Fuzzy Magnetic Color Image Segmentation and Advanced Edge Detection

Christy T. George

***Abstract*—In this paper, color image segmentation based on fuzzy logic has been studied. An efficient Fuzzy logic inference engine based on magnetic fields has been implemented in this project so as to intelligently extract color information in the given image and classify it into the predominant color pyramid with the help of artificial color magnets. This also forms the basis for the priority based edge detection. Sobel operator is used in this project which is intelligently fused with the result of the above mentioned method to enhance the output so as to obtain a priority based enhanced edge detection output.**

Experimental results have demonstrated the effectiveness and superiority of the proposed method after extensive set of color images was tested.

***Index Terms*—predominant color, fuzzy, image segmentation, color magnets, magnetic field, sensitivity, color pyramid, Sobel, priority, edge detection**

I. Introduction

IMAGE segmentation serves as the key of image analysis and pattern recognition. It's a process of dividing an image into different regions with similar attributes [Pratt(1991)]

Image segmentation is a low-level image processing task That aims at partitioning an image into homogeneous Regions .In order to facilitate practical manipulation, recognition and object-based analysis of multimedia resources, partitioning pixels in an image into groups of coherent properties is indispensable—this process is regarded as image segmentation. Hundreds of methods for color image segmentation have been proposed in the past years. These methods can mainly be classified into two categories: one is contour-based and the other is region–based. Methods of the first category use discontinuity in an image to detect edges or contours in the image, and then use them to partition the image. Methods of the second category try to divide pixels in an image into different groups corresponding to coherent properties such as color etc., that is, it mainly use decision criteria to segment an image into different regions according to the similarity of the pixels..

Color image segmentation can be divided into following categories: Statistical approaches, Edge detection, region splitting& merging approaches.

Color of an image can carry much more information than grey level. Colors are one of the most important features considered in biological visual systems, since it is used to discern objects and patterns, even in conditions of equiluminance [Levine(1985)].Since humans are trichromats, which means that most of the visible color can be produced by a composition of three independent light colors, digital color images usually have three components: *red, green* and *blue.*

These three colors form the basic building blocks of our predominant color pyramid which in various combinations is responsible for forming other shades of color.

Fuzzy logic is increasingly being employed in various fields, including signal processing, image segmentation, pattern recognition, medical field, industrial automation, speech production and recognition, and business. Fuzzy logic is conceptually easy to understand, flexible, tolerant to imprecise data, can model nonlinear functions of arbitrary complexity, can be blended with conventional control techniques& mainly it is based on natural language. Fuzzy logic is the codification of common sense. The point of fuzzy logic is to map an input space to an output space, and the primary mechanism for doing this is a list of if-then statements called rules. All rules are evaluated in parallel, and the order of the rules is unimportant.

II. Procedure

A. Predominant Color Image Pyramid

In this module each pixel is analyzed one at a time & placed into one of the seven color bins of the Predominant Color Image Pyramid as shown in the fig 1(a). Sorting of each pixel is done on the basis of the *dominating* RGB value at each pixel point & is placed into one of the seven bins i.e. exclusive R bin, exclusive G bin, exclusive B bin, R=G bin, G=B bin, R=B bin& finally R=G=B bin. Now suppose if we encountered upon a pixel carrying values such as R=.65, G=.65& B=.11 it would be categorized into the R=G bin. Likewise if a pixel is encountered with the value of R greater than the G&B values it

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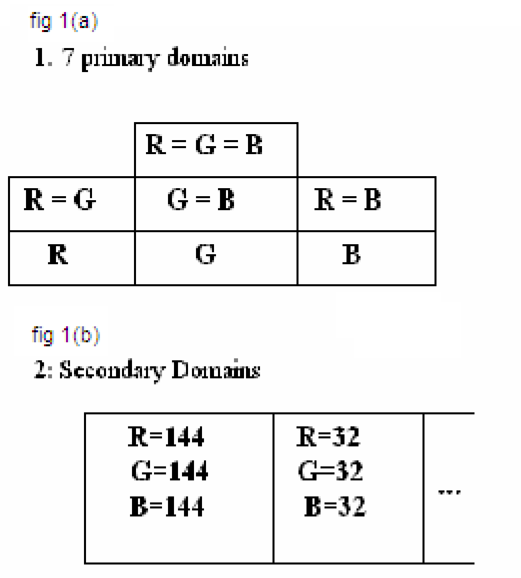
would be directly be placed into the Exclusive R bin. And if the values of R,G&B are all the same then it would be placed in the R=G=B bin.

