

Optimisation of Saliency-driven Image Content Ranking Parameters

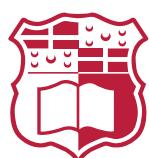
Matthew Kenely

Supervisor: Dr. Dylan Seychell

Co-Supervisor: Prof. Ing. Carl James Debono

June 2024

*Submitted in partial fulfilment of the requirements
for the degree of Science in Information Technology (Honours) (Artificial
Intelligence).*



L-Università ta' Malta
Faculty of Information &
Communication Technology

Abstract

Lorem ipsum dolor sit amet, consectetur adipiscing elit. Mauris sed ipsum risus. Nulla aliquet quis quam sed eleifend. Donec rutrum, dolor id vulputate pharetra, nulla tortor laoreet nisl, pellentesque dapibus velit dolor suscipit purus. Phasellus vitae eleifend sem. Integer ultricies ex in neque pellentesque, vitae facilisis orci aliquam. In pellentesque mollis turpis, eu tristique lacus eleifend nec. Vestibulum orci neque, rhoncus vitae convallis eu, suscipit quis dui. Nulla libero elit, porta sit amet sagittis vel, placerat sit amet tortor. Aliquam hendrerit dolor sit amet sollicitudin ornare. Aliquam placerat sodales est, in vestibulum nisl efficitur in. Nulla venenatis aliquam sem, at volutpat nisl pellentesque eleifend. Praesent vitae euismod nulla, eget vehicula turpis. Duis quis tellus vitae nisi tempus tincidunt.

Nam quis aliquet nisi, non pharetra ligula. Phasellus pulvinar mattis neque, nec interdum justo condimentum hendrerit. Mauris fermentum venenatis faucibus. Pellentesque egestas eleifend libero, quis placerat ante fermentum et. Suspendisse accumsan gravida rhoncus. Vestibulum auctor sodales vehicula. Pellentesque a urna et elit placerat laoreet a quis turpis. Morbi ut sem at nunc posuere malesuada vel nec libero. Nam et urna suscipit, bibendum diam sed, aliquet leo. Lorem ipsum dolor sit amet, consectetur adipiscing elit. Ut pretium mauris et nulla malesuada, mattis tristique lectus molestie. Aenean accumsan iaculis quam, eget varius libero placerat eu. Fusce mauris justo, vulputate a sollicitudin a, malesuada at est. Sed ac augue elit. Maecenas massa lorem, tincidunt vitae neque et, maximus dictum tellus.

Acknowledgements

Lorem ipsum dolor sit amet, consectetur adipiscing elit. Mauris sed ipsum risus. Nulla aliquet quis quam sed eleifend. Donec rutrum, dolor id vulputate pharetra, nulla tortor laoreet nisl, pellentesque dapibus velit dolor suscipit purus. Phasellus vitae eleifend sem. Integer ultricies ex in neque pellentesque, vitae facilisis orci aliquam. In pellentesque mollis turpis, eu tristique lacus eleifend nec. Vestibulum orci neque, rhoncus vitae convallis eu, suscipit quis dui. Nulla libero elit, porta sit amet sagittis vel, placerat sit amet tortor. Aliquam hendrerit dolor sit amet sollicitudin ornare. Aliquam placerat sodales est, in vestibulum nisl efficitur in. Nulla venenatis aliquam sem, at volutpat nisl pellentesque eleifend. Praesent vitae euismod nulla, eget vehicula turpis. Duis quis tellus vitae nisi tempus tincidunt.

Nam quis aliquet nisi, non pharetra ligula. Phasellus pulvinar mattis neque, nec interdum justo condimentum hendrerit. Mauris fermentum venenatis faucibus. Pellentesque egestas eleifend libero, quis placerat ante fermentum et. Suspendisse accumsan gravida rhoncus. Vestibulum auctor sodales vehicula. Pellentesque a urna et elit placerat laoreet a quis turpis. Morbi ut sem at nunc posuere malesuada vel nec libero. Nam et urna suscipit, bibendum diam sed, aliquet leo. Lorem ipsum dolor sit amet, consectetur adipiscing elit. Ut pretium mauris et nulla malesuada, mattis tristique lectus molestie. Aenean accumsan iaculis quam, eget varius libero placerat eu. Fusce mauris justo, vulputate a sollicitudin a, malesuada at est. Sed ac augue elit. Maecenas massa lorem, tincidunt vitae neque et, maximus dictum tellus.

