Intensity Transformation

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COSC 4393 Digital Image Processing

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02 May 2019

ABSTRACT

In this report we explore the different aspects of intensity transformation within a few key areas of focus. The process behind the GUI development for the stated topic, as well as the discoveries and interpretations made in during said process are furthermore so also defined within our findings. All coding was done with a heavy emphasis on a crucial-aspects-only library dependency, with all actual algorithms being implemented ourselves using the teachings from this semester.

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Introduction

Intensity transformation within digital image processing is defined as the process of making image adjustments based off of a base image and the pixel intensity values. Reasoning behind this process is usually to bring out a more accurate picture, especially useful in the medical industry when altering pixels in MRI/CAT scans, X-Rays, etc. so that a clear focus can be provided on finding the underlying problem. However, such a process is necessary for our day to day consumer lives as well for when we use devices with a display such as a computer, phone, tv, etc. and the image luminance needs to be adjusted to display a proper level of brightness. This is but only two areas of examples the wide applications of intensity transformation apply to. Within this report we will further look at intensity transformation from the perspective of our GUI development as well as our observations in over eight separate areas, with those being: Image Negative, Histogram, Histogram Equalization, Histogram Matching, Histogram Shaping, Contrast Stretch, Log Transformation, and Power-Law Gamma Transformation.

Experiment Details

1. No image adjustment functions were obtained from pre-built libraries, all code directly applicable to the alteration of images was derived from our knowledge given what we have covered and learned from this semester.
2. GUI build was focused on being user friendly and bug-free.
3. Extra focus to go beyond class expectations by having a form of A.I. implemented to help scan, deficiency categorize, and output a recommended transformation to the user given an uploaded image.

Results

Due to the size of the project and nature of this class, our areas of coverage were split up amongst the levels of topics we wished to cover, implement, and overall develop into the GUI for user consumption. From this there were different types of things observed by us individuals working together as a collective, the next few pages we show our results over the subtopics within their respective categories. The results are executed by 3 parts, firstly the definition of the subtopic to help clarify what exactly is being spoken about, secondly is the implementation, this is more so real-world implementation aspects we learned about while working on this project rather as to our code itself which is already provided in this project and not the focus of the report itself. The nature of this report is to showcase our findings and first-hand experiences from what we have learned while implementing this project, and that is exactly what is defined in the last category, observations.

Image Negative

Description:

Image negative is the alteration of an image by the process of inverting pixel values. Essentially the lower the input pixel value is, the higher the output pixel value will be. This is useful for enhancing white or grey details in dark areas of a region.

Implementation:

Image negatives are useful to focus on details which cannot be initially seen because of the neighboring intensity values. This can in turn help bring clarity to image aspects, one example could be seen in the figure below where the negative helps show more details as to the internal structure and areas of the guard ship, which originally are hard to distinguish in the base image. This is also useful in helping editing aspects which aren’t easily seen off the base image, further explained in my observations.

