Abstract

RESEARCH on biomedical engineering has undergone a resurgence in the last decade. Design of a *low-cost, real-time, low-power biomedical system with the facility of intelligent adaptivity for automated therapeutic purpose suitable for telemedicine applications* was the driving force of the research described in this dissertation. The key focus of this work is the subsystem design of real-time DSP/DIP units for the signal and image transformation and compression. Siliconization being a potential solution for realization of real-time processors, the DSP/DIP algorithms has been implemented on the same in this dissertation. The primary emphasis of these designs lies on fast computation rate, low-power compatibility and low hardware complexity.

The most widely used and versatile form of signal processing involves the transforms like Discrete Fourier Transform (DFT), Discrete Hartley Transform (DHT), Discrete Cosine Transform (DCT) and Discrete Sine Transform (DST). The first two transforms (DFT and DHT) are used for spectral analysis, while DCT and DST are widely used for data compression. All these transforms involve trigonometric multiplication which can be accomplished by circular vector rotation. CO-ordinate Rotation DIgital Computer (CORDIC) arithmetic unit has been used as the basic processing element for the computation of these transforms. The salient features of the design of this chip involves - (a) unified architecture for computation of DFT/DCT/DHT/DST (b) low-power compatibility (c) high throughput (d) low complexity and (e) low hardware overhead. This chip has been implemented in ASIC environment.

Apart from 1-D signal processing, the biomedical system involves immense amount of image processing. Many of the biomedical systems need to transmit moving images. This demands real-time processing to accommodate the requirements of video-conferencing. Complex discrete wavelet transform (CDWT) has been implemented on VLSI using CORDIC (circular and hyperbolic) as the basic processing element. Though, the CORDIC-based CDWT processor provides high frequency design, but for System-On-Chip (SOC) application it is area intensive. For this reason, a CSD-multiplier based CDWT processor has been designed with reduced area overhead, though at the cost of throughput.

Beside the phase-based method, presently transformation in the temporal domain is also highly appreciated in the motion picture compression and transmission. The key problem of 3-D discrete wavelet transform is the high wait time that makes it unsuitable for real-time processes. A new running 3D-DWT algorithm has been proposed in this dissertation which reduces the wait time to make it efficient enough for real-time processing. A 4-tap orthogonal Daubechies filter based architecture has been proposed for 3D-DWT with reduced computational redundancy. Another architecture has also been designed for a generic K-tap filter. The salient features of the design being high throughput rate, on-line transformation, low memory requirement and low hardware complexity.

Encoding image in transform domain is another key area of work in this dissertation. The prevalent wavelet-based coding algorithms, though, have high compression ratio, but at the cost of high computational burden. A low complexity, coding algorithm has been proposed in this dissertation. Beside that, a VLSI architecture has also been proposed for the implementation of the coding algorithm. Another major area of problem in bit-plane coding lies in the high clock requirement in data scanning from the conventional RAM. To resolve the problem a new RAM organization has been proposed which ensures faster data access.

The work presented herein is pursued with the target of designing a low-cost, real-time, low-power biomedical system, with the facility of intelligent adaptivity for automated therapeutic purpose, suitable for telemedicine applications. As a case study, however, signal and image processing for the Doppler ultrasonography system is chosen in this work. Along with the transform and coding units, image processing for analysis of biomedical images is of importance in the entire system design.

Finally, the work extends to determine arterial contour from ultrasonography images for diagnostic reasons. To address the intricacies involved with the biomedical images, a new low-complexity, inertial active contour detection has been proposed and tested on biomedical as well as on synthetic images.

The work in this dissertation is just a footstep on the long path, to be trodden. Only a few of the units for the automated patient care system has been addressed. More fields of researches are wide open for design of the dream system conceived.