Contents

Abstract	i
Acknowledgements	ii
Contents	iii
1 Introduction	1
2 Background	2
2.1 Saliency	2
2.2 Entropy	2
2.3 Literature Review	2
3 Methodology	4
3.1 Python scripts	4
3.1.1 main.py	4
4 Experimentation	5
4.1 Experiment 1 – Average Entropy Maximisation	5
4.2 Experiment 2 – Resolution Variation	7
4.2.1 Fixed Grid Size	7
4.2.2 Average Entropy Maximisation	7
4.3 Experiment 3 – Flower Sepal Abnormalities	8
A Sample A	11
B Sample B	12

1 Introduction

In 2018, Seychell *et al.* developed **SaRa** [1], an approach which allows for the automatic ranking of the saliency of objects within images without the prior need of a trained model. This approach splits images into a grid and processes each segment individually. The aim of this project is to analyse how varying the size of this grid, as well as the resolution of the input images, affects the generated content ranking results, and optimise the parameters of **SaRa** accordingly.

All images presented in this project are taken from the **COTS** Dataset [2] or taken by myself.

2 Background

2.1 Saliency

This project is primarily concerned with **saliency**, a computer vision problem where the goal is to automatically characterise parts of an image which stand out relative to neighbouring regions [3] (e.g. a scene where the subject in the foreground stands out relative to the background).

Saliency models are typically trained using a reference image and a corresponding saliency map.



Figure 2.1 Reference image of a book (subject) against a green background

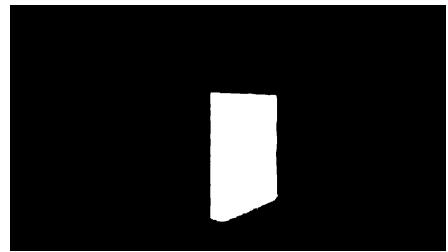


Figure 2.2 Corresponding saliency mask for the image in Figure 2.1

2.2 Entropy

2.3 Literature Review

Algorithm 1 Pseudocode for an Evolutionary Algorithm

\mathcal{P} = Population Size

χ = Number of Generations

ω = Crossover Probability

ψ = Mutation Probability

```

population = GenerateInitialPopulation( $\mathcal{P}$ )
for  $1, 2, \dots, \chi$  do
    offspring = TournamentSelection(population,  $\mathcal{P}$ )
    for  $c_i \in$  offspring,  $i = 1, 3, 5, \dots, \mathcal{P}$  do
         $z =$  random(0, 1)
        if  $z < \omega$  then
            Crossover( $c_i, c_{i+1}$ )
        end if
    end for
    for  $c_i \in$  offspring do
         $z =$  random(0, 1)
        if  $z < \psi$  then
            Mutate( $c_i$ )
        end if
    end for
    CalculatePopulationFitness(offspring)
    population = NSGA-II([population + offspring],  $\mathcal{P}$ )
end for
  
```

3 Methodology

I used the Python code developed by Seychell *et al.* as a basis for this project, restructured it, removed redundant variables and one-line functions, added function docstrings and reformatted it to conform to the PEP-8 style guide. The source code for this project is available [here](#).

3.1 Python scripts

3.1.1 main.py

```
1 def main():
2     n = 25
3
4     path = '../COTS Dataset/Part 1 - Single Objects/objects/'
5     name = 'cmt_mug_colour.jpeg'
6     im = path + name
7
8 if __name__ == "__main__":
9     main()
```

Listing 3.1 Python example

4 Experimentation

4.1 Experiment 1 – Average Entropy Maximisation

In this experiment, I implemented a Python script which runs the **SaRa** algorithm on different images at different grid sizes (from 5×5 up to 14×14). The average entropy of the top 25% highest-ranked grid segments at each grid size configuration is calculated in order to determine which grid size gives the largest proportion of entropy for a given image.