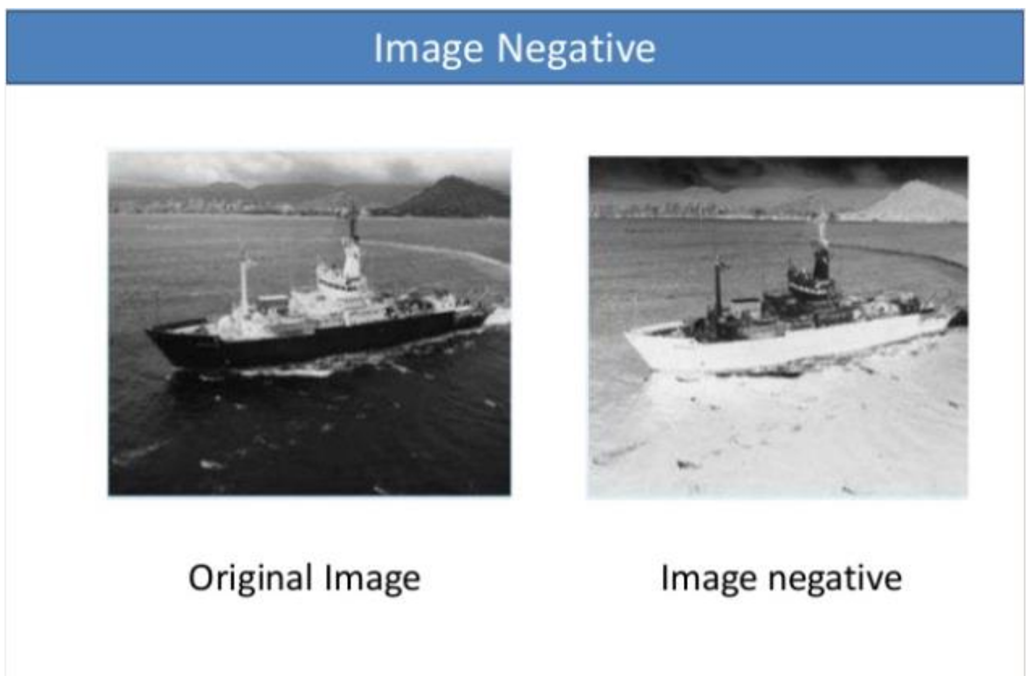

Figure 1

Observations:

Prior to researching in depth on this project I always only thought of image negatives as what would be used to develop back in the old days off of film in photography. I never realized that images themselves could be used to help bring clarity to aspects that aren’t easily seen, nor did I realize that you can use image negatives to improve your base image and that a lot of people, particularly those who have jobs regarding use of photoshop, use this to adjust to help bring out areas needed of improvement, as one person goes on to state “…black and white visual help layers so that you can see the work that should be done using local dodge and burn, like I would when retouching” (Decaillet).

Histogram

Description:

Histograms are the bases of nearly all our intensity transformations, as they convert the input image into statistical information. This displays data of pixel intensity into a frequency occurrence range of data. From a histogram alone we do not do much alteration at all, as it is the representation of base input data, but we use this as a template/input to make all other alterations.

Implementation:

Uses of Histogram are numerous, a histogram provides a look at how the intensity values of a given image lie, and give us an idea of what may need to be adjusted, as well as provide a base values for the function needed to adjust them.

Observations:

As someone who considers himself an amateur photographer, I never really understood what exactly the point of a histogram was prior to this class. When I took photos on my DSLR camera, a histogram would always pop up next to the image on the LCD display, but I never gave it too much thought. I remember once looking up what exactly it was, mainly to see if I could stop from it showing, and realized that it was basically the image in a graph representation but always thought what I possibly could need that information for. Now having gone through this class I realize just the abundance of aspects this information provides. I have started trying to memorize the shapes (which I'll explain later in the respective area) as well as the outputs the tend to give, to make sure I'm making the most out of my photography. I still don't understand all the different actions that can be done to adjust a histogram and exactly what forms should be used for certain photography styles (landscape, macro, etc.) but that is something I look forward to learning about given the knowledge I have obtained from this class.

Histogram Equalization

Description:

Histogram equalization is essentially the process of increasing image contrast by flattening out the histogram over a domain. It is done so by adjusting the image intensities to enhance the contrast, usually affecting the global contrast of images where the image data is represented within close contrast values, thus resulting in a better intensity distributed histogram.

Implementation:

Histogram equalization helps transfer intensities from one clustered area to a spread, and this is ideal when taking in dark imagery, and spreading the intensities to provide a more clear contrast image.

