

CSE 490 GZ
Introduction to Data Compression
Winter 2004

Group Testing for Image Compression
GTW
GT-DCT

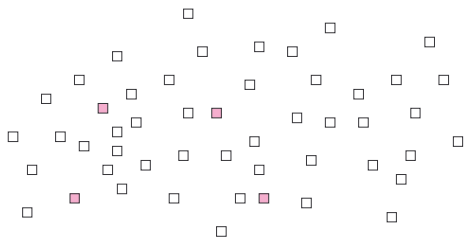
Group Testing (Dorfman 1943)

- 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

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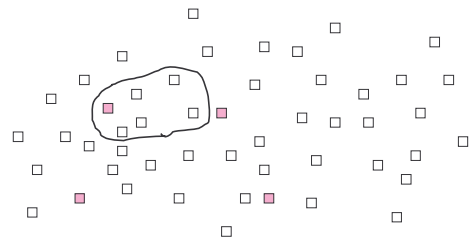
Group Testing (Dorfman 1943)



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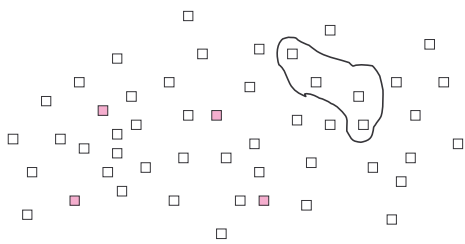
Group Testing (Dorfman 1943)



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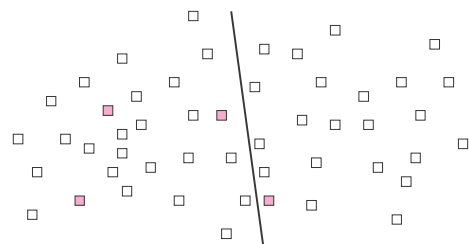
Group Testing (Dorfman 1943)



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Group Testing (Dorfman 1943)



classes to reduce group tests

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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

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Hwang's Group Testing Algorithm (1972)

- Repeat a **Group Iteration** until all significant items are found
- Group Iteration
 - 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

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Group Iteration of size 8

| | Group Test Result | Code |
|---|-------------------|------|
| ? ? ? ? ? ? ? ? | Insignificant | 0 |
| I I I I I I I I | | |

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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 |
| I I I I I S ? ? | | |

- Equivalent to elementary Golomb code of order 8

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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

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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

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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

$$k = \left\lceil -1 / \log_2 p \right\rceil$$

Same as the adaptive Golomb coding algorithm.

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GTW Classes

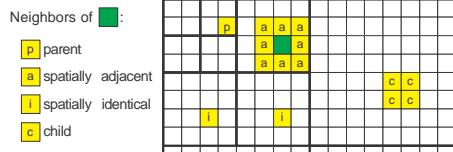
- Coefficients with similar characteristics put into the same class
- Classes are ordered so that classes with coefficients more likely to be significant are tested first.
- Class characteristics
 - Significant neighbor count
 - pattern type
 - Subband level

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Significant Neighbor Metric

- Count # of significant neighbors
- Example Neighborhood

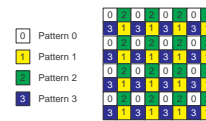


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Pattern Type

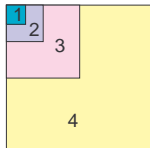
- Accounts for correlation exists between neighbors
 - Example pattern types for a subband



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Subband Level



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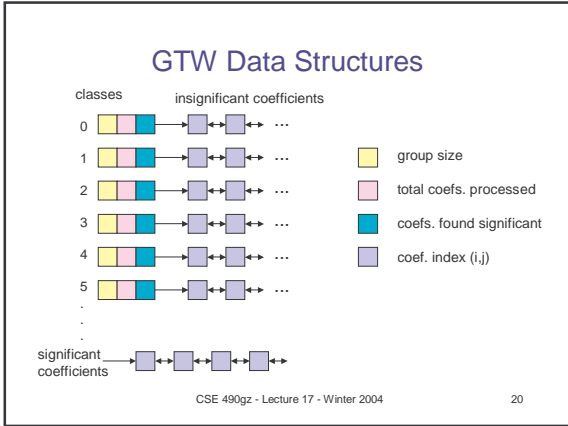
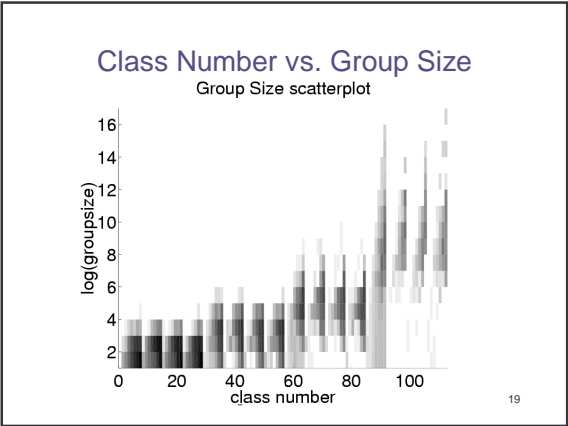
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Class Ordering

