Bi-Level Image Compression

EECE 545: Data Compression

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Overview

- Introduction to Bi-Level Image Compression
- Existing Facsimile Standards:
  - G3 (MR)
  - G4 (MMR)
  - JBIG[1]
- New Bi-Level Standards:
  - JBIG2

Introduction: Meet Dave

Dave and his Mom:

Definition: Bi-Level

Multi-Level
(Gray Scale)

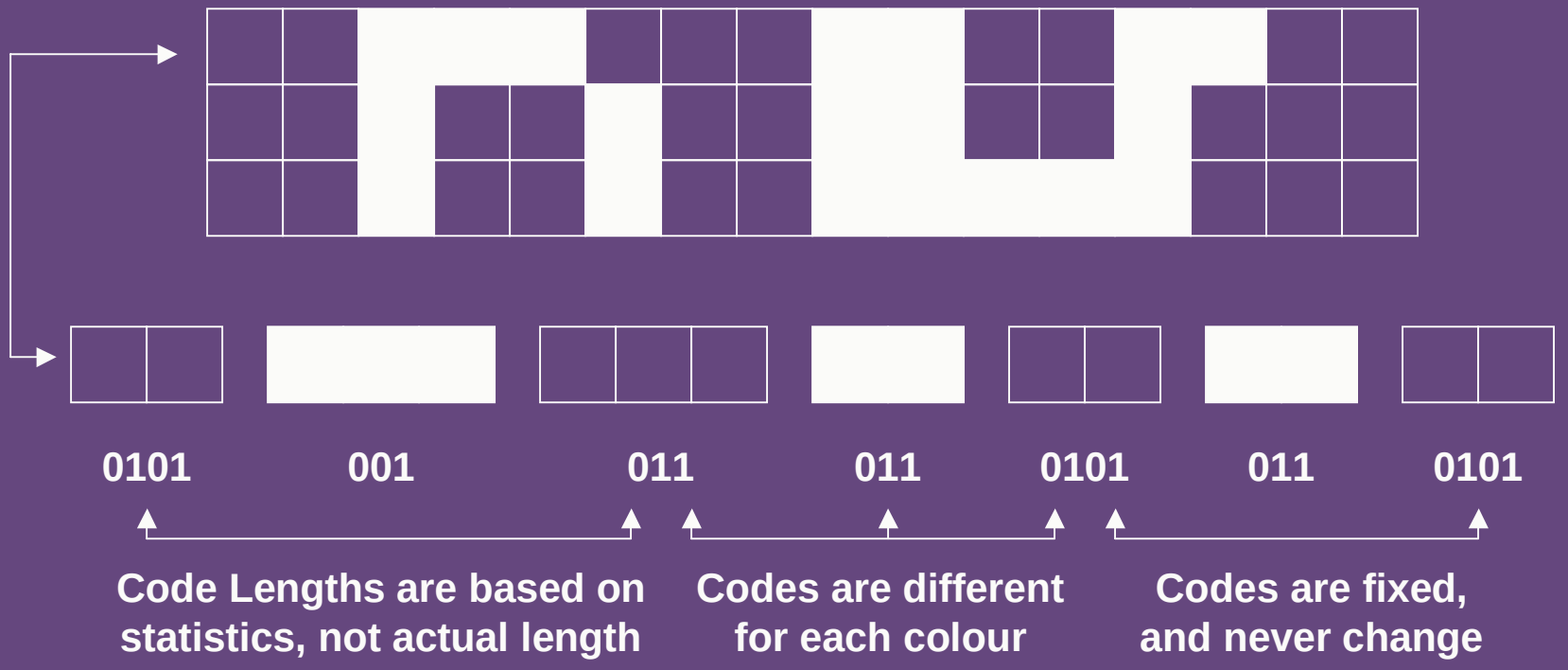
Bi-Level
(Black & White)

Properties of Bi-Level Images

- Mostly High Frequency
- Often Very High Resolutions:
  - Computer Monitor: 96dpi
  - Fax Machine: 200dpi
    - 1 page fax (8.5” x 11” x 200dpi) ~= .5 Meg
  - Laser Printer: 600dpi (1 page = 4.2 Megs)
  - High-End Printing Press: 1600dpi (30 Megs!)
- Will often contain text, halftoned images and line-art (graphs, equations, logos, etc.)

