A Study of Classic Image Segmentation Methods

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Introduction

- Image segmentation
- Mathematical morphology
- Hierarchy in segmentation

Objectives

- Develop research skills
- Learn and research about classic segmentation methods in the filed
- Compare and classify these methods
- Develop solutions to help with this task

Studied Algorithms

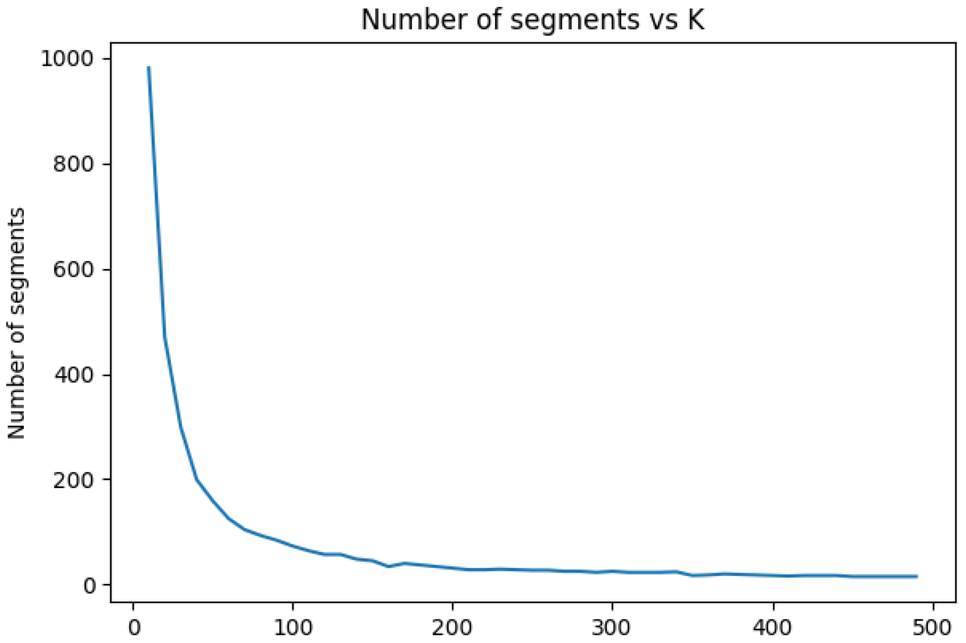
- Felzenszwalb’s algorithm
- Saliency Map
- Image Foresting Transform (IFT)
- Watershed
- Random Walks

Felzenszwalb’s Algorithm

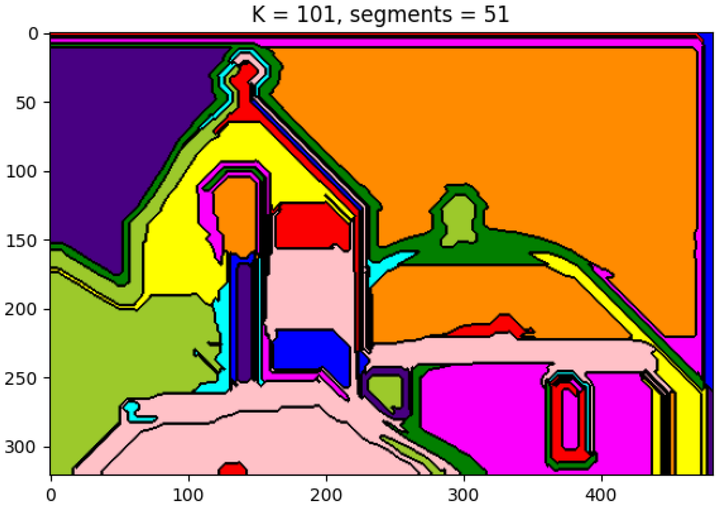
- Introduced by Felzenszwalb et al.
- Uses graph theory to segment an image grouping pixels together
- Has a parameter ‘K’, responsible for controlling the number of segments
- Implemented in the Python library ‘scikit-image’

Felzenszwalb’s Algorithm

- Given a value ’N’, we should generate an image with a number of segments as close as possible to 'N'
- **Problem:** no good way of guessing a value of ‘K' for a given ’N’
- **Solution:** binary search



Felzenszwalb's Algorithm



Watershed

- We interpret the image as a topological space
- Areas of high pixel values are our “mountains” and areas of low pixel values are our “valleys”
- Simulating filling this space with water, gives us information on how to segment this image
- Implemented in C in the library ‘ift-demo' by Falcão et. al.

