

Optical Character Recognition

Lecture 2



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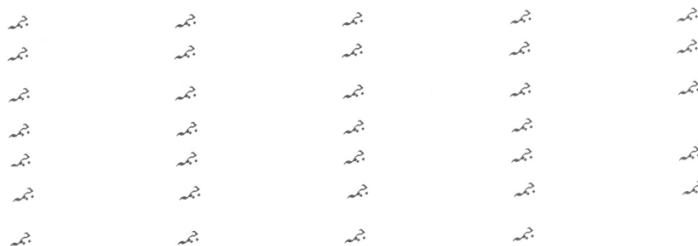
Lecture-2 Agenda

- Groups Discussion
- Image
 - Image matrix
 - Pixel
 - Color intensities
 - Connected component
 - Line
 - Column

Groups Discussion

Scope for data finalization

1. Extract at least 15 unique shapes having 50 real samples
 1. 35 for training
 2. 15 for testing
2. Synthesized data for Complete OCR Testing
 1. At least 15 syllable strings of each shape distributed in an image so that phases of OCR can be tested



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Scanning Guidelines

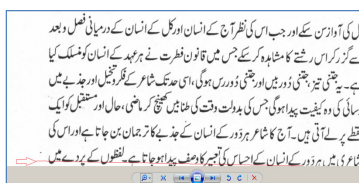
- Image must be scanned at 300 DPI
- Gray scale version of the image must be generated
- There should not page frame in the scanned document see Figure . While scanning ,crop the image appropriately so that text only image can be saved see Figure.
- Image must be saved in .jpg file format
- Image should not be edited through any picture editing tool once it is scanned and saved because while saving the edited image, the resolution and image quality can be suffered.
- Image should not be skewed see Figure.



Figure 1. Image with Page Frame



Figure 2. Cropped Image



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Image Processing

- Image

- Image is a matrix having rows and columns
- Size (Dimension)= *Height x Width*

| | Columns → | | | | | | | | | | | | | | | | Width=16 |
|----|-----------|---|---|---|---|---|---|---|---|---|----|----|----|----|----|----|----------|
| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | |
| 0 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | |
| 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | |
| 2 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | |
| 3 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | |
| 4 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | |
| 5 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | |
| 6 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | |
| 7 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | |
| 8 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | |
| 9 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | |
| 10 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | |
| 11 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | |
| 12 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | |

Rows ↓
Height=13

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Image Processing

- Pixel

- A cell in a matrix is called pixel or smallest unit in an image indicated by row number and column number which has some value i.e. **intensity**

Pixel(X coordinate OR row index, Y coordinate OR column index)
= Intensity value

| | Columns → | | | | | | | | | | | | | | | | Width=16 |
|----|-----------|---|---|---|---|---|---|---|---|---|----|----|----|----|----|----|----------|
| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | |
| 0 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | |
| 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | |
| 2 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | |
| 3 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | |
| 4 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | |
| 5 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | |
| 6 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | |
| 7 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | |
| 8 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | |
| 9 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | |
| 10 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | |
| 11 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | |
| 12 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | |

Rows ↓
Height=13

Pixel (8,4)=1 (Intensity value)
Pixel(2,6)=1 (Intensity value)
Pixel(5,11)=1 (Intensity value)

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Image Processing

- Color Intensities
 - Black and White Image (0 or 1)

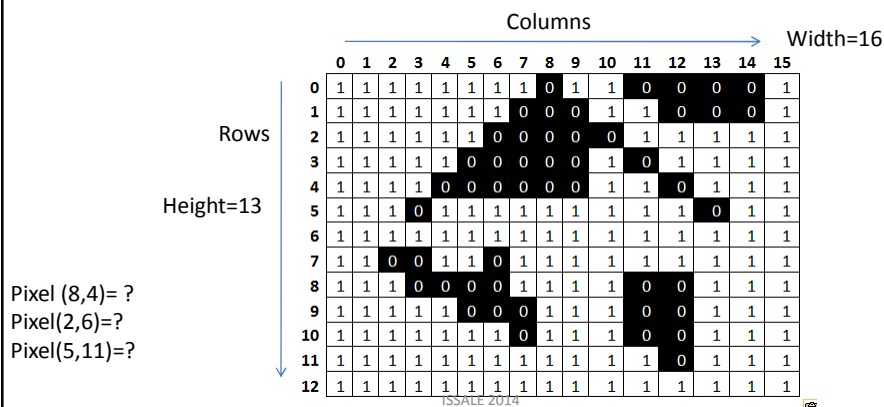


Image Processing

- Gray scale image (0-255 intensity values)

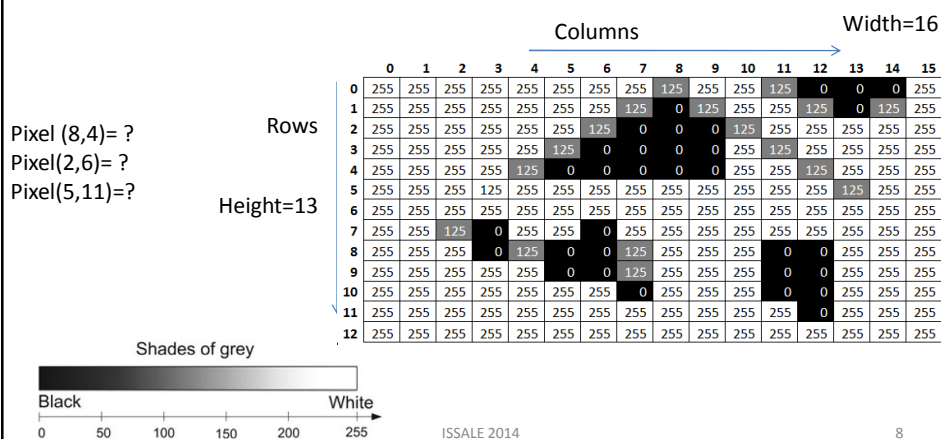
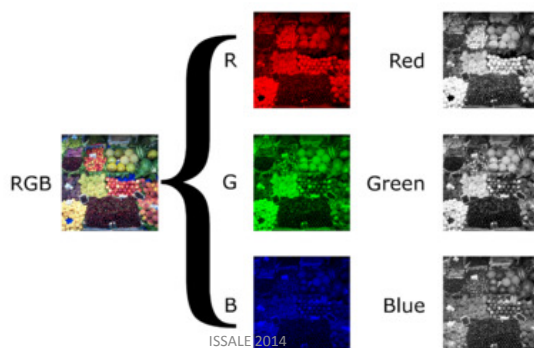