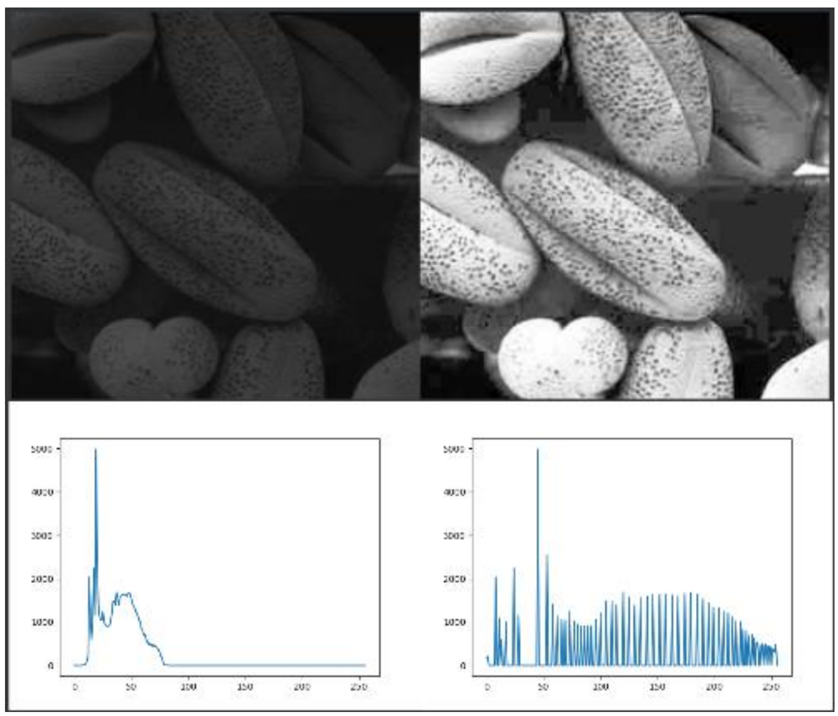

Figure 2

Observations:

Histogram equalization is something, after gone through this class and project, I am going back into my old photographs, specifically ones I took when cave exploring, and seeing if I can improve the quality. I love cave exploring and night time photography, a common issue is that my images turn out sometimes like the first image in figure 2 shown above, but now this has brought forth one form that helps me improve that, but one thing I still need more experience in is understanding if equalization would be the ideal format versus the other formats learned through this project. Is equalization always the ideal form I want to go with compared to matching, or is it only ideal for when I want to deal with macro images in dark outputs? This is what I look forward to learning from experimentation.

Histogram Matching

Description:

Histogram matching matches the histogram of a given source image to that desired of a target image. This process or method is also sometimes referred to as histogram specification. For this a derived histogram is needed from the two images, the base histogram and the specified. The transformation is implemented via the transformation function on the original image to produce the output image.

Implementation:

Histogram matching is used in real world implementations when you want to adjust the values of an image compared to another image. This can be seen in figure 3, but a real world application can be used as to say when you're taking multiple photos, say as in a photoshoot, but the better shot is lacking in the quality/impact that another shot is providing. Rather than having to redo the entire shot to achieve that same effect, you can adjust the values of the histogram's base shot to achieve a matched value of the other shot. This way you avoid having to retake a shot altogether.

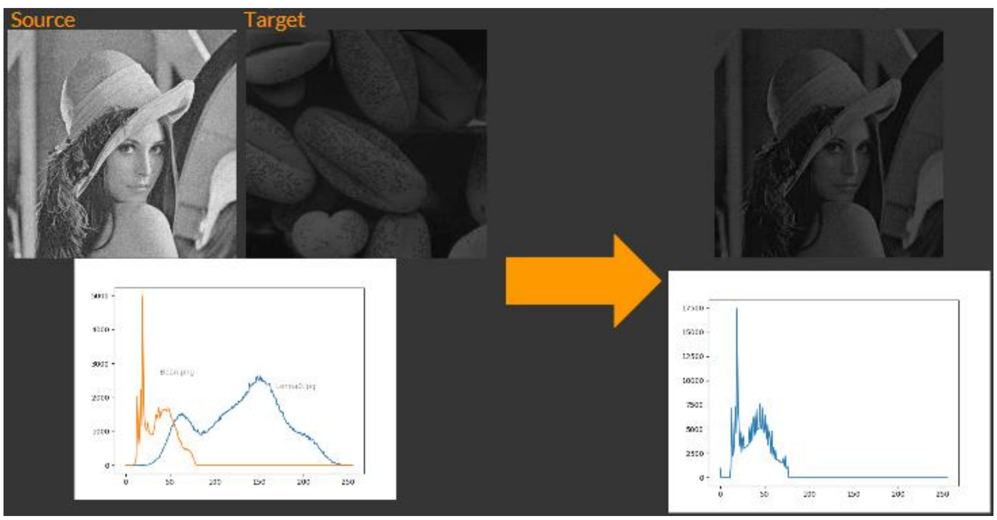

Figure 3

Observations:

Prior to learning about this method, I would adjust files in Photoshop just by adding layers of gradient or shading on top of a base image to achieve a darkness that would fit in with the other aspects within the file. This would make my work much harder when doing commissions because this would create numerous layers to work with, which if you didn't know, would also have to be placed in certain order, but if you wanted to implement another layer in between those without getting the same effect, you would have to merge the previous layers (in this case the shading/gradient layers), but when you would merge, you could not go back and re-adjust the base values adjusted in that shading. This method has now brought forth a way for me to just adjust the overall key layers in reference to the main, something I only learned from this class.

Histogram Shaping

Description:

Histogram shaping is the process of modifying an image by altering its base histogram to another histogram shape. Similar thus to histogram matching, however, here the focus of histogram alteration is shaping the input values to a specific style. Most common styles of histogram shapes are bell-shaped, bimodal, right-skewed, j-shaped, u-shaped, and uniform.

Implementation:

There is no best histogram shape, but different applications are useful for different images, however sometimes you wish to adjust the histogram of an image to provide more certain aspects that can only be seen in other shapes and this is where histogram shaping comes into play. It takes the given histogram and transforms it to the desired shape, however another use is taking the bases shape and adjusting it so that it fits the shape it already is somewhat achieving but in a better fitting form.

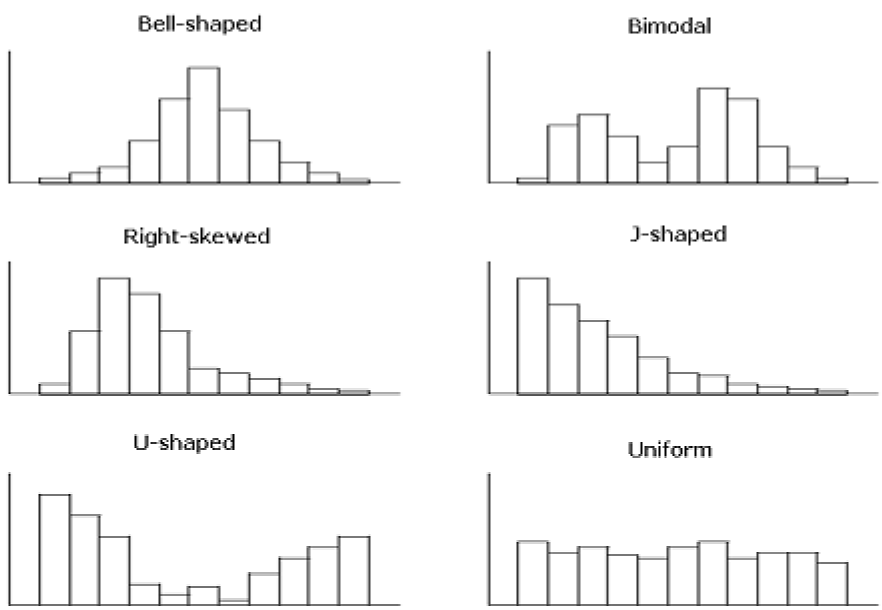

Figure 4

Observations:

Histogram shaping became the bread-and-butter of our A.I. in determining a recommended aspect transformation within our GUI. A histogram alone provides a lot of base information, but when we wanted to create something that could give an ideal recommendation we needed to understand how shapes effect an image. Every transformation is essentially a form of shaping, and thus when implementing the recommendation A.I. we took the base histogram and tried to derive an input shape and what shape it would ideally match, of course there were other aspects to consider such as highest/lowest value, concentration of intensities, etc. but besides those everything else was focused on what the concurrent shape was and what would be the ideal adjustment for it.

