EE 576 - Image Segmentation

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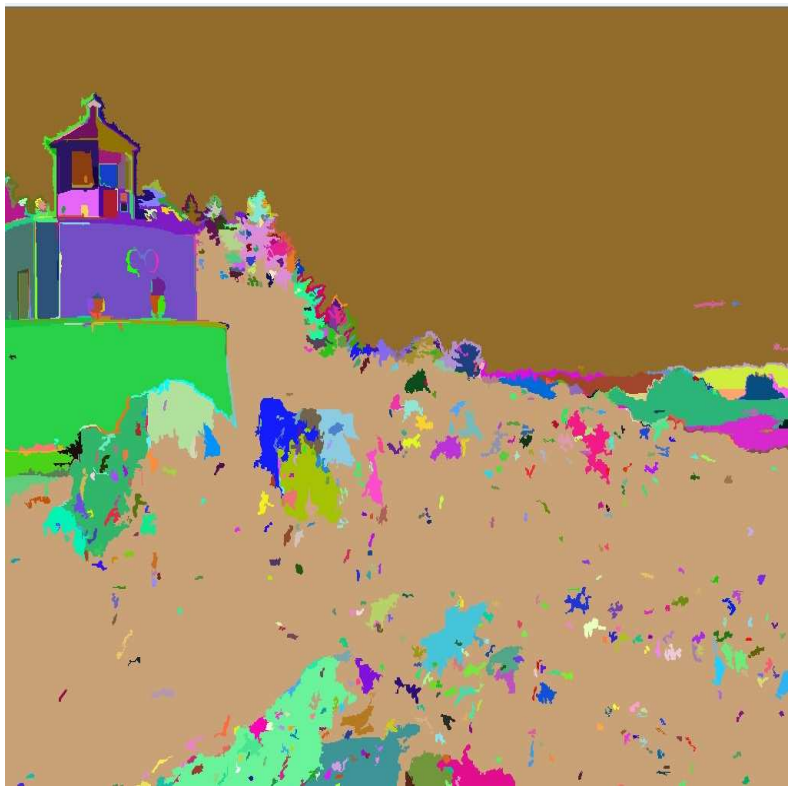
Segmentation

Segmentation: Finding regions in the image that go together. Done via finding discontinuities in some features – usualy color, intensity, etc.

- Object boundaries
- Surface boundaries
- Reflective boundaries (Texture)
- Illumination boundaries (Shadow)
- Noise

Segmented Images



Proposed Approaches:

Four categories:

- Pixel-based approaches: Operations such as thresholding [1] or histogram [2].
- Region-based approaches: Split and merge or region growing [3].
- Edge based approaches: Edge flow or deformable contours such as snakes.
- Graph based approaches: Segments as grouped nodes [4, 5]

Connectedness

Alternative definitions of connectedness:

- Four connectedness – only edge adjacent pixels are neighbours.
- Eight connectedness – here both edge and corner adjacent cells are considered neighbours.
- The Jordan Curve Theorem - A simple closed curve separates the plane into two simply connected components – the inside and the outside.

Connectedness

1	0	1
0	1	0
1	0	1

Problems

- With 4-connectedness $\rightarrow$ 9 separate objects.
- With 8 connectedness, there is an object that creates a closed curve, but the background element in the middle is also connected to the outside. Hence a contradiction!

6-Connectedness

- The ideal solution $\Longrightarrow$ A hexagonal grid which gives us 6-connectedness.
- Consider object pixels as 8 connected and background points as 4 connected (or vice versa)
- Skew the rectangular grid via shifting preceeding row by 1/2 pixel right and succeeding row by 1/2 pixel left.

6-Connectedness

An arrangement where the center pixel is connected to its four immediate neighbours (as in 4-connectedness) plus two of its diagonal neighbours. T

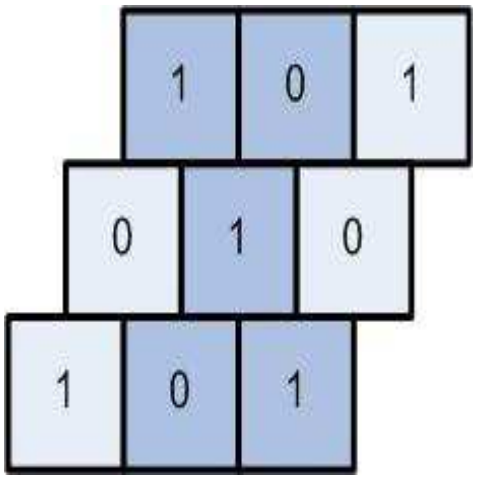


Figure: 6-Connectedness example

Connected Component Analysis

First identify the connected components, that is the distinctly connected blobs that correspond to each object in the image.
Suppose the image is converted to a binary image form.
First, note that for the first two definitions, two properties hold:

1. Symmetricity – $x\ y \implies y\ x$
2. Transivity – $x\ y,\ y\ z \implies x\ z$

Algorithm – General Description

A scan of the the image using a typical raster scan, row by row, top to bottom, left to right. At each pixel x^i, first note the following definitions:

- x^i: The particular pixel
- x^{i-1} Pixel to its left (already labelled)
- x^a: Pixel above the pixel
- x^{aa}: The pixel above x^a

Connected Components Algorithm

Scan from top to bottom, from left to right
if $I(x^i) = 0$ do nothing
Else if labeled(x^{aa})
    label(x^i) =label(x^{aa})
Else if (not labeled(x^{i-1})) and (not labeled(x^a))
    label(x^i) = lastlabelno+1;
Else if labeled(x^{i-1}) xor labeled(x^a)
    label(x^i) = label
Else if labeled(x^{i-1}) and labeled(x^a)
   if label(x^{i-1}) = label(x^a)
      label(x^i)= label(x^a)
Else
      label(x^i) = label(x^{i-1}) or label(x^i) = label(x^a) and record equivalence of labels

Connected Components Algorithm –

First application of this algorithm $\Rightarrow$ Determine the label equivalences in order to label each connected component in the image uniquely.

Using Morphology

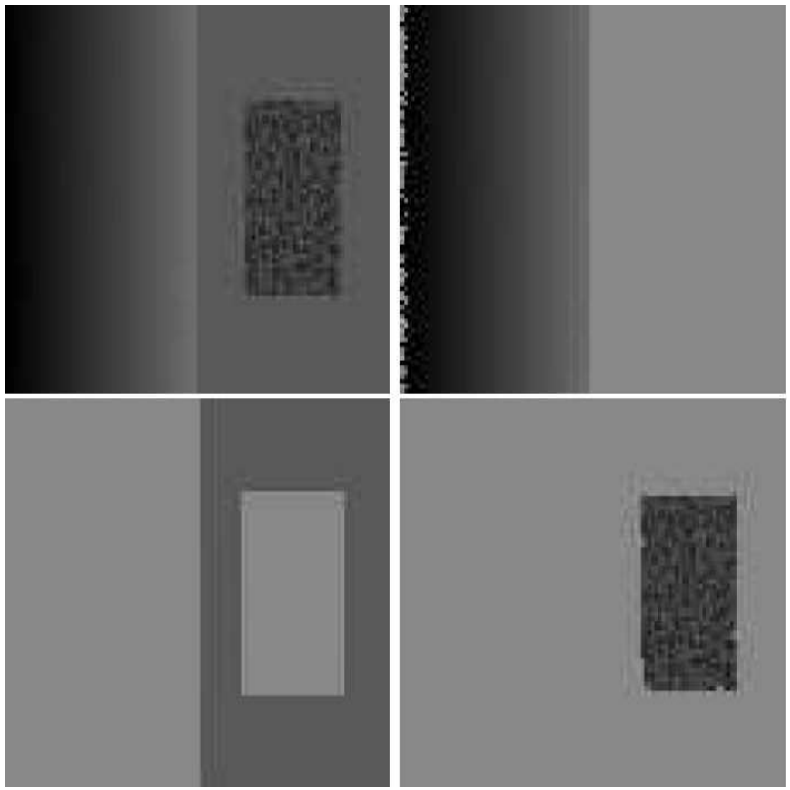
- A - a connected component in an image X
- A point x in A is known,

The following iterative expression yields all the elements of A:

