements will be managed based on observations of change in computational speed and power of the implementation, in addition to any distinct variation within the produced outcomes. Such alterations will modify the critical aspects of the implementation in an attempt to produce better results by reviewing the structure of its operations, characteristics used for detecting salient regions, the bottom-up approach implemented and other major areas of code which are crucial towards its application. The data and graphs produced through the obtained results will have some influence towards perceiving improvement for the benefit of this proposal. Reflection upon alternative visual saliency detection approaches will deliver some ideas of areas that can potentially be enhanced, but the foundations of the approach will remain the same as this project revolves around experimenting with a bottom-up approach.

The need for improvement with regards to the user-interface is not necessary as the main focus of this project is on visual saliency detection and so the user-interface is a mere addition to facilitate some complexity and visual design that will aid with the navigation of the simulation. Therefore, improvements will solely focus upon the implementation. Much change amongst the structure of the map will not be undertaken as its formulation will follow the concept of key saliency map models. However, observations of various types of saliency maps and the different information they provide to the user will be identified in an attempt to utilize all the information we can when attempting to find the salient regions of a scene. New ideas of improvements may be discovered during the production of the implementation as it is challenging to illustrate every potential improvement until the basis of the code is produced.

K. Perception of Depth

The influence of depth cues plays a crucial role in the detection of objects within a 3D environment. Its proposition alongside the use of other characteristics can enhance the performance of the saliency detection approach integrated. Depth has not been a fundamental aspect of visual saliency but its incorporation can be effective due to the possibilities of being able to separate objects of similarity which other features cannot excel in doing so. It brings an additional channel of which essential information can be extracted with regards to the shapes of the objects.

However, the level of difficulty that depth cues oppose in comparison to traditional characteristics is far greater in both its complexity and time scale. Therefore, the perception of depth will be perceived as an advanced deliverable and is only endeavored once all other elements are fully compiled. The analysis of depth within visual saliency detection may be undertaken separately in relation to the other implemented characteristics due to the additional functionality necessities it requires in order to operate and so separate results and analytical data may be retrieved. Comparison of results can be undertaken to illustrate how the concept of depth is far superior in the context of 3D environments in comparison to other features that mainly operate upon 2D environments and the approaches in which it enhances both the saliency maps obtained and any additional data that may be analysed for evaluation.

L. References

A. Borji and L. Itti. (2012). State-of-the-art in visual attention modeling. TPAMI.

A. Ciptadi, T. Hermans, and J. M. Rehg (2013). An In Depth View of Saliency. [online] - http://www.cc.gatech.edu/~thermans/papers/ciptadi-bmvc2013.pdf [accessed January 2015]

C. Koch and S. Ullman (1985). Shifts in selective visual attention: towards the underlying neural circuitry. *Human Neurobiology*.

Congyan Lang , Tam V. Nguyen , Harish Katti , Karthik Yadati , Mohan Kankanhalli , Shuicheng Yan (2012) Depth matters: influence of depth cues on visual saliency. *Proceedings of the 12th European conference on Computer Vision.*

Ernest Niebur (2007) Saliency Map. Scholarpedia, 2(8) :2675, revision #76787 [online] - http://www.scholarpedia.org/article/Saliency_map [accessed January 2015].

G. Bradski (2000). The OpenCV Library. Dr. Dobb's Journal of Software Tools.

Igor Ryabstov (2014) Igor Ryabstov- homepage [online] - http://www.ryabtsov.com/visual-saliency-framework-on-pure-python/ [accessed January 2015] [**FIGURE 1]**

Itti, L., Koch, C. (2000) A saliency-based search mechanism for overt and covert shifts of visual attention. Vision Res., 40:1489-1506.

Lab and Prof. Laurent Itti, University of Southern California, (2000) [online] http://ilab.usc.edu/bu/ [accessed January 2015] [**FIGURE 3]**

Laurent Itti , Christof Koch , Ernst Niebur (1998) A Model of Saliency-Based Visual Attention for Rapid Scene Analysis, IEEE Transactions on Pattern Analysis and Machine Intelligence, v.20 n.11, p.1254-1259

Ouerhani, N., Hugli, H. (2000) Computing visual attention from scene depth. In: ICPR .

T. Jost, N. Ouerhani, R. von Wartburg, R. Müri, H. Hugli (2004). Contribution of depth to visual attention: comparison of a computer model and human . *Proc. Early cognitive vision workshop*.

Xiaodi Hou and Liqing Zhang, Saliency Detection: A Spectral Residual Approach [online] http://www.klab.caltech.edu/~xhou/papers/cvpr07.pdf [accessed January 2015]

Zhiyong Yang - Vision as a fundamentally statistical Machine (2012). [online] http://cdn.intechopen.com/pdfs-wm/39296.pdf [accessed January 2015] [**FIGURE 2]**