It was also observed that in each primary bins of the color image pyramid several secondary domains as shown in Fig 1(b) also came into existence i.e. colors of different intensities but with same primary property as described above.

Figure 1: Conceptual color pyramids



If the image was to be segregated based only on this logic, it was observed that the image could not be properly segmented as immense singularity & abrupt color leaks came into existence as shown if fig 2.Now if such a segmentation was to applied for sensitive applications such as MRI scans in medical fields to detect brain tumor it would result in incorrect diagnosis due to such catastrophic results.

Figure 2: Simple segregation

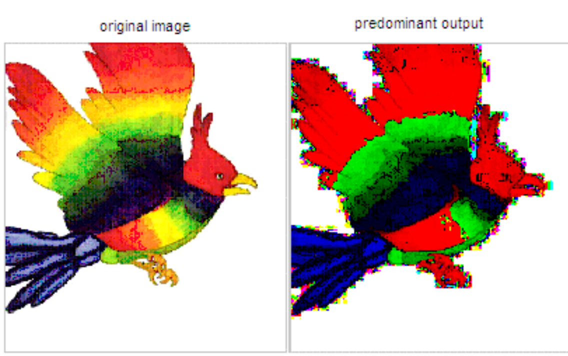


fig 2

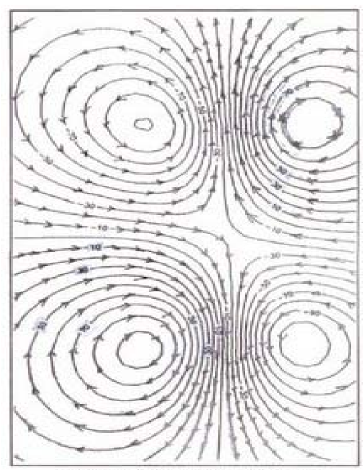
Let’s take a value suppose R=.65, G=.64 & B=.11 where maximum value of any of this can only be .255.Now if we carefully observe the difference between the R&G values. We observe that the difference between them as a mere .01. Here the question comes whether to classify this pixel as belonging to Excusive R bin or the R=G bin. Clearly it would be more apt if we classify this pixel as belonging to R=G bin than the exclusive R bin. Classification of such pixels into the exclusive bins was found as the reason of color leaks& singularity in the above scenario as shown in fig 2. To solve such an uncertainty problem we have proposed a fuzzy method based on magnetic principals as described in the next section.

B. Fuzzy Color Magnets

This uncertainty of where to place the pixel as shown before can be dealt with the help of a fuzzy inference engine based on color magnets principal.

Magnets are pieces of iron, steel, alloy, ore, etc., having the properties of attracting iron and of pointing approximately north and south when suspended. It radiates out a magnetic field which is an area of force around a magnet capable of attracting magnetic substance or materials capable of acquiring magnetic properties.

Figure 3(G): Magnetic fields interacting with each other

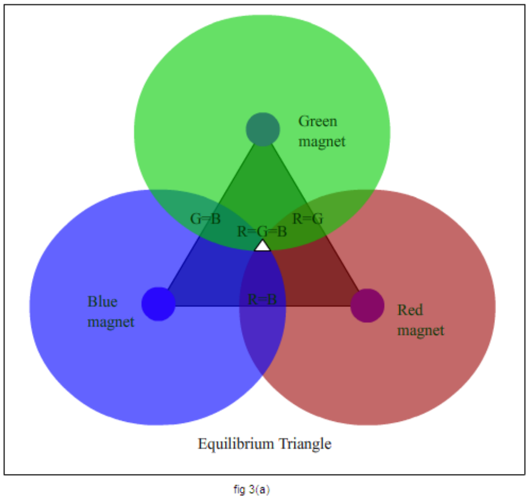


This actual graphic mapping of a magnet shows its lines of force by measuring the intensity of the magnetic field every 1/16" at each point on a grid, covering the entire magnet, as well as some of the field in the area around the magnet. (See page # 29 for description of method.) This measurement of the strength of the magnetic field is rated in gauss.