Image Processing

- Color Image (RGB) Image
 - Three layers of **Red**, **Green**, **Blue** components
 - Each component contains values between 0-255



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Digital Image Processing

- Connected Component
 - Object/Region of **adjacent pixels which share the same set of intensity values**

| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 |
|----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|
| 0 | 255 | 255 | 255 | 255 | 255 | 255 | 255 | 255 | 0 | 255 | 255 | 125 | 125 | 125 | 125 | 255 |
| 1 | 255 | 255 | 255 | 255 | 255 | 255 | 255 | 0 | 0 | 0 | 255 | 255 | 125 | 125 | 125 | 255 |
| 2 | 255 | 255 | 255 | 255 | 255 | 255 | 0 | 0 | 0 | 0 | 0 | 255 | 255 | 255 | 255 | 255 |
| 3 | 255 | 255 | 255 | 255 | 255 | 0 | 0 | 0 | 0 | 0 | 255 | 0 | 255 | 255 | 255 | 255 |
| 4 | 255 | 255 | 255 | 255 | 0 | 0 | 0 | 0 | 0 | 0 | 255 | 255 | 0 | 255 | 255 | 255 |
| 5 | 255 | 255 | 255 | 0 | 255 | 255 | 255 | 255 | 255 | 255 | 255 | 255 | 255 | 0 | 255 | 255 |
| 6 | 255 | 255 | 255 | 255 | 255 | 255 | 255 | 255 | 255 | 255 | 255 | 255 | 255 | 255 | 255 | 255 |
| 7 | 255 | 255 | 90 | 90 | 255 | 255 | 90 | 255 | 255 | 255 | 255 | 255 | 255 | 255 | 255 | 255 |
| 8 | 255 | 255 | 255 | 90 | 90 | 90 | 90 | 255 | 255 | 255 | 255 | 200 | 200 | 255 | 255 | 255 |
| 9 | 255 | 255 | 255 | 255 | 255 | 90 | 90 | 90 | 255 | 255 | 255 | 200 | 200 | 255 | 255 | 255 |
| 10 | 255 | 255 | 255 | 255 | 255 | 255 | 90 | 255 | 255 | 255 | 200 | 200 | 255 | 255 | 255 | 255 |
| 11 | 255 | 255 | 255 | 255 | 255 | 255 | 255 | 255 | 255 | 255 | 255 | 200 | 255 | 255 | 255 | 255 |
| 12 | 255 | 255 | 255 | 255 | 255 | 255 | 255 | 255 | 255 | 255 | 255 | 255 | 255 | 255 | 255 | 255 |

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Digital Image Processing

- How many connected components

| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31 | 32 |
|----|---|---|---|---|---|---|---|---|---|---|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|
| 0 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 1 | 1 | 1 | 1 | 0 | 1 | 1 | 0 | 0 | 0 | 0 | 1 | 1 | 1 | 1 | 1 |
| 2 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 0 | 0 | 1 | 1 | 0 | 0 | 0 | 1 | 1 | 0 | 1 | 1 | 0 | 0 | 1 | 1 | 1 | 0 | 0 | 0 | 1 | 1 | 1 | 1 | 1 | |
| 3 | 1 | 1 | 1 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 1 | 1 | 1 | 0 | 0 | 1 | 0 | 0 | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | |
| 4 | 1 | 1 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 1 | 1 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | |
| 5 | 1 | 1 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 0 | 1 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | |
| 6 | 1 | 1 | 1 | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 1 | 1 | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | |
| 7 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | |
| 8 | 1 | 1 | 0 | 0 | 1 | 1 | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | |
| 9 | 1 | 1 | 1 | 0 | 0 | 0 | 1 | 1 | 1 | 1 | 0 | 0 | 1 | 1 | 1 | 1 | 0 | 1 | 1 | 0 | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 1 | 1 | 1 | |
| 10 | 1 | 1 | 1 | 1 | 1 | 0 | 0 | 0 | 1 | 1 | 1 | 0 | 0 | 1 | 1 | 1 | 0 | 0 | 1 | 0 | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 1 | 0 | 1 | 1 | |
| 11 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 1 | 1 | 1 | 0 | 0 | 1 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 1 | 1 | 0 | 0 | 0 | 0 | 1 | 1 | |
| 12 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 1 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 1 | 0 | 1 | 1 | 1 | | | | 0 | 1 |
| 13 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 1 | | | | | | 1 | 1 |
| 14 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |

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Digital Image Processing

- How many connected components of foreground pixels
- Eight connected components or nine connected components ?

| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31 | 32 |
|----|---|---|---|---|---|---|---|---|---|---|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|
| 0 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | |
| 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 1 | 1 | 1 | 0 | 1 | 1 | 0 | 0 | 0 | 0 | 1 | 1 | 1 | 1 | 1 | |
| 2 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 0 | 0 | 1 | 1 | 0 | 0 | 0 | 1 | 1 | 0 | 1 | 1 | 0 | 0 | 1 | 1 | 1 | 0 | 0 | 0 | 1 | 1 | 1 | 1 | 1 | |
| 3 | 1 | 1 | 1 | 1 | 1 | 0 | 0 | 0 | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 0 | 1 | 0 | 0 | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | |
| 4 | 1 | 1 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 1 | 1 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | |
| 5 | 1 | 1 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 0 | 1 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | |
| 6 | 1 | 1 | 1 | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 1 | 1 | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | |
| 7 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | |
| 8 | 1 | 1 | 0 | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 1 | 1 | 1 | 1 | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | |
| 9 | 1 | 1 | 1 | 0 | 0 | 0 | 1 | 1 | 1 | 1 | 1 | 0 | 0 | 1 | 1 | 1 | 1 | 0 | 1 | 1 | 0 | 0 | 1 | 1 | 1 | 1 | 1 | 0 | 1 | 1 | 1 | 1 | |
| 10 | 1 | 1 | 1 | 1 | 1 | 0 | 0 | 0 | 1 | 1 | 1 | 0 | 0 | 1 | 1 | 1 | 0 | 1 | 0 | 0 | 0 | 1 | 1 | 1 | 1 | 0 | 0 | 1 | 0 | 1 | 1 | 1 | |
| 11 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 1 | 1 | 1 | 0 | 0 | 1 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 1 | 1 |
| 12 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 1 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 1 | 0 | 1 | 1 | 1 | | | | 0 | 1 |
| 13 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 1 | | | | | | 1 | 1 |
| 14 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |

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Digital Image Processing

- Connected Component Information

Connected Component of 125 Intensity Value

1. **Coordinates:** (x(row index),y (column index))

| | | | | | | | | | | | | | | | | |
|----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|
| 0 | 255 | 255 | 255 | 255 | 255 | 255 | 255 | 255 | 0 | 255 | 255 | 125 | 125 | 125 | 125 | 255 |
| 1 | 255 | 255 | 255 | 255 | 255 | 255 | 255 | 0 | 0 | 0 | 255 | 255 | 125 | 125 | 125 | 255 |
| 2 | 255 | 255 | 255 | 255 | 255 | 255 | 0 | 0 | 0 | 0 | 255 | 255 | 255 | 255 | 255 | 255 |
| 3 | 255 | 255 | 255 | 255 | 255 | 0 | 0 | 0 | 0 | 0 | 255 | 0 | 255 | 255 | 255 | 255 |
| 4 | 255 | 255 | 255 | 255 | 0 | 0 | 0 | 0 | 0 | 0 | 255 | 255 | 0 | 255 | 255 | 255 |
| 5 | 255 | 255 | 255 | 0 | 255 | 255 | 255 | 255 | 255 | 255 | 255 | 255 | 255 | 255 | 0 | 255 |
| 6 | 255 | 255 | 255 | 255 | 255 | 255 | 255 | 255 | 255 | 255 | 255 | 255 | 255 | 255 | 255 | 255 |
| 7 | 255 | 255 | 90 | 90 | 255 | 255 | 90 | 255 | 255 | 255 | 255 | 255 | 255 | 255 | 255 | 255 |
| 8 | 255 | 255 | 255 | 90 | 90 | 90 | 90 | 255 | 255 | 255 | 255 | 200 | 200 | 255 | 255 | 255 |
| 9 | 255 | 255 | 255 | 255 | 255 | 90 | 90 | 90 | 255 | 255 | 255 | 200 | 200 | 255 | 255 | 255 |
| 10 | 255 | 255 | 255 | 255 | 255 | 255 | 90 | 255 | 255 | 255 | 255 | 200 | 200 | 255 | 255 | 255 |
| 11 | 255 | 255 | 255 | 255 | 255 | 255 | 255 | 255 | 255 | 255 | 255 | 255 | 255 | 255 | 255 | 255 |
| 12 | 255 | 255 | 255 | 255 | 255 | 255 | 255 | 255 | 255 | 255 | 255 | 255 | 255 | 255 | 255 | 255 |

Digital Image Processing

- Connected Component Information

Connected Component of 125 Intensity Value

• **Coordinates:** (x(row index),y (column index))
 {(0,11),(0,12),(0,13),(0,14), (1,12), (1,13),(1,14)}
 }

| | | | | | | | | | | | | | | | | |
|----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|
| 0 | 255 | 255 | 255 | 255 | 255 | 255 | 255 | 255 | 0 | 255 | 255 | 125 | 125 | 125 | 125 | 255 |
| 1 | 255 | 255 | 255 | 255 | 255 | 255 | 255 | 0 | 0 | 0 | 255 | 255 | 125 | 125 | 125 | 255 |
| 2 | 255 | 255 | 255 | 255 | 255 | 255 | 0 | 0 | 0 | 0 | 255 | 255 | 255 | 255 | 255 | 255 |
| 3 | 255 | 255 | 255 | 255 | 255 | 0 | 0 | 0 | 0 | 0 | 255 | 0 | 255 | 255 | 255 | 255 |
| 4 | 255 | 255 | 255 | 255 | 0 | 0 | 0 | 0 | 0 | 0 | 255 | 255 | 0 | 255 | 255 | 255 |
| 5 | 255 | 255 | 255 | 0 | 255 | 255 | 255 | 255 | 255 | 255 | 255 | 255 | 255 | 255 | 0 | 255 |
| 6 | 255 | 255 | 255 | 255 | 255 | 255 | 255 | 255 | 255 | 255 | 255 | 255 | 255 | 255 | 255 | 255 |
| 7 | 255 | 255 | 90 | 90 | 255 | 255 | 90 | 255 | 255 | 255 | 255 | 255 | 255 | 255 | 255 | 255 |
| 8 | 255 | 255 | 255 | 90 | 90 | 90 | 90 | 255 | 255 | 255 | 255 | 200 | 200 | 255 | 255 | 255 |
| 9 | 255 | 255 | 255 | 255 | 255 | 90 | 90 | 90 | 255 | 255 | 255 | 200 | 200 | 255 | 255 | 255 |
| 10 | 255 | 255 | 255 | 255 | 255 | 255 | 90 | 255 | 255 | 255 | 255 | 200 | 200 | 255 | 255 | 255 |
| 11 | 255 | 255 | 255 | 255 | 255 | 255 | 255 | 255 | 255 | 255 | 255 | 255 | 255 | 255 | 255 | 255 |
| 12 | 255 | 255 | 255 | 255 | 255 | 255 | 255 | 255 | 255 | 255 | 255 | 255 | 255 | 255 | 255 | 255 |