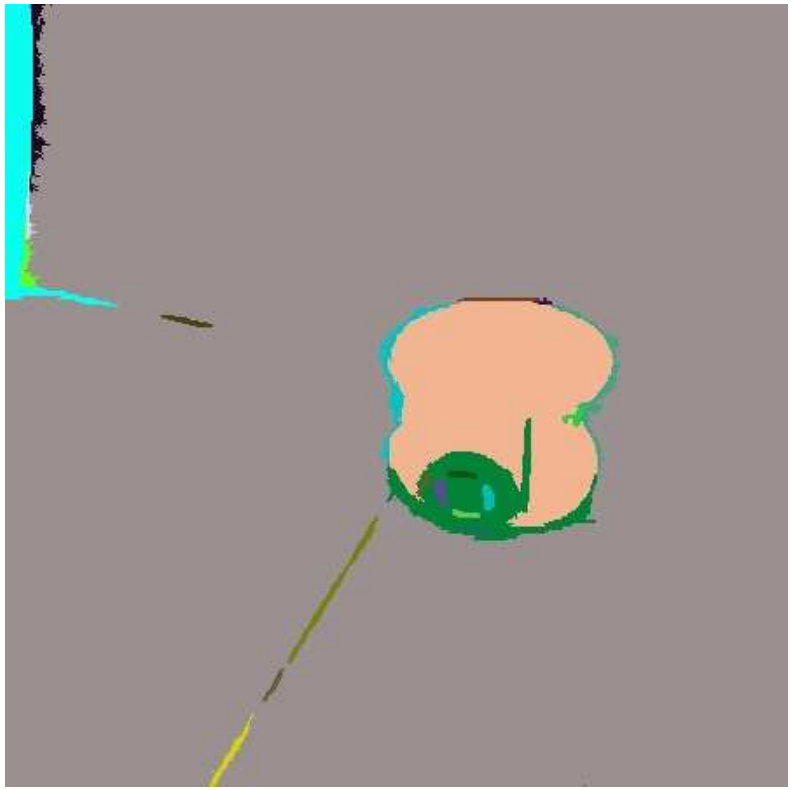
$X_0 = \{x\}$
$X_k = (X_{k-1} \oplus B) \cap X$
`If` $X_k = X_{k-1}$ `stop, else go to step 2`

In this case, $A = X_k$.

Graph-Based Segmentation



Segmented Images

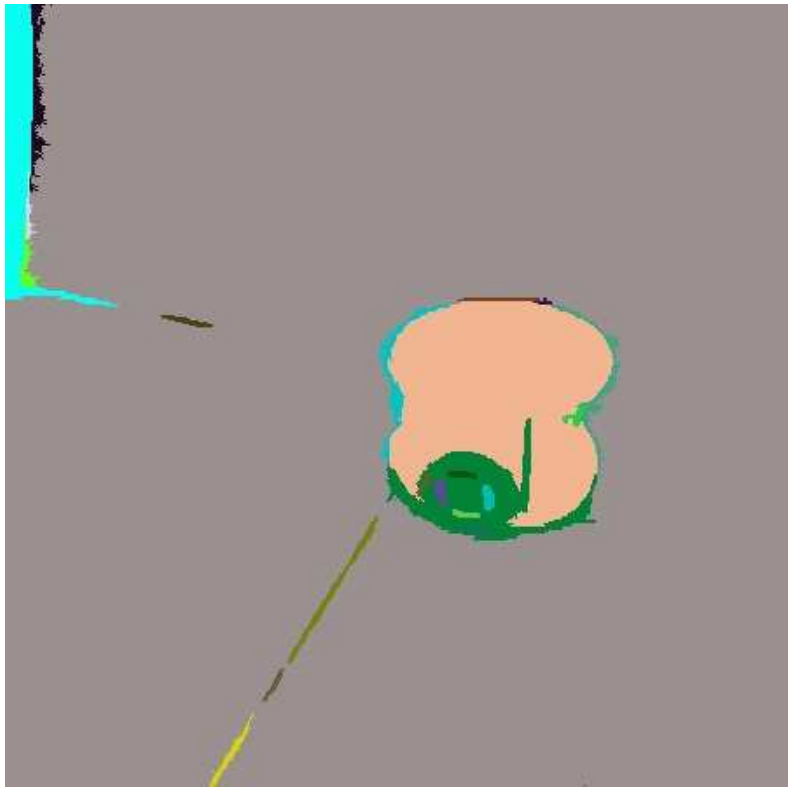


Graph Representation

Image Graph $g = (\mathcal{R}, \mathcal{E})$

- Set of edges $\mathcal{E}(g) = \{ij | e_{ij} = e_{ji} = 1\}$
- **Segments** e_{ij}
- $e_{ij} = 1$, Segment $i = \cup$ Segment j
- If $e_{ij} = 1$ and $e_{ji} = 1$, Subsegment via noting an edge relation
- Each edge e_{ij} - Weight of an edge that measures the dissimilarity between the two pixels connectedby that edge

Segmented Images



Popular Methods

- eCognition: Outdoors (airborne data) with 3 parameters (shape, compactness & scale) [6]. Problems in indoors!
- JSEG (J Image Segmentation): Region growing. Limitations due to color quantization and varying shades [7]
- FH (Felzenszwalb-Huttenlocher): Graph based algorithm that captures perceptually important non-local image characteristics. Problems with segmenting thin elongated objects [8]
- SRG (Seeded Region Growing) and
- EDISON (The Edge Detection and Image Segmentation)
- Other methods: HIS (Hierarchical Image Segmentation) and CBIR (Content Based Image Retrieval).
- Comparative study: A hybrid method based on FH and EDISON yield best results [9].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