Magnets have two poles the north and the south. When same poles are brought together they repel each other &if opposite poles are brought together they attract each other. If a magnet or an iron piece comes into the magnetic field of another magnet, the magnets or iron pieces gets attracted to the stronger magnet.

Here we assume the three basic colors that are, the red, blue & green as three separate color magnets, having similar properties as that of a common magnet. The magnetic fields emitted by a color magnet, is assumed to be circular in nature. Three magnets having equal magnetic strength are kept on the three vertices of the equilibrium triangle. The Equilibrium triangle is an equilateral triangle such that if magnets are kept on its vertices their magnetic fields do not disturb each other. Hence they remain stable on their original positions as shown in the fig 3(a)

Fig 3(a): Equilibrium triangle with three color magnets placed on its vertex



Now all the pixels of the color image to be segregated are placed in this equilibrium triangle depending upon its RGB value. If the values of the pixel under consideration are such that it is more inclined towards one of these three magnets then they get attracted towards that particular magnet & gets placed in its particular exclusive bin i.e. either the R or the G or the B bin. If some group of pixels lie in between two or more magnets such that they stay in the equilibrium region as shown in the fig above due to the resultant attractive forces on the pixel is coming out zero, then they stay in that region. These regions can be R=G region, G=B region, R=B region& finally R=G=B region.

The center of this triangle is named the void zone as it indicates the point zero where all the three RGB values are zero. As we move towards any particular magnet for e.g. the R Magnet then the value of R increases. Hence more chances of it getting attracted towards the exclusive R bin depending on its respective counterparts that is the G & the B values also. Hence based on this assumption axis the color pixels are placed accordingly in the equilibrium triangle space.

The region of magnetic influence in the Equilibrium triangle of a magnet as shown in fig 3(a) is directed by its magnetic sensitivity value. Greater the sensitivity value, lesser is the chances of that pixel to be categorized in the exclusive bin. And lesser the sensitivity value, greater is the chances of that pixel to be categorized in the exclusive bin. Thus, the edges of the equilibrium triangle, is so adjusted on the basis of magnetic sensitivity value, such that the color magnets placed on its vertices remains undisturbed. Clearly more the value of sensitivity more is the bandwidth of the bi or tri combination color region. Hence, depending upon the area of application the sensitivity value has to be adjusted accordingly so that singularity & color leakages are reduced to an insignificant amount as shown in fig 4(a). These outputs as shown in the next section can be displayed in R, G, B, RG, RB, GB & RGB Windows such that the segmented output can be better displayed. In this paper only one image has been displayed in the seven window output. But it is to be noted that the other images shown in this paper can be displayed in such as fashion also with such precision & quality, as per the desire or the area of application.