Contrast Stretch

Description:

Contrast stretch, also referred to sometimes as normalization, is a transformation technique that improves the contrast within an image by taking the range of intensity values that exist and stretching them across a domain of desired value.

Implementation:

Contrast stretching, or normalization, is normally "…used to improve the contrast of an image without distorting the relative graylevel intensities too significantly" (Contrast Stretching). This is done in real world implementations where the given image is lacking clarity, in comparison to histogram equalization, this only applies a linear scaling function.

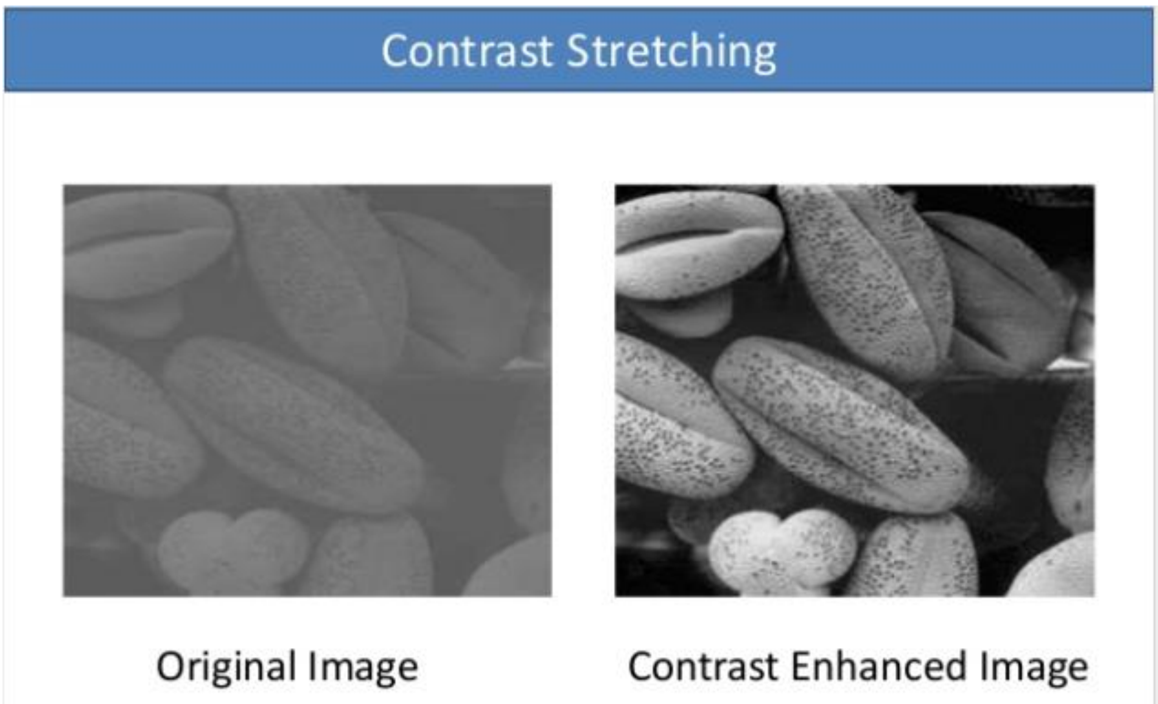

Figure 5

Observations:

As briefly stated within implementation subtopic, my main questions on contrast stretching was answered, and that was what the difference between using histogram equalization versus this was? I was looking at the output images in our GUI and seeing nearly the same effect to my personal opinion, using both methods, this of course could also have been due to the image used and maybe a different image would have brought out a more clear difference. However, as I did more research, I realized that this method is only linear scaling, and thus outputs an image that is less harsh in comparison to the more sophisticated counter-part of histogram equalization.

Log Transformation

Description:

Log transformation works by increasing the detail, or contrast, of lower intensity values within a given image. This transforms low intensity values to higher, it also effects high intensity values, but the effect is not nearly as impactful as it is on lower values

Implementation:

The use of log transformation is to adjust the dark pixels in an image in a logarithmic transformation compared to the higher pixel values. The main use of this in real world applications is where you wish to have a control over some value *c* to adjust the image to the level of enhancement you are looking for. This compared to other methods, provides a level of control to the user, that others don't.

