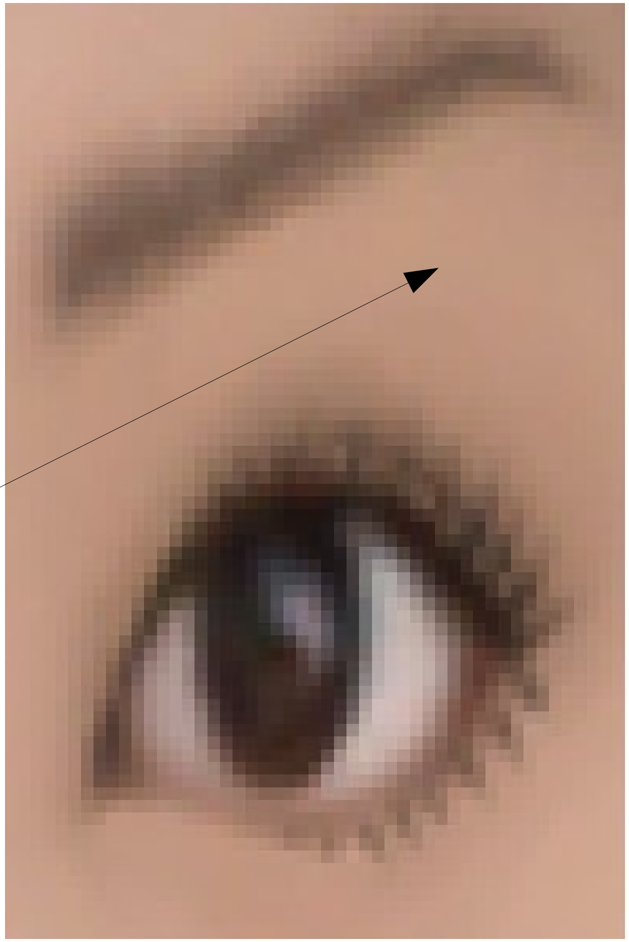
SYDE 575: Introduction to Image Processing

Image Compression
Part 2: Example of DXTC and 3Dc

Example of DXTC

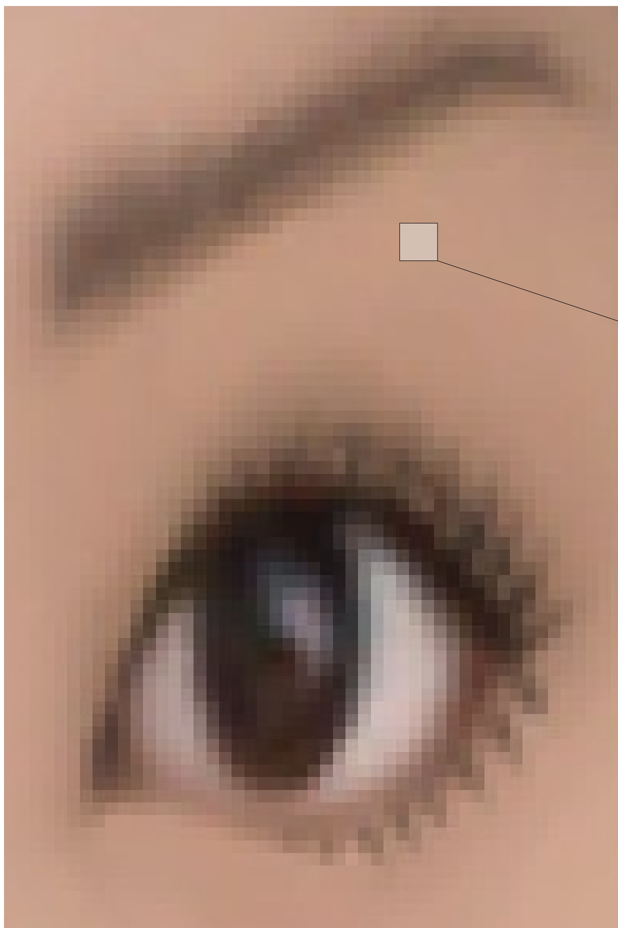
- Suppose we are given a color texture represented in R8G8B8 format.



