Abstract

The rapid outbreak of Diabetes is now considered to be a pandemic disease. There is no such permanent cure for diabetes as of now, but continuous monitoring of blood glucose can control it. Currently, available blood glucose meters are invasive, painful, costly and unable to perform repeated measurements. Painless, sample-free, low-cost, continuous, and non-invasive blood glucose measurement is the possible way out to combat this unrelenting disease. Photoacoustic Spectroscopy is selected for investigation, which involves excitation of the tissue media by intense optical radiation, whose absorption by the glucose molecule is followed by heat release due to non-radiative relaxation. The heat released causes thermoelastic expansion of the medium leading to the generation of a pressure wave which is proportional to the amount of optical absorption by the concentration of glucose molecule. This dissertation proposes a low cost reconfigurable embedded back-end architecture for high-speed data acquisition, noise cleaning and real-time display for a photoacoustic (PA) based continuous Non-invasive Blood Glucose Measurement (NBGM) system to combat deadly Diabetes. The signal to noise ratio (SNR) improvement of repeated photoacoustic waveforms is accomplished by the coherent averaging with trigger unit added as intellectual property (IP) core to the embedded back-end. The maximum sampling speed of the analog to digital converter (ADC) AD9265 interfaced with the embedded system is 125 MSPS which supports digitization of the signal in real-time. The architecture for embedded back-end has been implemented using XC2VP-30-7FF896VIRTEX-II PRO device, and the result of the proposed architecture is displayed on LCD in real-time.

Prediction of blood glucose from the turbid blood in the human body is a challenging task to perform. To make the system more robust, a futuristic PA imaging system is being developed which can be used for better diagnosis. PA imaging is also suitable for detecting endogenous chromophores such as hemoglobin, lipid, and melanin. The generated image using PA technique suffers a lot from impulse noise. A Real Time Impulse Noise Removal (RTINR) algorithm and its hardware architecture are proposed for denoising of PA images corrupted with fixed valued impulse noise. In the proposed RTINR, the corrupted pixel is first detected and restored to either the median or previous pixel value depending on the number of corrupted pixel in the current processing window throughout the image. The hardware complexity of RTINR is significantly lower as it requires 21 comparators, 4 adders, and 2 memory line buffers which, in turn, improve execution time. MATLAB simulation of RTINR algorithm results in better visual quality and superior quantitative performance in comparison to different denoising schemes based on the following *parameters: PSNR, IEF, MSE, EKI, SSIM, and FOM evaluated using gray images of size* 512×512. *The reported maximum post place and route frequency of 360.88 MHz is achieved by hardware simulation of proposed RTINR architecture using VIRTEX7 FPGA device. Therefore, RTINR is capable of denoising images of size* 512×512 *at 686 frames per second (fps). The architecture has also been synthesized using UMC 90 nm technology where 103 mW power is consumed at a clock frequency of 100 MHz with the gate count of 2.3K (NAND2) including two memory buffers.*

Keywords: Diabetes, Photoacoustics, Pulsed Photoacoustic Spectroscopy, coherent averaging, continuous non-invasive blood glucose monitor, embedded system, photoacoustic signal, SNR, impulse noise, image denoising, image quality, PSNR, field programmable gate array.