G : Grid sizes 5×5 to 14×14

H : Entropy

I_g : Image with **SaRa** grid applied

S : Highest ranked grid segments

$$\operatorname{argmax}_{g \in G} \sum_{i=1}^{\frac{1}{4} \times g^2} H(I_g\{S[i]\})$$

Below is a comparison of the results of this approach being applied to two different images. I chose these images specifically to demonstrate that this approach is able to adapt grid size according to how many areas of the image are salient (i.e. how large the subjects in the photo are in proportion to the size of the image) – the tagine in `tajin.colour.jpeg` is larger than the mug in `cmt_mug.colour.jpeg`.



Figure 4.1 tajin.colour.jpeg



Figure 4.2 cmt_mug.colour.jpeg

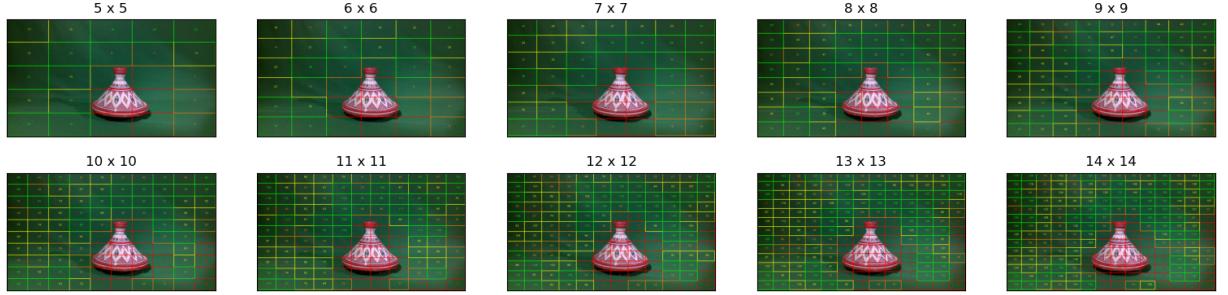


Figure 4.3 SaRa implemented on `tajin_colour.jpeg` using grid sizes from 5×5 up to 14×14

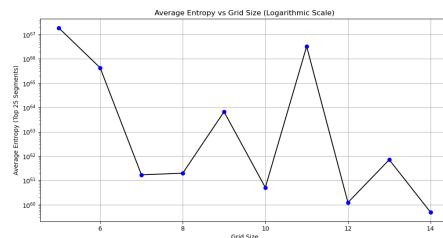


Figure 4.4 Average entropy vs Grid Size in `tajin_colour.jpeg`

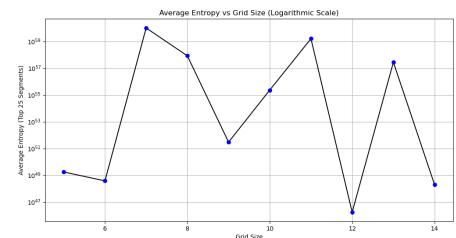


Figure 4.5 Average entropy vs Grid Size in `cmt_mug_colour.jpeg`

There are peaks in the average amount of entropy generated when the grids align to the salient objects in the images in such a way that the entropy within each segment is maximised.