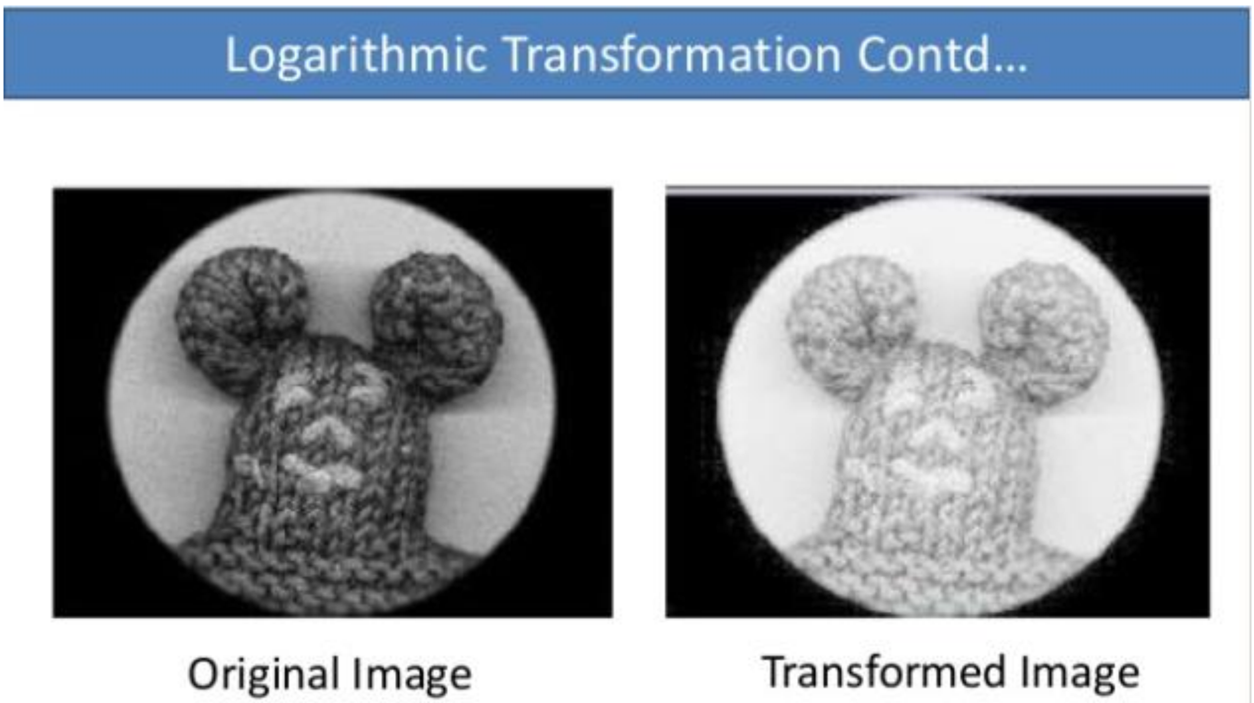

Figure 6

Observations:

One thing that constantly came to question during this project was what exactly the difference was between these methods that provide such similar outputs if seen just at a visual level. All of these different methods at just input output glance can seem similar in the sense that the output image is darker or lighter, sometimes sharper or smoother, etc. So the main repetitive question that was answered through this project implementation and research is the key differences. For this subtopic that difference was providing a level of control to the user, that I can put in a certain input value for the level of effect and enhancement I would want, whereas other areas adjust according to a given shape, or a histogram highest intensity, etc.

Power-Law Gamma Transformation

Description:

The purpose of this is to fix the power-law response phenomena found in display and capture devices. This works by using the power law transformation function and taking the values of gamma, if gamma is greater the darker the output image is.

Implementation:

The main use of gamma correction is in our display screens, where each output device has different corrections, the correction of a monitor and TV are not the same, but they can be adjusted to provide the same level of display to a degree.

