PIXELS TO PICTURES

A PROGRAMMING COURSE ON IMAGES WITH MATLAB

Instructor Guide

Module 2: What is RGB?

Prerequisite Domain Knowledge: None

Expected Completion Time: 60 minutes

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Pixels have RGB Colors

Expected Duration: 30 minutes

Learning Objectives

- Know the Primary Colors used in a digital image.
- Create a variety of colors by combining the primary colors in different proportions.
- Connect the color of each pixel in an image to one combination of the primary colors.

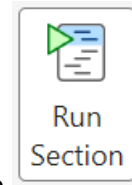### Materials

- MATLAB®
- Handout "RGB Color Table"

Steps

Ask the students to open MATLAB Online, and have them give you a thumbs up when they have done so.

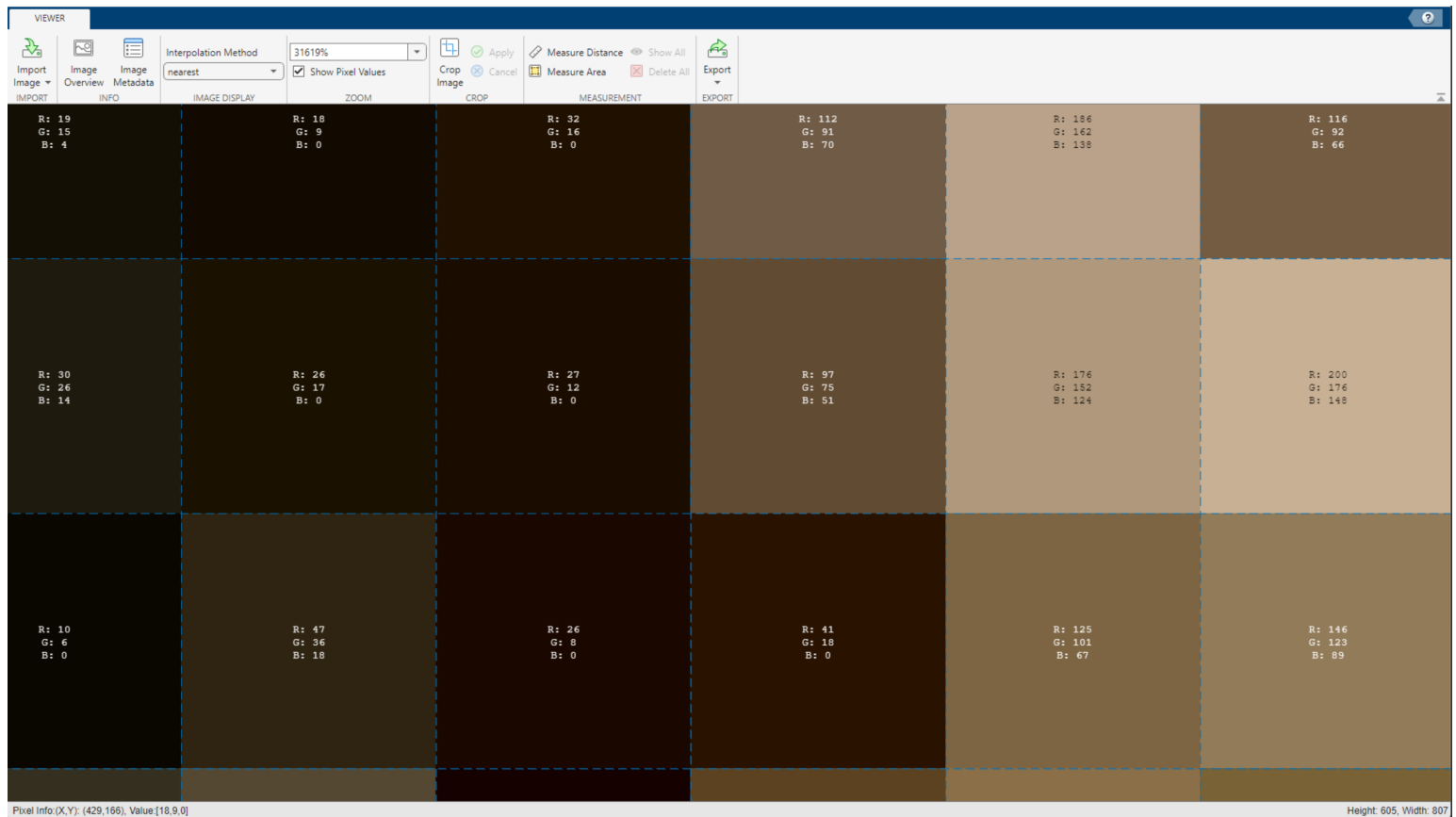- Ask the students to open the following script:

```
open 'RGBPixels.mlx'
```

- Have them run the first section named "Open "Big Ben" image in Image Viewer" by clicking the blue bar

on the left of the section, or by clicking into the section and then clicking the button in the MATLAB toolstrip.
- Have students zoom in to the fullest till you can see the text on each pixel.

Each pixel has the letters R, G, and B written on it with some numbers next to each of them. Ask:

- *What do you think the R, G, and B stand for?*
- *Has anyone heard of the Primary Colors? How might this apply to images in MATLAB?*
- *What do you think the numbers represent?*

To get a better understanding of the numbers and what it means to mix these primary colors, ask the students to follow along with you on their computer.

     • In MATLAB, navigate to the **APPS** tab, click on the down arrow button and select the Colors RGB App .

Colors RGB

This will open up the Colors RGB App as show below.

Encourage students to explore what happens to the color as they change the different values.

During this exploration, tell students that they should first change one color at a time. Pose the following questions to direct the students' exploration. Ask:

     • *What is the value range for each of the colors?*
     • *What happens to the color as each of the values are closer to 0? Closer to 255?*
     • *What happens to the color if all of the values are set to 0? To 255?*
     • Students should notice that with all of the sliders set to 0, the color will be black. With all set to 255, the color will be white.
   • *How can you create a color that is purely red? Other colors?*

- The green and blue sliders will be set to 0, but with the red slider set to 255, the color will be a bright red. Respectively, the other sliders will do the same for blue and green.
- *How does the color change as you increase the value on one slider?*
- Students should notice that the lower values give a darker shade of red because it's closer to black and the higher values give a brighter shade.
- *What other colors can you make? What values are needed to create those colors?*

Give each student (or each group if working in pairs) the **RGB Color Table Handout** so they can try out a few color combinations.

```
web('worksheets_and_handouts/RGBColorTable.pdf', '-browser');
```

After about 10 minutes, gather students for a brief discussion. Ask:

- *What results did you find for the guiding questions?*
- *What other discoveries did you make while exploring the ColorRGB app?*
- *How do the numbers we saw in the imageViewer Pixel Region compare to what we saw in the Colors RGB tool?*
- Students should notice that the numbers we saw in the imageViewer Pixel region next to the R, G, and B letters are basically the same as the ones we see in the Colors RGB app.
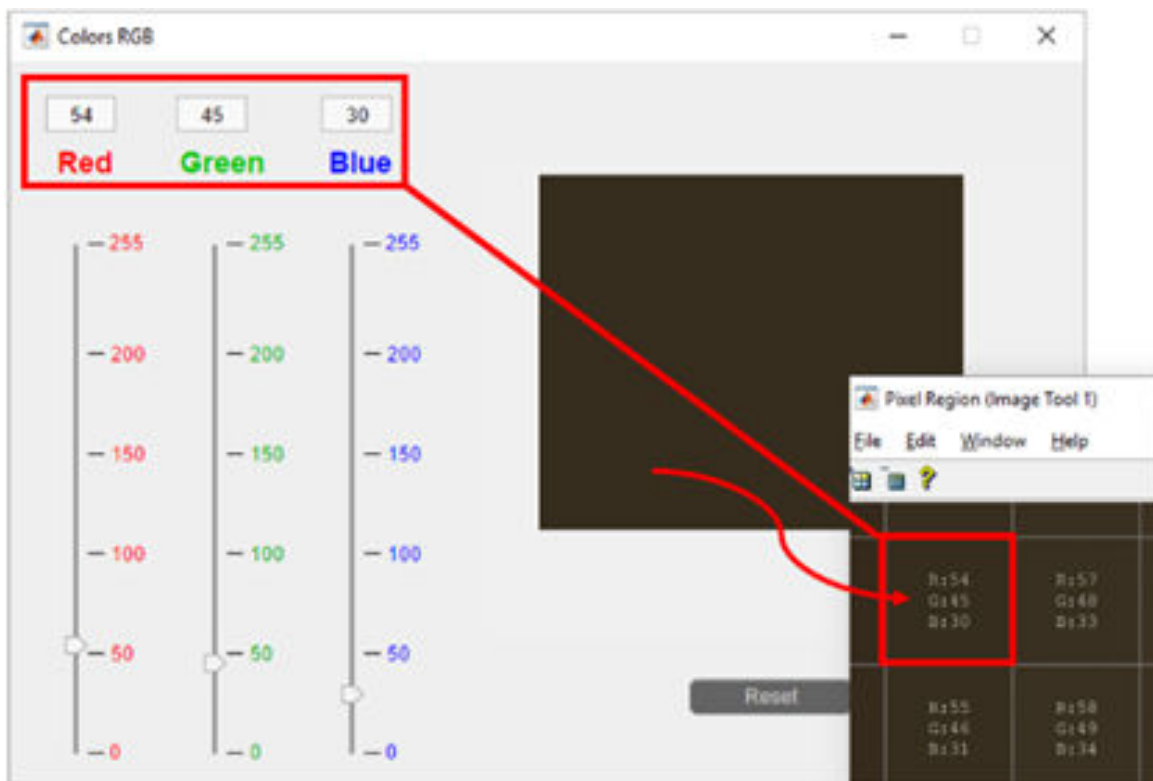
Note: If any student asks why is the range for the colors going from 0 - 255 and not from 0 – 100 or 0 – 500, tell them that it is an excellent question which will be explained in the next topic.

RGB Color Range

Expected Duration: 15 minutes

Learning Objectives

- State that computers interpret all information as a series of 0s and 1s called bits.
- Understand the connection between an 8-bit storage of color on a computer and why pixel values for each color range from 0 – 255.

Materials

- MATLAB®
- Demo PDF "RBG Color Range"

Steps

Show them the **RGB Color Range** PDF:

```
web('demos/RGBColorDemo.pdf', '-browser');
```

Ask:

- *How have you heard the terms bits or bytes used?*
- Students may mention MegaBytes, GigaBytes, etc. as a unit of storage in computers.
- *Have you ever heard the phrase computer language or binary code?*
- Accept all answers from students that relate to the language that computers "speak".

Using the slideshow, explain to students that computers interpret every command we provide it as a bunch of 0s and 1s.

- One 0 or 1 is called a bit, 8 bits is called a byte.
- The terms MegaBytes and GigaBytes in terms of computer, phones, etc means how many of those 0s and 1s can a computer store.
- 1 KiloByte ~ 1000 bytes ~ 8000 bits
- 1 MegaByte ~ 1000,000 bytes ~ 8000,000 bits
- 1 GigaByte ~ 1000,000,000 bytes ~ 8000,000,000 bits

Tell students that the computer uses one byte (8 bits) to represent each of the three primary colors.

- 2^8 = 256 shades of each color. Hence the range of each color goes from 0 – 255, where 0 indicates absence of the color. Therefore, if we provide a pixel value higher than 255, the computer caps the value at 255. Similarly, a value lower than 0 is capped at 0.

Distribute the **Bit Combination** worksheet to each group of students.

```
web('worksheets_and_handouts/BitCombination.pdf', '-browser');
```

Ask them to try and figure out all the 2^3 = 8 combinations 3 switches or bits would give them. If they are having trouble, ask them to break it into 4 categories

- All switches are off (already given)
- Only 1 switch is on, others are off
- 2 switches are on, 1 is off
- All switches are on
- After about 10 minutes, gather the students to discuss their findings. Students should share which combinations results in the correct output.

Explore Color Illusion

Expected Duration: 15 minutes

Learning Objectives

- Explain that the human eye's perception of a color is relative to the color's surroundings, but the true RGB values are fixed.

Materials

- MATLAB®
- Worksheet "Color Illusions"

Steps

Tell students that they will now explore how are viewed. Ask:

- *How do humans view/perceive color?*
- *Do we all see the same color when looking at a particular object?*
- Students may mention colorblindness, and that some people are not able to see certain colors.
- Colorblindness is an example of how people can perceive different colors, while looking at the same object.
- *"Types of Colour Blindness" - http://www.colourblindawareness.org/colour-blindness/types-of-colour-blindness/*

Ask the students to reopen the following script:

```
open 'RGBPixels.mlx'
```

Ask the students to run the second section named "Illusion 1" to open the 'Illusion1.jpg' file.

It should open up the image of two slabs, shown below, in the Image Viewer App.
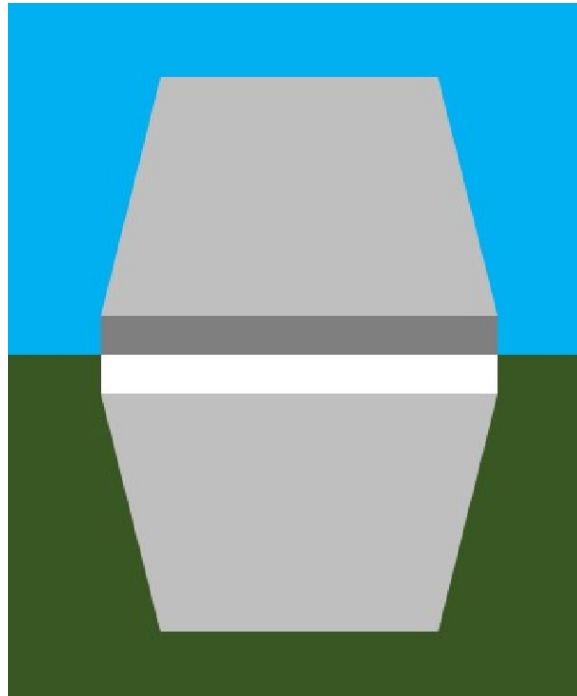
Ask:

- *Which of the slabs is darker?*
- Most of the students will say the upper slab.
- *Place your fingers to cover the joining point of the slabs. Which of the slabs is darker now?*
- Students should notice that the slabs look like they are the same color.
- *How can we prove that the slabs are the same color?*
- Students should mention that they can zoom into the picture to find out what the RGB values are for the slabs.

Explain to students that in the original image, since the upper slab is placed immediately above a darker gray portion, the whole slab looks gray, whereas since the lower slab is placed immediately below a white patch, the whole slab looks white. This is how the human eye is perceiving the colors but it's not the true RGB values.

Distribute the **Color Illusions Worksheet** to the students.

```
web('worksheets_and_handouts/ColorIllusions.pdf', '-browser');
```

You may want to complete the first activity on the worksheet with the students so they understand what they need to do and ask them to complete the second activity by themselves.

Ask the students to follow along with you on their computer. Students will need to use their knowledge of RGB values to determine whether the slabs are the same color.

Everyone should already have the first illusion image open in MATLAB from the Live Script.

In the Image Viewer, zoom into the photo to see the RGB values of the pixels in the upper and lower slab, and ask the students to note these down in the worksheet:
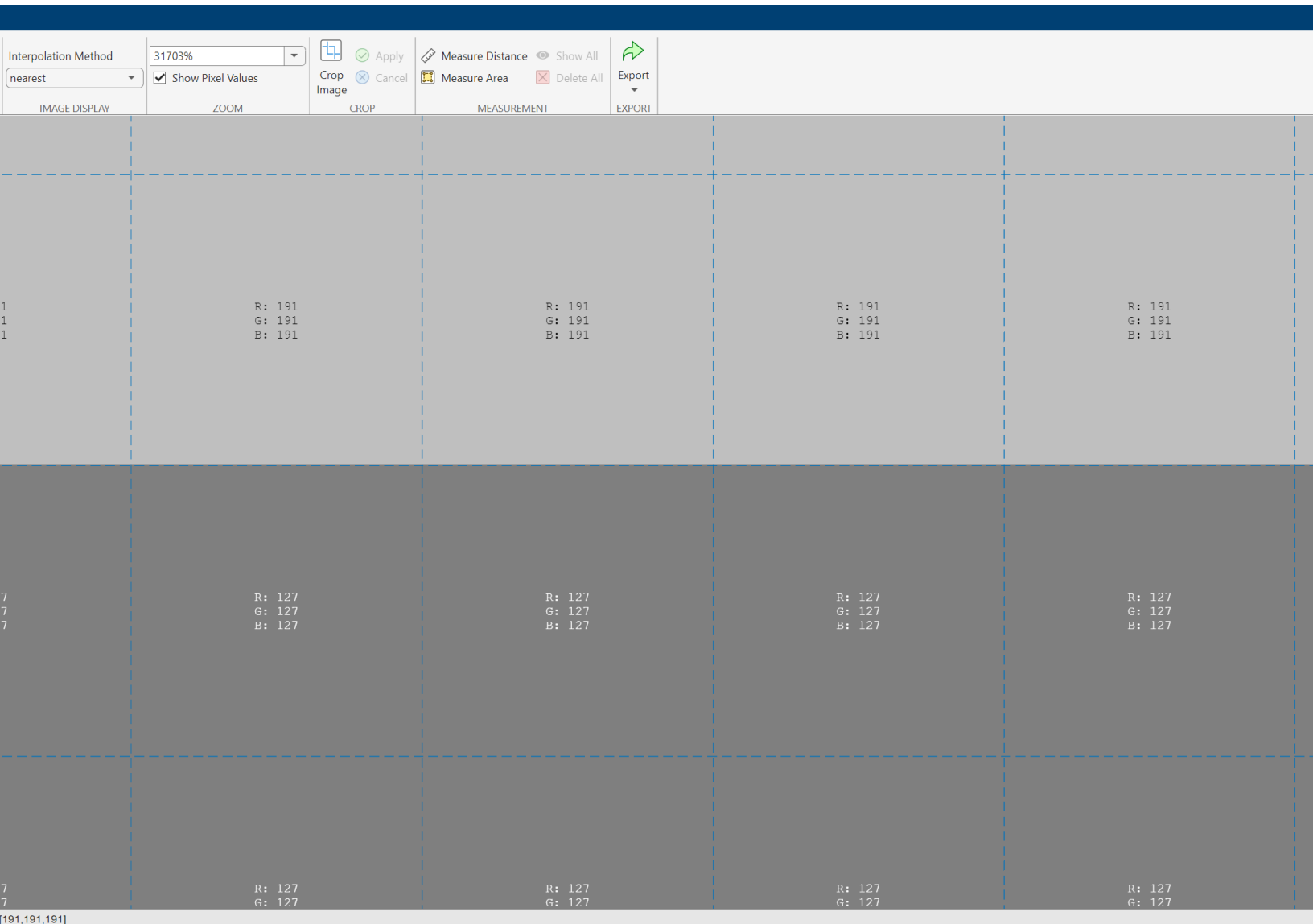
Ask students:

- *What evidence do you have that proves whether the slabs have the same or different values?*

- They are the same. This proves that even though the eyes are seeing different colors, the RGB values show that they are in fact the same.

Ask students to close the Image Viewer app and continue to the next illusion on the worksheet.

Ask the students to run the section named "Illusion 2" to open the 'Illusion2.jpg' file.

For this illusion, students will need to determine whether one of the suns is brighter than the other, or if this is another illusion.

Ask:

- *How might you be able to figure out if one sun is brighter than the other?*
- Students should mention that they can find out what the RGB values are for each sun.

Tell students that in addition to the 2 illusions in the worksheet, there are 3 others that they can choose to explore. They will have 10 minutes to explore the other illusions. Remind students that they should record the RGB values for each illusion they explore.
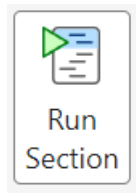
Students can use the button to try each of the illusions individually.

At the end of 10 minutes, gather students to share what they have discovered about each of the illusions. Ask:

- *How does the human eye's perception of images compare to the RGB values of an image?*
- *Do you think it is difficult or easy to trick the human eye?*