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Full Length Research Paper

Ultrasound image acquisition by a personal computer- Application of artificial neural network

Mitra Ahmad Soltani-MD, MS

Lutalo Medical Research Corporation 15- Shariaty all- Kord St- Ressalat HW- Tehran –Iran.
E-mail: m_a_sol@yahoo.com. Tel: 00989127964990.

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Traditional probes consist of 40 to 60 crystals each attached to a pin attached to a specialized cable of minimum 2 to 3 m. Each crystal has piezoelectric properties. To capture images by personal computers to improve accessibility and reduce the cost of having ultrasonic image with special reference to obstetrics and gynecology emergency settings, a probe was designed consisting of three Doppler transducers (each with 4 pins hence generating 4 signals, altogether 12 signal) that by an analog switching with micro (1000 HZ per second) can generate 12000 signals per second changing the scan line form linear into a plane. The signals are translated into WAV sound format file that can be displayed by a Windows-based program of a personal computer. The pattern produced is created by the sound of blood flow in an organ. This vascular pattern was matched with traditional sonography of the organ. By training the network, the resolution of images can be improved further based on the formula:
output = 0.77*target + 38. The probe can capture images 1/6 resolution of a traditional probe, deeper penetration (19 cm depth), 1/34 price and weight of a traditional ultrasound equipment

Key words: Doppler transducers, scan line, artificial neural network, ultrasound, obstetrics and gynecology.

INTRODUCTION

Ultrasound imaging is based on the same principles involved in the sonar used by bats, ships, fishermen and the weather service. When a sound wave strikes an object, it bounces back, or echoes. By measuring these echo waves, it is possible to determine the objects' size, shape and nature. Doppler ultrasound is a special application of ultrasound that can measure the direction and speed of blood cells as they move through vessels (Radiologyinfo.org, 2011). There are two types of Doppler system (Figures 1a and b):

1. Continuous wave systems use continuous transmission and reception of ultrasound. Continuous wave Doppler is used in adult cardiac scanners to investigate the high velocities in the aorta.
2. Pulsed Wave Ultrasound are used in general and obstetric ultrasound scanners which allows measurement of the depth (or range) of the flow site. It is used to provide data for Doppler sonograms and color flow images. The best resolution of the sonogram occurs when the B-mode image and color image are frozen, allowing all the time to be employed for spectral Doppler (Deane, 2002).

MATERIALS AND METHODS

For the objective of providing an image acquisition system in an emergency setting of Obstetrics and Gynecology (pelvic and Lower Quadrants views for determination of intraperitoneal free fluid, fetal presentation and viability, and intrauterine space in instrumentations), a probe was designed based on three goals of isolating analog and digital signals, minimizing connector pin counts, and reducing power and cost.

Traditional probes consist of 40 to 60 crystals each attached to a pin attached to a specialized cable of minimum 2 to 3 m cable. Each crystal has piezoelectric properties. The claimed probe consists of three Doppler transducers (Summit Doppler Systems,

Figure 1. Comparisons of two types of Doppler systems, a and b.