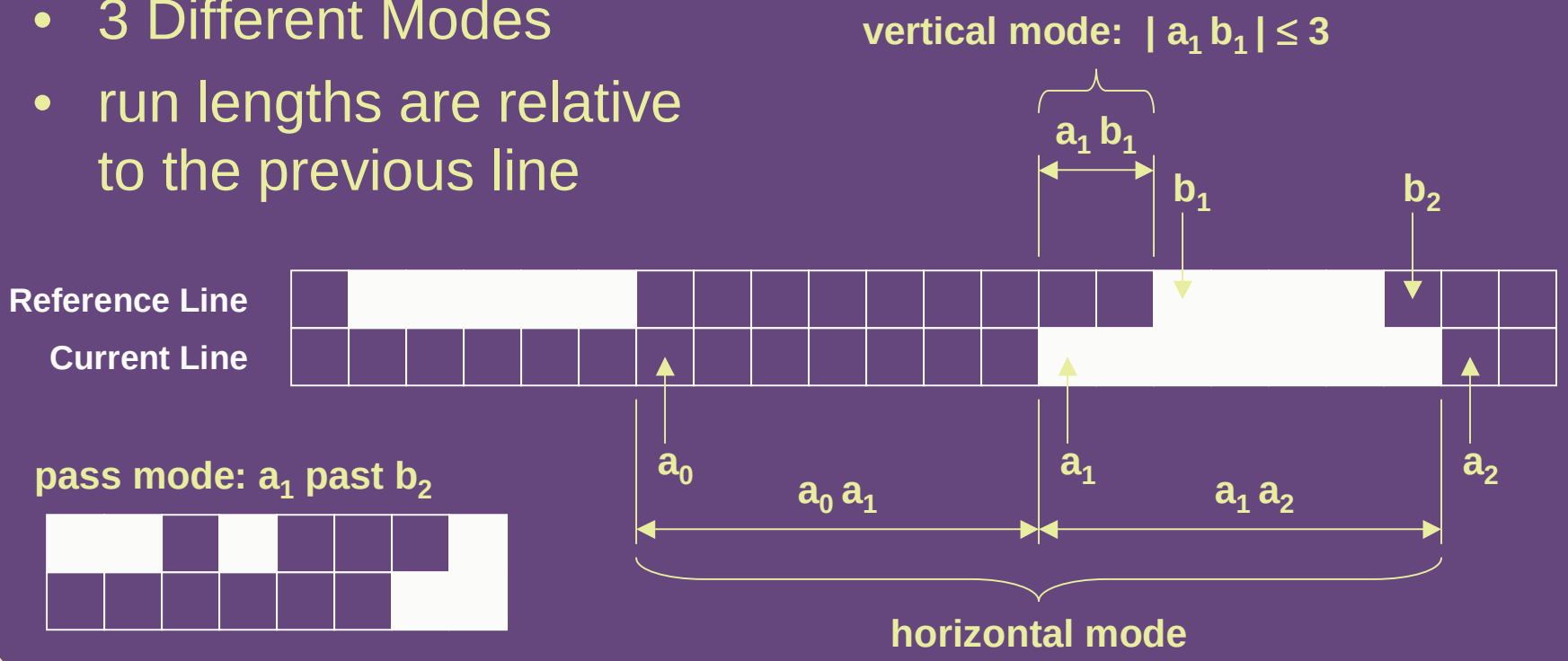
Existing Fax Standards

- T.4 (Group 3) MH (Modified Huffman): Huffman & Run-Length Encoding (RLE)



Existing Fax Standards

- T.6 (Group 4) MMR (Modified Modified Read): Huffman Coding & Modified RLE
  - 3 Different Modes
  - run lengths are relative to the previous line



Existing Fax Standards

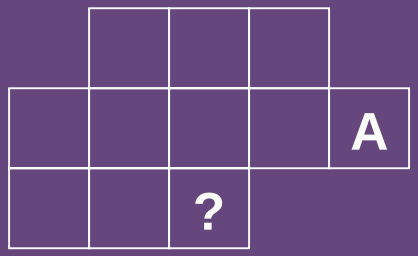
- T.4 (Group 3)
  - MH - Modified Huffman (and RLE)
  - MR - Modified Read
    - Uses information from previous line
    - Uses MH mode every k lines for error correction
- T.6 (Group 4)
  - MMR - Modified Modified Read
    - Uses information from previous line
    - Assumes Error-Free Environment

Existing Fax Standards

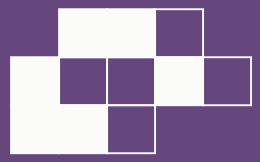
- JBIG[1] (T.82 -- March, 1993)
- **J**oint **Bi**-Level **I**mage Experts **G**roup
  - Committee with Academic & Industrial members:
    - ISO (International organization of National Bodies)
    - ITU-T (Regulatory body of the United Nations)
- Arithmetic Coding (QM Coder)
- Context-based prediction
- Progressive Compression (Display)

Existing Fax Standards

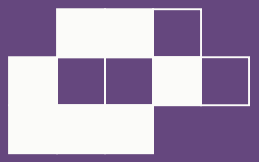
- Standard JBIG1 Context:



- ? = Pixel to be coded
- A = **A**daptive pixel (which can be moved)
- Example:



= 17%

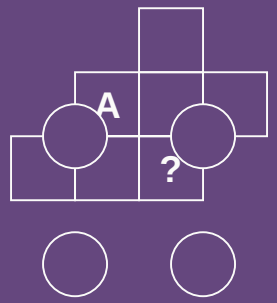


= 83%

Existing Fax Standards

- JBIG1: Progressive Compression (Display)

- Standard defines how to reduce the image
- Predictive context uses information from previous resolution level



Existing Fax Standards

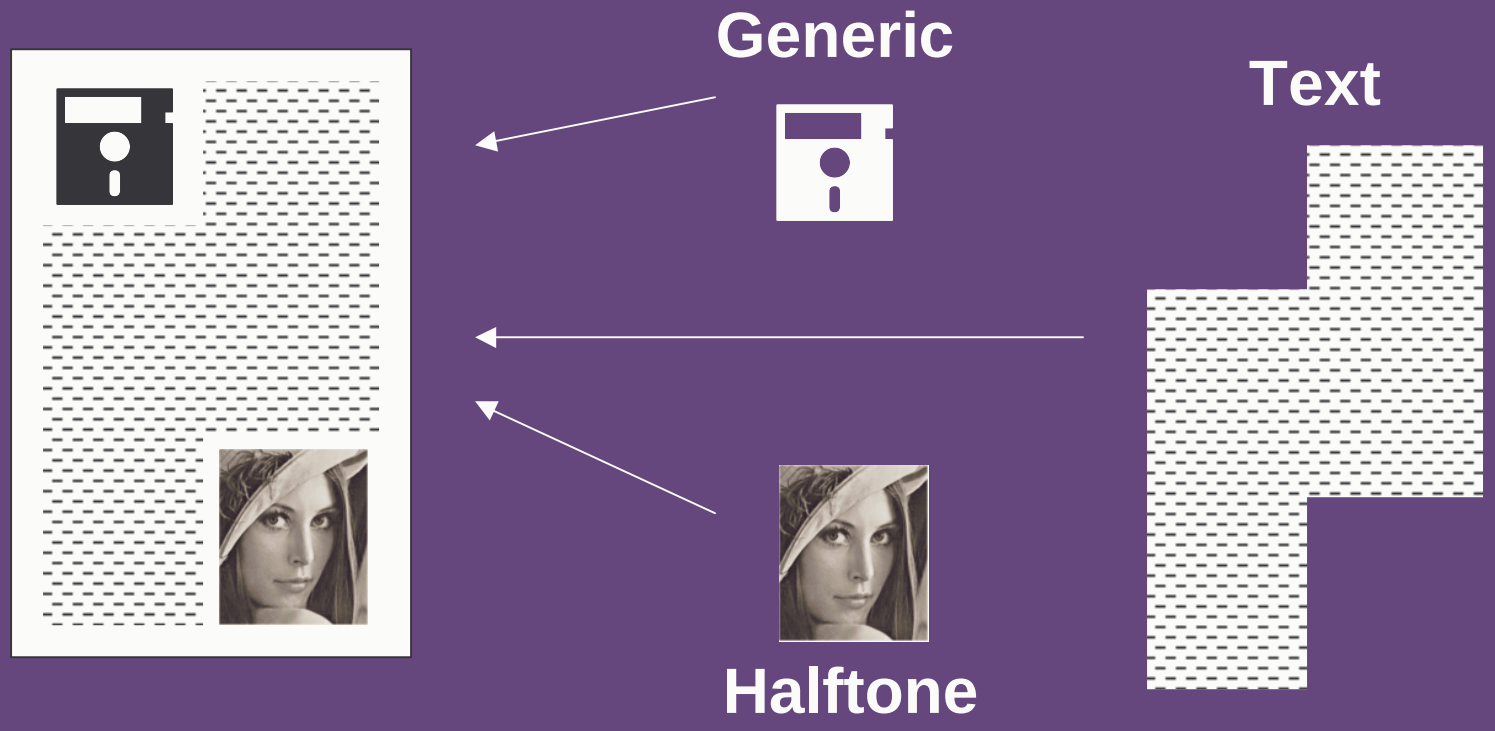
- Arithmetic Q Coder
  - Numerous variations: Q, QM, MQ
    - Used by JBIG[1] , JPEG, JBIG2 & J2K
    - Different probability tables, byte markers, etc.
- Adaptive Coder
- 16-bit Precision (32-bit C register)
- Uses numerous Approximations:
  - Fixed Probability Table
  - No Multiplication