(R,G,B)=(192,150,128)

Example of DXTC

- Divide image into 4x4 blocks



(188, 146, 124)	(188, 146, 124)	(187, 145, 123)	(183, 143, 118)
(186, 144, 122)	(187, 142, 121)	(187 142, 121)	(184, 144, 119)
(186, 144, 122)	(187, 142, 121)	(187 142, 121)	(182, 142, 117)
(186, 144, 122)	(187, 142, 121)	(187 142, 121)	(184, 144, 119)

Example of DXTC

- Store two 16-bit representative color values C0 (high) and C1 (low) in R5G6B5 format

(188, 146, 124)	(188, 146, 124)	(187, 145, 123)	(183, 143, 118)
(186, 144, 122)	(187, 142, 121)	(187 142, 121)	(184, 144, 119)
(186, 144, 122)	(187, 142, 121)	(187 142, 121)	(182, 142, 117)
(186, 144, 122)	(187, 142, 121)	(187 142, 121)	(184, 144, 119)

(R,G,B)=(188,146,124)

↓

(R,G,B)=(24,37,16) C0

(R,G,B)=(182,142,117)

↓

(R,G,B)=(23,36,15) C1

Example of DXTC

- Compute two additional color values
- (e.g., using simple interpolation)

(R,G,B)=(24,37,16) C0

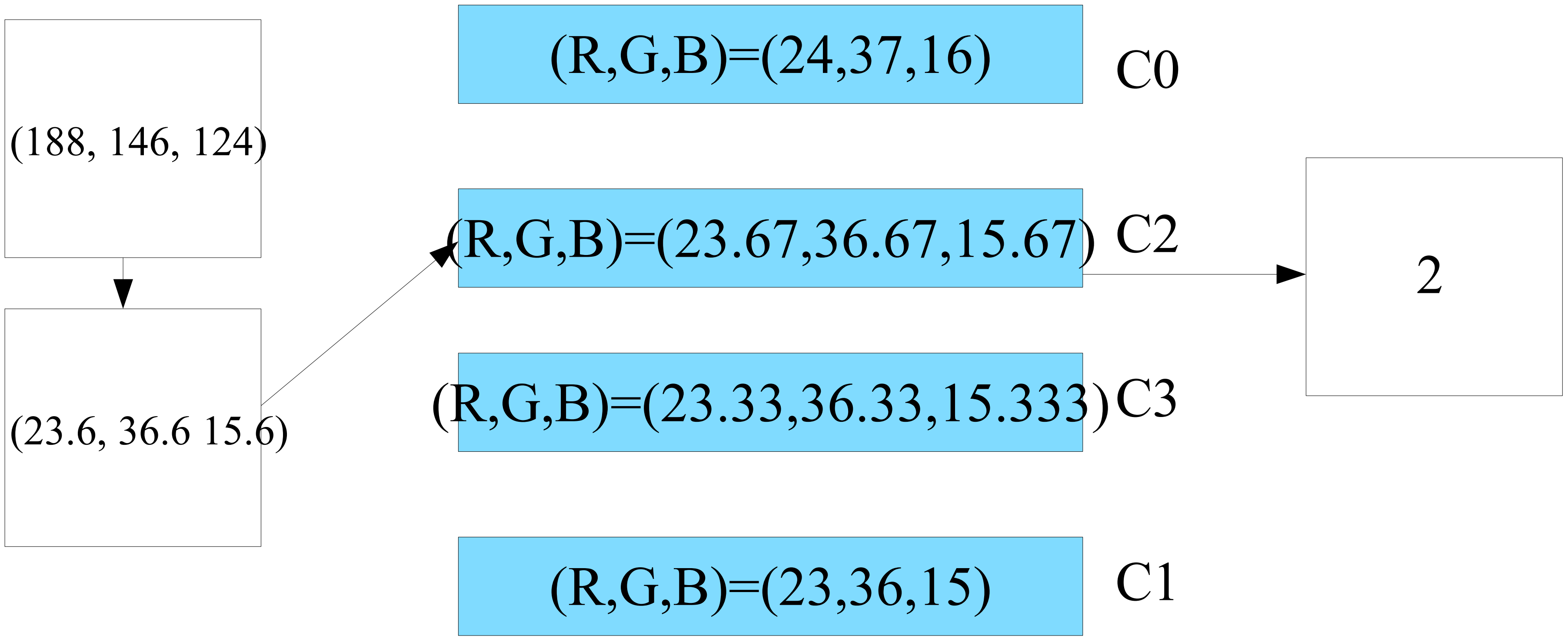
(R,G,B)=(23.67,36.67,15.67) C2

(R,G,B)=(23.33,36.33,15.333) C3

(R,G,B)=(23,36,15) C1

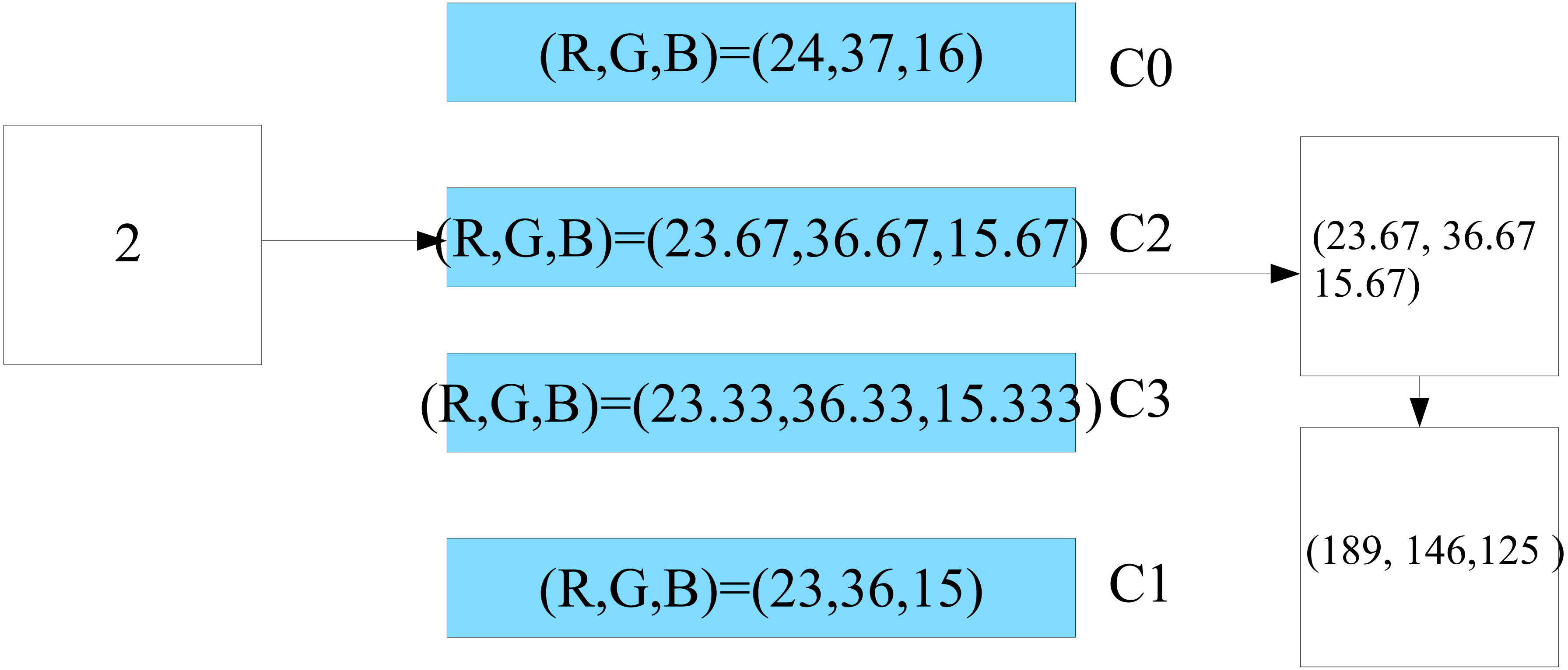
Example of DXTC

