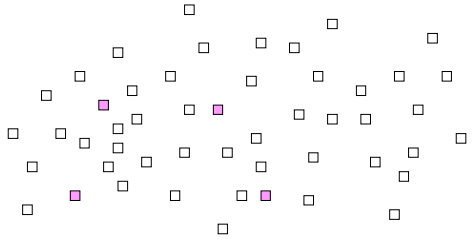
CSE 490 GZ
Introduction to Data Compression
Winter 2002

Group Testing for Image Compression
GTW
GT-DCT

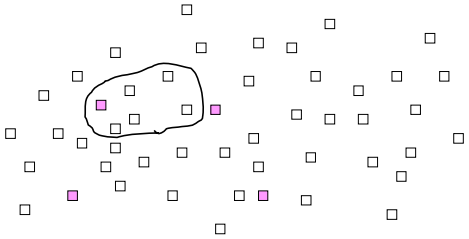
Group Testing (Dorfman 1943)

- Given n items, with s items significant
- Use group tests to identify significant items
  - Group test of size k
    - Group is insignificant: all k items insignificant
    - Group is significant: at least one significant
- Goal: Minimize number of group tests

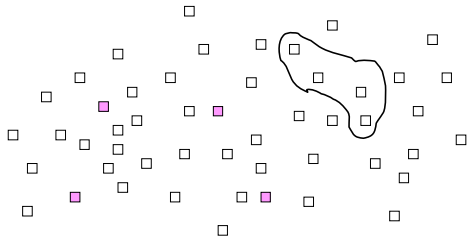
Group Testing (Dorfman 1943)



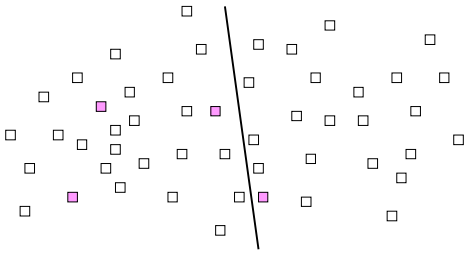
Group Testing (Dorfman 1943)



Group Testing (Dorfman 1943)



Group Testing (Dorfman 1943)



classes to reduce group tests

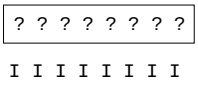
Zerotree Coding as Group Testing

- Coefficients = items
- Testing trees for significance = group test
- Zerotree coding = one particular group testing algorithm
- Zerotree coding & group testing have similar goals

Hwang's Group Testing Algorithm (1972)

- Repeat a Group Iteration until all significant items are found
- Group Interation
  - Test group G containing k unidentified items
  - If G is significant, find a significant item in $\log_2 k$ tests
    - Each subsequent test is a subset of G
    - Size of test group is halved each time

Group Iteration of size 8



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Group Test Result	Code
Insignificant	0

Group Iteration of size 8

	Group Test Result	Code
? ? ? ? ? ? ? ?	Significant	1
? ? ? ? ? ? ? ?	Insignificant	0
I I I I ? ? ? ?	Significant	1
I I I I ? ? ? ?	Insignificant	0
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- Equivalent to elementary Golomb code of order 8

Group Testing for Wavelet Image Coding (GTW)

- Hong and Ladner (2000)
- New method for encoding significance pass:
  - Uses Hwang's Group Testing Algorithm
  - Divide wavelet coefficients into classes
  - Every group test performed is on coefficients in the same class
  - No arithmetic coding

GTW Significance Pass Overview

- Repeat until all coefficients are coded
  - Pick a set of coefficients from the class that is most likely to have significant coefficients.
  - Do one group iteration on the set. The group size is determined by the adaptive group tester.
    - Output the results of the group tests
  - If a significant coefficient is found then
    - Output its sign
    - Update classes of neighboring coefficients

GTW's adaptive group tester

- Choosing group iteration size k:
  - Ramp up: start with k=1
    - While group insignificant, double k
  - Steady state: use past history to estimate probability p of insignificance
    - Optimal k using Gallager & Van Voorhis' (1975) result

$$k = \left\lceil \frac{-1}{\log_2 p} \right\rceil$$

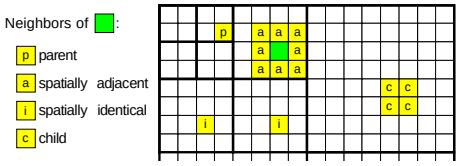
Same as the adaptive Golomb coding algorithm.