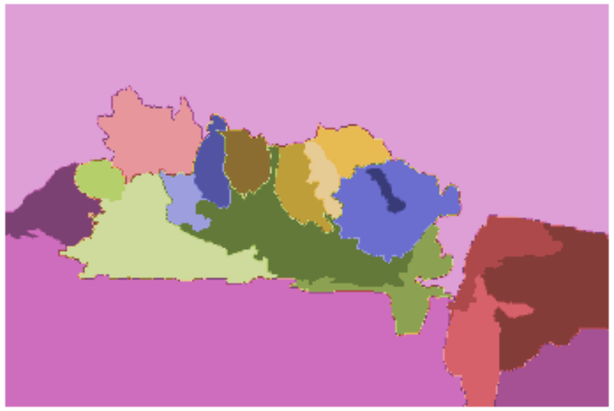
Watershed

- In order to run this algorithm, we need to provide it ‘seeds’, they are the ‘water sources'
- Each seed generates one segment in our final image
- We use the saliency map algorithm to generate these seeds, and the highest ’N' are selected to segment the image
- Saliency map has a implementation in C in the library ‘sm’, by Cousty et. al

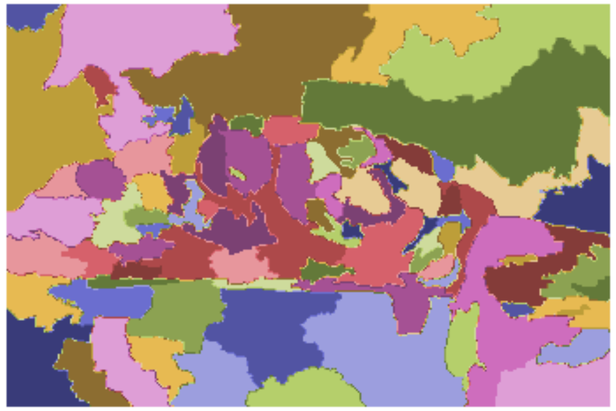
Watershed

original image

jaguar - 20 segments



jaguar - 100 segments



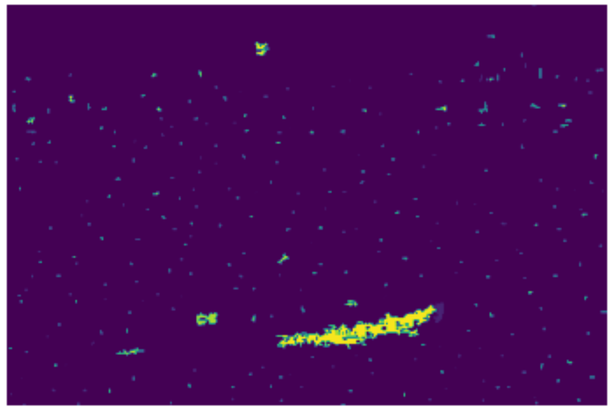
Random Walks

- Starting with a set of markers, neighboring pixels are visited accordingly to an equation
- Has an implementation in Python, in the ‘scikit-image’ library
- As markers, the same seeds (generated using the ‘sm' library) utilized in the watershed method were utilized