Assign a value from 0 to 3 to each pixel based on closest color value



Example of DXTC

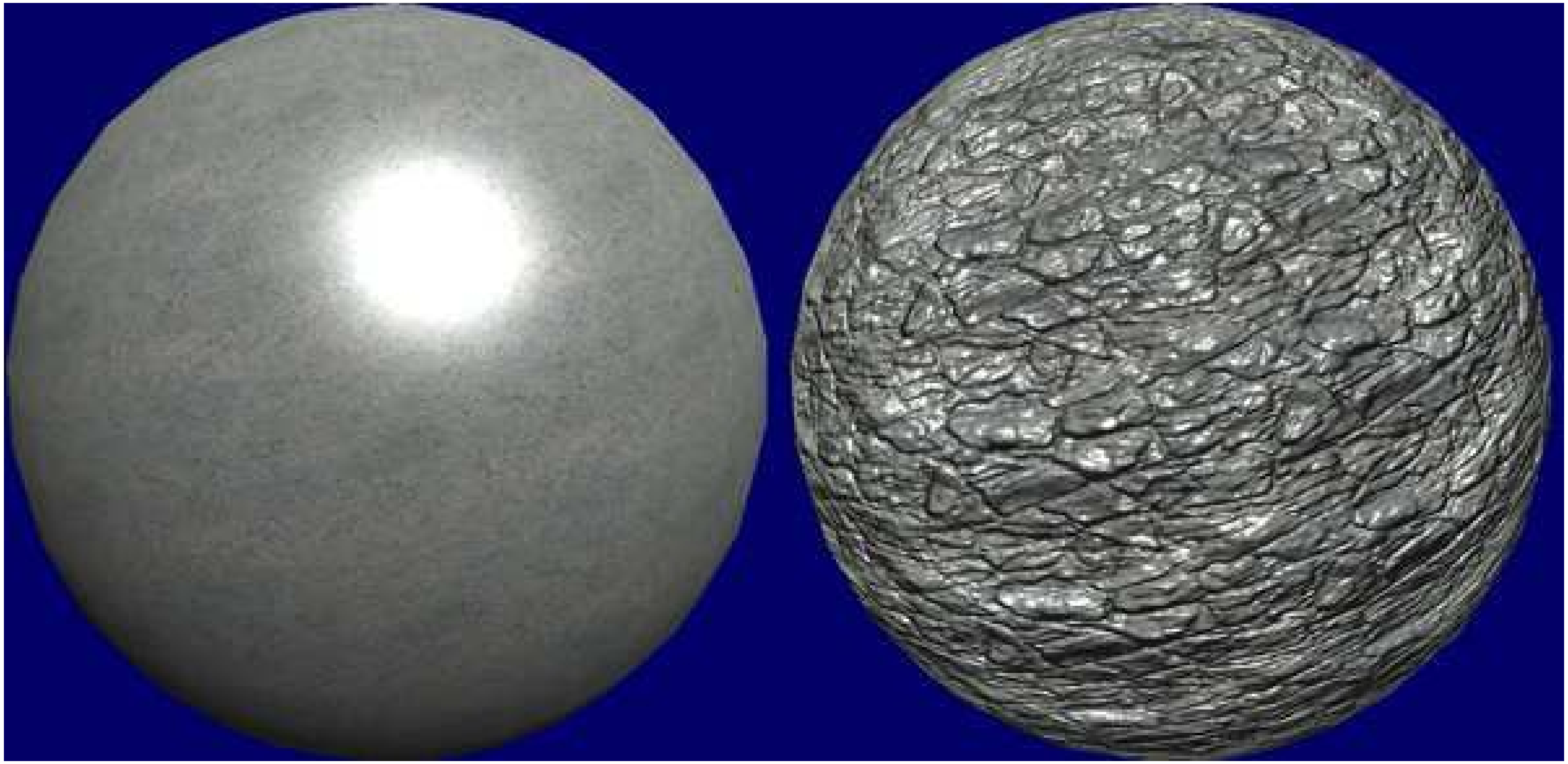
To decode, replace values from lookup table with one of the four color values



Normal Mapping

- Complex 3D models in a scene provide a greater sense of realism within a 3D environment
- However, it is expensive from both a computational and memory perspective to process such complex 3D models with high geometric detail
- Solution: use normal mapping to give the sense that there is more geometric detail by changing lighting based on supposed geometry

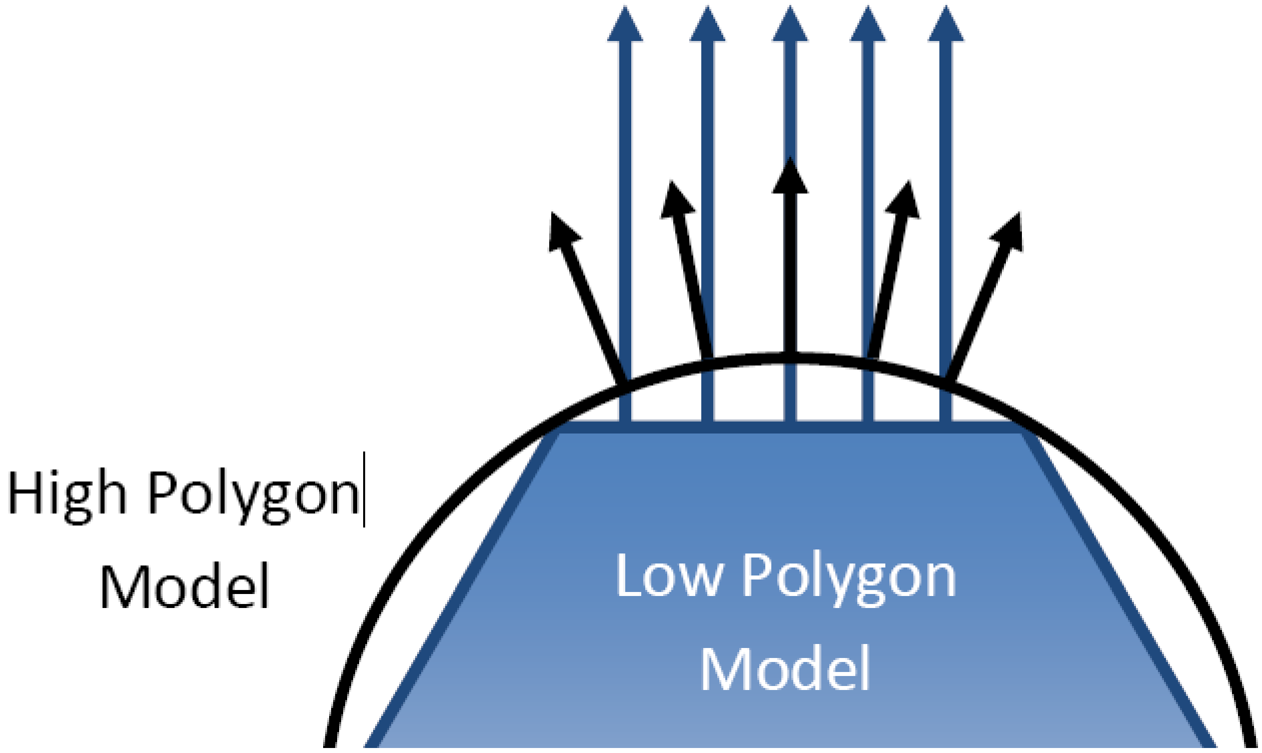
Normal Mapping



Creating Normal Maps

- Create high resolution model and a corresponding low resolution model you want to use
- Cast ray from each texel on low-res model
- Find intersection of ray with high-res model
- Save the normal from high-res model where the ray intersects

Normal Mapping



3Dc

- Each pixel in a normal map has three values (x,y,z), which represent a normal vector
- The x,y, and z coordinates of a normal vector are independent from each other
- This makes DXTC poorly suited for compressing normal maps since it relies on inter-channel correlations
- Solution: 3Dc, an extension of BTC for normal maps

How does 3Dc work?

- Instead of operating on all channels together, treat x, y, and z coordinate channels separate from each other
- In most systems, all normal vectors are unit vectors with a length of 1
- Also, z component assumed to be positive since it should point out of the surface

How does 3Dc work?

- Idea: Instead of storing z, compute z based on x and y

$$z = \sqrt{1 - (x^2 + y^2)}$$

- Since z is not stored, storage requirements have effectively been reduced by 1/3!

How does 3Dc encoding work?

- Steps:
  - Discard z channel
  - For the x and y channels, divide normal map into 4x4 blocks
  - For each block, store two 8-bit representative coordinate values (V0 and V1)
  - Compute 6 intermediate coordinate values by using simple linear interpolation between V0 and V1

How does 3Dc encoding work?

- Steps:
  - Assign a value from 0 to 7 to each pixel based on the closest of the 8 coordinate values V0,V1,...,V7
    - Creates a 4x4 3-bit lookup table for storage

How does 3Dc decoding work?

- Steps:
  - For each block in the x and y channels, replace values from lookup table with one of the 8 coordinate values (2 stored values and 6 interpolated values)
  - Compute z based on x and y to get all three coordinates for each normal vector

3Dc Compression Rate

- Suppose we are given an 4x4 normal map, with each pixel represented by x, y, and z values ranging from 0 to 2^16-1 each.
- The amount of bits required to store this image in an uncompressed format is 4x4x(3x16bits)=768 bits
- The bit rate of the normal map in an uncompressed format is 48 bpp (bits per pixel)

3Dc Compression Rate

- Supposed we compress the normal map using 3Dc
- The high and low representative coordinate values V0 and V1 each require 8 bits
- Each value in the 4x4 lookup table represents 8 possible values, thus requiring 4x4x3bit=48 bits

3Dc Compression Rate

- 2 of the three channels must be stored (i.e., 2 lookup tables, 2 sets of V0 and V1, etc.)
- The amount of bits required to store this color image in 3Dc compressed format is (2x8bits+48bits)x2=128 bits
- The bit rate of the normal map in a 3Dc compressed format is 128/16=8bpp
- Effective compression rate for 3Dc in this case is:
  - 48/8=6:1 compression

3Dc Compression Results