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Computer Graphics and Image Processing

Lecture B5

Region Detection and Description

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Contents

- Blob finding
- Blob description
- Tracking

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Definition

- A blob is a set of pixels that
  - Share some property
  - Are connected
    - Can trace a path from one member to all others

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Share Some Property

- Are properties of two adjacent pixels sufficiently similar to infer that they're from the same object?
- Are a pixel's properties sufficiently similar to the properties of the adjacent blob for it to be included?

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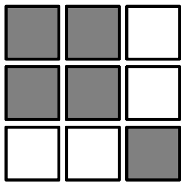
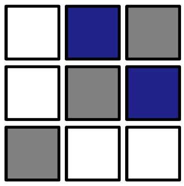
- Thresholding the grey value
  - Pixels' values = {0, 1}
  - Grouping is simple
    - Pixels are from the same object if they have the same value
- Other properties
  - Can define statistical tests based on blob's properties
    - pdf of grey values or colours
  - Can build a classifier to answer the question

Connectivity

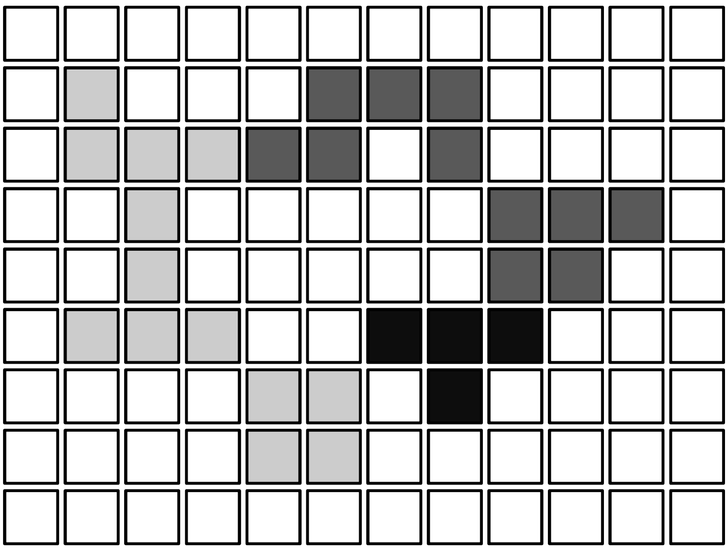
- 4 connected
  - Objects joining at corners can be disconnected



- 8 connected
  - Solves corner problem, but can pierce thin objects



- You decide



Connected Component Analysis

- Aims
  - To identify groups of contiguous pixels
  - To label separate blobs

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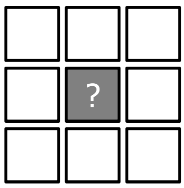
Algorithm

First pass

Work from left to right and top to bottom



1. If zero neighbours have a label

   Pixel receives the next free label

2. If one or more neighbours have the same label

   Pixel receives same label;

3. If two or more neighbours have different labels

   Pixel receives one label, equivalence is recorded

Second pass

Work from left to right and top to bottom

Relabel all equivalent labels

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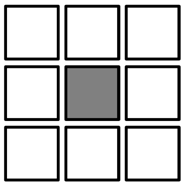
Case 1

- No labelled neighbours
  - Give this pixel the next free label



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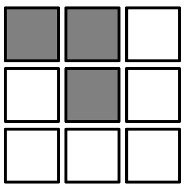
Case 2

- One or more neighbours with the same label
  - Give this pixel the same label



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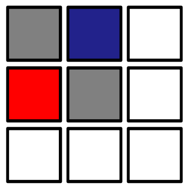
Case 3

- Two or more labels with different labels
  - Give this pixel one of the labels
  - Record that all labels are parts of the same blob/group

  - blue and red are really grey



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Pass Two

- First decide the new labels
  - Equivalence table
    - T[blue] = grey, T[red] = grey, etc
    - Will have a non-sequential entries
      - Blue, grey are now unused
  - Needs to be reordered to give a sensible set of labels
    - 0 for background
    - 1, 2, … for regions
- Pass through the image reassigning labels

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Blob Description

- Descriptive information can be derived from blobs:
  - Moments of area
  - Chain codes
  - Colour distribution

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Moments of area

- Formal definition

$$M_{\alpha\beta} = \sum_{image} x^{\alpha} y^{\beta} f(x, y)$$

- Image, *f(x,y)* is binary (= 0, 1)

  $\alpha = \beta = 0$ gives sum of pixels

  $(\alpha,\beta) = (1,0)$ gives sum of x values of region's pixels (and vice versa)
- $(M_{10}/M_{00}, M_{01}/M_{00})$ gives region's centre of gravity

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Central Moments of Area

$$M_{\alpha\beta} = \sum_{image} (x - \bar{x})^{\alpha} (y - \bar{y})^{\beta} f(x, y)$$

- $(\bar{x}, \bar{y})$ is the centre of gravity
- Can move the region and the central moments don't change
- Orientation, θ, is given by

$\tan 2\theta = 2M_{11}/(M_{20} - M_{02})$

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Notes

- Moments can be defined for all values of α and β
- There's a limit to the number of useful ones
- Can use lower order moments to make higher order ones invariant to
  - Position
  - Orientation
  - Size of region
- Can compute for non-binary images
- Can modify computation to use labelled blobs
- Values of the moments can be used to discriminate blobs based on size/shape

