Ultrasound Image Analysis through Pixel Duplication and Structural Measurements

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Abstract

Currently doctors have to manually select two points on the edges of structures of interest in an ultrasonic image to determine the distance between those two points. The size of the structures is then used to make diagnostic decisions. In this project, a graphical user interface is designed for semi-automatically determining the size of structures in medical images. Image preprocessing techniques, such as filtering and segmentation, are applied to original and pixel-duplicated (enlarged) images. Pixel duplication is an image enhancement method which reduces data loss through filtering. Then, edge detection algorithms are used to extract boundaries of structures in the pictures. The effects of pixel duplication on the structural measurement values are demonstrated by comparing the results to original images. The final goal of this project is to automate measurement of structures in ultrasound scans.

Introduction

A graphical user interface (GUI) has been developed to analyze ultrasound images and extract the characteristics of structures of interest automatically. The current methods used clinically involve user visual inspection of and then interaction with the image, which can be time consuming. The goal of this project is to automate the detection and characterization of structures and cavities in ultrasound images, particularly fetal ultrasound scans, to assist the doctors in their evaluation of disease or growth state. The image analysis methods implemented so far include pixel duplication, mean (average) window filtering, segmentation, and edge detection. Pixel duplication is a method that enlarges the images such that small structures are not eliminated by filtering and similar operations. Other characteristics, such as structural area, perimeter, length of major and minor axes, as well as other attributes are in the process of being implemented. This presentation demonstrates the pixel duplication process, the developed GUI, the results of the techniques available through the GUI, and the advantages of pixel duplication.

Methodology

Pixel Duplication:

The figure below demonstrates the pixel duplication process; each pixel is cloned in a 2x2, 3x3, or 4x4 neighborhood, enlarging the original image 4, 9 and 16 times the original size, respectively.

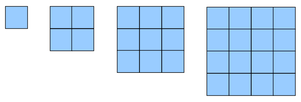
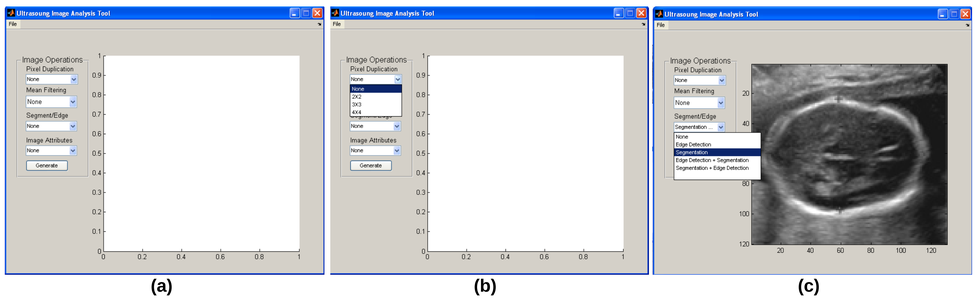


Figure 1. Pixel Duplication Process: (a) single pixel (b) 2x2 neighborhood pixel duplication; (c) 3x3 neighborhood pixel duplication; (d) 4x4 neighborhood pixel duplication)

GUI Design and Available Methods:

MATLAB software is used to create the GUI. The GUI provides a simple interface for the user to automatically manipulate an image. The user chooses the image to be loaded through the file menu. Through drop down menus the user chooses the operations to be applied to the uploaded image. The drop down menus provide techniques such as pixel duplication, mean filtering, segmentation and edge detection. Other image attributes, such as blob area, perimeter, major/minor axis length, are also included in the design. The grid area on the GUI is where the image is loaded to. Once the operation is selected, the user hits the generate button and the resulting image is displayed on the image pane.



(a) (b) (c)

Figure 2. GUI Design and Available Methods: (a) basic view (b) pixel duplication menu (c) segmentation/edge menu with an uploaded image

Results and Analysis

Figure 3 shows a series of sample GUI outputs for segmentation and edge detection applied to the original, pixel duplicated, filtered, and duplicated and filtered images.

