Image Processing and Image Enhancement

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Grade Level:

High School

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Introduction:

Image processing modifies pictures to improve them (enhancement, restoration), extract information (analysis, recognition), and change their structure (composition, image editing). Images can be processed by optical, photographic, and electronic means, but image processing using digital computers is the most common method because digital methods are fast, flexible, and precise.

An image can be synthesized from a micrograph of various cell organelles by assigning a light intensity value to each cell organelle. The sensor signal is "digitized"-- converted to an array of numerical values, each value representing the light intensity of a small area of the cell. The digitized values are called picture elements, or "pixels," and are stored in computer memory as a digital image. A typical size for a digital image is an array of 512 by 512 pixels, where each pixel has value in the range of 0 to 255. The digital image is processed by a computer to achieve the desired result.

Image enhancement improves the quality (clarity) of images for human viewing. Removing blurring and noise, increasing contrast, and revealing details are examples of enhancement operations. For example, an image might be taken of an endothelial cell, which might be of low contrast and somewhat blurred. Reducing the noise and blurring and increasing the contrast range could enhance the image. The original image might have areas of very high and very low intensity, which mask details. An adaptive enhancement algorithm reveals these details. Adaptive algorithms adjust their operation based on the image information (pixels) being processed. In this case the mean intensity, contrast, and sharpness (amount of blur removal) could be adjusted based on the pixel-intensity statistics in various areas of the image.

Image processing technology is used by planetary scientists to enhance images of Mars, Venus, or other planets. Doctors use this technology to manipulate CAT scans and MRI images. Image processing in the laboratory can motivate students and make science relevant to student learning. Image processing is an excellent topic for classroom application of science research techniques.

Purpose:

The purpose of this laboratory activity is to allow students to explore how digitized images can be processed and enhanced using computer software. This lab is probably more suitable for high school students.

Objectives:

The teacher will use image processing techniques in the classroom because it:

- integrates science, mathematics, and technology.
- emphasizes the use of intellectual and physical tools to support inquiry, spreading the emphasis from simply learning concepts and results to the processes of science.

- introduces students to central mathematical and scientific concepts in a context of technologically supported active learning.
- offers entry and success at many different levels (depending upon student interest and ability) and by many different paths (e.g., graphical, analytical, and geometrical).

Materials:

- IBM-compatible computer with at least a 386 microprocessor, eight MB of RAM, Windows 3.1 or later (see below for Macintosh users)
- Digitized image saved in TIF format (may be brought in by the student or supplied by the teacher)
- Image processing software such as Paint Shop Pro software (can be obtained as shareware in many book stores or from JASC, Inc., 10901 Red Circle Drive, Suite 340, Minnetonka, MN 55343, telephone (612) 930-9171, FAX (612) 930-9172 for a nominal fee). Other image processing software, such as NIH Image (for the Macintosh user) may also be used.

Preparation:

The software may be installed on the computer hard drive or run from the disk. The teacher should work with the Paint Shop Pro software before assigning the students this laboratory activity, so that student questions may be more easily answered as the students become more involved in the activity. Check to make sure the software is working on all the computers before starting the activity. This activity can be completed in one 45-minute lab period but may extended very easily to three or even four lab periods. It might be helpful to assign students some reading on image processing and image enhancement before engaging students in the activity. Precede the lab with a class discussion on how image enhancement is being used in the world of science.

Procedure:

Students may work in groups of two or three with one computer and one copy of Paint Shop Pro software per group. Each student in the group should have the opportunity to work with at least three of the image processing functions of the software. The teacher should monitor the group to make sure every member of the group participates in this activity. Have each group save their images so that they may be observed at a future time if needed. The teacher could give the groups names or numbers under which to save their images.

The students will manipulate their images using the following image processing functions:

- brightness/contrast
- gamma correction
- despeckle
- erode
- dilate
- blur
- sharpen

- soften
- edge enhance
- add border

Safety:
There are no hazards associated with this lab activity. However, if your school has a computer use policy for students, review the policy with your students.

Questions to Ask:
- What is image processing?
- What is image enhancement?
- What are some practical applications of image processing?
- What are some practical applications of image enhancement?