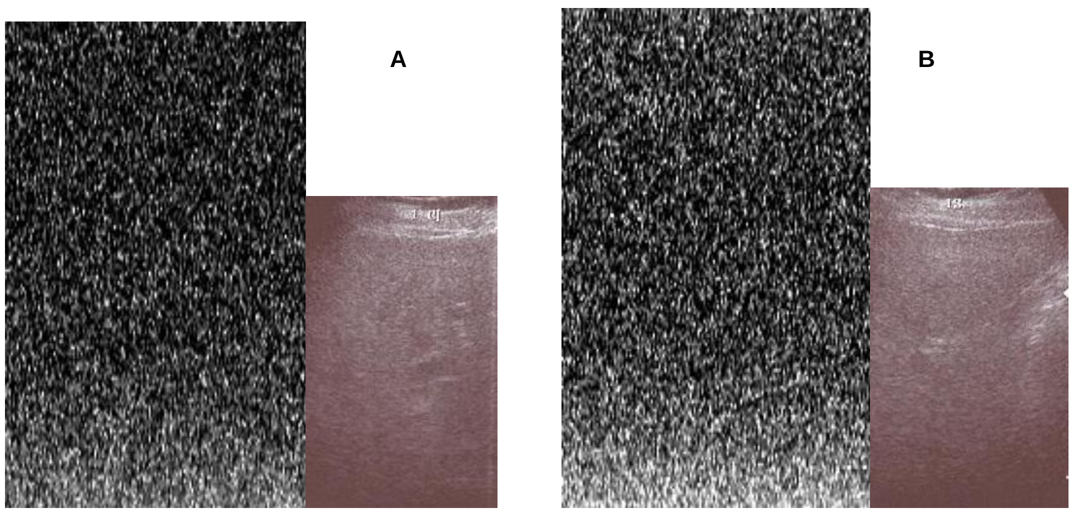

Figure 2. A) Right Upper Quadrant –Coronal view of the Invented probe and the Traditional probe; B) RUQ- Sagital view of invented probe and traditional probe.

Inc.LifeDop user manual 2011) with 4 pins each generating 4 signals that by an analog switching can generate 12000 signals per second changing the linear image into a plane. The signals are translated into WAV format that is displayed by a Windows- based program (Beskow and Sjölander, 2011) which can also provide concentrating all echoes into the central lobe. In a traditional probe of 77000 signals per second the depth of penetration is 1 cm per period of 13 µs (one-millionth of a second) (Fleischer et al., 2004). The period of the invented probe is 250 µs which gives the penetration of 19 cm but the resolution is 1/6 of the traditional probe.

The simplicity of the probe causes deeper penetration, less unwanted divergence, but at the expense of resolution. But the solution of this problem is by image modifying software with hamming properties (Anderson and MacNeill, 1999) applicable to personal computers.

To estimate the degree of fitness of images obtained from the probe with traditional image acquisition, a clinical trial was designed. Nine points on the abdomen were chosen and marked to apply the probes (I-probe and T-probe) perpendicular to the surface in coronal and sagital planes. The procedure was: taking the image by the T-probe (right angle to the skin, in coronal and then sagital view) and then by I-probe in that order. This was the rule because subject's position, bladder fullness and GI contents can alter images to a great extent. The points were in the Right Upper Quadrant (Figures 2a and b), Right Kidney region (Figures 3a and b), Right Lower Quadrant (Figures 4a and b), Left Upper Quadrant (Figures 5a and b), Left kidney region (Figures 6a and b) Left Lower Quadrant (Figures 7a and b), Heart (Figures 8a and b), Suprapubic (Figures 9a and b) and Pelvis (Figures 10a and b). Eighteen images were obtained as controls (inputs or targets) for their 18 matched images captured by the I-probe (output). Images were cropped and modified by Wavelet tool box so they can be processed in MATLAB in R2011a. Then the Neural Network was trained to calculate the average square difference between outputs and targets (MSE) and the correlation between outputs and targets based on Levenberg Marquardt Back Propagation (R). The results are presented in Table 1.

RESULTS

According to table-1, the R value obtained by tests of fitness shows that the invented probe (I-probe) images were correlated with the traditional convex probe (T-

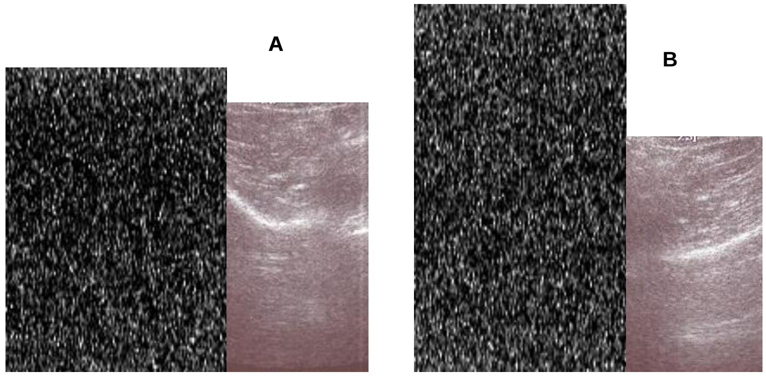

Figure 3. A) Right Kidney region- Coronal view of the Invented probe and the Traditional probe; B) Sagital view of the invented probe and the Traditional probe.

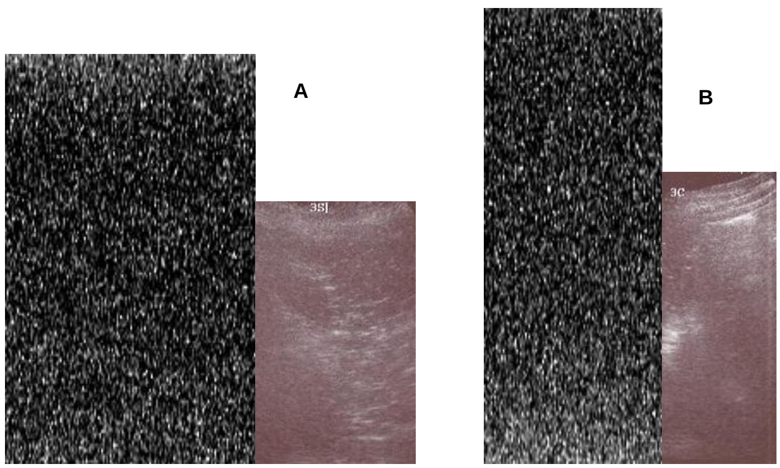

Figure 4. A) Right Lower Quadrant- Coronal view of the Invented probe and the Traditional probe; B) Right Lower Quadrant- Sagital view of the invented probe and the Traditional probe.

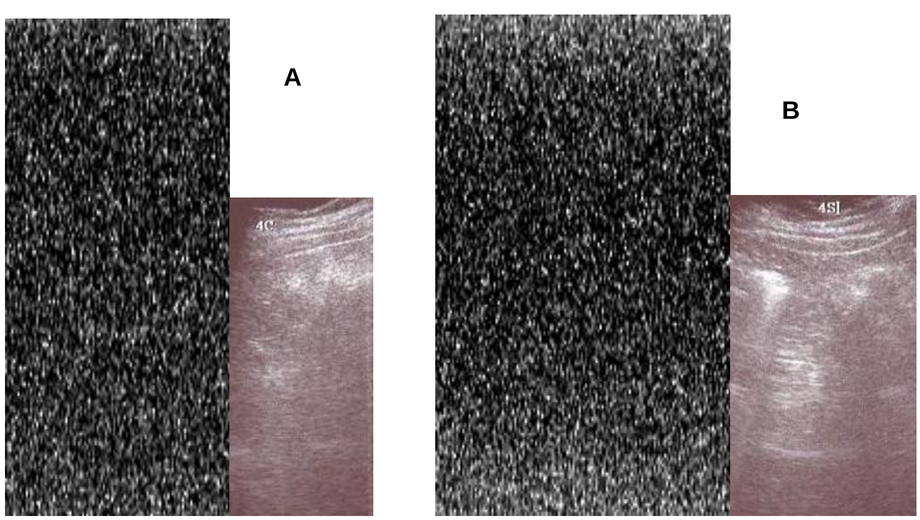

Figure 5. A) Left Upper Quadrant- Coronal view of the Invented probe and the Traditional probe; B) Sagital view of the invented probe and the Traditional probe.

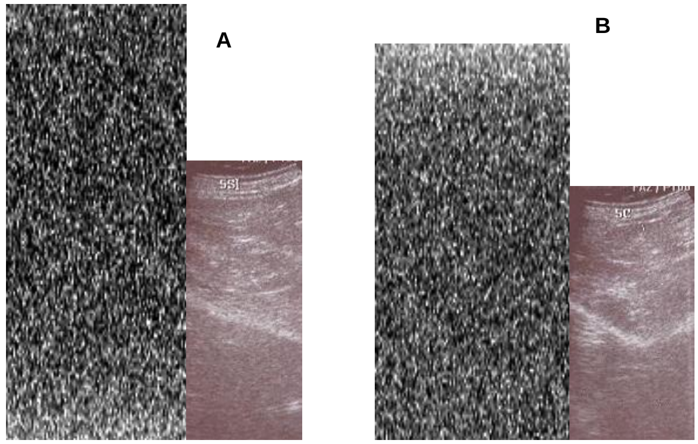

Figure 6. A) Left kidney region- Coronal view of the Invented probe and the Traditional probe; B) Sagital view of the invented probe and the Traditional probe.

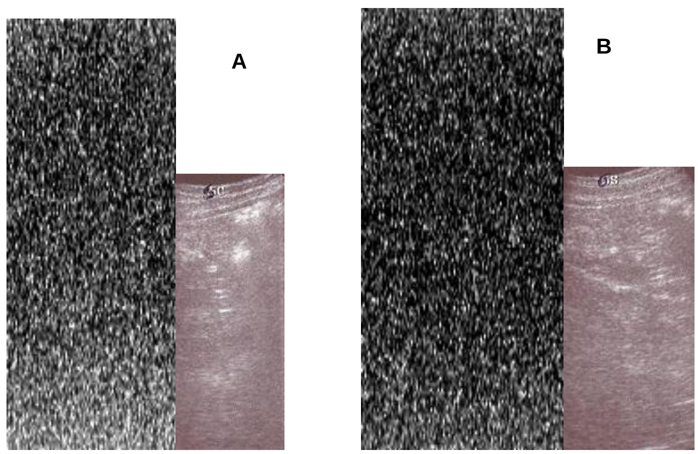

Figure 7. A) Left Lower Qualdrant - Coronal view of the Invented probe and the Traditional probe; B) Sagital view of the invented probe and the traditional probe.

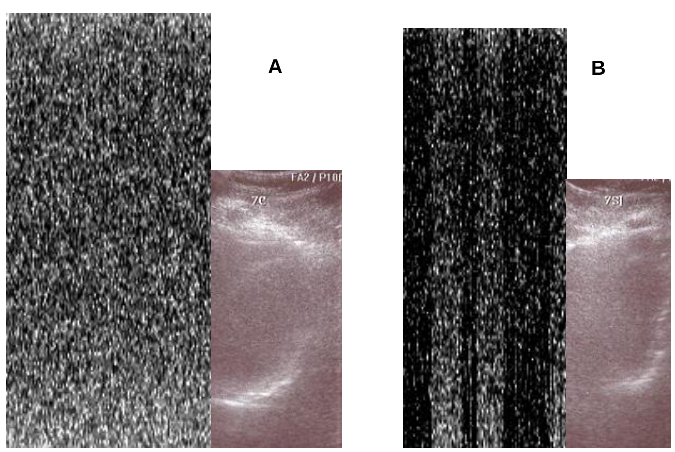

Figure 8. A) Heart- Coronal view of the invented probe and the Traditional probe; B) : Heart- Sagital view of the invented probe and the Traditional probe.

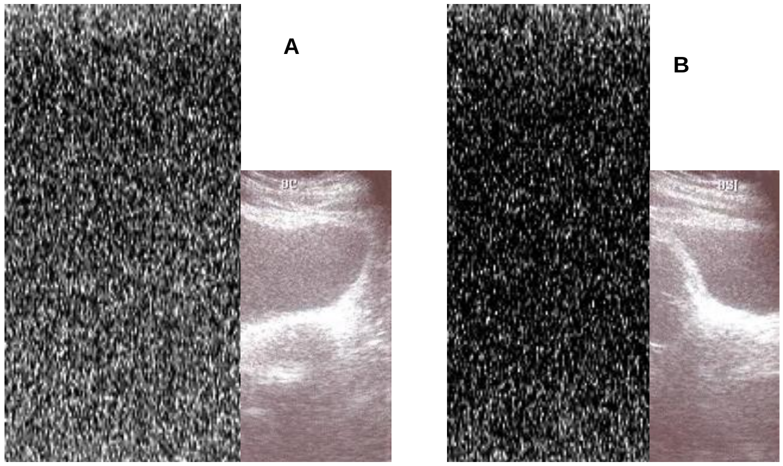

Figure 9. A) Suprapubic - Coronal view of the invented probe and the traditional probe; B) Sagital view of the invented probe and the traditional probe.

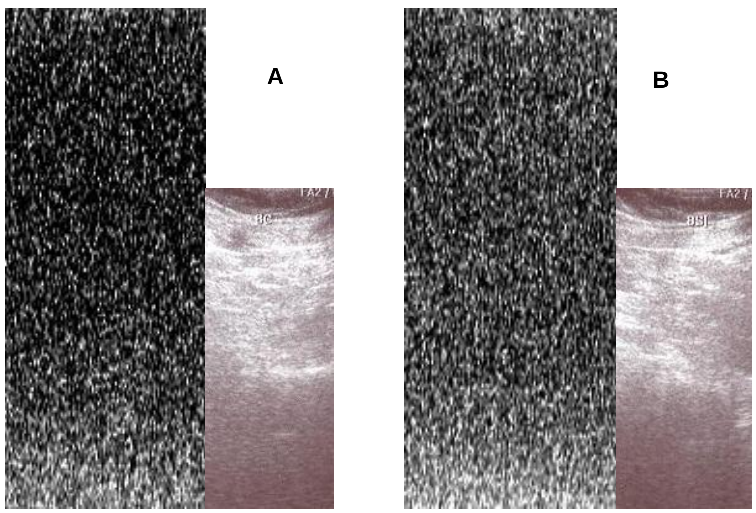

Figure 10. A) Pelvis- Coronal view of the invented probe and the traditional probe; B) Sagital view of the invented probe and the traditional probe.

probe) images. The R values in the order from higher to lower was from Right Upper Quadrant (coronal view = 8.59) (sagital = 8.44),Pelvis (c = 8.81, s = 8.76), Right Kidney (c = 7.55, s = 4.17), Left Upper Quadrant (c = 7.54, s = 7.74), Right Lower Quadrant (c = 7.52,s = 5.48), Left Kidney (c = 7.27, s = 6.00), Left Lower Quadrant (c = 5.42, s = 5.11), Suprapubic (c = 4.90, s = 5.89), and the heart (c = 4.36, s = 6.75). This means that the I-probe can be used for its objective of utility in emergency settings of obstetrics and gynecology (Pelvic and lower quadrants views for determination of intra abdominal free fluid, fetal presentation and viability, and intrauterine space in instrumentations). By training the network, the resolution of images can be improved further based on the formula:

Output = 0.77*target + 38 (Figure 11). In order to test the network, an image taken by the I-probe was given to the network and it provided the image based on its training.

Conclusions

To achieve three goals of isolating analog and digital signals, minimizing connector pin counts, and reducing power and cost, three Doppler transducers each having 4 pins (generating 4 signals) were connected to an analog switching to generate 12000 signals per second changing

Table 1. Results of test of fitness of I-probe images with T-probe images.

Site	Plane	Training MSE	Training R
RUQ	Coronal	134.22	8.59
	Sagital	154.34	8.44
RLQ	Coronal	324.39	7.52
	Sagital	513.29	5.48
Right Kidney	Coronal	242.83	7.55
	Sagital	187.01	4.17
LUQ	Coronal	392.69	7.54
	Sagital	347.81	7.74
LLQ	Coronal	488.60	5.42
	Sagital	460.75	5.11
Left Kidney	Coronal	274.33	7.27
	Sagital	292.74	6.00
Heart	Coronal	637.00	4.36
	Sagital	429.39	6.75
suprapubic	Coronal	1215.64	4.90
	Sagital	1159.07	5.89
Pelvis	Coronal	501.18	8.81
	Sagital	487.92	8.76

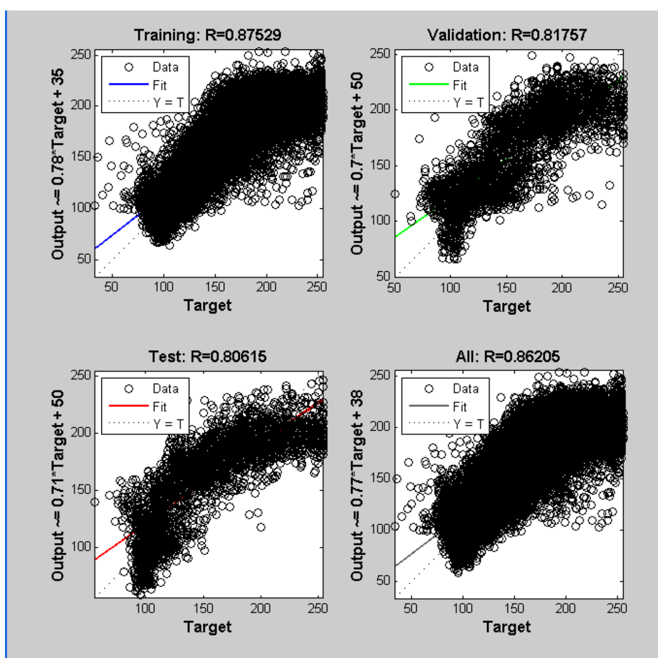

Figure 11. Fitness of Images captured by the invented probe with Images captured by the traditional probe.

the linear images into a plane. The signals are translated into WAV format displayed by a Windows- based program could provide images 1/6 resolution of a traditional probe, with 19 cm depth penetration, 1/34 price and weight of a traditional ultrasound equipment.

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