Edge Detection in Medical Ultrasound Images Using Adjusted Canny Edge Detection Algorithm

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Introduction

- Edge detection is the process of detecting distinct boundaries in an image. Significant fluctuations in pixel intensity distinguish the boundaries between items in a scene. This procedure is troublesome for images with noise since both noise and edges contain high frequency components.
- This research proposes an edge detector in ultrasound images of internal organs using an adjusted Canny Edge Detection Algorithm. The proposed technique employs a modification for the original approach where instead of using a Gaussian filter for removing the speckle noise, a combination of a median filter and a dynamically weighted smoothing filter has been proposed.
- Experimental results demonstrated that with suitable threshold values for the modified Canny operator, ultrasound images with noisy edges may be satisfactorily detected.

Material and Methods

In this article, an adjusted Canny Edge Detection Algorithm has been proposed. This algorithm is one of the most popular edge detectors in the medical field. However, since it employs a Gaussian filter in the first step to remove image noise, it cannot be used in ultrasound images, as the image noise (speckle noise) is not removable with this filter. To address this issue, a combination of a median filter and a dynamically weighted smoothing filter is proposed to replace the Gaussian filter. A further explanation of these methods is given as follows:

· **Median filter:** The median filter sets the value of each pixel to the median of the pixel and its n adjacent pixels to remove the image noise. In this approach, the value n has been determined empirically. An example of the median calculation [1] is the following:

$$m = x_k; k = \frac{(n+1)}{2} \quad (1)$$

$$m = \frac{(x_k + x_l)}{2}; k = \frac{n}{2}; l = \frac{n}{2} + 1 \quad (2)$$

To completely eliminate the noise, large neighbourhoods could be used. However, oversensitivity and other problems would result from this action. To deal with this problem, this work employs three phases where four, eight, or twelve additional pixels are considered filter mask members (one, two, or three on each side, excluding diagonals).

· **Dynamic weighted smoothing filter:** In this approach, the proposed smoothing filter is based on an empirically determined mean filter with a dynamically adjusted kernel. This type of filter attempts to remedy the weakness of the smoothing effect by weighting the kernel pixels and assigning a higher weight to the central pixel, which is deemed more significant.

The Canny operator from the second step is then used after the adjusted median and dynamic weighted smoothing filter.

Result and Discussion

To test the proposed method, which was implemented in Matlab R2015a, ultrasound images of phantom kidneys were used. The experimental outcomes consist of testing the presented algorithm with various threshold values to identify the optimal one while comparing those outcomes to the results obtained with the original Canny detector.The output parameters that resulted are as follows:

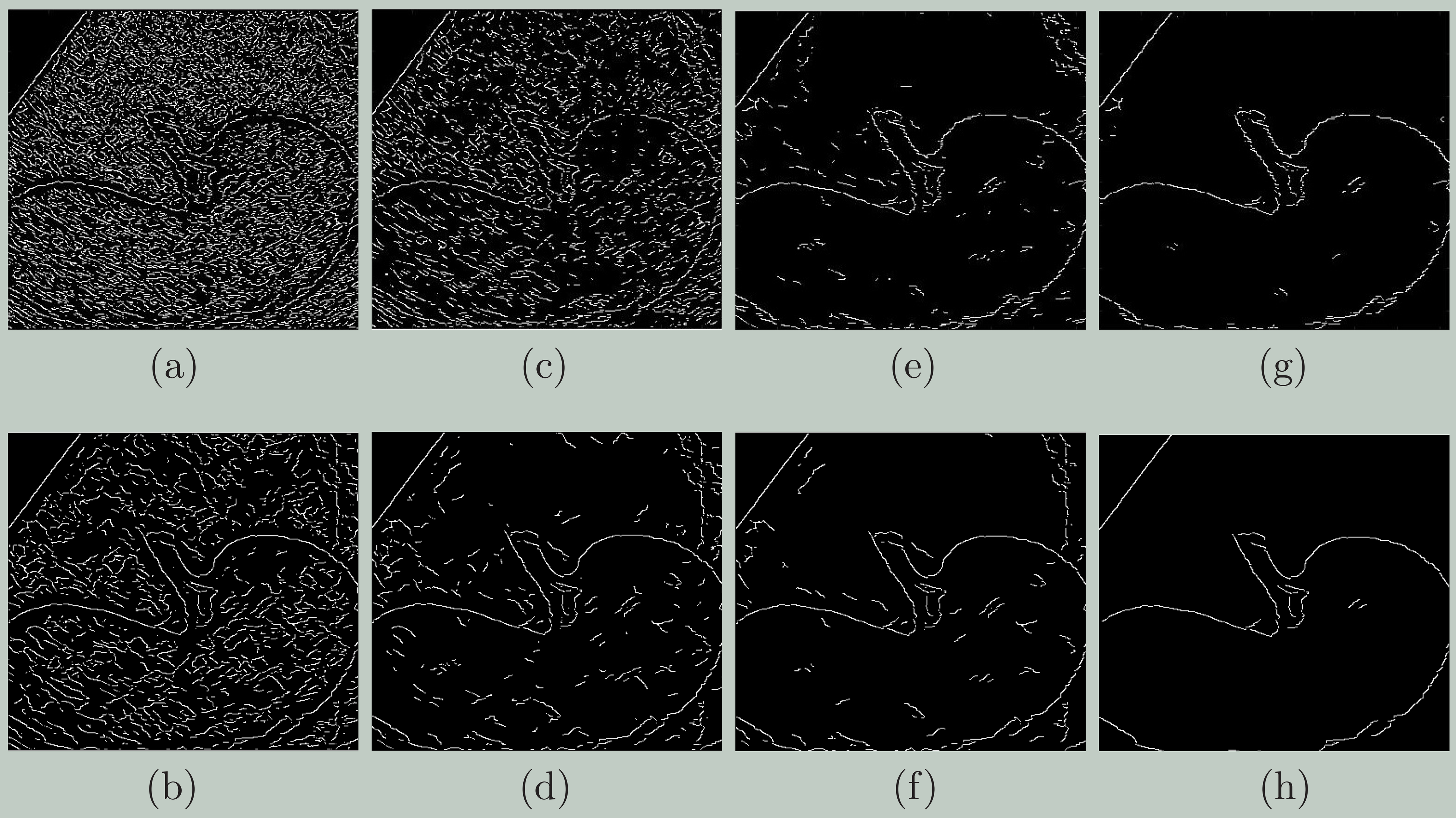

Fig. 1. Edge detection using original Canny (top row) and our proposed modified Canny operator (bottom row) with threshold values: (a) and (b) T1=0.4 T2=1.5, (c) and (d) T1=0.9 T2=1.3, (e) and (f) T1=0.9 T2=1.8 and (g) and (h) T1=1.5 T2=2.4

The different steps followed to obtain the final results of this approach are given as follows:

1. In the initial iteration, the selected threshold values were 0.4 and 1.5. As shown in Fig. 1(a) and 1(b), these threshold values triggered the recognition of many noisy parts as edges. With our proposed method, however, less noise was accepted as edges than with the original Canny operator.

2. In the second experiment, T1 was increased while T2 was diminished, obtaining a set of values of 0.9 and 1.3. With this configuration of values, slightly fewer false edges were detected, but the results are still unsatisfactory. Again, the original Canny operator (Fig. 1(c)) saw most of the image as edges because of the noise in the image. Nevertheless, using our proposed method (Fig. 1(d)), edges are already distinguishable, but some noise was also identified as edges.

3. In the next step, in order to improve results, it was tested whether increasing the second threshold would produce better outcomes, therefore, the threshold values were set to 0.9 and 1.8. As shown in Fig. 1(f), even though some noise is still recognised as edges, the occurrence of this phenomenon was significantly reduced compared to the previous experiment, and the edges were detected significantly better. Again, the proposed method outperforms the original Canny operator (Fig. 1(e)).

4. Finally, in the last iteration of this experiment, the threshold values of 1.5 and 2.4 were determined. With this configuration, kidney contours were clearly distinguished, and all noise from the original image was eliminated. With the proposed method (Fig. 1(h)), edge lines were found and connected more accurately than with the original Canny operator (Fig. 1(g)).

Conclusion

In this paper, an algorithm based on Canny operator for edge detection in medical ultrasound images has been proposed. This method employs a median filter for the elimination of speckle noise, followed by weighted smoothing filters for the control of the remaining noise, as opposed to the Gaussian filter found in the original Canny detector. A phantom ultrasound image of a kidney was employed to test the proposed algorithm. With optimal threshold values for the modified Canny operator, edges in noisy ultrasound images can be successfully recognised, according to experimental findings. Future research may include threshold optimisation and algorithmic adjustments to adapt the developed approach to various organs and types of noise.

References

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