Phash algorithm for images

Conversion of images into their phash and calculation of the threshold that determines when two images are actually the same.

# Phash algorithm

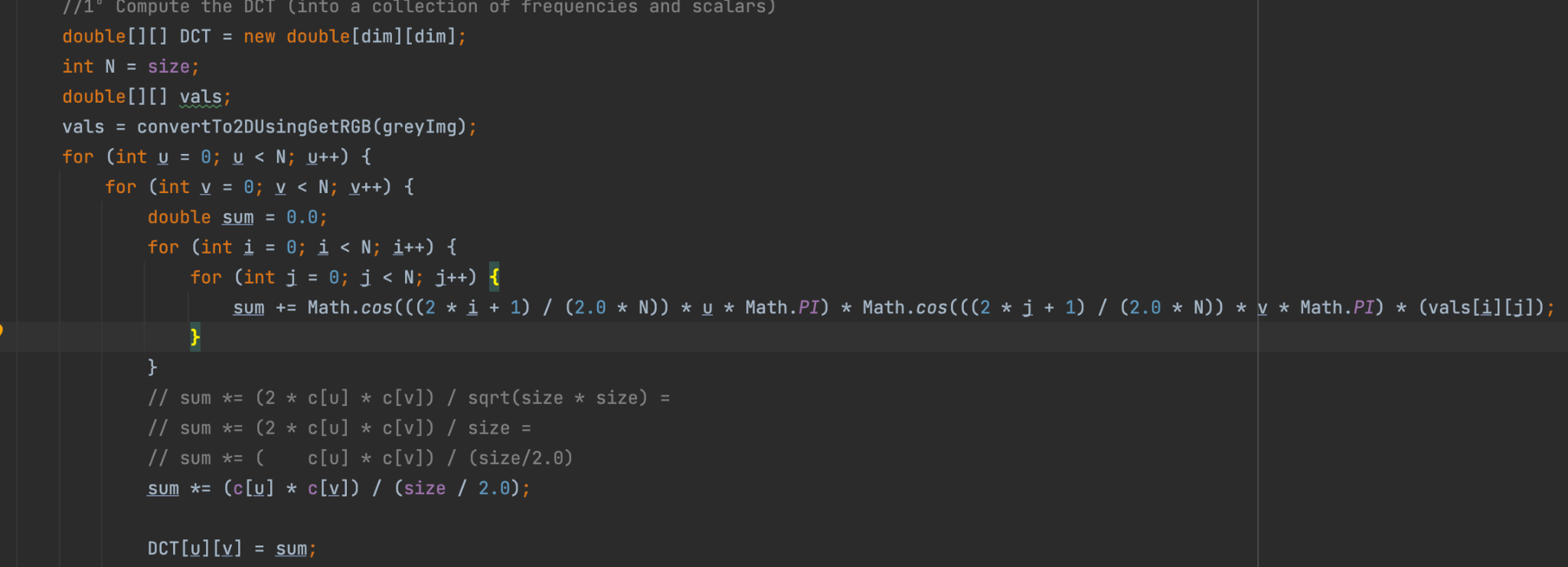
To calculate the phash associated with an image, the following steps must be followed:

1. Resize the image to a scale of 32 x 32
2. Apply a filter that converts the colors (RGB) to grayscale
3. Calculate the DCT associated with the gray image
4. Pass the values ​​obtained to a sequence of bits (given that the image has a scale of 32 x 32, we must obtain 1024 bits). To do this we must calculate the average of the colors (in grayscale) of the image. If the pixel is above it will be interpreted as a 1 and if not as a 0.
5. We convert the bits to hexadecimal (it must have a length of 256 characters since 1024 / 4 = 256)

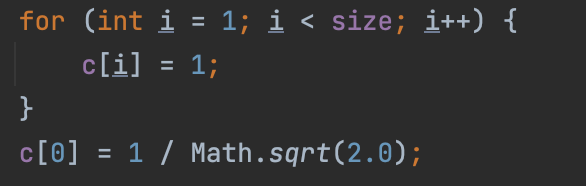
## DCT

DCT stands for discrete cosine transform. The algorithm is the following:



Implementation in Java:

Being size equal to 32 and vals must be initialized in the following way:



### Example 1

For this example I have used the following image as reference: <https://scopely.widen.net/content/j5p955e5g1/original/MPY-18136_Wrecking-Ball-resizes_1200x1500_V2.jpg?u=3mz6gd&download=true&x.share=t>

In the lower images you can see the different conversions of the image through the different steps:



The phash associated with this image would be the following:

* Binary:

0100010101011010000010111000101110011100001100011010010010100111110100001011010111110000111111001001110010010111001110111000000010011110100001110100101101001111011000110100101001110100001101111001001101111010110100110011000101100110000110011000010011001110011111000000100110011100000011000100110101111000101111010101100001110001101110100011000101111011000111000001010001101101011100010010000111110100001010100001000110111001001011010001001010010111101101100100011101001100100001001101011111000101101000001100100101001110000110011010110010110111100110100010100011011010010001111100001010111000100001000011101000010111001101110000001011111000000111001110001101011111001111000100010011101010000101000001111010101001110011011011010010111010111000111001011000001001101010001010100101010110001010001110111001111110110010001111100001010101001100101010000011111101100001010000110011111101100000011010111101010110011000110100001001010111101101100100010111011110001101101101111000101001101110101011010011100001100010000101110001110101

* Hexadecimal: 455a0b8b9c31a4a7d0b5f0fc9c973b809e874b4f634a7437937ad331661984ce7c099c0c4d78bd5871ba317b1c146d7121f42a11b92d1297b6474c84d7c5a0c94e19acb79a28da47c2b8843a173702f81ce35f3c44ea141ea9cdb4bae39609a8a95628ee7ec8f85532a0fd850cfd81af56634257b645de36de29bab4e1885c75

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## Hamming distance

To calculate the differences between 2 images we will use the calculated phash for each image (in binary). With both phash in binary we will calculate the hamming distance, which will tell us how many bits (pixels) differ from one image to another.

### Example 2

Based on the previous image and a new one (being this image the previous one but reducing its size in a 50 %) we obtain the following hamming distance:

* Hamming distance = 54

Since the image has a total of 1024 bits having 54 bits different is a good ratio (5,27 %)

If we calculate the hamming distance of the 1º image and the same image but with a watermark we obtain the following hamming distance:

* Hamming distance = 166

In this case the percentage of different pixels have increased quite a bit ( 16,21 %)

*(More examples can be found in the appendix)*

# How to determine the threshold

In order to know which would be the ideal threshold that would determine when two images are the same or not different "experiments" have been carried out to take measurements.

*These measurements can be found in the appendix*.

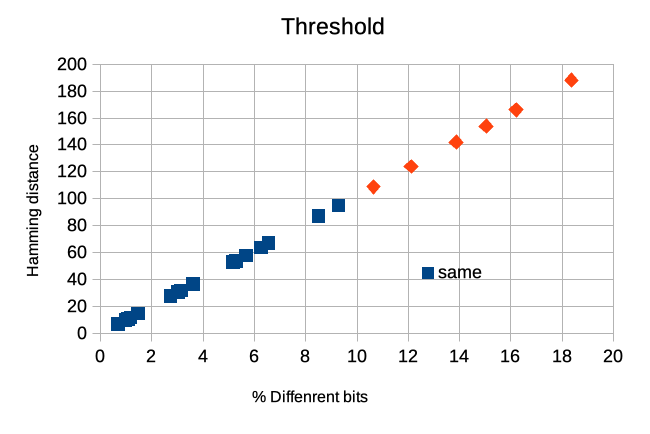
In the table below the percentage of different bits for the same images can be seen:

| Hamming distance | % different bits |
| --- | --- |
| 53 | 5.17578125 |
| 28 | 2.734375 |
| 87 | 8.49609375 |
| 32 | 3.125 |
| 12 | 1.171875 |
| 12 | 1.171875 |
| 54 | 5.2734375 |
| 31 | 3.02734375 |
| 95 | 9.27734375 |
| 67 | 6.54296875 |
| 11 | 1.07421875 |
| 10 | 0.9765625 |
| 37 | 3.61328125 |
| 64 | 6.25 |
| 121 | 11.81640625 |
| 7 | 0.68359375 |
| 15 | 1.46484375 |
| 58 | 5.6640625 |

In the table below the percentage of different bits for the different images can be seen:

| Hamming distance | % different bits |
| --- | --- |
| 154 | 15.0390625 |
| 166 | 16.2109375 |
| 142 | 13.8671875 |
| 188 | 18.359375 |
| 124 | 12.109375 |
| 109 | 10.64453125 |

Based on this we can ensure that (usually) different images are above 10% and the images which are identical are below it. If we ignore the results presented in orange in the table (for these measurements the images had been drastically reduced to 75% of their size) we can even further narrow the threshold, this new threshold would be equal to a 7%.



# Appendix

## Links to “official” images

Roque = <https://scopely.widen.net/content/tvkl1flyei/original/MSF-17998_Delta-TC-Gameplay--Rogue_EN_1080x1080_C1_V1.jpg?u=3mz6gd&download=true&x.share=t>

Monopoly= <https://scopely.widen.net/content/j5p955e5g1/original/MPY-18136_Wrecking-Ball-resizes_1200x1500_V2.jpg?u=3mz6gd&download=true&x.share=t>

Summer crests= <https://scopely.widen.net/content/nyee1wzdcf/original/KM-18111_Community_Summer_Crest_Contest_EN_1200x630_V2-1.jpg?u=3mz6gd&download=true&x.share=t>

## Results

| Rogue |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Image1 | Image2 | Size image1 | Size image2 | Hamming Distance | Comments | | | | | | |
| scopely.jpeg | scopely\_ReducedHalf.jpg | 1080 × 1080 | 540 × 540 | 58 | Resize image to half its size | | | | | | |
| scopely.jpeg | scopely\_Cat.jpeg | 1080 × 1080 | 1080 x 1080 | 109 | Watermark of a cat inserted | | | | | | |
| scopely.jpeg | scopely\_Reduced25.jpg | 1080 × 1080 | 810 × 810 | 37 | Resize image 25% less than original | | | | | | |
| scopely.jpeg | scopely\_ReducedFit.jpg | 1080 × 1080 | 800 x 800 | 64 | Resize image in order to fit the screen ( 800 pixels) | | | | | | |
| scopely.jpeg | scopely\_Reduced75.jpg | 1080 × 1080 | 270 x 270 | 121 | Resize image 75% less than original | | | | | | |
| scopely.jpeg | scopely\_X2.jpg | 1080 × 1080 | 2160 × 2160 | 7 | Image enlarged twice its original size | | | | | | |
| scopely.jpeg | scopely\_X1-5.jpg | 1080 × 1080 | 1625X1615 | 15 | Image enlarged 540 pixels | | | | | | |
| scopely.jpeg | scopely\_MA.jprg | 1080 × 1080 | 1080 × 1080 | 124 | Watermark of a text inserted | | | | | | |
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| Summer crests |  |  |  |  |  |  |  |  |  |  |  |
| Image1 | Image2 | Size image1 | Size image2 | Hamming Distance | Comments | | | | | | |
| Test.jpg | Test\_Reduced50.jpg | 1200 x 630 | 600 x 315 | 53 | Resize image to half its size | | | | | | |
| Test.jpg | Test\_Reduced25.jpg | 1200 x 630 | 900 x 473 | 28 | Resize image 25% less than original | | | | | | |
| Test.jpg | Test\_Reduced75.jpg | 1200 x 630 | 300 x 158 | 87 | Resize image 75% less than original | | | | | | |
| Test.jpg | Test\_ReducedFit.jpg | 1200 x 630 | 800 x 420 | 32 | Resize image in order to fit the screen ( 800 pixels) | | | | | | |
| Test.jpg | Test\_X2.jpg | 1200 x 630 | 2400 x 1260 | 12 | Image enlarged twice its original size | | | | | | |
| Test.jpg | Test\_X1-5.jpg | 1200 x 630 | 1740x 914 | 12 | Image enlarged 540 pixels | | | | | | |
| Test.jpg | Test\_cat.jpg | 1200 x 630 | 1200 x 630 | 142 | Watermark of a cat inserted | | | | | | |
| Test.jpg | Test\_MA.jpg | 1200 x 630 | 1200 x 630 | 188 | Watermark of a text inserted | | | | | | |
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| Monopoly |  |  |  |  |  |  |  |  |  |  |  |
| Image1 | Image2 | Size image1 | Size image2 | Hamming Distance | Comments | | | | | | |
| Test2.jpg | Test2\_Reduced50.jpg | 1200 x 1500 | 600 x 750 | 54 | Resize image to half its size | | | | | | |
| Test2.jpg | Test2\_Reduced25.jpg | 1200 x 1500 | 900 x 1125 | 31 | Resize image 25% less than original | | | | | | |
| Test2.jpg | Test2\_Reduced75.jpg | 1200 x 1500 | 300 x 375 | 95 | Resize image 75% less than original | | | | | | |
| Test2.jpg | Test2\_ReducedFit.jpg | 1200 x 1500 | 480 x 600 | 67 | Resize image in order to fit the screen ( 800 pixels) | | | | | | |
| Test2.jpg | Test2\_X2.jpg | 1200 x 1500 | 2400 x 300 | 11 | Image enlarged twice its original size | | | | | | |
| Test2.jpg | Test2\_X1-5.jpg | 1200 x 1500 | 1740 x 2175 | 10 | Image enlarged 540 pixels | | | | | | |
| Test2.jpg | Test2\_cat.jpg | 1200 x 1500 | 1200 x 1500 | 154 | Watermark of a cat inserted | | | | | | |
| Test2.jpg | Test2\_MA.jpg | 1200 x 1500 | 1200 x 1500 | 166 | Watermark of a text inserted | | | | | | |