Fig 3(b): Previous image with F.M.C.I.S

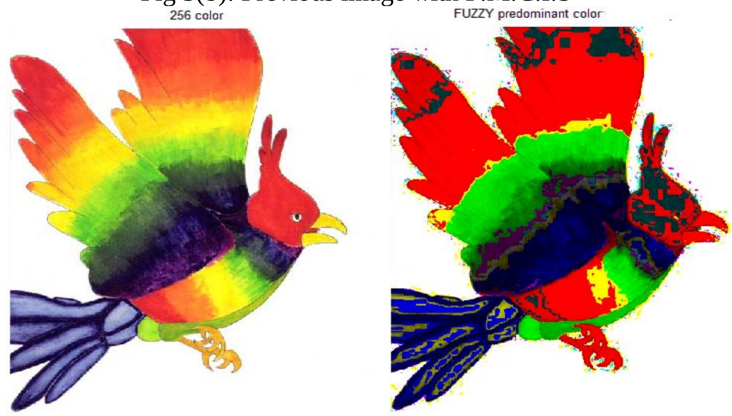


Fig3(c): F.M.C.I.S on MRI Scans

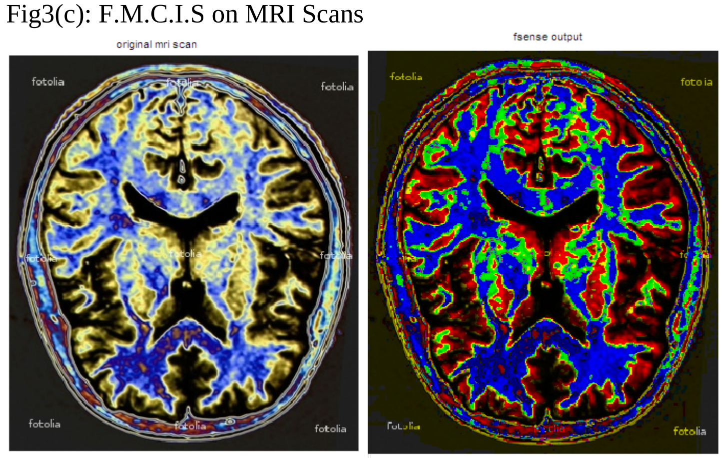


Fig3 (d): F.M.C.I.S on a butterfly's image showing segmented results

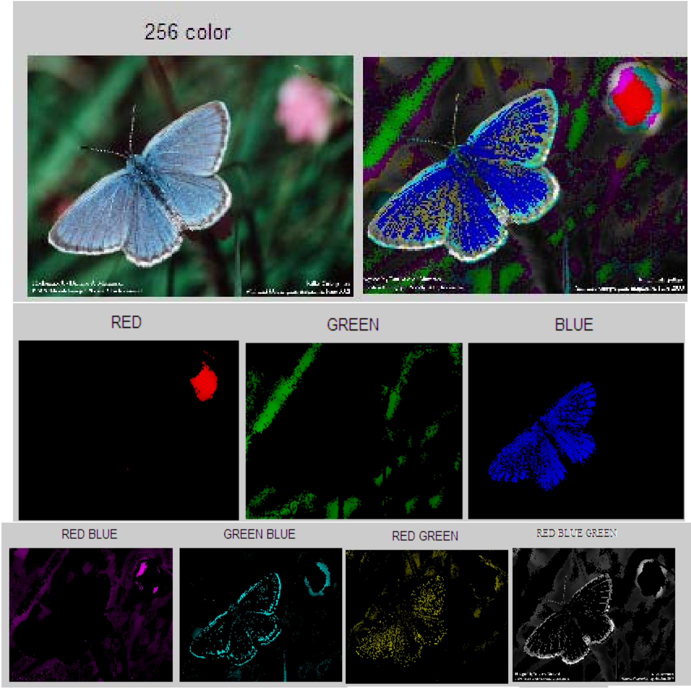
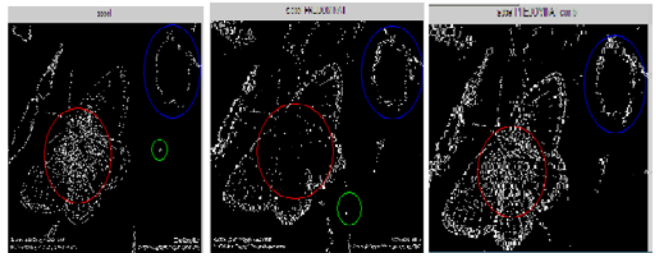


fig3 (e): Demonstrating effect of applying different values of magnetic sensitivity on an image

C. *Enhanced edge detection*

In an image there are some things that only edges can tell and some things that only colors can tell mainly due to the presence of color & texture in an image. So it is important that we do not discriminate either of them so as to obtain a proper result. It was experimentally proved that by directly applying Sobel operator on an image the information in the color domain is never properly depicted. And if we had solely considered the color domain the information in the edge domain that is usually considered never gets properly depicted.

So it is important that we combine these two results to obtain a highly efficient result.



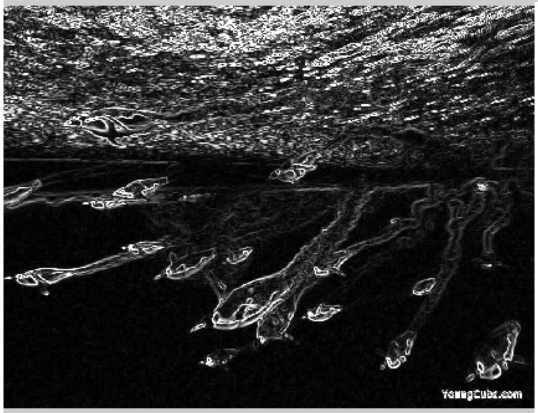
The first image in fig 4(a) is the Sobel applied directly and the second is the Sobel applied on the predominant color image. The red circle shows details present in the Sobel result & not present in the Predominant Sobel result. The blue circle shows details not present in the Sobel result but present in the Predominant Sobel result. Green circle shows the noise present in these two images. As you can clearly observe the details were combined giving a better detailed image. But excess noise was introduced this problem was tackled using Sobel gradient method.