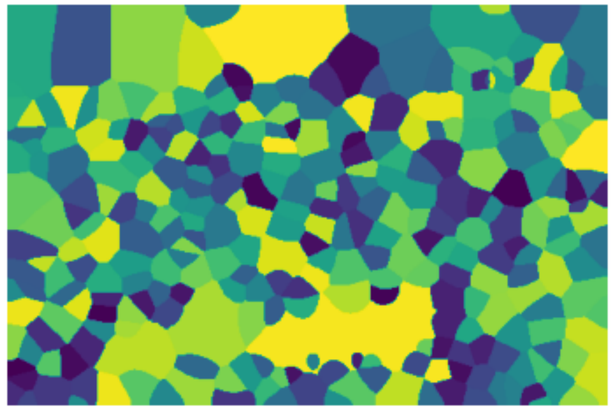
Random Walks

Original Image

Seeds



Random Walker

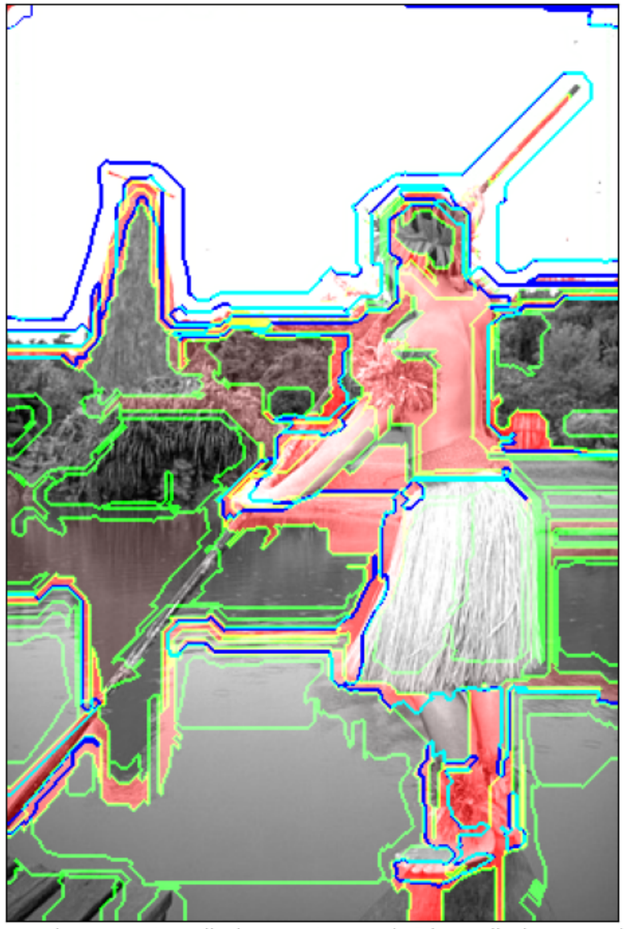


Methodology

- For each algorithm, two segmentations of different sizes were generated
- They were overlayed, and doing such we can visualize the hierarchy between these segmentations
- The results were visually classified, in 4 different categories:
    - no shifts (all cells aligns with theirs father's).
    - only small shifts (no considerable shifts were observed).
    - large shifts (between 1 and 10 considerable shifts happened).
    - many large shifts (more than 10 considerable shifts are present).

Results

Felzenszwalb

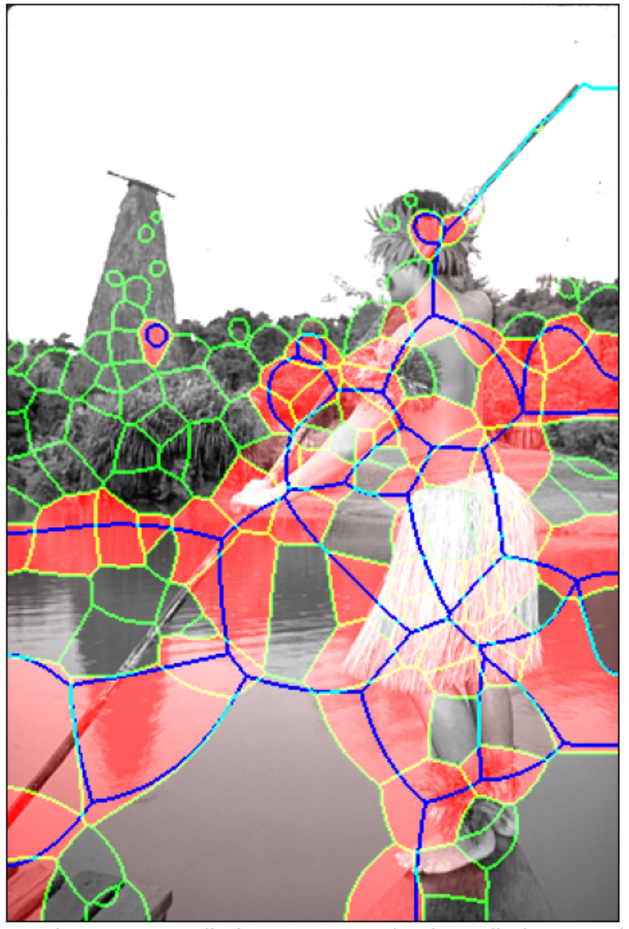


many large countour displacement errors (>5 large displacements)

Watershed

only small countour displacement errors (only small displacements)