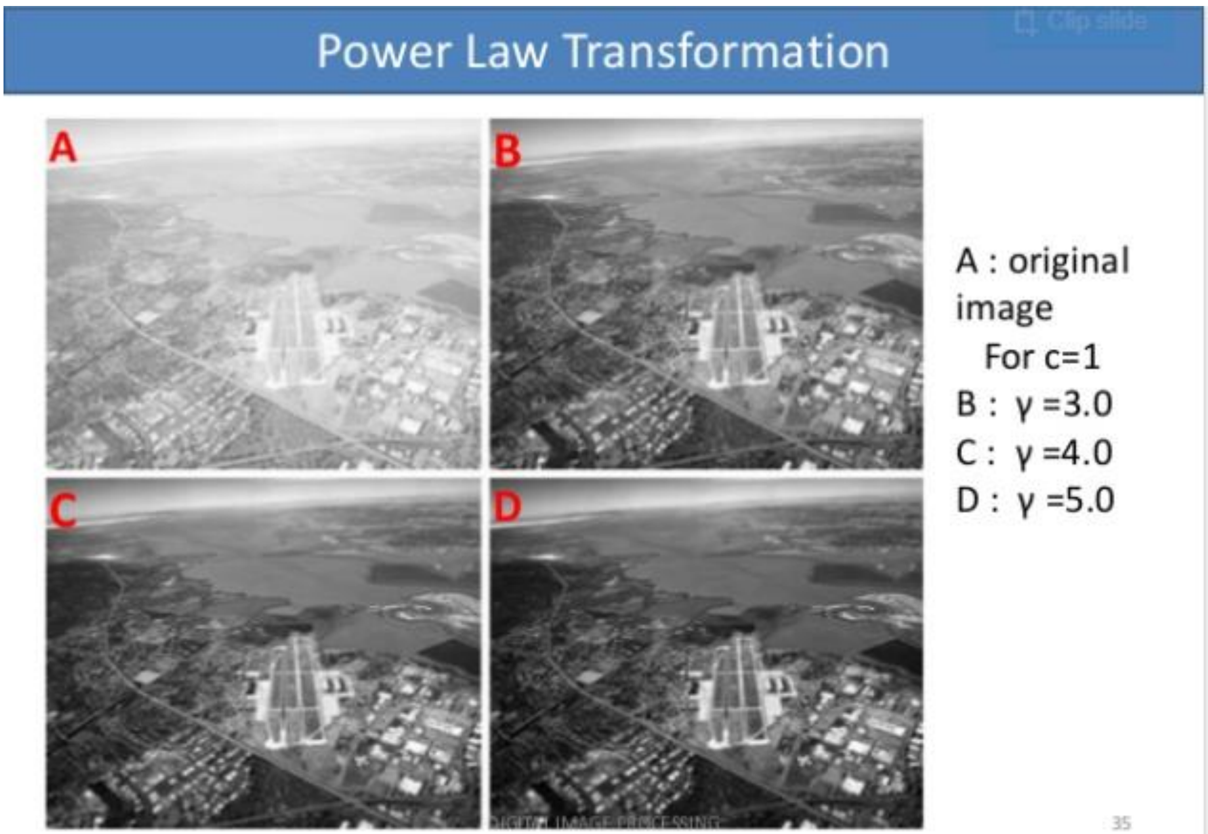

Figure 7

Observations:

What I observed from this was an understanding of how come I would have to adjust the brightness on say my computer versus my LCD tv to see the similar level effect on a movie, I can even go as far as to infer that this is something that would have to be done on a different form factor such as OLED as each display device has its own separate correction level for gamma. This is an interesting aspect, and understanding obtained, because prior to this I never really understood why different display devices couldn't just normalize/have a uniform output on the display, clarity/pixel resolution aside, why weren't they all displaying to the same level of brightness/darkness.