In this module Sobel was chosen mainly due to its simplicity& sufficient immunity to noise.

In this, edges in the image that have more importance are highlighted. This priority of one edge over another edge is decided by comparing the output got by applying the Sobel on the black& white image of the original image and the output got by applying Sobel on the black and white image of the predominant color output. This comparing is done with the help of a thresholding value. This resulted in an output which was comparatively superior to the image which only used Sobel output. Especially images of nature where pictures of water was involved was not able to give the expected output by simply applying Sobel. But with our approach images were better defined.

Figure 3(f): sample image for the advanced edge detection

Figure 3(G): Advanced edge detection applied on the sample image



D. Conclusion

The major contributions of this article arise from the formulation of a new approach, i.e. fuzzy magnetic colour image segmentation & advanced edge detection, to logically identify and extract the logically coherent pieces in the image thus providing improved computational efficiency in the image segmentation & edge detection techniques. By manipulating the basic R, G&B features in the image in this new fashion it can be inferred from the outputs that significant features in the image can be logically extracted as well as undetectable edges can also be efficiently identified

E. Acknowledgement

I express my deep sense of gratitude to all those people, who had helped me directly or indirectly to complete this project.

Above all Praise be to God for his divine mercies, wisdom & great favor that he has shown, constantly walking before the development of this project. For it is rightly said: “The Lord is my Sheppard.” - PSALMS 23:1

