Waterpixels Generation

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Definition of Superpixels

Superpixels

Superpixels are groups of pixels that are similar in color and/or texture, and are typically used as a preprocessing step for image segmentation and object recognition tasks. They provide a way to reduce the complexity of an image by grouping together pixels that belong to the same object or region.

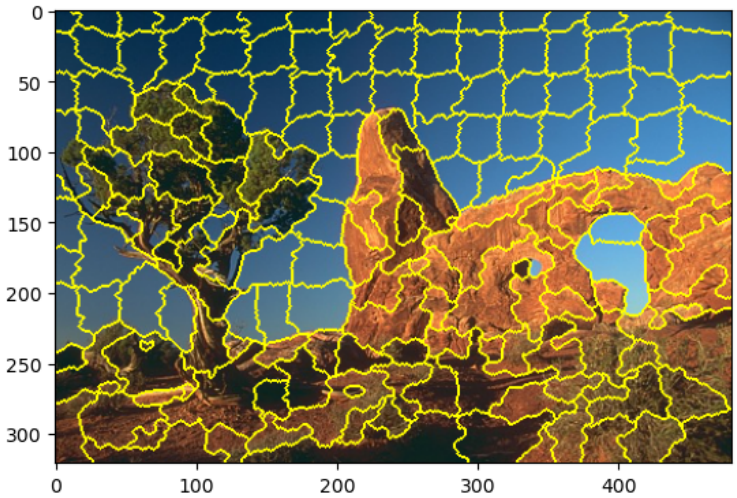


Figure: Example of an image with superpixels overlaid

Properties of Superpixels

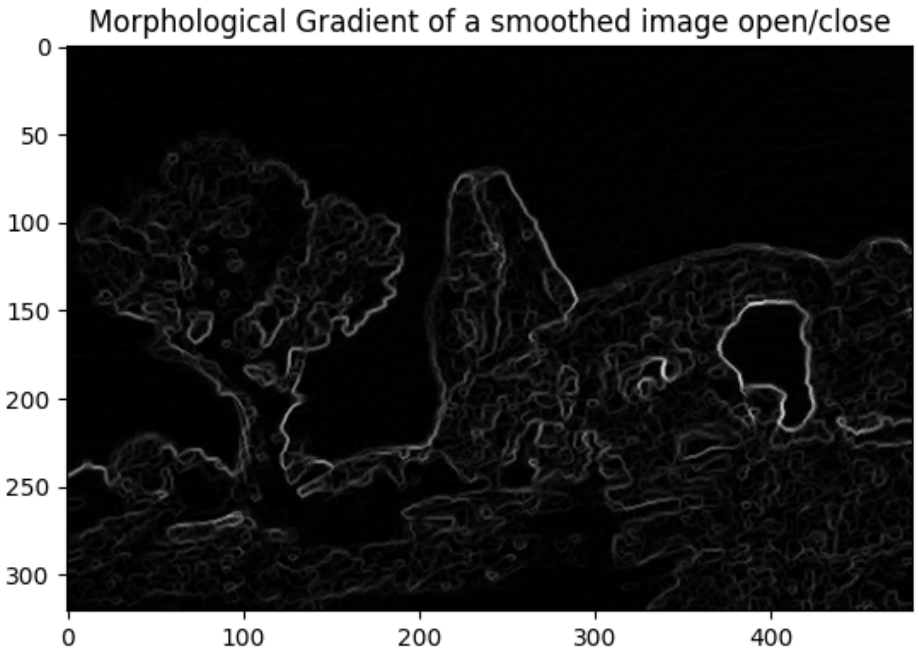
- Superpixels are regions in an image that are perceptually meaningful and homogeneous.
- They are used as a preprocessing step for various computer vision tasks such as segmentation, object recognition, and image compression.
- The two main properties of superpixels are:
  1. Boundary Adherence: Superpixels should adhere well to object boundaries in the image. This property ensures that objects are not split across multiple superpixels.
  2. Regularity: Superpixels should have a regular shape and size. This property ensures that the superpixels are easy to work with and can be used as a consistent unit for further processing.

Steps to Generate Waterpixels

1. Computation of the gradient of an image: a morphological gradient
2. Definition of regular cells on the image centered on the vertices of a regular grid; we choose cell centers in the grid
3. Selection of one marker per cell
4. Spatial regularization of the gradient with the help of a distance function
5. Application of the watershed transformation on the regularized gradient defined in step 4 from the markers defined in step 2

