

# Optimisation of Saliency-driven Image Content Ranking Parameters

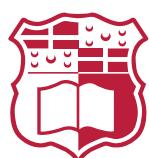
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June 2024

*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

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# Acknowledgements

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# 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

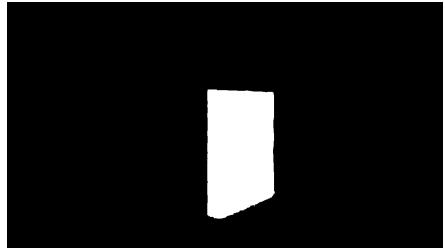
### 2.1 Saliency

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] and attract visual human attention.

Saliency models typically utilise Convolutional Neural Network (CNN) architectures and are trained using reference images paired with manually annotated corresponding saliency maps (an  $n$ -bit grayscale image where pixel values denote the level of saliency of a particular region, with 0 implying no saliency, and  $n$  implying maximum saliency).



**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

Generally, entropy (denoted by  $H$ ) is a scientific concept and physical property associated with a state of disorder, randomness, or uncertainty. When applied to the context of saliency, entropy refers to the measure of uncertainty or randomness in a saliency map, i.e. the extent to which pixel values are uniformly distributed in the map [4].

Shown in Equation 2.1 is Shannon's entropy equation.

$$H(X) = - \sum_{i=1}^{|t|} P(x_i) \log_2(P(x_i)) \quad (2.1)$$

In [1], rather than applying Shannon's entropy to the entirety of a saliency map, it is used to calculate a score for each of the individual grid segments and rank them accordingly.

### 2.3 Literature Review

---

**Algorithm 1** Pseudocode for an Evolutionary Algorithm

---

$\mathcal{P}$  = Population Size

$\chi$  = Number of Generations

$\omega$  = Crossover Probability

$\psi$  = 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  $5 \times 5$  up to  $14 \times 14$ ). 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  $5 \times 5$  to  $14 \times 14$

$H$  : Entropy

$I_g$  : Image with **SaRa** grid applied

$S$  : Highest ranked grid segments

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

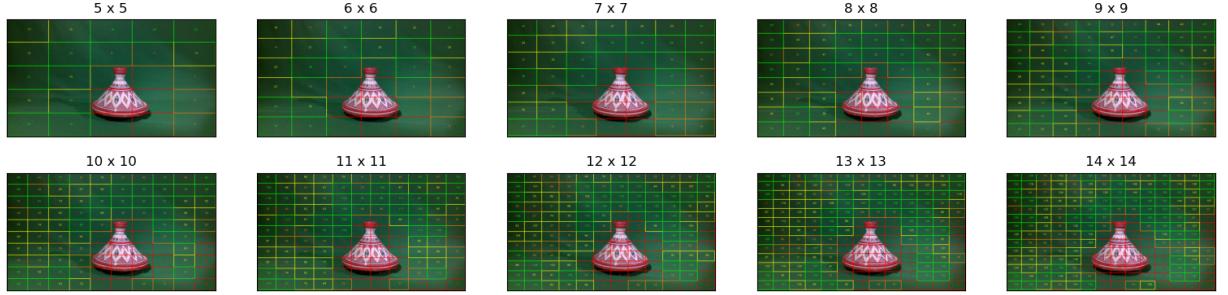
Below is a comparison of the results of this approach being applied to two different images. I chose these images specifically to demonstrate that this approach is able to adapt grid size according to how large the salient objects in the scene are in proportion to the size of the image – the tagine in `tajin_colour.jpeg` is larger than the mug in `cmt_mug_colour.jpeg`.