Where to Go from Here:
This lab could be used when discussing CAT scans or MRI images or any process used in the manipulation of images. This would be a good time to invite a medical image processing technologist, physiologist, or doctor into the classroom to discuss the advantages of image processing and enhancing in the study and diagnosis of diseases.

References And Resources:
1. A later version of Paint Shop Pro shareware may be downloaded from the Internet at: http://www.shareware.com or http://www.hotfiles.com.
2. A good resource on image enhancement and image processing is: Russ, John C., 1992. The Image Processing Handbook, CRC Press, 2000 Corporate Blvd. NW Boca Raton, FL 33431.
3. Images to be used for manipulation may be a scanned photograph (saved in TIF, BMP, JPEG, or GIF format) or may be downloaded from the Internet.
   Some possible image sources are:
   a. NASA Mars Missions (http://mpfwww.jpl.nasa.gov/)
   b. Interactive Frog Dissection (http://teach.virginia.edu/go/frog)
   c. The Heart: Online Exploration (http://sln.fi.edu/biosci/biosci.html)
   d. Schmidel Web Resources (http://schmidel.com/)
   e. Innerbody (http://www.innerbody.com)
   f. Cells Alive (http://www.cellsalive.com/)

Suggestions For Assessment:
Students should complete a group laboratory report including a brief but thorough description of how their image was changed or enhanced using each of the ten processing functions.

Image Processing and Image Enhancement

Student Activity Sheet

Purpose: To explore how digitized images can be processed and enhanced using computer software.

Materials:

- IBM-compatible computer with at least a 386 microprocessor, eight MB of RAM, Windows 3.1 or later
- Digitized image saved in TIF format (may be brought in by the student or supplied by the teacher)

Objectives:

1. The student will understand the practical and real world application of image processing and image enhancement
2. The student will learn to manipulate images in the following ways:
    - brightness/contrast: the student will alter the brightness and contrast of the image
    - gamma correction: the student will apply a gamma correction value to the colors of an image to correct for differences in gamma levels between the computer's monitor and the equipment (such as a scanner) used to produce the image
    - despeckle: the student will remove unwanted specks or "noise" from the image
    - erode: the student will bring out the darker colors of the image
    - dilate: the student will bring out the brighter colors of the image
    - edge enhance: the student will enhance the details found in the edge of the image
    - blur: the student will blend together pixels of the image
    - sharpen: the student will create more contrast between neighboring pixels
    - soften: the student will blend the edges of neighboring pixels
    - add a border: the student will produce a colored border of their choice for the image.

Procedure:

1. Open Paint Shop Pro by double clicking the Paint Shop Pro icon.
2. Go to File, then Open; select drive A and load your image.
3. Select Colors from the menu, then select BRIGHTNESS/CONTRAST. Change the brightness of your image by clicking on the left-right arrows. Preview your image. Result? Change the contrast and preview your image. Result?
4. Select GAMMA CORRECTION (gamma correction values are displayed from 0.01 to 4.99) and a value for your image will be displayed to the left. Increase the value of this number, click OK. Result? Decrease the value of this number, click OK. Result?

5. From the menu, select Image, select Special Filters, and then select DESPECKLE. How does the new image compare with the original?
6. Select ERODE from the menu. How does the new image differ from the original?
7. Select DILATE from the menu. Compare the original image with the new one.
8. From the Image menu, select Edge Filters, and then select EDGE ENHANCE. How does this function alter the original image?
9. Select Normal Filters from the Image menu, and then select BLUR. Compare the two images; is the new image clearer?
10. Now select SHARPEN from the Normal Filters menu. Are there any differences in the two images?
11. Select SOFTEN from the Normal Filters menu. In what respect, if any, is the new image better than the original?
12. To enhance the appearance of your image, from the Image menu, select ADD A BORDER. You may choose to make your border symmetric or you may have your border only on the top, bottom, left, or right of the image. Choose Select Color to determine the color of your border.

For Further Exploration:
If time permits, go back to the menu and select other options you did not get to discover during this laboratory activity. Report on what you discovered.

Assessment:
Write a brief, but thorough, report on how your image was enhanced or changed with each of the ten image processing functions you used.