Digital Image Processing

- Connected Component Information

Connected Component of 125 Intensity Value

- **Coordinates:** (x(row index),y (column index))
- {(0,11),(0,12),(0,13),(0,14), (1,12), (1,13),(1,14)}
- **TOP:** min(X-coordinate) i.e. 0

| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 |
|----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|
| 0 | 255 | 255 | 255 | 255 | 255 | 255 | 255 | 255 | 0 | 255 | 255 | 125 | 125 | 125 | 125 | 255 |
| 1 | 255 | 255 | 255 | 255 | 255 | 255 | 255 | 0 | 0 | 0 | 255 | 255 | 125 | 125 | 125 | 255 |
| 2 | 255 | 255 | 255 | 255 | 255 | 255 | 0 | 0 | 0 | 0 | 0 | 255 | 255 | 255 | 255 | 255 |
| 3 | 255 | 255 | 255 | 255 | 255 | 0 | 0 | 0 | 0 | 0 | 0 | 255 | 0 | 255 | 255 | 255 |
| 4 | 255 | 255 | 255 | 255 | 0 | 0 | 0 | 0 | 0 | 0 | 255 | 255 | 0 | 255 | 255 | 255 |
| 5 | 255 | 255 | 255 | 0 | 255 | 255 | 255 | 255 | 255 | 255 | 255 | 255 | 255 | 255 | 0 | 255 |
| 6 | 255 | 255 | 255 | 255 | 255 | 255 | 255 | 255 | 255 | 255 | 255 | 255 | 255 | 255 | 255 | 255 |
| 7 | 255 | 255 | 90 | 90 | 255 | 255 | 90 | 255 | 255 | 255 | 255 | 255 | 255 | 255 | 255 | 255 |
| 8 | 255 | 255 | 255 | 90 | 90 | 90 | 90 | 255 | 255 | 255 | 255 | 200 | 200 | 255 | 255 | 255 |
| 9 | 255 | 255 | 255 | 255 | 255 | 90 | 90 | 90 | 255 | 255 | 255 | 200 | 200 | 255 | 255 | 255 |
| 10 | 255 | 255 | 255 | 255 | 255 | 255 | 255 | 90 | 255 | 255 | 255 | 200 | 200 | 255 | 255 | 255 |
| 11 | 255 | 255 | 255 | 255 | 255 | 255 | 255 | 255 | 255 | 255 | 255 | 200 | 255 | 255 | 255 | 255 |
| 12 | 255 | 255 | 255 | 255 | 255 | 255 | 255 | 255 | 255 | 255 | 255 | 255 | 255 | 255 | 255 | 255 |

Digital Image Processing

- Connected Component Information

Connected Component of 125 Intensity Value

- 1. **Coordinates:** (x(row index),y (column index))
- {(0,11),(0,12),(0,13),(0,14), (1,12), (1,13),(1,14)}
- **TOP:** min(X-coordinate) i.e. 0
- **Bottom:** max(X-coordinate) i.e. 1

| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 |
|----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|
| 0 | 255 | 255 | 255 | 255 | 255 | 255 | 255 | 255 | 0 | 255 | 255 | 125 | 125 | 125 | 125 | 255 |
| 1 | 255 | 255 | 255 | 255 | 255 | 255 | 255 | 0 | 0 | 0 | 255 | 255 | 125 | 125 | 125 | 255 |
| 2 | 255 | 255 | 255 | 255 | 255 | 255 | 0 | 0 | 0 | 0 | 0 | 255 | 255 | 255 | 255 | 255 |
| 3 | 255 | 255 | 255 | 255 | 255 | 0 | 0 | 0 | 0 | 0 | 0 | 255 | 0 | 255 | 255 | 255 |
| 4 | 255 | 255 | 255 | 255 | 0 | 0 | 0 | 0 | 0 | 0 | 255 | 255 | 0 | 255 | 255 | 255 |
| 5 | 255 | 255 | 255 | 0 | 255 | 255 | 255 | 255 | 255 | 255 | 255 | 255 | 255 | 255 | 0 | 255 |
| 6 | 255 | 255 | 255 | 255 | 255 | 255 | 255 | 255 | 255 | 255 | 255 | 255 | 255 | 255 | 255 | 255 |
| 7 | 255 | 255 | 90 | 90 | 255 | 255 | 90 | 255 | 255 | 255 | 255 | 255 | 255 | 255 | 255 | 255 |
| 8 | 255 | 255 | 255 | 90 | 90 | 90 | 90 | 255 | 255 | 255 | 255 | 200 | 200 | 255 | 255 | 255 |
| 9 | 255 | 255 | 255 | 255 | 255 | 90 | 90 | 90 | 255 | 255 | 255 | 200 | 200 | 255 | 255 | 255 |
| 10 | 255 | 255 | 255 | 255 | 255 | 255 | 255 | 90 | 255 | 255 | 255 | 200 | 200 | 255 | 255 | 255 |
| 11 | 255 | 255 | 255 | 255 | 255 | 255 | 255 | 255 | 255 | 255 | 255 | 200 | 255 | 255 | 255 | 255 |
| 12 | 255 | 255 | 255 | 255 | 255 | 255 | 255 | 255 | 255 | 255 | 255 | 255 | 255 | 255 | 255 | 255 |

Digital Image Processing

- Connected Component Information

Connected Component of 125 Intensity Value

- **Coordinates:** (x(row index),y (column index))
- {(0,11),(0,12),(0,13),(0,14), (1,12), (1,13),(1,14)}
- **TOP:** min(X-coordinate) i.e. 0
- **Bottom:** max(X-coordinate) i.e. 1
- **LEFT :** min(Y-coordinate) i.e. 11

| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 |
|----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|
| 0 | 255 | 255 | 255 | 255 | 255 | 255 | 255 | 255 | 0 | 255 | 255 | 125 | 125 | 125 | 125 | 255 |
| 1 | 255 | 255 | 255 | 255 | 255 | 255 | 255 | 0 | 0 | 0 | 255 | 255 | 125 | 125 | 125 | 255 |
| 2 | 255 | 255 | 255 | 255 | 255 | 255 | 0 | 0 | 0 | 0 | 255 | 255 | 255 | 255 | 255 | 255 |
| 3 | 255 | 255 | 255 | 255 | 255 | 0 | 0 | 0 | 0 | 0 | 255 | 0 | 255 | 255 | 255 | 255 |
| 4 | 255 | 255 | 255 | 255 | 0 | 0 | 0 | 0 | 0 | 0 | 255 | 255 | 0 | 255 | 255 | 255 |
| 5 | 255 | 255 | 255 | 0 | 255 | 255 | 255 | 255 | 255 | 255 | 255 | 255 | 255 | 255 | 0 | 255 |
| 6 | 255 | 255 | 255 | 255 | 255 | 255 | 255 | 255 | 255 | 255 | 255 | 255 | 255 | 255 | 255 | 255 |
| 7 | 255 | 255 | 90 | 90 | 255 | 255 | 90 | 255 | 255 | 255 | 255 | 255 | 255 | 255 | 255 | 255 |
| 8 | 255 | 255 | 255 | 90 | 90 | 90 | 90 | 255 | 255 | 255 | 255 | 200 | 200 | 255 | 255 | 255 |
| 9 | 255 | 255 | 255 | 255 | 255 | 90 | 90 | 90 | 255 | 255 | 255 | 200 | 200 | 255 | 255 | 255 |
| 10 | 255 | 255 | 255 | 255 | 255 | 255 | 90 | 255 | 255 | 255 | 200 | 200 | 255 | 255 | 255 | 255 |
| 11 | 255 | 255 | 255 | 255 | 255 | 255 | 255 | 255 | 255 | 255 | 255 | 200 | 255 | 255 | 255 | 255 |
| 12 | 255 | 255 | 255 | 255 | 255 | 255 | 255 | 255 | 255 | 255 | 255 | 255 | 255 | 255 | 255 | 255 |

Digital Image Processing

- Connected Component Information

Connected Component of 125 Intensity Value

- **Coordinates:** (x(row index),y (column index))
- {(0,11),(0,12),(0,13),(0,14), (1,12), (1,13),(1,14)}
- **TOP:** min(X-coordinate) i.e. 0
- **Bottom:** max(X-coordinate) i.e. 1
- **LEFT :** min(Y-coordinate) i.e. 11
- **RIGHT:** max(Y-coordinate) i.e. 14

| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 |
|----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|
| 0 | 255 | 255 | 255 | 255 | 255 | 255 | 255 | 255 | 0 | 255 | 255 | 125 | 125 | 125 | 125 | 255 |
| 1 | 255 | 255 | 255 | 255 | 255 | 255 | 255 | 0 | 0 | 0 | 255 | 255 | 125 | 125 | 125 | 255 |
| 2 | 255 | 255 | 255 | 255 | 255 | 255 | 0 | 0 | 0 | 0 | 255 | 255 | 255 | 255 | 255 | 255 |
| 3 | 255 | 255 | 255 | 255 | 255 | 0 | 0 | 0 | 0 | 0 | 255 | 0 | 255 | 255 | 255 | 255 |
| 4 | 255 | 255 | 255 | 255 | 0 | 0 | 0 | 0 | 0 | 0 | 255 | 255 | 0 | 255 | 255 | 255 |
| 5 | 255 | 255 | 255 | 0 | 255 | 255 | 255 | 255 | 255 | 255 | 255 | 255 | 255 | 255 | 0 | 255 |
| 6 | 255 | 255 | 255 | 255 | 255 | 255 | 255 | 255 | 255 | 255 | 255 | 255 | 255 | 255 | 255 | 255 |
| 7 | 255 | 255 | 90 | 90 | 255 | 255 | 90 | 255 | 255 | 255 | 255 | 255 | 255 | 255 | 255 | 255 |
| 8 | 255 | 255 | 255 | 90 | 90 | 90 | 90 | 255 | 255 | 255 | 255 | 200 | 200 | 255 | 255 | 255 |
| 9 | 255 | 255 | 255 | 255 | 255 | 90 | 90 | 90 | 255 | 255 | 255 | 200 | 200 | 255 | 255 | 255 |
| 10 | 255 | 255 | 255 | 255 | 255 | 255 | 90 | 255 | 255 | 255 | 200 | 200 | 255 | 255 | 255 | 255 |
| 11 | 255 | 255 | 255 | 255 | 255 | 255 | 255 | 255 | 255 | 255 | 255 | 200 | 255 | 255 | 255 | 255 |
| 12 | 255 | 255 | 255 | 255 | 255 | 255 | 255 | 255 | 255 | 255 | 255 | 255 | 255 | 255 | 255 | 255 |

Digital Image Processing

- Connected Component Information

Connected Component of 125 Intensity Value

- **Coordinates:** (x(row index),y (column index))

{(0,11),(0,12),(0,13),(0,14), (1,12), (1,13),(1,14)}

- **TOP:** min(X-coordinate) i.e. 0
- **Bottom:** max(X-coordinate) i.e. 1
- **LEFT :** min(Y-coordinate) i.e. 11
- **RIGHT:** max(Y-coordinate) i.e. 14
- **Height of CC :** Bottom-TOP +1
i.e. 1-0+1=2

| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 |
|----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|
| 0 | 255 | 255 | 255 | 255 | 255 | 255 | 255 | 255 | 0 | 255 | 255 | 125 | 125 | 125 | 125 | 255 |
| 1 | 255 | 255 | 255 | 255 | 255 | 255 | 255 | 0 | 0 | 0 | 255 | 255 | 125 | 125 | 125 | 255 |
| 2 | 255 | 255 | 255 | 255 | 255 | 255 | 0 | 0 | 0 | 0 | 255 | 255 | 255 | 255 | 255 | 255 |
| 3 | 255 | 255 | 255 | 255 | 255 | 0 | 0 | 0 | 0 | 0 | 255 | 0 | 255 | 255 | 255 | 255 |
| 4 | 255 | 255 | 255 | 255 | 0 | 0 | 0 | 0 | 0 | 0 | 255 | 255 | 0 | 255 | 255 | 255 |
| 5 | 255 | 255 | 255 | 0 | 255 | 255 | 255 | 255 | 255 | 255 | 255 | 255 | 255 | 255 | 0 | 255 |
| 6 | 255 | 255 | 255 | 255 | 255 | 255 | 255 | 255 | 255 | 255 | 255 | 255 | 255 | 255 | 255 | 255 |
| 7 | 255 | 255 | 90 | 90 | 255 | 255 | 90 | 255 | 255 | 255 | 255 | 255 | 255 | 255 | 255 | 255 |
| 8 | 255 | 255 | 255 | 90 | 90 | 90 | 90 | 255 | 255 | 255 | 255 | 200 | 200 | 255 | 255 | 255 |
| 9 | 255 | 255 | 255 | 255 | 255 | 90 | 90 | 90 | 255 | 255 | 255 | 200 | 200 | 255 | 255 | 255 |
| 10 | 255 | 255 | 255 | 255 | 255 | 255 | 255 | 90 | 255 | 255 | 255 | 200 | 200 | 255 | 255 | 255 |
| 11 | 255 | 255 | 255 | 255 | 255 | 255 | 255 | 255 | 255 | 255 | 255 | 255 | 255 | 255 | 255 | 255 |
| 12 | 255 | 255 | 255 | 255 | 255 | 255 | 255 | 255 | 255 | 255 | 255 | 255 | 255 | 255 | 255 | 255 |

Digital Image Processing

- Connected Component Information

Connected Component of 125 Intensity Value

- **Coordinates:** (x(row index),y (column index))

{(0,11),(0,12),(0,13),(0,14), (1,12), (1,13),(1,14)}

- **TOP:** min(X-coordinate) i.e. 0
- **Bottom:** max(X-coordinate) i.e. 1
- **LEFT :** min(Y-coordinate) i.e. 11
- **RIGHT:** max(Y-coordinate) i.e. 14
- **Height of CC :** Bottom-TOP +1
i.e. 1-0+1=2
- **Width of CC:** RIGHT-LEFT+1
i.e. 14-11+1=4

| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 |
|----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|
| 0 | 255 | 255 | 255 | 255 | 255 | 255 | 255 | 255 | 0 | 255 | 255 | 125 | 125 | 125 | 125 | 255 |
| 1 | 255 | 255 | 255 | 255 | 255 | 255 | 255 | 0 | 0 | 0 | 255 | 255 | 125 | 125 | 125 | 255 |
| 2 | 255 | 255 | 255 | 255 | 255 | 255 | 0 | 0 | 0 | 0 | 255 | 255 | 255 | 255 | 255 | 255 |
| 3 | 255 | 255 | 255 | 255 | 255 | 0 | 0 | 0 | 0 | 0 | 255 | 0 | 255 | 255 | 255 | 255 |
| 4 | 255 | 255 | 255 | 255 | 0 | 0 | 0 | 0 | 0 | 0 | 255 | 255 | 0 | 255 | 255 | 255 |
| 5 | 255 | 255 | 255 | 0 | 255 | 255 | 255 | 255 | 255 | 255 | 255 | 255 | 255 | 255 | 0 | 255 |
| 6 | 255 | 255 | 255 | 255 | 255 | 255 | 255 | 255 | 255 | 255 | 255 | 255 | 255 | 255 | 255 | 255 |
| 7 | 255 | 255 | 90 | 90 | 255 | 255 | 90 | 255 | 255 | 255 | 255 | 255 | 255 | 255 | 255 | 255 |
| 8 | 255 | 255 | 255 | 90 | 90 | 90 | 90 | 255 | 255 | 255 | 255 | 200 | 200 | 255 | 255 | 255 |
| 9 | 255 | 255 | 255 | 255 | 255 | 90 | 90 | 90 | 255 | 255 | 255 | 200 | 200 | 255 | 255 | 255 |
| 10 | 255 | 255 | 255 | 255 | 255 | 255 | 255 | 90 | 255 | 255 | 255 | 200 | 200 | 255 | 255 | 255 |
| 11 | 255 | 255 | 255 | 255 | 255 | 255 | 255 | 255 | 255 | 255 | 255 | 255 | 255 | 255 | 255 | 255 |
| 12 | 255 | 255 | 255 | 255 | 255 | 255 | 255 | 255 | 255 | 255 | 255 | 255 | 255 | 255 | 255 | 255 |

Digital Image Processing

- Connected Component Information

Connected Component of 125 Intensity Value

- **Coordinates:** (x(row index),y (column index))
 {(0,11),(0,12),(0,13),(0,14), (1,12), (1,13),(1,14)}

| | | | | | | | | | | | | | | | |
|----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|
| 0 | 255 | 255 | 255 | 255 | 255 | 255 | 255 | 255 | 0 | 255 | 255 | 125 | 125 | 125 | 255 |
| 1 | 255 | 255 | 255 | 255 | 255 | 255 | 255 | 0 | 0 | 0 | 255 | 255 | 125 | 125 | 255 |
| 2 | 255 | 255 | 255 | 255 | 255 | 255 | 0 | 0 | 0 | 0 | 0 | 255 | 255 | 255 | 255 |
| 3 | 255 | 255 | 255 | 255 | 255 | 0 | 0 | 0 | 0 | 0 | 0 | 255 | 0 | 255 | 255 |
| 4 | 255 | 255 | 255 | 255 | 0 | 0 | 0 | 0 | 0 | 0 | 255 | 255 | 0 | 255 | 255 |
| 5 | 255 | 255 | 255 | 0 | 255 | 255 | 255 | 255 | 255 | 255 | 255 | 255 | 255 | 0 | 255 |
| 6 | 255 | 255 | 255 | 255 | 255 | 255 | 255 | 255 | 255 | 255 | 255 | 255 | 255 | 255 | 255 |
| 7 | 255 | 255 | 90 | 90 | 255 | 255 | 90 | 255 | 255 | 255 | 255 | 255 | 255 | 255 | 255 |
| 8 | 255 | 255 | 255 | 90 | 90 | 90 | 90 | 255 | 255 | 255 | 255 | 200 | 200 | 255 | 255 |
| 9 | 255 | 255 | 255 | 255 | 255 | 90 | 90 | 90 | 255 | 255 | 255 | 200 | 200 | 255 | 255 |
| 10 | 255 | 255 | 255 | 255 | 255 | 255 | 255 | 90 | 255 | 255 | 255 | 200 | 200 | 255 | 255 |
| 11 | 255 | 255 | 255 | 255 | 255 | 255 | 255 | 255 | 255 | 255 | 255 | 255 | 255 | 255 | 255 |
| 12 | 255 | 255 | 255 | 255 | 255 | 255 | 255 | 255 | 255 | 255 | 255 | 255 | 255 | 255 | 255 |