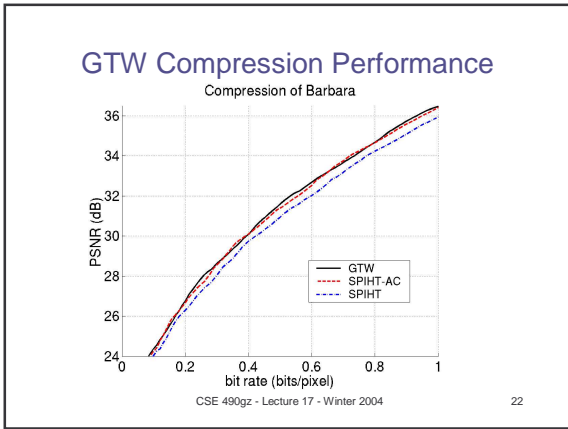
- Significant neighbor count
 - children count for at most 1
 - 0,1,2 or 3 or more
- Pattern Types 4 and Subband levels 7
- Total number of classes 112
- Ordering
 - First by significant neighbor count (large to small)
 - Second by pattern type (small to large)
 - Third by subband level (small to large)

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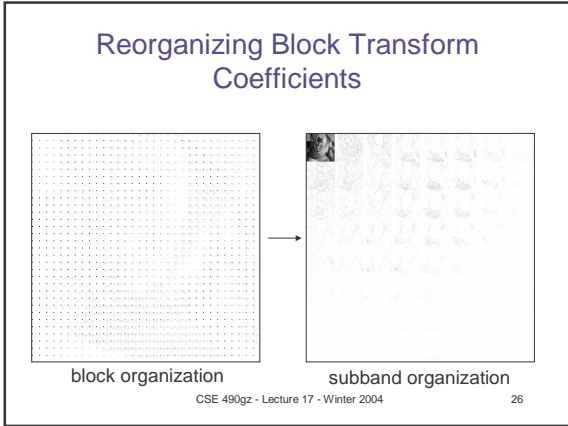
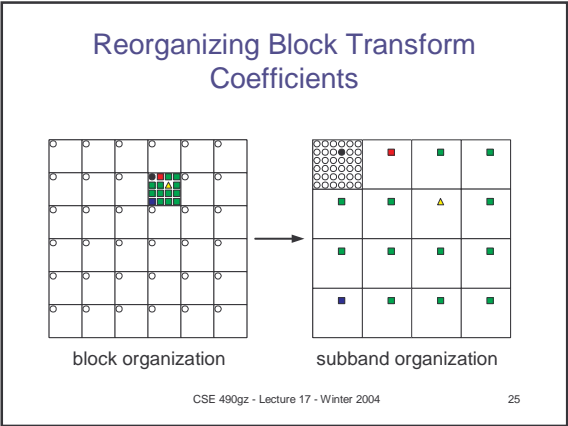


- ### Decoding
- Decoding algorithm is identical to the encoding algorithm except
 - Decoder knows the results of group test from the compressed bit stream
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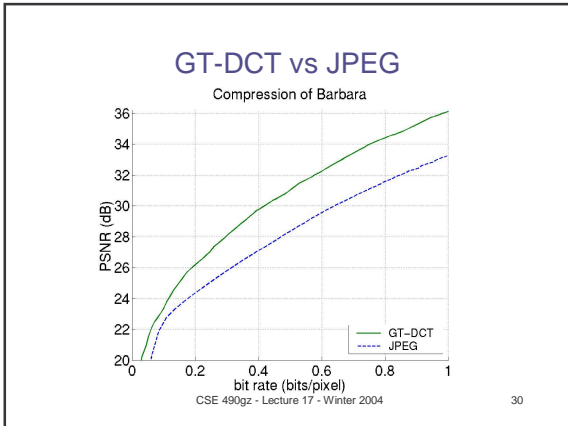
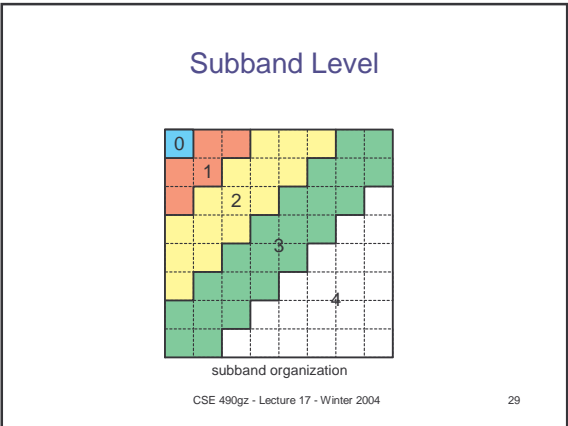
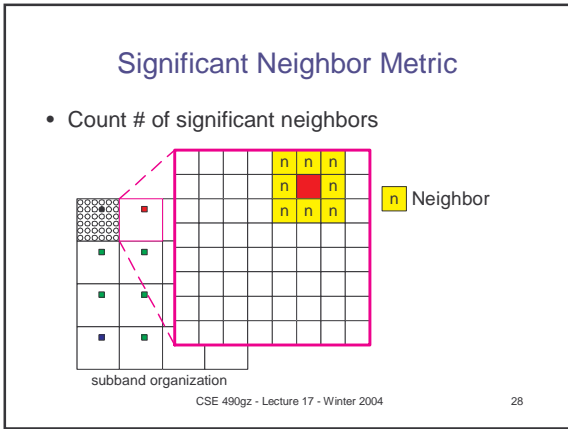


- ### Flexibility of Group Testing
- Flexibility
 - Significant data sent first
 - Classes defined to focus of significant data
 - Data can move from class to class
 - We always get a progressive coder
 - Applications
 - DCT
 - Lapped Transforms
 - Wavelet Packets
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- ### 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.
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- ### GT-DCT Classes
- Based on subband reorganization of coefficients
 - Class characteristics
 - Significant neighbor metric
 - Subband level
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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