GTW Classes

- Coefficients with similar characteristics put into the same class
- Classes are ordered so that classes with coefficients more likely to be significant are tested first.
- Class characteristics
  - Significant neighbor count
  - pattern type
  - Subband level

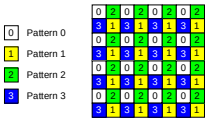
Significant neighbor metric

- Count # of significant neighbors
- Example Neighborhood

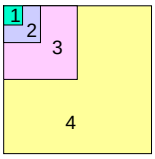


Pattern Type

- Accounts for correlation exists between neighbors
  - Example pattern types for a subband



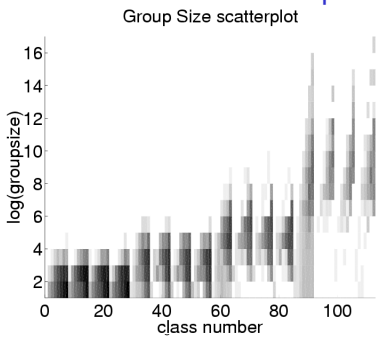
Subband level



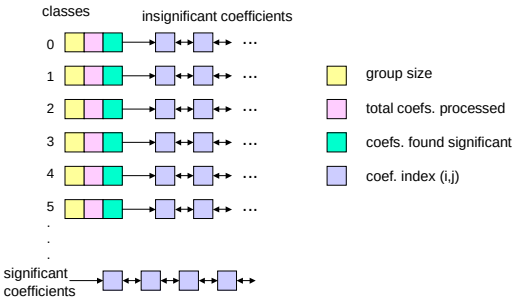
Class Ordering

- Significant neighbor count
  - children count for at most 1
  - 0,1,2 or 3 or more
- Pattern Types 4 and Subband levels 7
- Total number of classes 112
- Ordering
  - First by significant neighbor count (large to small)
  - Second by pattern type (small to large)
  - Third by subband level (small to large)

Class Number vs. Group Size



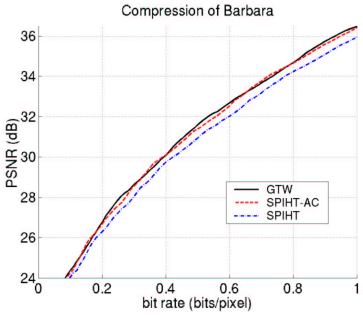
GTW Data Structures



Decoding

- Decoding algorithm is identical to the encoding algorithm except
  - Decoder knows the results of group test from the compressed bit stream

GTW Compression Performance



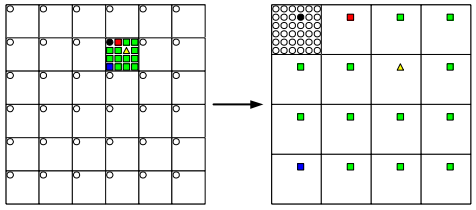
Flexibility of Group Testing

- Flexibility
  - Significant data sent first
  - Classes defined to focus of significant data
  - Data can move from class to class
  - We always get a progressive coder
- Applications
  - DCT
  - Lapped Transforms
  - Wavelet Packets

GT-DCT

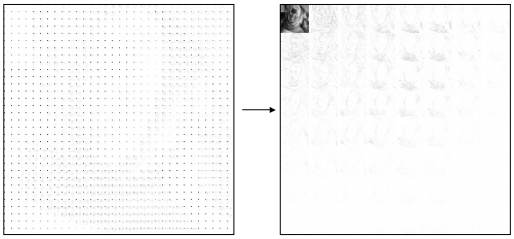
- Hong, Ladner, Riskin (2001)
- Group testing for the discrete cosine transform.
- We do bit-plane coding of the DCT coefficients.
- DCT classes are defined.
- Group testing done first on the classes that have the smallest group size.

Reorganizing Block Transform Coefficients



block organization subband organization

Reorganizing Block Transform Coefficients



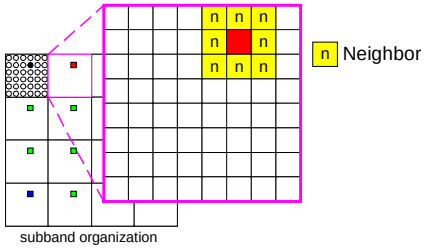
block organization subband organization

GT-DCT Classes

- Based on subband reorganization of coefficients
- Class characteristics
  - Significant neighbor metric
  - Subband level

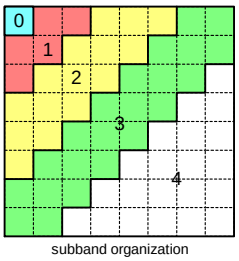
Significant Neighbor Metric

- Count # of significant neighbors



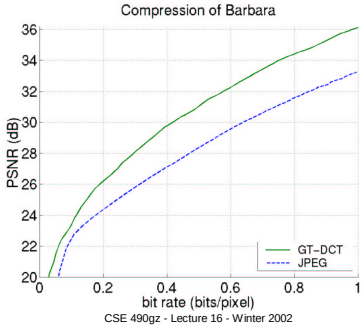
subband organization

Subband Level



subband organization

GT-DCT vs JPEG



Group Testing Notes

- Group testing provides a unified and flexible way to approach bit-plane coding of transformed images.
  - Need good classes (contexts)
  - Need good group testing algorithms (adaptive Golomb coding works)
- Compression performance is outstanding
- Group testing is quite a bit more time consuming than JPEG and SPIHT.
  - need some good data structures and engineering