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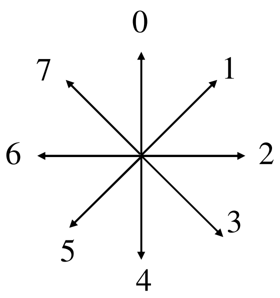
Chain Codes



Trace the object outline -
follow pixels on boundary, keeping the interior of the object to one side
Chain code is the direction of the jump to the next pixel

Description is
position independent,
orientation dependent

Can also use differential chain codes

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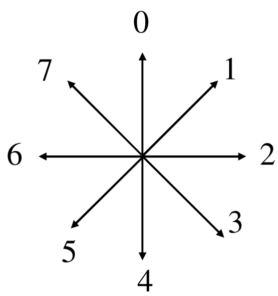
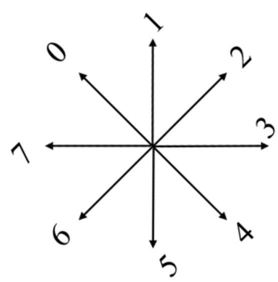
Differential chain codes





"0" is my direction of movement from the previous pixel.
Important property is rotational invariance

Perimeter From Chain Code

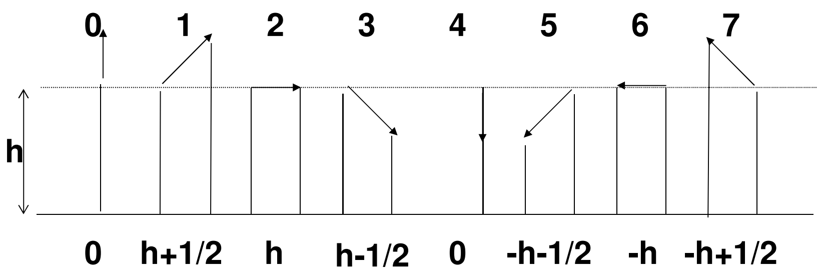
From regular (not differential) codes

Even codes have length 1
Odd codes have length √2

Perimeter length = #even + √2 #odd

(Basic length measurement is the pixel side.)

Area From Chain Code



h is measured from an arbitrary datum,
-h when you're below the line
e.g. y co-ordinate of start of codes.

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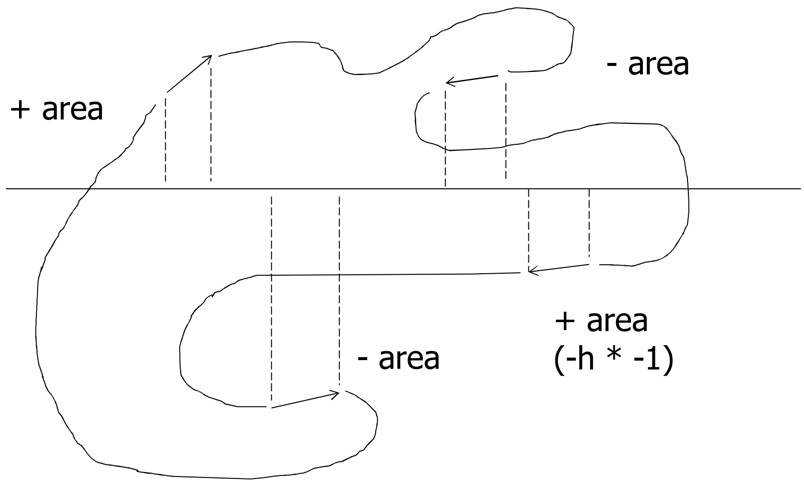
Example



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Colour Distribution

- This is a useful characteristic of blobs, independent of
  - Area
  - Orientation
- Typically record H, S components
  - (or U V, or ...)
  - Normalise out the brightness
- E.g. Use in tracking people

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Blob Tracking (Aside)

- How do we match a blob at $t = t_2$ with a blob at $t = t_1$?
- Look for invariant properties
  - What will be the same at both times?
- Matching difficulties
  - Might have a lot of blobs
  - The blob population might change

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Combinatorial Problem

- N blobs in frame t
- M blobs in frame t+1
- Which subsets of N best match which subsets of M?
- A large number of combinations

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Predictive Tracking

- For each blob, maintain
  - Current location
  - Current velocity
    - How far and in what direction did it move from previous location
  - Invariants
- Predict
  - Location of this blob in next frame
- Verify
  - Is there a blob near the predicted location?
  - Do predicted blob and this blob have same invariants?

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Verification

- Near
  - Velocity estimate may be incorrect
  - Velocity may change
  - Should maintain an estimate of error in velocity
    - This defines a search window for the blob's possible location
- Same invariants e.g. colour
  - Lighting change
  - Change in orientation
  - Looking for probable matches

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What if?

- Multiple blobs at predicted location?
  - Need to record this in case they split in future
- No blobs at predicted location?
  - Keep track of the missing blob for a while
- Blobs where there was no prediction?
  - A new blob has appeared

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Summary

- Mostly chapter 6

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I think there is a world market for maybe five computers

Thomas J Watson, chairman IBM, 1943