Chapter 38
GPU Based Modified HYPR Technique:
A Promising Method for Low Dose Imaging

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ABSTRACT

Medical imaging has grown tremendously over the decades. The computed tomography (CT) and Magnetic resonance imaging (MRI) are considered to be most widely used imaging modalities. MRI is less harmful, but one cannot underestimate the harmful side effects of CT. A recent study reveals the fact of increasing risk of cancer as a side effect for patients undergoing repeated CT scans. Hence the design of the low dose imaging protocol is about the immense importance in the current scenario. In this paper, the authors present modified highly constrained back projection (M-HYPR) as a most promising technique to address low dose imaging. Highly constrained back projection (HYPR) being iterative in nature is computational savvy, and is one of the main reasons for being neglected by CT developers. The weight matrix module, being root cause for huge computation time is modified in this work. Considerable speed up factor is recorded, as compared original HYPR (O-HYPR) on a single thread CPU implementation. The quality of the reconstructed image in each platform has been analyzed. Recorded results upholds M-HYPR algorithm, and appreciates usage of graphical processing units (GPU) in medical imaging applications.

1. INTRODUCTION

Radiation and radiation dose reduction are problems of immense importance in medical imaging today (Ikeda et al., 2014; Araki et al., 2015a). CT is under special surveillance as it has turned out to be the single principal contributor to radiation exposure (Araki et al., 2015b). During last two decades imaging increased for nearly every imaging modality under observation. Over this period, record conveys that

USG increased by nearly 40 percent, CT two hundred percent, and MRI nearly three hundred percent. Nuclear Medicine examinations remained stable. There is a considerable increase in the total number of imaging tests and types of test with age. However the cost of radiology imaging is almost doubled over the decade in spite of greater usage of more expensive technologies. The number of patients undergoing repeated imaging also increased over a period of time. About five percent of patients underwent more than five CT tests yearly. Approximately one percent of patients had more than ten CT scans annually among patients who underwent CT.

The number of CT screenings performed in the United States alone has been recorded to be more than 60 million studies annually (IMV Medical Information Division, 2006; Mettler et al., 2008) apprehensions regarding the effects of medical radiation exposure have also increased (Lee et al., 2004). Recent record suggests that medical radiation exposure may considerably increase the risk of unfavorable radiation effects (Hall et al., 2008; Brenner et al., 2003). It is projected that $0.4 \pm 0.1\%$ of current cancers in the United States are due to CTs done in the past and that this may increase to as high as $1.75 \pm 0.25\%$ with present rates of CT usage (Brenner et al., 2004; National Institute of Environmental Health Sciences, 2007) Cumulative risks may be even elevated for certain adult patient populations, mostly for those requiring multiple or multiphase studies, as well as in obese patients requiring increased radiation dose for adequate tissue penetration (Brenner et al., 2007). The radiation dose reduction and management has become the current issue for public and technical discussion.

One possible solution to address this issue is to slightly undersample image acquisition, which results in reduced received radiation, but with improved temporal resolution. However, due to undersampling, streaking artifacts will be generated in the final image. These streaking artifacts become more prominent the larger is the undersampling (Jung et al., 2010). Next, an appropriate image reconstruction method is to be applied to the acquired data which attempts to pay off for some of the effects of the image undersampling. These methods are called a low dose imaging protocols. Mathematically, the problem of image reconstruction from incomplete projection data is an ill-posed inverse problem with significantly many solutions (Mistretta et al., 2006).

1.1. Existing Methodologies

Literature survey is being carried out in two dimensions; one looking for methodologies to execute low dose imaging techniques on the parallel computing environment, and other for various techniques reported for achieving low dose imaging.

1.1.1. Parallel Computing Environment

Three approaches are feasible to speed up the process of reconstruction, as represented in Table 1. These three approaches can be combined as they are not exclusive to each other. Improving the algorithm itself for quicker convergence rates as well as for more efficient implementation of back projection is the first approach (Wang et al., 1993; Katsevich et al., 2002; Hudson et al., 1994).

In hardware acceleration approach, to conduct the high computation modules such as forward-projection and backprojection use of graphic processing unit (GPU) is explored (Cabral et al., 1994; Mueller et al., 2000). Common arithmetic operations can be incorporated on the chip in modern GPUs. However, specially designed chips that are installed on most commercial CT scanners are exceptional. The GPU also features a completely programmable interface, and some of them enable high-level programming

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