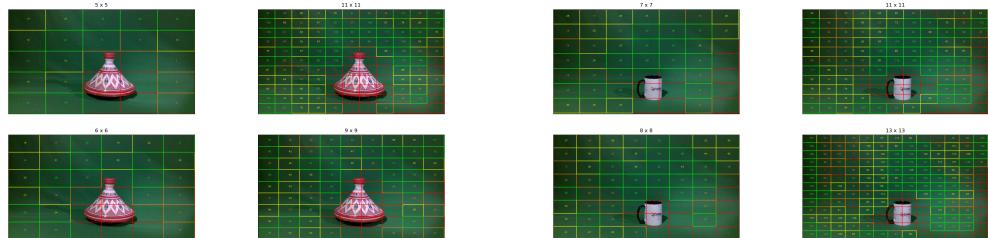


Figure 4.6 Top 4 grid sizes which result in the largest average amount of entropy in `tajin_colour.jpeg`

Figure 4.7 Top 4 grid sizes which result in the largest average amount of entropy in `cmt_mug_colour.jpeg`

Shown in Figure 4.8 and Figure 4.9 are the optimal grid sizes for maximising the amount of entropy generated in each of the images. It is notable that the tagine (the larger object) has a smaller grid size, i.e. each segment is larger.



Figure 4.8 tajin_colour.jpeg
with maximised entropy grid size
(5×5)



Figure 4.9 cmt_mug_colour.jpeg
with maximised entropy grid size
(7×7)

4.2 Experiment 2 – Resolution Variation

4.2.1 Fixed Grid Size

4.2.2 Average Entropy Maximisation

4.3 Experiment 3 – Flower Sepal Abnormalities



Figure 4.10 Botrytis cinerea (gray mold) on a flower

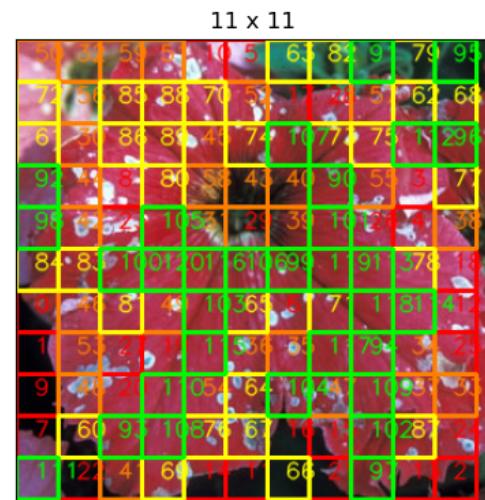


Figure 4.11 Corresponding SaRa grid

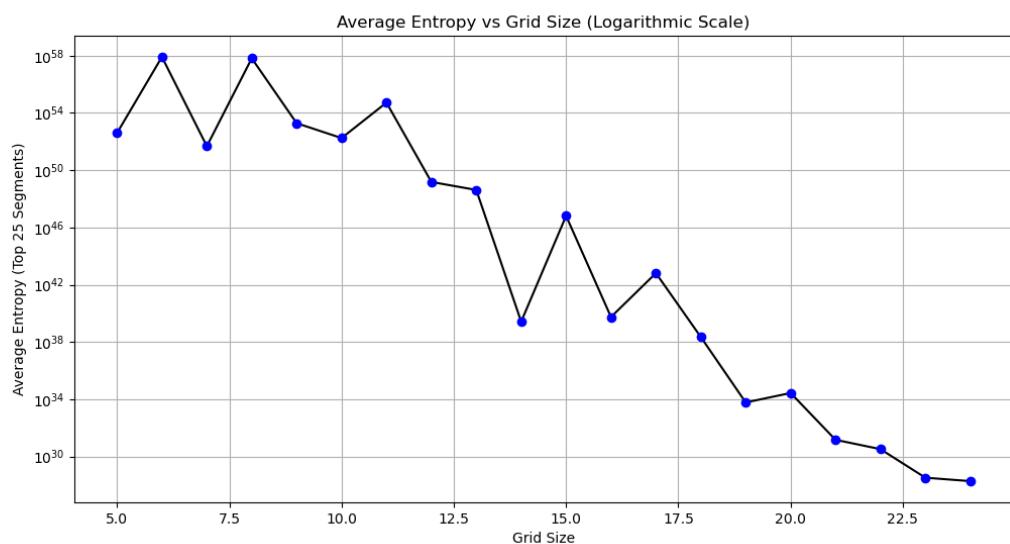


Figure 4.12 Average entropy vs Grid Size in the unhealthy flower (increased entropy throughout the image, especially at lower segment sizes)