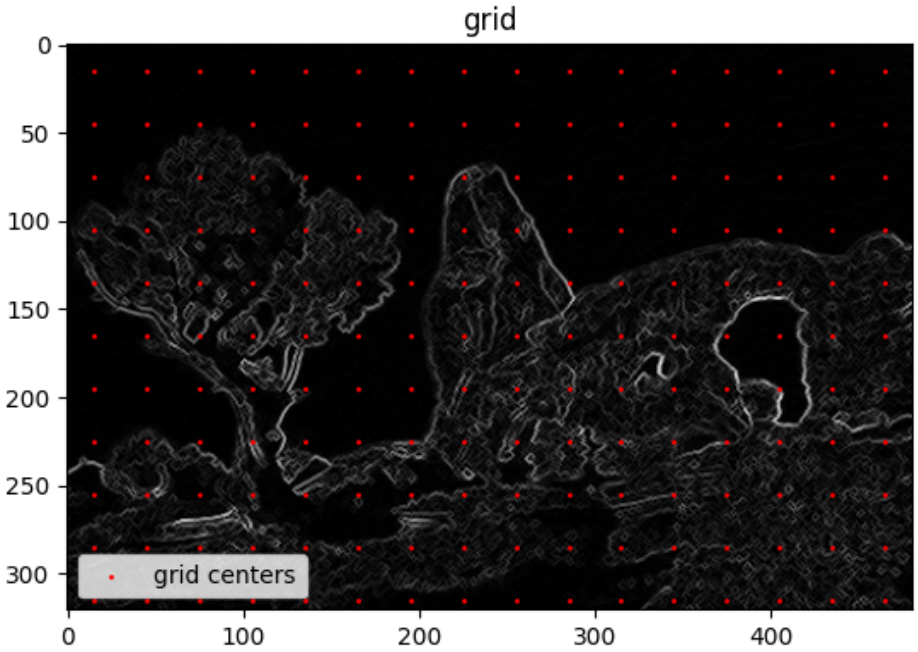
Computation of the Gradient of an Image: A Morphological Gradient

- Smoothing of the image using morphological opening and closing
- Conversion of the picture from three-channel color to one-gray level channel
- Calculation of the morphological gradient through erosion subtracted from dilation of the image



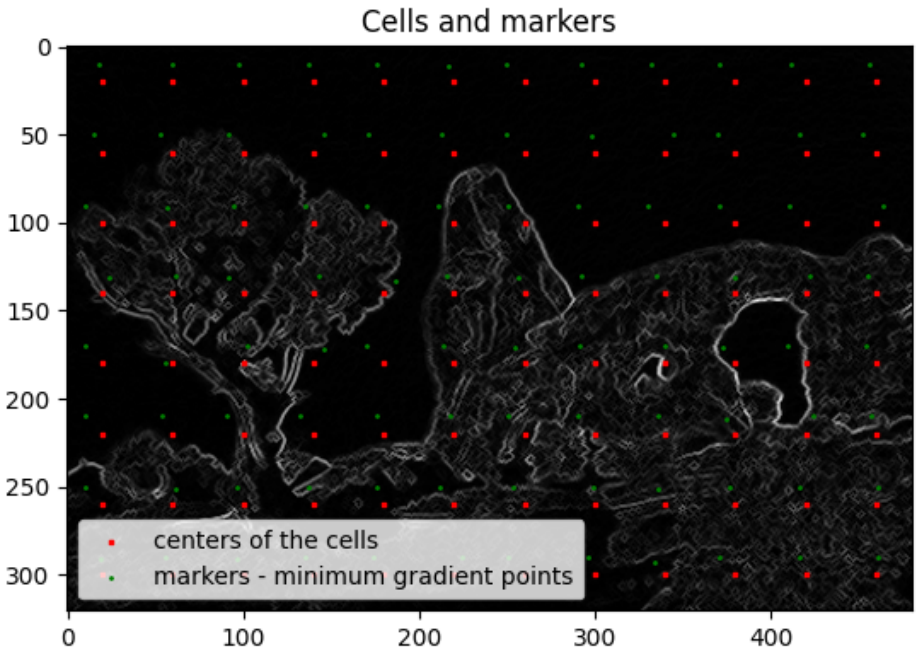
Definition of Regular Cells on the Image

- Each cell corresponds to the generation of a unique water pixel
- The choice of one marker per cell offers total control over the number of SP
- The center of cells or the minimal points of the gradient can be used as markers



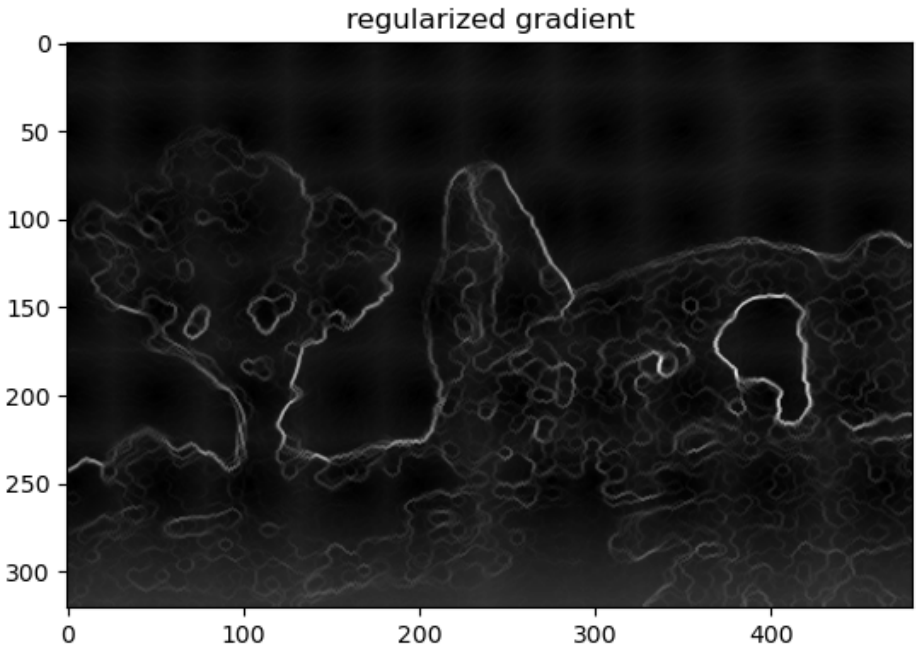
Selection of One Marker per Cell

- The selection of markers has enforced the pertinence of future superpixel-boundaries but also the regularity of their pattern
- The importance of marker selection and its impact on the resulting superpixels is discussed



Spatial Regularization of the Gradient with the Help of a Distance Function

- A technique to regulate the gradient in a spatially coherent manner, balancing between boundary adherence and regularity
- The image gradient is taken as input and a regularized gradient is produced
- A function that calculates the distance between points in the image domain and a set of markers is implemented



Spatial Regularization of the Gradient

Distance Function d_Q

$$d_Q(p) = \frac{2}{\sigma} \min_{i \in [1,N]} d(p, q_i)$$

where $Q = q_{i1 \leq i \leq N}$ is a set of N connected components of the image f,$p \in D$ is a pixel in the domain of the image, σ is the grid step, and $d(p, q_i)$ is the Euclidean distance between pp and q_i.

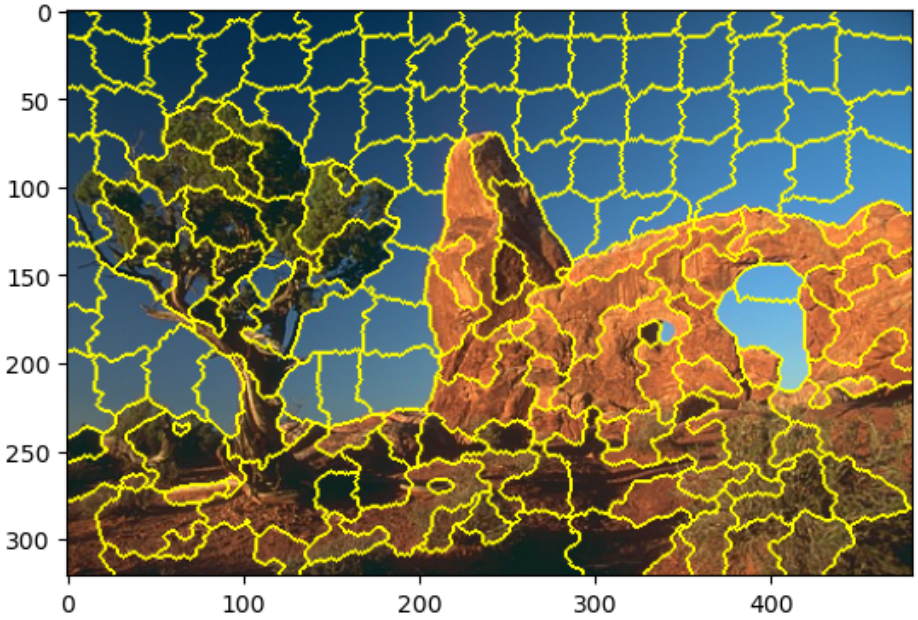
Regularized Gradient

$$g_{\text{reg}} = g + k \cdot d_Q$$

where g is the gradient of the image f, d_Q is the distance function defined above, and k is the spatial regularization parameter.

Application of the Watershed Transformation

- The watershed transformation is applied on the regularized gradient defined in step 4 from the markers defined in step 2
- An image partition is obtained, where each region corresponds to a water pixel



Conclusion

Summary of Our Study

In this study, we presented an efficient algorithm for generating waterpixels, a type of superpixel that follows the boundaries of objects in an image. Our algorithm uses a combination of morphological operations and the watershed transform to generate high-quality waterpixels in a fast and efficient manner.

Key Findings

- Our algorithm is able to generate waterpixels that closely follow the boundaries of objects in an image, resulting in high-quality superpixels.
- Additionally, we have developed a web app that allows users to easily test our method with different parameters, making the process of generating waterpixels even faster and more convenient.