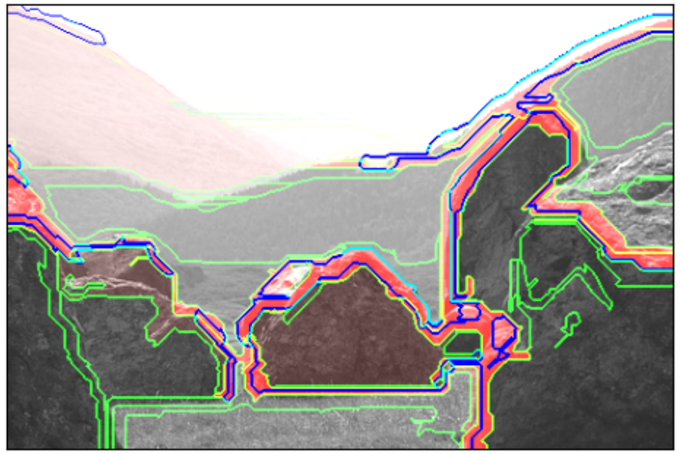
Random Walker



many large countour displacement errors (>5 large displacements)

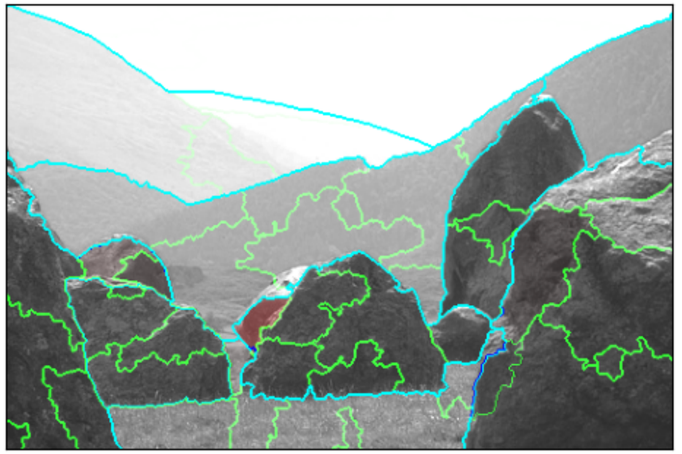
Results

Felzenszwalb



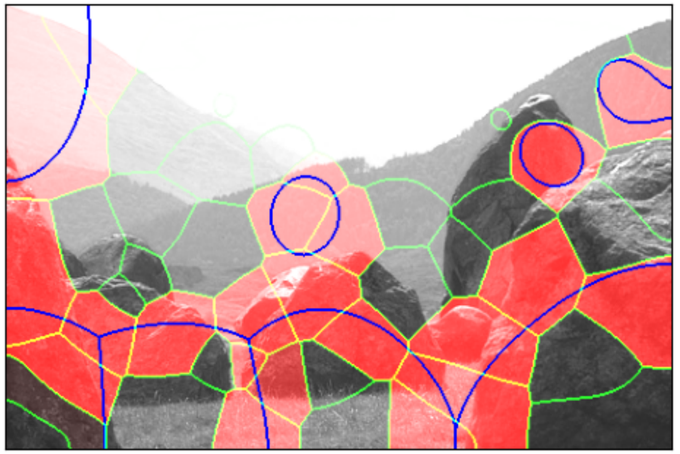
few large countour displacement errors (1-5 large displacements)

Watershed



only small countour displacement errors (only small displacements)

Random Walker



many large countour displacement errors (>5 large displacements)

Results

- Regarding the quality of the segmentation, watershed by far had the best results
- Felzenszwalb has mixed results, being acceptable in some case, and not so good at others, especially in low frequency areas
- Random Walks has the worst results, likely due to the markers used

Results

- Regarding the hierarchy, watershed did again performed the best, with most shifts being small, and a few large
- Felzenszwalb has a lot of large shifts, but did manage, with a few results having a few less
- Random Walks has big shifts all over the place, and all results were classified as having “many large shifts"

Class	FS	WS	RW	Total
no shifts	0	0	0	0
only small shifts	0	10	0	10
large shifts	5	12	0	17
many large shifts	20	3	25	48

Conclusions

- During these 3 months, I've learned a lot of skills that will help me in my professional and academic careers
- I had a taste of how to conduct a research project by myself, learn new skills, read articles and develop solutions to real problems
- Worked with researchers from other cultures and countries
- The results I've got even though are now ground-breaking or revolutionary, mean a lot to me as a student

Thank You!