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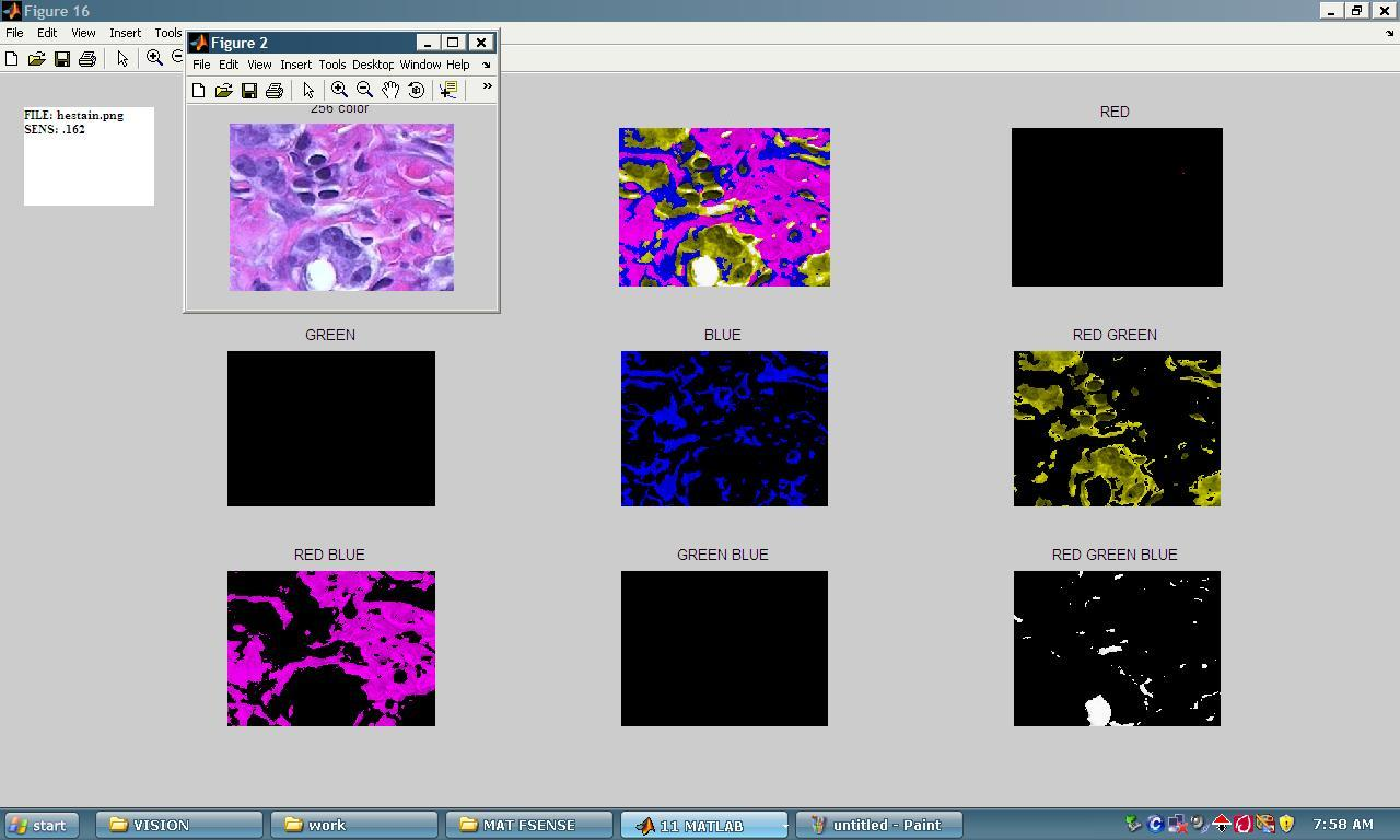
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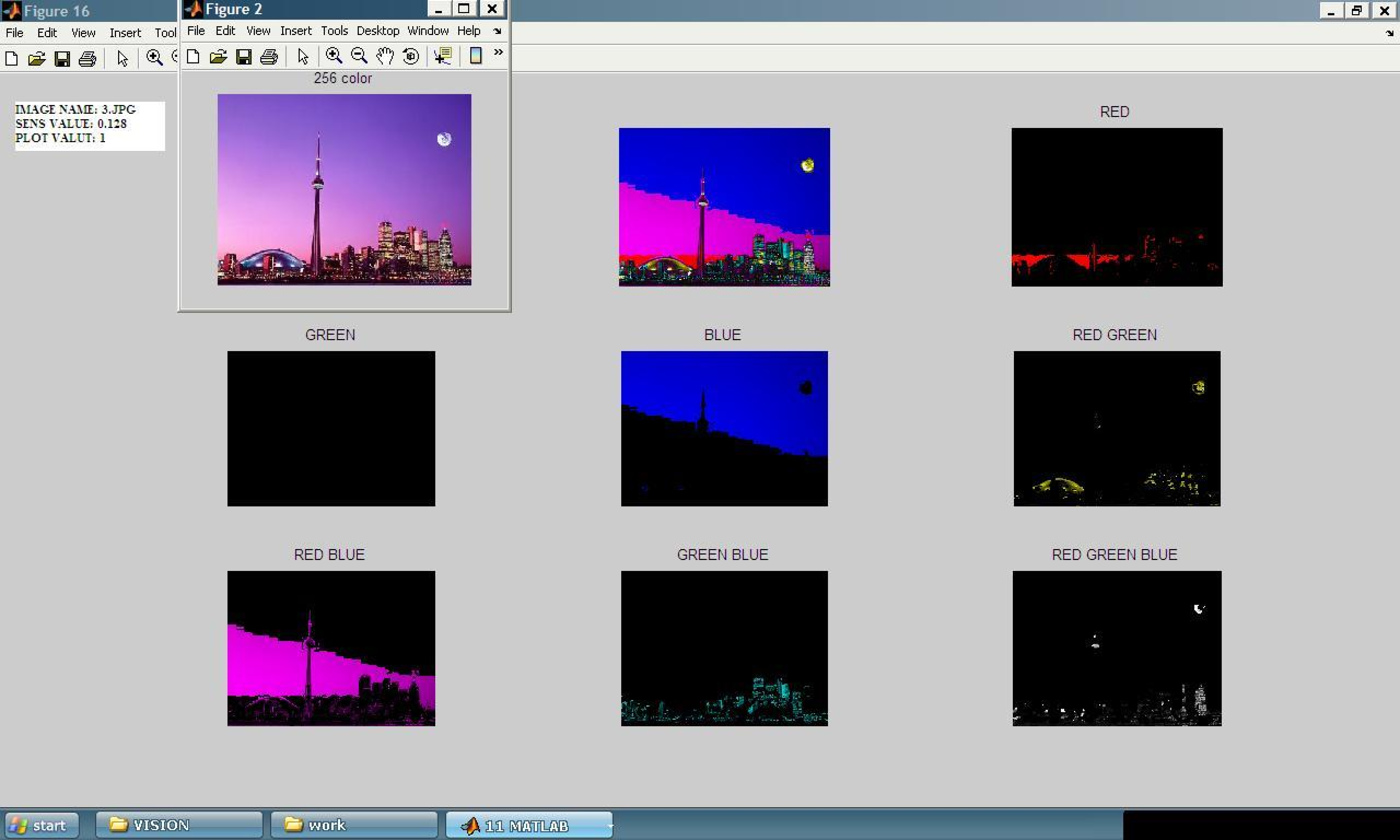
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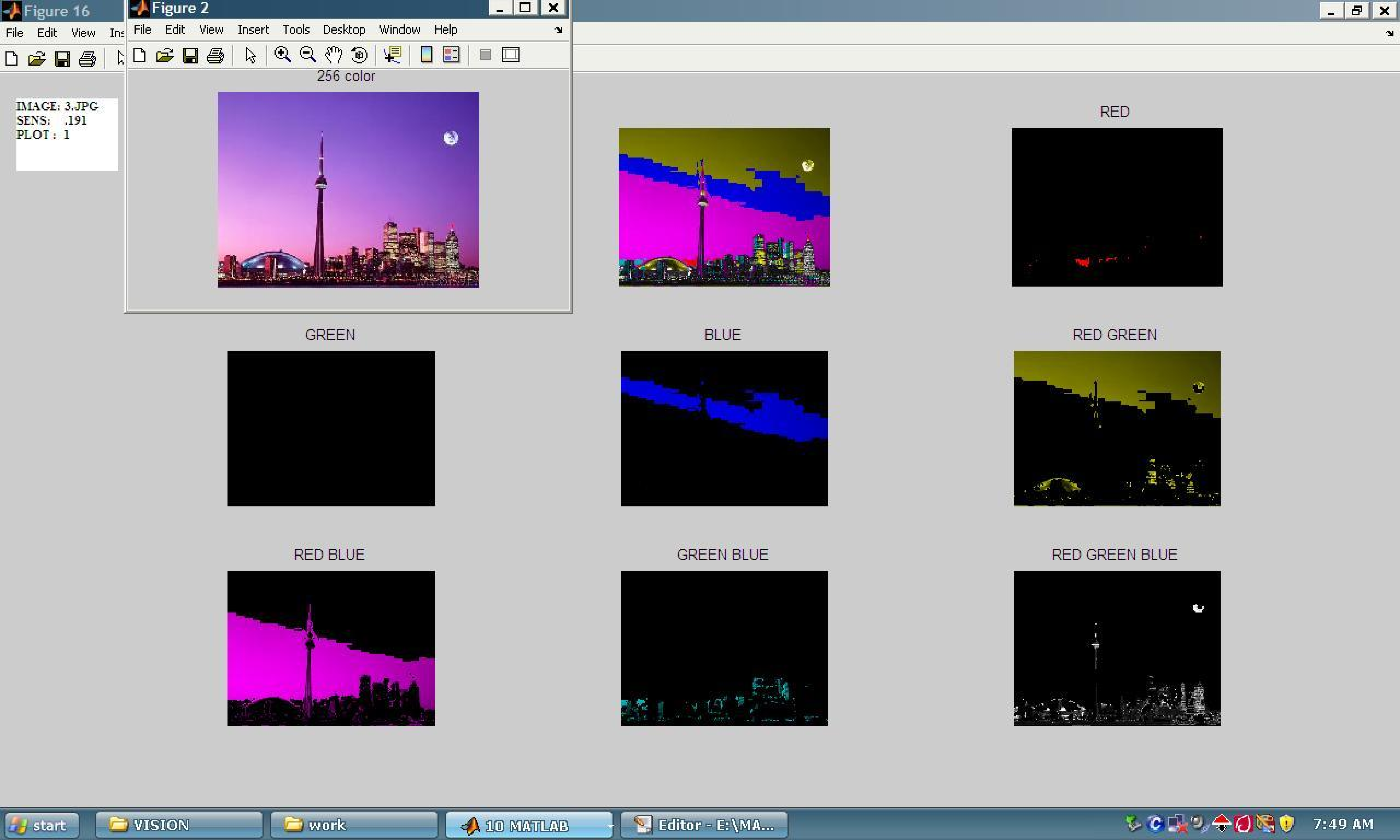

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