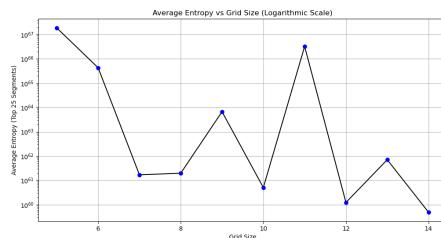
Figure 4.1 `tajin_colour.jpeg`



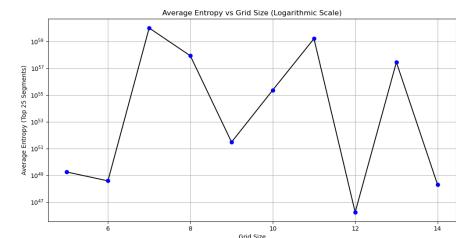
Figure 4.2 `cmt_mug_colour.jpeg`



**Figure 4.3** SaRa implemented on `tajin_colour.jpeg` using grid sizes from  $5 \times 5$  up to  $14 \times 14$

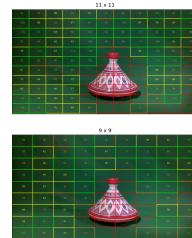


**Figure 4.4** Average entropy vs Grid Size in `tajin_colour.jpeg`

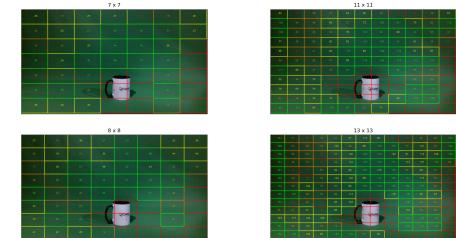


**Figure 4.5** Average entropy vs Grid Size in `cmt_mug_colour.jpeg`

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.

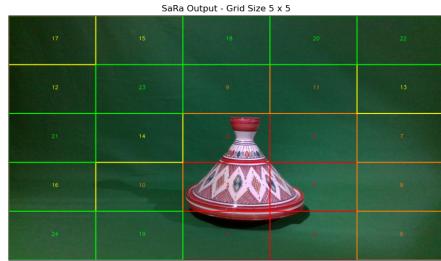


**Figure 4.6** Top 4 grid sizes which result in the largest average amount of entropy in `tajin_colour.jpeg`



**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 grid segments. 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  
( $5 \times 5$ )



**Figure 4.9** cmt\_mug\_colour.jpeg  
with maximised entropy grid size  
( $7 \times 7$ )

## 4.2 Experiment 2 – Resolution Variation

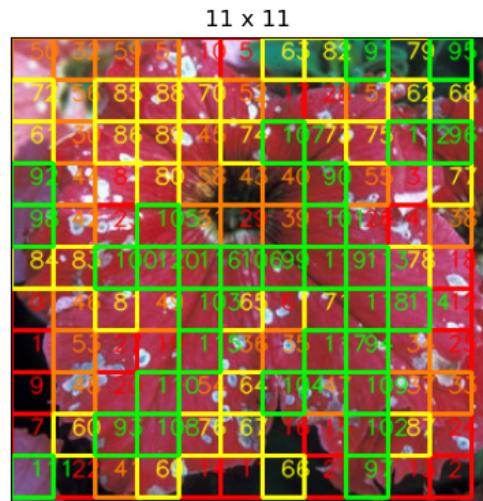
### 4.2.1 Fixed Grid Size

### 4.2.2 Average Entropy Maximisation

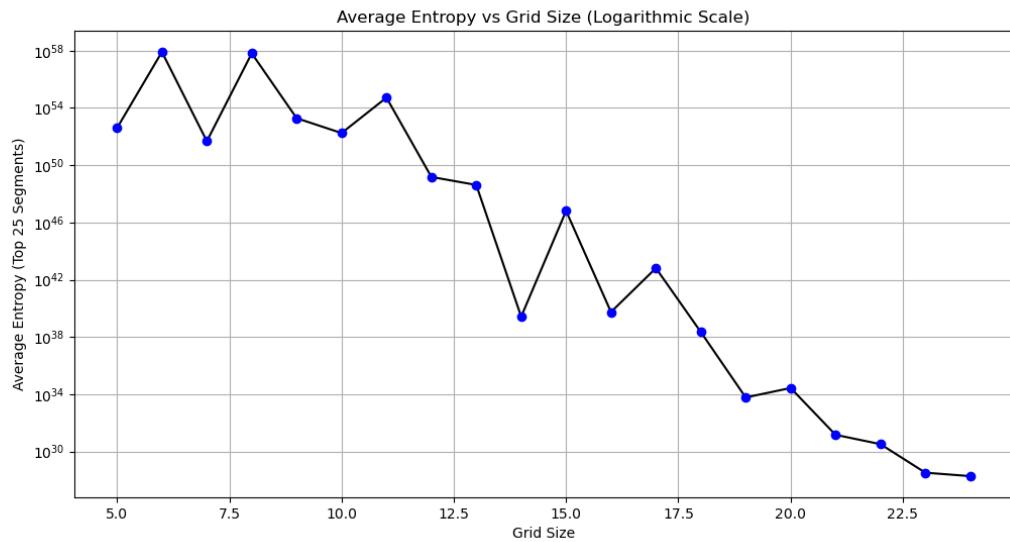
### 4.3 Experiment 3 – Flower Sepal Abnormalities



