Optimisation of Saliency-driven Image Content Ranking Parameters

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Abstract

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Acknowledgements

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Contents

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.

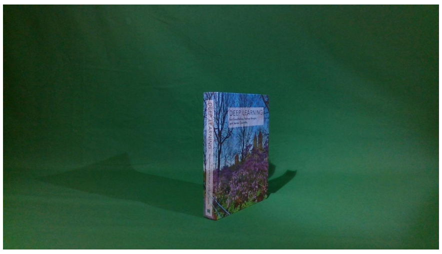

Figure 2.1 Reference image of a book (subject) against a green background

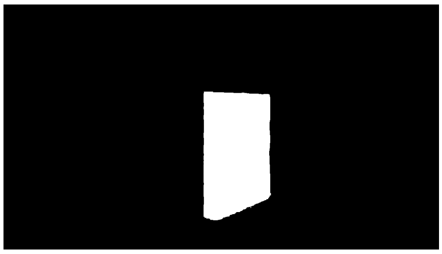

Figure 2.2 Corresponding saliency mask for the image in Figure **2.1**

2.2 Entropy

2.3 Literature Review

Algorithm 1 Pseudocode for an Evolutionary Algorithm

```
𝒫 = Population Size
χ = Number of Generations
ω = Crossover Probability
ψ = Mutation Probability

population = GenerateInitialPopulation(𝒫)
for 1, 2, ..., χ do
    offspring = TournamentSelection(population, 𝒫)
    for c_i ∈ offspring, i = 1, 3, 5, ..., 𝒫 do
        z = random(0, 1)
        if z < ω then
            Crossover(c_i, c_{i+1})
        end if
    end for
    for c_i ∈ offspring do
        z = random(0, 1)
        if z < ψ then
            Mutate(c_i)
        end if
    end for
    CalculatePopulationFitness(offspring)
    population = NSGA-II([population + offspring], 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 dosctrings and reformatted it to confirm to the PEP-8 style guide. The source code for this project is available **here**.

3.1 Python scripts

3.1.1 main.py

```python
def main():
    n = 25

    path = '../COTS Dataset/Part 1 - Single Objects/objects/'
    name = 'cmt_mug_colour.jpeg'
    im = path + name

if __name__ == "__main__":
    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.

$$\begin{aligned} G &: \text{Grid sizes } 5 \times 5 \text{ to } 14 \times 14 \\ H &: \text{Entropy} \\ I_g &: \text{Image with } \textbf{SaRa} \text{ grid applied} \\ S &: \text{Highest ranked grid segments} \end{aligned}$$

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

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

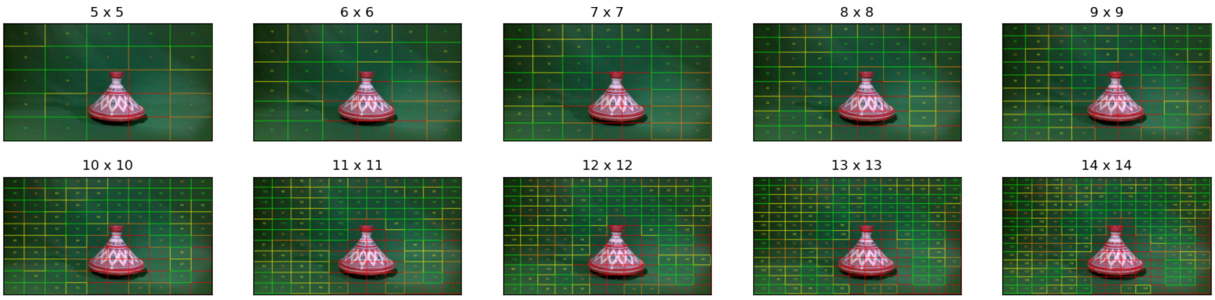

Figure 4.3 **SaRa** implemented on **tajin_colour.jpeg** using grid sizes from 5×5 up to 14×14

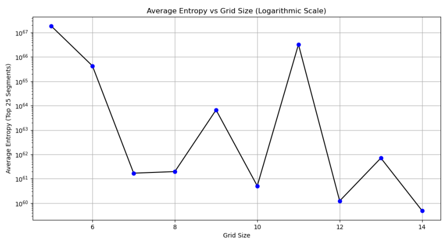

Figure 4.4 Average entropy vs Grid Size in **tajin_colour.jpeg**

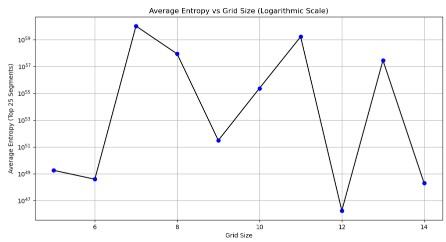

Figure 4.5 Average entropy vs Grid Size in **cmt_mug_colour.jpeg**

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.

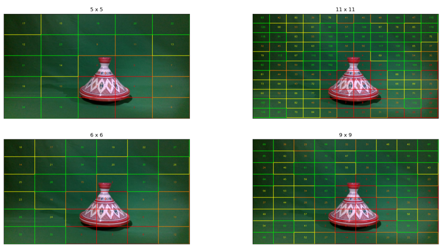

Figure 4.6 Top 4 grid sizes which result in the largest average amount of entropy in **tajin_colour.jpeg**

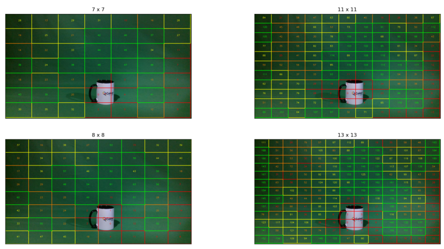

Figure 4.7 Top 4 grid sizes which result in the largest average amount of entropy in **cmt_mug_colour.jpeg**

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.

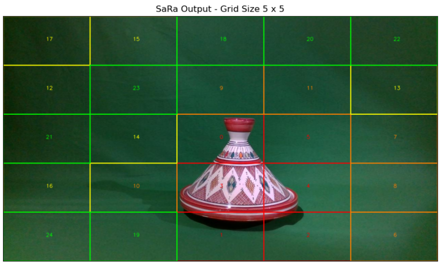

Figure 4.8 tajin_colour.jpeg with maximised entropy grid size (5×5)

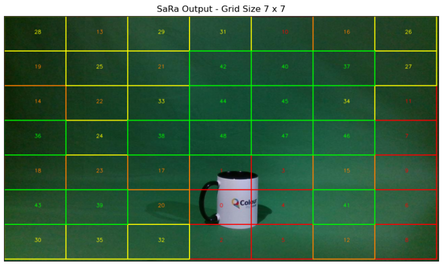

Figure 4.9 cmt_mug_colour.jpeg with maximised entropy grid size (7×7)

4.2 Experiment 2 – Resolution Variation

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

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Appendix B Sample B

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