Figure 4.13 Healthy flower

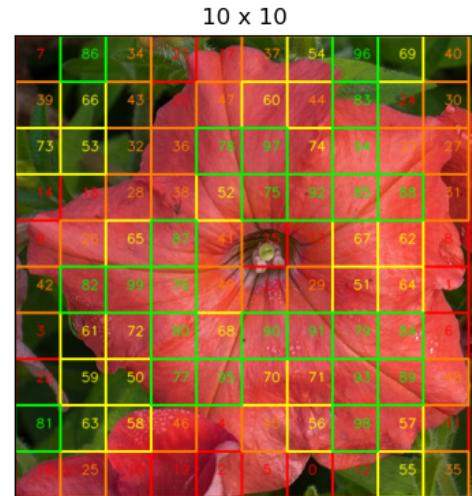


Figure 4.14 Corresponding SaRa grid (uniform entropy except in the middle where the pistil is present)

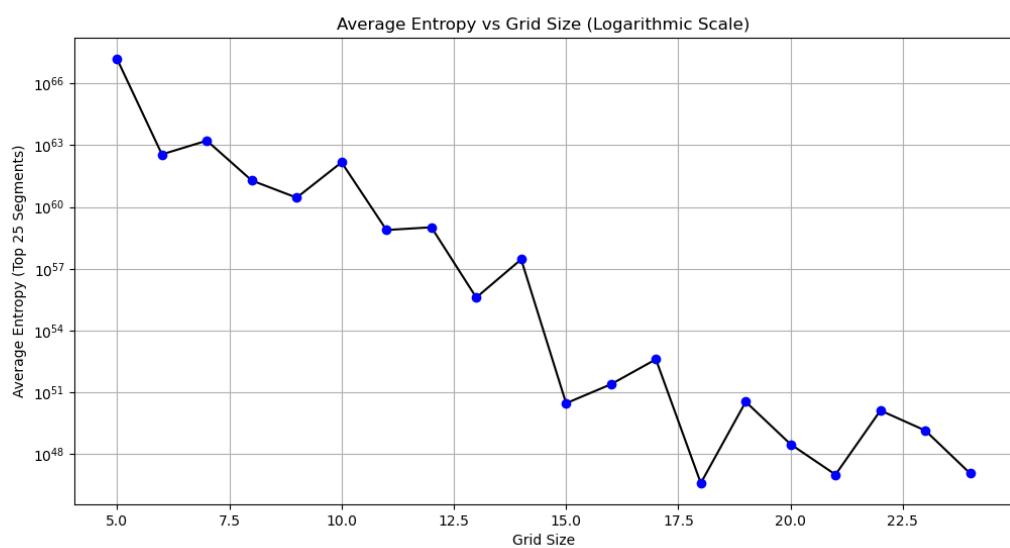


Figure 4.15 Average entropy vs Grid Size in the healthy flower

References

- [1] D. Seychell and C. J. Debono, “Ranking regions of visual saliency in RGB-D content,” en, 2018, Accepted: 2022-03-01T17:18:37Z Publisher: IEEE. DOI: 10.1109/IC3D.2018.8657902. [Online]. Available: <https://www.um.edu.mt/library/oar/handle/123456789/90087> (visited on 07/11/2023).
- [2] D. Seychell, C. J. Debono, M. Bugeja, J. Borg, and M. Sacco, “COTS: A Multipurpose RGB-D Dataset for Saliency and Image Manipulation Applications,” *IEEE Access*, vol. 9, pp. 21 481–21 497, 2021, Conference Name: IEEE Access, ISSN: 2169-3536. DOI: 10.1109/ACCESS.2021.3055647.
- [3] A. Borji and L. Itti, “State-of-the-Art in Visual Attention Modeling,” *IEEE Transactions on Pattern Analysis and Machine Intelligence*, vol. 35, no. 1, pp. 185–207, Jan. 2013, Conference Name: IEEE Transactions on Pattern Analysis and Machine Intelligence, ISSN: 1939-3539. DOI: 10.1109/TPAMI.2012.89.