New Standards

- JBIG2 (T.88 -- February 2000)
- First *"lossy"* bi-level standard
- Supports Three basic coding modes:
  - Generic (MMR or JBIG[1]-like arithmetic)
  - Halftone
  - Text
- Image can be *segmented* into regions
  - Each region can be coded with a different method

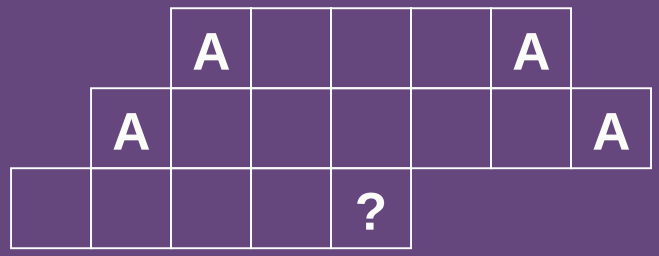
JBIG2 - Compound Documents

- Segmentation is performed on compound documents to detect different regions



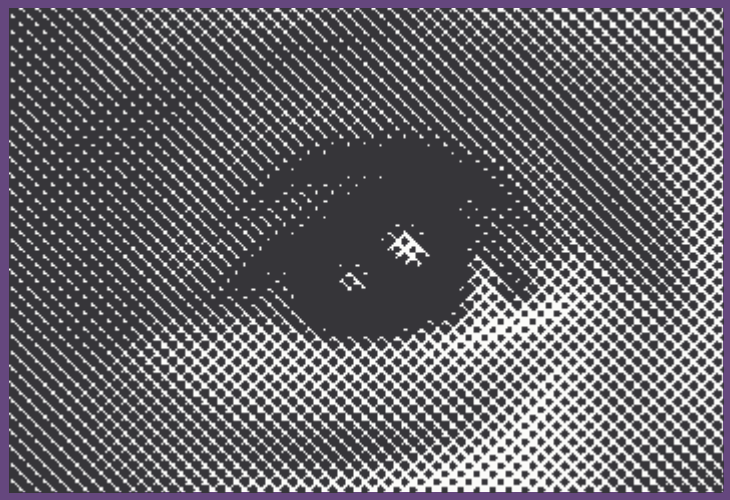
JBIG2 - Generic Coding

- The core coding method of JBIG2 has not changed that much from previous methods
- There are two methods available in generic coding:
  - MMR (Group 4)
  - MQ Arithmetic Coding (similar to JBIG[1]) larger contexts are available:



JBIG-2 Halftone Coding

- A halftone is coded as a multi-level image, along with a pattern and grid parameters



- The decoder constructs the halftone from the multi-level image and the pattern
- The multi-level image is coded as bi-level bit-planes, with the generic coder

JBIG2 - Text Coding

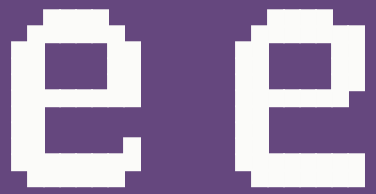
- Each symbol is encoded in a dictionary with generic coding:

- And then, the image is constructed by adding images from the dictionary:

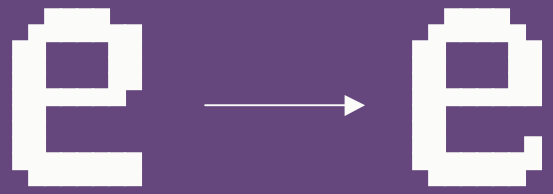
- The symbol ID and the (relative) co-ordinates are coded

JBIG2 - Text Coding

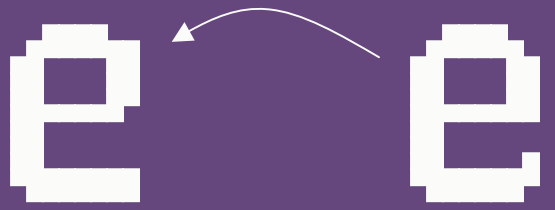
- In actual documents, many symbols are very similar -- often due to scanning or spacial quantization errors



- Lossy Coding:
  Hard Pattern Matching



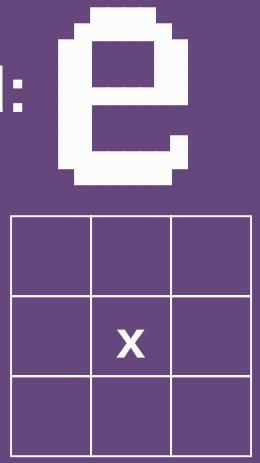
- Lossless Coding:
  Soft Pattern Matching



JBIG2 - Soft Pattern Matching

- Soft Pattern Matching (*refinement* coding) is when a symbol is coded using a similar, previously coded symbol to provide additional context information.

Already coded:



To be coded: