**DAILY ASSESSMENT**

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| **Course:** | **Coursera** | **USN:** | **4AL15EC 024** |
| **Topic:** | **Digital image processing 4: Application** | **Semester & Section:** | **8th - A** |
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| **FORENOON SESSION DETAILS** |
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**REPORT –**

**How does image compression work?**[**#**](https://www.keycdn.com/support/what-is-image-compression#how-does-image-compression-work)

There are two kinds of image compression methods - [lossless vs lossy](https://www.keycdn.com/support/lossy-vs-lossless). Let's take a quick look at them both.

**Lossless compression**[**#**](https://www.keycdn.com/support/what-is-image-compression#lossless-compression)

Lossless compression is a method used to reduce the size of a file while maintaining the **same quality as before it was compressed**. For example, in a DSLR camera, you probably have the option to save photos as either RAW or JPEG. RAW files have no compression and are great if you're a professional photo editor. But they take up more space. JPEG, on the other hand, won't fill up your hard drive as fast, but some of the data is lost in the conversion.

Types of lossless images include:

* **RAW** - Found in many DSLRs, and keeps all the light data received from the camera's sensor. For a professional, this great news. However, these files types tend to be quite large in size. Additionally, there are different versions of RAW, and you may need certain software to edit the files.
* **PNG** - Compresses images to keep their small size by looking for patterns on a photo, and compressing them together. The compression is reversible, so once you open a PNG file, the image recovers exactly.
* **BMP** - A format found exclusively to Microsoft. It's lossless, but not frequently used.

It should also be noted that converting a lossy photo back to lossless won't restore the photo's data.

**Lossy compression**[**#**](https://www.keycdn.com/support/what-is-image-compression#lossy-compression)

In order to give the photo an even smaller size, lossy compression discards some parts of a photo. However, this doesn't mean the photo will look bad. Here are the two main types of lossy compression.

**JPG**[**#**](https://www.keycdn.com/support/what-is-image-compression#jpg)

Also known as [JPEG](https://www.keycdn.com/support/difference-between-jpg-and-jpeg), this format gets rid of bits and pieces of a photo that you may notice depending upon the level of compression you apply. A normal amount of compression will not be noticeable, while extreme compression may be obvious.

There are also other ways a JPG image's quality may be reduced. If you [rotate the JPG](http://petapixel.com/2012/08/14/why-you-should-always-rotate-original-jpeg-photos-losslessly/) too much, you'll notice a difference in quality. This is because the photo has to **recompress itself with every rotation**, losing some data in the process. There are however programs out there that rotate a JPG losslessly. The same degradation applies if you save a JPG multiple times.

**GIF**[**#**](https://www.keycdn.com/support/what-is-image-compression#gif)

GIF compresses files by reducing the number of colors it has. If the photo has more than 256 colors (the maximum amount of colors older computers could have) this format will make the image look less appealing. The best use for GIFs are for images that are animated.

The example below shows a comparison between GIF images which range from 8 colors to 256 colors.

**Methods of compression**[**#**](https://www.keycdn.com/support/what-is-image-compression#methods-of-compression)

Now that we've discussed various image formats, the following explains a few **image compression methods** used to achieve either lossless or lossy compression. These algorithms, or variations of these algorithms, are also what is used in image compression tools and services.

**Deflate**[**#**](https://www.keycdn.com/support/what-is-image-compression#deflate)

[Deflate](https://en.wikipedia.org/wiki/DEFLATE) is a lossless data compression algorithm used for PNG images. It uses a combination of LZ77 and Huffman coding to achieve compression results that do not affect the quality of the image.

**Run-length**[**#**](https://www.keycdn.com/support/what-is-image-compression#run-length)

[Run-length encoding](https://en.wikipedia.org/wiki/Run-length_encoding) is a form of lossless compression that takes redundant strings or runs of data and stores them as one unit. Say you have a picture of red and white stripes, and there are 12 white pixels and 12 red pixels. Normally, the data for it would be written as WWWWWWWWWWWWRRRRRRRRRRRR, with W representing the white pixel and R the red pixel. Run length would put the data as 12W and 12R. Much smaller and simpler while still keeping the data unaltered.

**Transform**[**#**](https://www.keycdn.com/support/what-is-image-compression#transform)

[Transform](http://www.dspguide.com/ch27/6.htm) encoding is a lossy compression commonly used for JPEGs. There are millions of shades of colors, and transform encoding takes colors that have similar shades and makes them one single value. Depending upon the compression value you define (i.e. the number of shades of colors you group together) you may or may not notice a difference in the image's quality.

## Frequency analysis

We only consider finite-size images and therefore the only frequency analysis tool that we need is a two-dimensional extension of the DFT. In this lecture we will see how the concept of basis vector can be extended in a straightforward way to two-dimensional signals and how the DFT formula extends immediately to the space of (N\times M)(*N*×*M*)-sized images.

One very notable fact in image processing, however, is that Fourier analysis does not play such a major role. Most of the information in an image is encoded by its edges (as

we learn in infancy from coloring books), but edges represent signal discontinuities that, in the frequency domain, affect mostly the global phase response and are therefore hard to see. In fact, the much larger importance of the phase over the magnitude in the DFT of an image is a remarkable difference with one-dimensional Fourier analysis.

We will first define the DFT for two dimensional signals.

And then we will look at the amount of information that we can extract from the magnitude and the phase of the DFT of an image. Fourier analysis of two dimensional signals can be developed exactly as we did for the one dimensional case. Since here we're concerned mostly with digital images, namely finite support two dimensional images.

We will only review the definition of the two dimensional DFT. So let's consider a two dimensional finite support signal of support big N1 times big N2. The DFT is defined as the double sum for the first index that goes from 0 to big N1 minus 1. And the second index that goes from 0 to big N2 minus 1, of the values of the dimensional signal over the support. Times the product of two complex exponentials. Whose frequencies are 2 pi over N1 and 1k1, and 2 pi over N2 and 2K2. The products of these two complex exponentials represents a basis function for the space of images of size N1 times N2.

The DFT can be easily inverted just like we did in the one dimensional case. We take basically complex exponentials with the sign reversed and we repeat the sum. Taking now the DFT coefficients in to the sum. Normalization is by convention applied to the inverse formula. And in this case we have to divide the sum by the product of N1 times N2. It is certainly instructive to look in more detail at the basis functions for the space of N1 times N2 images. These have the form that we have shown before in the DFT sum. And we can easily prove like in the one dimensional case, that they are orthogonal. There are N1 times N2 basis functions for an image of that size. And so it would be very hard to look at each one of them even for images of moderate size.

But we can try and plot some key representative basic functions to give you an idea.

Of what the building blocks are for an image in Fourier space. We will show these basis functions by plotting the real part only as a grayscale image. Where the value of zero is indicated by black and the value of one is indicated by white.

So here we have the space of 256 by 256 pixel images, and this is one of the simplest basis functions that we can plot. We keep the vertical frequency at zero, and the horizontal frequency spans one period, between zero and 255. So if we were to look at this in a three dimensional space, we could plot. This is the image plane and these are the values of the basis function. And this is a wave, a solid wave, that goes like this.

So, it goes down and then it goes up again. And here we have the white part and here we have the black part. We can invert the roles of the vertical and horizontal frequency.

And we get an image which is simply a 90 degree rotation of the previous one. We can increase the horizontal frequency at this point for k1 equal to 2. We will have that the basis function spans two periods.Over the support of the image And if we swap the roles of the frequency, we obtain, again, We can increase the frequency even more, and

the density of these bands will increase correspondingly. Whenever the vertical frequency and the horizontal frequency are the same, the bands will be angled at 45 degrees. And by varying the frequencies, we can obtain a wide range of different angles for the bands.

The good news is that the two dimensional DFT basis functions are separable. And so the DFT can be computed in a separable way. In particular, we first compute a 1D-DFT along the columns. So if this is our image of size N1 times N2 we first compute N1 DFTs of size N2 along the columns. And once we're done with that, we compute 1D-DFTs along the rows. So computationally speaking we first need to compute N1 DFTs of size N2. We know that we can use the FFT algorithms. So the cost will be N2 log in base 2 of N2. And then we need to compute N2 FFTs of size N1. So that would be N1 log in

base 2 of N1. Which is much less than N1 N2 squared, the cost of implementing a two- dimensional DFT directly from the equation.

We can also express the 2D DFT in matrix form. For that we need to express first of all the signal, the two dimensional signal as a matrix. This is very straightforward because an N1 times N2 image is simply an N1 times N2 matrix. There is only the technicality that the orientation of the rows is inverted with respect to the Cartesian notations. So for instance, in the Cartesian plane N2 would go from, say, zero upwards. And this is our image. But if we express this in matrix notation, this element of the matrix normally is 0, 0. So there's a flipping of the vertical axis but this is just a technicality. You will also recall the N x N DFT matrix that we saw in Module 4.2. This is a standard DFT matrix of size N where W, recall, is simply e to the minus j 2 pi over capital N. With this notation in place let's look at the DFT formula once again. The inner summation is simply the product of the DFT matrix of size big N2 times the signal matrix. We call this intermediary matrix capital V and capital V belongs to the space of N2 times N1 matrices. Then the outer sum can be expressed as the right product of the matrix V we just defined times the DFT matrix of size capital N1. And so the resultant signal is a matrix that collects the DFT values for the image. In compact form, we can express the two-dimensional DFT as the product of a DFT matrix of size N2. Times the image times a DFT matrix of size N1.

So now we know how to compute a two-dimensional DFT. Well, can we look at one? We could try and plot the magnitude of the DFT since the DFT is a two dimensional signal. And therefore, it can be interpreted as an image. But, this wouldn't work. Because the dynamic range of the DFT is way too big for either a monitor screen or a piece of paper to represent. We wouldn't have enough grayscale level to show the details.

So we could try and normalize the values by dividing the DFT magnitude by its maximum value. And yet that wouldn't work either. Because for images on average the

distribution of the magnitude of Fourier coefficients follows a curve like this one. So what we have here is a few outliers here that really go above the average values of the coefficients. And some tail outliers here that drive the value

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| **AFTERNOON SESSION DETAILS**    What Problems Are the SDGs Trying to Solve?  Imagine you woke up one morning and discovered that all the world’s leaders had assembled to ask you—yes you—how to solve all the largest problems in the world. Where would you start?  Unemployment, poverty, inequality, education, hunger, climate change; these represent just a subset of the problems that face us today. To make things more complicated, many of these issues are interrelated. There is an undeniable relationship between health and access to clean water. Education is critical for making strides towards gender equality. And so on. We can’t address these issues in isolation. We must work together to solve them.  The Sustainable Development Goals address these problems and their interlinkages, and highlight the need for greater partnerships.  It can feel impossible to take stock of it all. Thankfully, the work of categorizing the problems of the world has already been done by an organization devoted to solving them—the UN. The SDGs are a blueprint for a better future, and for a more sustainable world.  The SDGs provide the framework for action. Most importantly, they give us clear, measurable and defined targets (169 of them to be exact) and indicators (232) that we all, regardless of sector, need to work towards.  The SDGs are the world’s to-do list.  What Is Sustainable Development?  Sustainable development meets the needs of the present without compromising the needs of future generations. The idea of sustainable development is multidimensional, and tackles the interdependencies among the SDGs with the goal of transforming our world for the better.  The 2030 Agenda for Sustainable Development is the basis of the SDGs and represents a shared global vision. The five dimensions of the 2030 Agenda—Prosperity, People, Planet, Peace, and Partnerships (The 5 P’s)—articulate the scope of this vision. This is an ambitious, systems-level approach to solve extreme global poverty, inequality, and climate change by 2030. At its heart is the principle of leaving no one behind.  The 5 P’s inform development policy and how work is ideally done. Work needs to account for the social, economic, and environmental consequences it generates.  And actions need to be carried out in partnership with appropriate means of implementation to tackle problems in a holistic and integrated way.  These problems are complex and require multidimensional solutions.  Dimension  Description  Prosperity  The idea of ending extreme poverty for the current generation.  People  Doing this in a way that leaves no one behind.  Planet  Addressing climate change, the loss of biodiversity, and protecting the planet.  Peace  Fostering peaceful and just societies.  Partnership  Doing all of this together globally. The 17 SDGs are often referred to as a social contract.  There’s Some Good News and a Long Way to Go  The good news is that we are seeing more and more cross-sector action around the SDGs.  People are becoming more aware of them and organizing around them. For example, there is fast-growing momentum on climate action among corporations, as well as in other sectors.  That said, there is still a long way to go with only a little over a decade left before the deadline. Measurement and accountability are key to make sure that we continue to make sufficient progress over time. Salesforce addresses the SDGs through its technology, philanthropy, and other initiatives across its various communities. We encourage everyone—including you—to also take stock of how people can engage with and deepen their impact on the SDGs. In the next unit, we’ll show you how you can take action and encourage others to do the same |