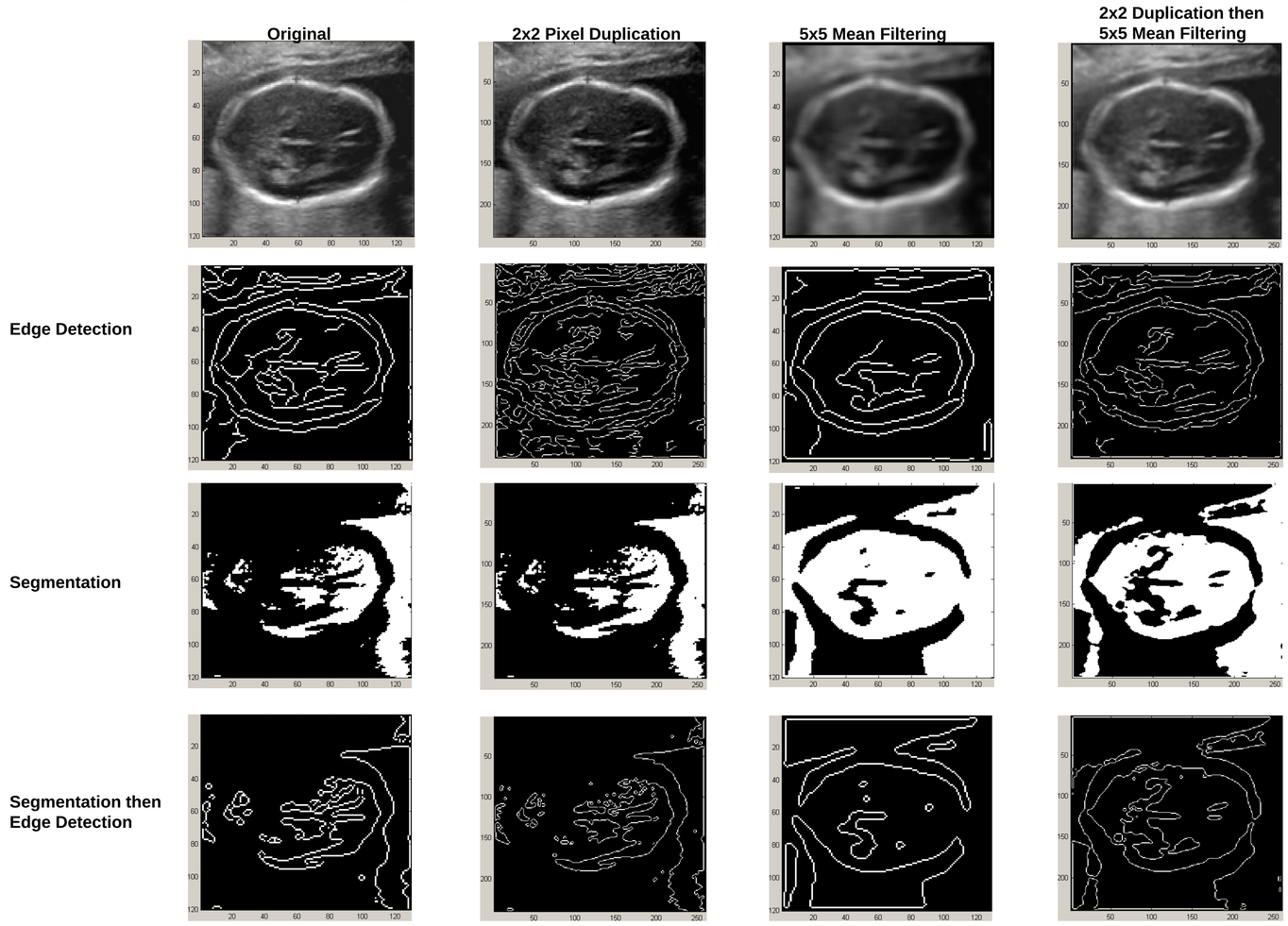


Figure 3. Segmentation and Edge Detection on Original, 2x2 pixel duplicated, 5x5 Mean Filtered, and 2x2 pixel duplicated then 5x5 mean filtered images.

As can be seen in Figure 3, pixel duplication allows the retention of more detail in structures when the image undergoes image processing operations. Pixel duplication before filtering allows the retention of structural detail when the image is exposed to segmentation, edge, or a combination of such operations.

Smoothing filters such as the mean filter above are applied to reduce jaggedness of edges of structures. The images in the final column retain the most detail through the image post processing operations, further demonstrating the advantages of pixel duplication.

Conclusions and Future Work

A GUI has been designed to allow uploading images and applying selected image processing algorithms. The advantage of pixel duplication in retaining structural detail is demonstrated in this work. Structures in the segmented images can now be further analyzed to determine individual attributes, such as the area, perimeter, major/minor axis as well as other shape and size-related parameters.

Increased detail in the final images will allow more accurate measurements of the structures of interest without the need for the clinician to accurately choose the end points representing the objects of interest. Future work involves expanding the possible attributes of structures to be automatically listed.

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References

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