Appendix A Sample A

Lorem ipsum dolor sit amet, consectetur adipiscing elit. Mauris sed ipsum risus. Nulla aliquet quis quam sed eleifend. Donec rutrum, dolor id vulputate pharetra, nulla tortor laoreet nisl, pellentesque dapibus velit dolor suscipit purus. Phasellus vitae eleifend sem. Integer ultricies ex in neque pellentesque, vitae facilisis orci aliquam. In pellentesque mollis turpis, eu tristique lacus eleifend nec. Vestibulum orci neque, rhoncus vitae convallis eu, suscipit quis dui. Nulla libero elit, porta sit amet sagittis vel, placerat sit amet tortor. Aliquam hendrerit dolor sit amet sollicitudin ornare. Aliquam placerat sodales est, in vestibulum nisl efficitur in. Nulla venenatis aliquam sem, at volutpat nisl pellentesque eleifend. Praesent vitae euismod nulla, eget vehicula turpis. Duis quis tellus vitae nisi tempus tincidunt.

Nam quis aliquet nisi, non pharetra ligula. Phasellus pulvinar mattis neque, nec interdum justo condimentum hendrerit. Mauris fermentum venenatis faucibus. Pellentesque egestas eleifend libero, quis placerat ante fermentum et. Suspendisse accumsan gravida rhoncus. Vestibulum auctor sodales vehicula. Pellentesque a urna et elit placerat laoreet a quis turpis. Morbi ut sem at nunc posuere malesuada vel nec libero. Nam et urna suscipit, bibendum diam sed, aliquet leo. Lorem ipsum dolor sit amet, consectetur adipiscing elit. Ut pretium mauris et nulla malesuada, mattis tristique lectus molestie. Aenean accumsan iaculis quam, eget varius libero placerat eu. Fusce mauris justo, vulputate a sollicitudin a, malesuada at est. Sed ac augue elit. Maecenas massa lorem, tincidunt vitae neque et, maximus dictum tellus.

Appendix B Sample B

Lorem ipsum dolor sit amet, consectetur adipiscing elit. Mauris sed ipsum risus. Nulla aliquet quis quam sed eleifend. Donec rutrum, dolor id vulputate pharetra, nulla tortor laoreet nisl, pellentesque dapibus velit dolor suscipit purus. Phasellus vitae eleifend sem. Integer ultricies ex in neque pellentesque, vitae facilisis orci aliquam. In pellentesque mollis turpis, eu tristique lacus eleifend nec. Vestibulum orci neque, rhoncus vitae convallis eu, suscipit quis dui. Nulla libero elit, porta sit amet sagittis vel, placerat sit amet tortor. Aliquam hendrerit dolor sit amet sollicitudin ornare. Aliquam placerat sodales est, in vestibulum nisl efficitur in. Nulla venenatis aliquam sem, at volutpat nisl pellentesque eleifend. Praesent vitae euismod nulla, eget vehicula turpis. Duis quis tellus vitae nisi tempus tincidunt.

Nam quis aliquet nisi, non pharetra ligula. Phasellus pulvinar mattis neque, nec interdum justo condimentum hendrerit. Mauris fermentum venenatis faucibus. Pellentesque egestas eleifend libero, quis placerat ante fermentum et. Suspendisse accumsan gravida rhoncus. Vestibulum auctor sodales vehicula. Pellentesque a urna et elit placerat laoreet a quis turpis. Morbi ut sem at nunc posuere malesuada vel nec libero. Nam et urna suscipit, bibendum diam sed, aliquet leo. Lorem ipsum dolor sit amet, consectetur adipiscing elit. Ut pretium mauris et nulla malesuada, mattis tristique lectus molestie. Aenean accumsan iaculis quam, eget varius libero placerat eu. Fusce mauris justo, vulputate a sollicitudin a, malesuada at est. Sed ac augue elit. Maecenas massa lorem, tincidunt vitae neque et, maximus dictum tellus.