An example of real world implementation can be seen here of the Power-Law Gamma Transformation with a Gamma value of 5 on an X-Ray image that was lacking detail on the spine

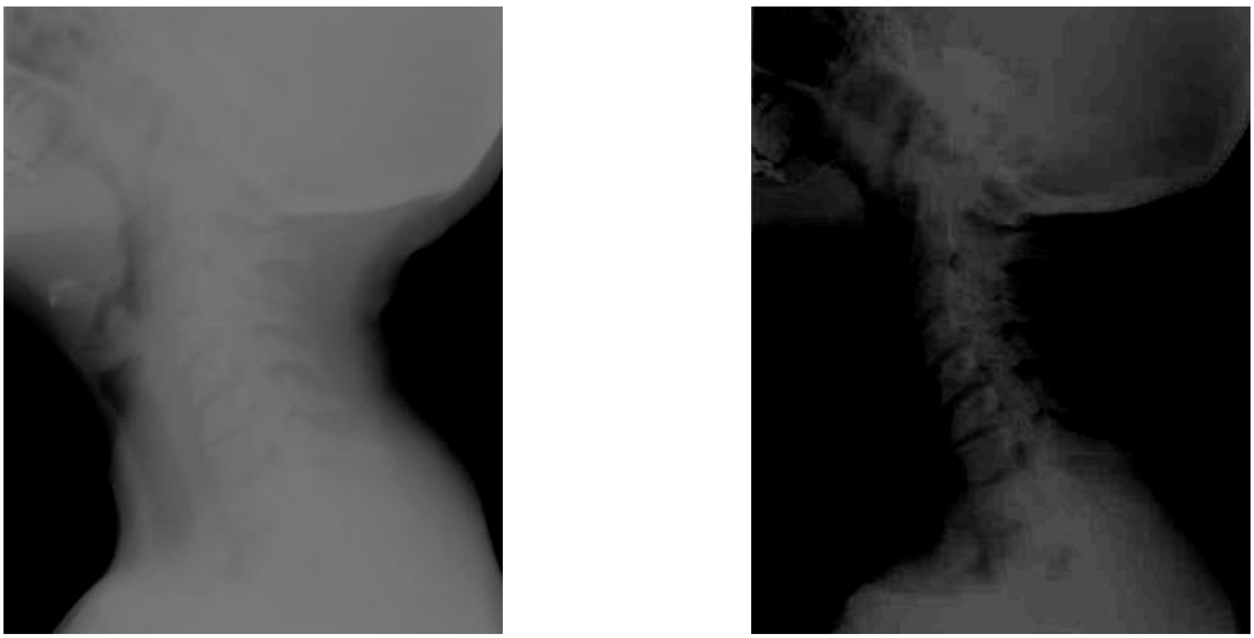

Figure 8

Conclusion

Intensity Transformation is the process of adjusting pixel values to obtain certain desired results, from our learnings in the classroom, through implementation of this project, and from further understanding and observations learned, we have obtained a greater understanding of the level of depth within this topic. Many things seem similar but act in very greatly different ways, and not every way is necessarily the ideal way to achieve the same output. The applications of intensity transformations in real world range all the way from medical industry to military to commercial. The applications are wide and numerous and are useful to understand when trying to achieve key desired outputs. Through this project we have learned and observed that there are such key differences that set aside what transformation would bring out the ideal aspects being searched for, as well as brought forth more questions as to what are the limitations of said areas, what are the advances and next areas of research being done, and so forth. What we have concluded however is that Intensity Transformation is a very powerful tool in the area of Digital Image Processing, it provides a great amount of control and information that can only be seen and understood through the understanding of the vast subareas that is covered by this area of image processing.

GUI Difficulties

The first of two main difficulties in creating the graphical user interface (GUI) was ensuring that the transformations behaved correctly with the interface. I believe each transformation function required a matrix for input, and output was also a matrix. Albeit similar to the first area of difficulties, the second difficulty was mainly making sure that the user would not encounter any bugs or unexpected behavior when using the GUI. The solution to both of these difficulties was to simply test the GUI to identify possible points of failure. Through this, I found many issues such as pressing “apply” without an original image which caused the code to fail. In situations like these where something necessary is missing from the user, a dialog now pops up and informs the user.

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