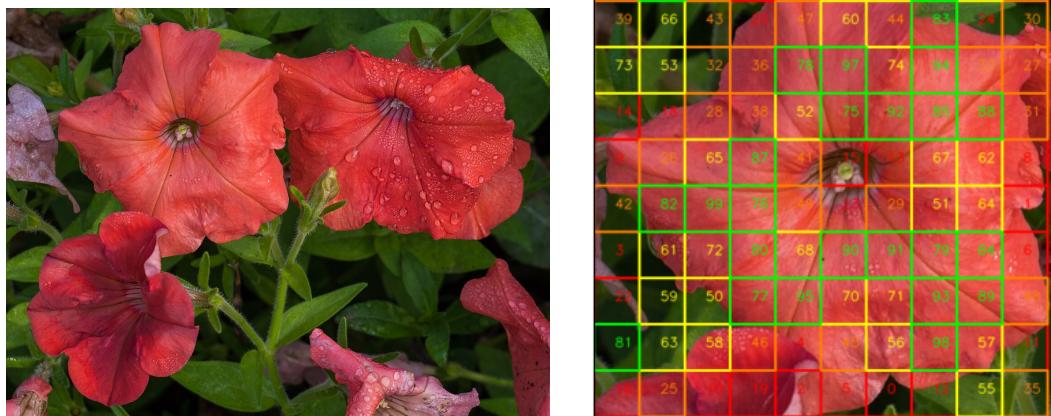
**Figure 4.10** Botrytis cinerea (gray mold) on a flower



**Figure 4.11** Corresponding SaRa grid (increased entropy throughout the image, especially at lower segment sizes)

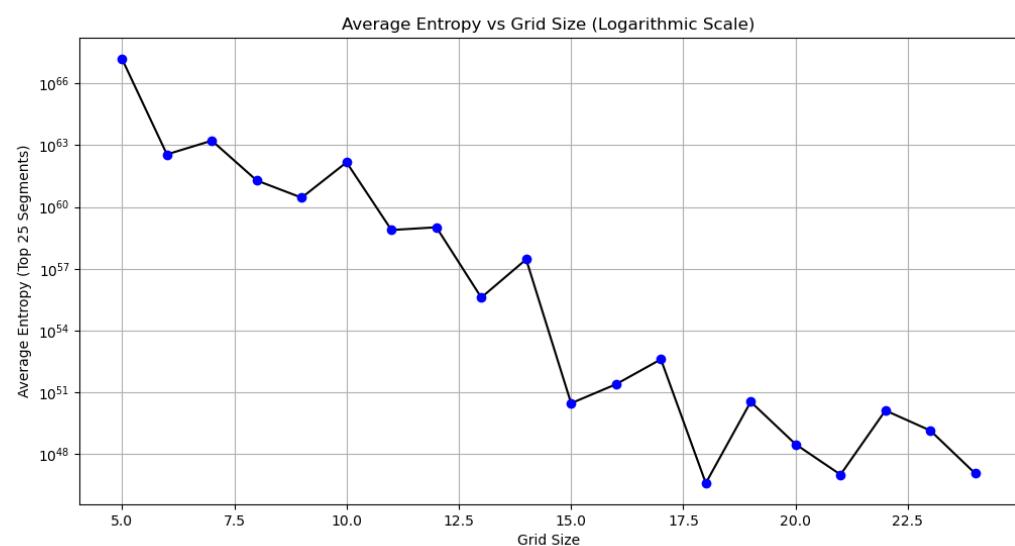


**Figure 4.12** Average entropy vs Grid Size in the unhealthy flower



**Figure 4.13** Healthy flower

**Figure 4.14** Corresponding SaRa grid (uniform lack of saliency except in the middle where the pistil is present)



**Figure 4.15** Average entropy vs Grid Size in the healthy flower

## **5 Evaluation**

# 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.
- [4] N. Bruce and J. Tsotsos, “Saliency Based on Information Maximization,” in *Advances in Neural Information Processing Systems*, vol. 18, MIT Press, 2005. [Online]. Available: <https://proceedings.neurips.cc/paper/2005/hash/0738069b244a1c43c83112b73514Abstract.html> (visited on 07/13/2023).

# Appendix A Sample A

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## Appendix B Sample B

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