- **TOP:** min(X-coordinate) i.e. 0
- **Bottom:** max(X-coordinate) i.e. 1
- **LEFT :** min(Y-coordinate) i.e. 11
- **RIGHT:** max(Y-coordinate) i.e. 14
- **Height of CC :** Bottom-TOP +1
i.e. 1-0+1=2
- **Width of CC:** RIGHT-LEFT+1
i.e. 14-11+1=4

Find Connected Component Information of 0, 90 and 200 intensities Objects

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Digital Image Processing

- Projection Profile

– Horizontal Histogram

- Plot of HH (total number of zeros in a row) is called Horizontal Histogram

| | | | | | | | | | | | | | | | | | |
|----|---|---|---|---|---|---|---|---|---|---|----|----|----|----|----|----|----|
| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | HH |
| 0 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 1 | 5 |
| 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 0 | 0 | 1 | 1 | 0 | 0 | 0 | 0 | 1 | 6 |
| 2 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 1 | 1 | 1 | 5 |
| 3 | 1 | 1 | 1 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 1 | 1 | 1 | 1 | 6 |
| 4 | 1 | 1 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 0 | 1 | 1 | 1 | 7 |
| 5 | 1 | 1 | 1 | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 1 | 1 | 2 |
| 6 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0 |
| 7 | 1 | 1 | 0 | 0 | 1 | 1 | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 3 |
| 8 | 1 | 1 | 1 | 0 | 0 | 0 | 0 | 1 | 1 | 1 | 1 | 0 | 0 | 1 | 1 | 1 | 6 |
| 9 | 1 | 1 | 1 | 1 | 1 | 0 | 0 | 0 | 1 | 1 | 1 | 0 | 0 | 1 | 1 | 1 | 5 |
| 10 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 1 | 1 | 1 | 1 | 0 | 0 | 1 | 1 | 1 | 3 |
| 11 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 1 | 1 | 1 | 1 |
| 12 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0 |

Digital Image Processing

- Projection Profile
 - Horizontal Histogram for Line Segmentation

| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | HH |
|----|---|---|---|---|---|---|---|---|---|---|----|----|----|----|----|----|----|
| 0 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 1 | 1 | 0 | 0 | 0 | 0 | 1 | 5 |
| 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 0 | 0 | 1 | 1 | 0 | 0 | 0 | 1 | 6 |
| 2 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 1 | 1 | 1 | 5 |
| 3 | 1 | 1 | 1 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 1 | 1 | 1 | 1 | 6 |
| 4 | 1 | 1 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 0 | 1 | 1 | 1 | 7 |
| 5 | 1 | 1 | 1 | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 1 | 1 | 2 |
| 6 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0 |
| 7 | 1 | 1 | 0 | 0 | 1 | 1 | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 3 |
| 8 | 1 | 1 | 1 | 0 | 0 | 0 | 0 | 1 | 1 | 1 | 1 | 0 | 0 | 1 | 1 | 1 | 6 |
| 9 | 1 | 1 | 1 | 1 | 1 | 0 | 0 | 0 | 1 | 1 | 1 | 0 | 0 | 1 | 1 | 1 | 5 |
| 10 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 1 | 1 | 1 | 0 | 0 | 1 | 1 | 1 | 3 |
| 11 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 1 | 1 | 1 | 1 | 1 |
| 12 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0 |

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Digital Image Processing

- Exercise Line Segmentation

How Many Lines
 Line # 1
 TOP:
 BOTTOM:
 LEFT:
 RIGHT:
 HEIGHT:
 WIDTH:

| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | HH |
|----|---|---|---|---|---|---|---|---|---|---|----|----|----|----|----|----|----|
| 0 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 1 | 1 | 0 | 0 | 0 | 0 | 1 | 5 |
| 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 0 | 0 | 1 | 1 | 0 | 0 | 0 | 1 | 6 |
| 2 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 1 | 1 | 1 | 5 |
| 3 | 1 | 1 | 1 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 1 | 1 | 1 | 1 | 6 |
| 4 | 1 | 1 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 0 | 1 | 1 | 1 | 7 |
| 5 | 1 | 1 | 1 | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 1 | 1 | 2 |
| 6 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0 |
| 7 | 1 | 1 | 0 | 0 | 1 | 1 | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 3 |
| 8 | 1 | 1 | 1 | 0 | 0 | 0 | 0 | 1 | 1 | 1 | 1 | 0 | 0 | 1 | 1 | 1 | 6 |
| 9 | 1 | 1 | 1 | 1 | 1 | 0 | 0 | 0 | 1 | 1 | 1 | 0 | 0 | 1 | 1 | 1 | 5 |
| 10 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 1 | 1 | 1 | 0 | 0 | 1 | 1 | 1 | 3 |
| 11 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 1 | 1 | 1 | 1 |
| 12 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0 |

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Digital Image Processing

- Exercise Line Segmentation

Line # 2

TOP:

BOTTOM:

LEFT:

RIGHT:

HEIGHT:

WIDTH:

| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | HH |
|----|---|---|---|---|---|---|---|---|---|---|----|----|----|----|----|----|----|
| 0 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 1 | 1 | 0 | 0 | 0 | 0 | 1 | 5 |
| 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 0 | 0 | 1 | 1 | 0 | 0 | 0 | 1 | 6 |
| 2 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 1 | 1 | 1 | 5 |
| 3 | 1 | 1 | 1 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 1 | 1 | 1 | 1 | 6 |
| 4 | 1 | 1 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 0 | 1 | 1 | 1 | 7 |
| 5 | 1 | 1 | 1 | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 1 | 1 | 2 |
| 6 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0 |
| 7 | 1 | 1 | 0 | 0 | 1 | 1 | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 3 |
| 8 | 1 | 1 | 1 | 0 | 0 | 0 | 0 | 1 | 1 | 1 | 1 | 0 | 0 | 1 | 1 | 1 | 6 |
| 9 | 1 | 1 | 1 | 1 | 1 | 0 | 0 | 0 | 1 | 1 | 1 | 0 | 0 | 1 | 1 | 1 | 5 |
| 10 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 1 | 1 | 1 | 1 | 0 | 0 | 1 | 1 | 1 | 3 |
| 11 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 1 | 1 | 1 | 1 |
| 12 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0 |

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Digital Image Processing

- Projection Profile
 - Vertical Histogram
 - Plot of VH is called Vertical Histogram

| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 |
|----|---|---|---|---|---|---|---|---|---|---|----|----|----|----|----|----|
| 1 | 1 | 1 | 0 | 0 | 1 | 1 | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 2 | 1 | 1 | 1 | 0 | 0 | 0 | 0 | 1 | 1 | 1 | 1 | 0 | 0 | 1 | 1 | 1 |
| 3 | 1 | 1 | 1 | 1 | 1 | 0 | 0 | 0 | 1 | 1 | 1 | 0 | 0 | 1 | 1 | 1 |
| 4 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 1 | 1 | 1 | 0 | 0 | 1 | 1 | 1 |
| 5 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 1 | 1 | 1 |
| 6 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| VH | 0 | 0 | 1 | 2 | 1 | 2 | 3 | 2 | 0 | 0 | 0 | 3 | 4 | 0 | 0 | 0 |

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Digital Image Processing

How many columns
 Column # 1
 TOP:
 BOTTOM:
 LEFT:
 RIGHT:
 HEIGHT:
 WIDTH:

| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 |
|----|---|---|---|---|---|---|---|---|---|---|----|----|----|----|----|----|
| 1 | 1 | 1 | 0 | 0 | 1 | 1 | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 2 | 1 | 1 | 1 | 0 | 0 | 0 | 0 | 1 | 1 | 1 | 1 | 0 | 0 | 1 | 1 | 1 |
| 3 | 1 | 1 | 1 | 1 | 1 | 0 | 0 | 0 | 1 | 1 | 1 | 0 | 0 | 1 | 1 | 1 |
| 4 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 1 | 1 | 1 | 0 | 0 | 1 | 1 | 1 |
| 5 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 1 | 1 | 1 |
| 6 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| VH | 0 | 0 | 1 | 2 | 1 | 2 | 3 | 2 | 0 | 0 | 0 | 3 | 4 | 0 | 0 | 0 |

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Digital Image Processing

Column # 2
 TOP:
 BOTTOM:
 LEFT:
 RIGHT:
 HEIGHT:
 WIDTH:

| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 |
|----|---|---|---|---|---|---|---|---|---|---|----|----|----|----|----|----|
| 1 | 1 | 1 | 0 | 0 | 1 | 1 | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 2 | 1 | 1 | 1 | 0 | 0 | 0 | 0 | 1 | 1 | 1 | 1 | 0 | 0 | 1 | 1 | 1 |
| 3 | 1 | 1 | 1 | 1 | 1 | 0 | 0 | 0 | 1 | 1 | 1 | 0 | 0 | 1 | 1 | 1 |
| 4 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 1 | 1 | 1 | 0 | 0 | 1 | 1 | 1 |
| 5 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 1 | 1 | 1 |
| 6 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| VH | 0 | 0 | 1 | 2 | 1 | 2 | 3 | 2 | 0 | 0 | 0 | 3 | 4 | 0 | 0 | 0 |

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Exercise

| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31 | 32 | | |
|----|---|---|---|---|---|---|---|---|---|---|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|---|---|
| 0 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 1 | 1 | 0 | 0 | 0 | 0 | 1 | 0 | 1 | 1 | 1 | 1 | 0 | 1 | 1 | 1 | 0 | 1 | 1 | 0 | 0 | 0 | 1 | 1 | 1 | 1 | 1 |
| 2 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 0 | 0 | 1 | 1 | 0 | 0 | 0 | 1 | 1 | 0 | 1 | 1 | 0 | 0 | 1 | 1 | 1 | 0 | 0 | 0 | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 3 | 1 | 1 | 1 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 0 | 1 | 0 | 0 | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 4 | 1 | 1 | 1 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 1 | 1 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 5 | 1 | 1 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 0 | 1 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 6 | 1 | 1 | 1 | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 1 | 1 | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 7 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 8 | 1 | 1 | 0 | 0 | 1 | 1 | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 1 | 1 | 1 | 1 | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 9 | 1 | 1 | 1 | 0 | 0 | 0 | 0 | 1 | 1 | 1 | 1 | 1 | 0 | 0 | 1 | 1 | 1 | 1 | 1 | 0 | 1 | 1 | 0 | 1 | 1 | 0 | 1 | 1 | 1 | 1 | 1 | 0 | 1 | 1 | 1 |
| 10 | 1 | 1 | 1 | 1 | 1 | 0 | 0 | 0 | 1 | 1 | 1 | 1 | 0 | 0 | 1 | 1 | 1 | 0 | 0 | 1 | 0 | 0 | 0 | 1 | 1 | 1 | 1 | 1 | 0 | 1 | 0 | 1 | 1 | 1 | 1 |
| 11 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 1 | 1 | 1 | 1 | 1 | 0 | 0 | 1 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 1 | 1 |
| 12 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 1 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 1 | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 13 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 14 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |

1. Segment Image into lines and find followings for each line
 - Top, Bottom, Left, Right, Height, Width and dimension
2. Segment Image into columns and find followings for each column
 - Top, Bottom, Left, Right, Height, Width and dimension
3. Segment line into columns and find followings for each column
 - Top, Bottom, Left, Right, Height, Width and dimension
4. Extract CC information of each CC in the image
 - Coordinates, Top, Bottom, Left, Right, Height, Width, dimension