Optimization for Breast Tomosynthesis Image Reconstruction

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Abstract

This work deals with the optimization of iterative image reconstruction algorithms using CUDA. An iterative implementation in IDL for Digital Breast Tomosynthesis (DBT) image reconstruction is partially parallelized. This method has never been attempted before for DBT. The clinical use of iterative algorithms is currently rejected since these algorithms are computationally intensive. However, they have the potential to reduce patient dose in DBT. Preliminary results showed that this implementation allowed a decrease in the reconstruction times of approximately 1.6 times, compared with the CPU implementation.

Introduction

- **Breast cancer** is the most common cancer among women.
- X-ray mammography is the current gold-standard technique for breast cancer detection, however it has some well-known limitations, which prompt the development of **Digital Breast Tomosynthesis (DBT)**, a 3D radiographic technique (Figure 1).

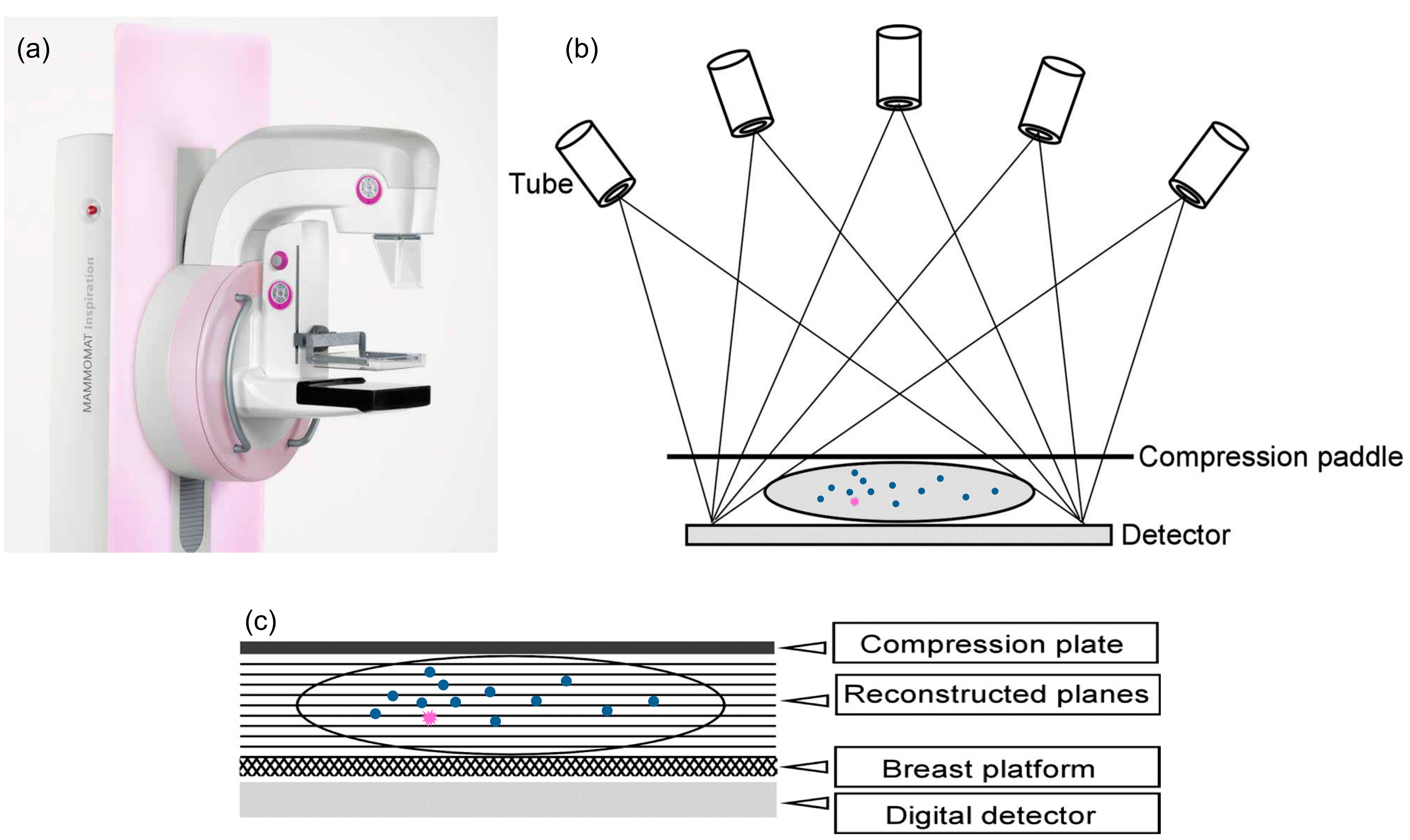


Figure 1. Basic principles of DBT. (a) Siemens MAMMOMAT Inspiration. (b) Image data (projections) are acquired from various angles as the X-ray tube moves. (c) The 3D reconstruction provides cross-sectional slices which make the pathologies (pink lesion) less likely to be obscured (in opposite to the overlap that would appear in X-ray mammography).

- The **3D reconstruction** methods need to be both **accurate** and **fast** in a clinical setting.
- **Iterative algorithms** are currently clinically rejected due to being **computationally intensive** (take too much time). However, they have the potential to **reduce patient dose** in DBT.
- This work aims to develop a **fast DBT-based image reconstruction** method that includes the implementation of iterative algorithms on **GPUs** using **CUDA**.

Materials & Methods

- **DBT system**: Siemens MAMMOMAT Inspiration, installed in Hospital da Luz, Lisbon, Portugal.
- **Interactive Data Language (IDL) implementation**: sequential implementation already developed within the research group.
- **Partially parallelized iterative algorithms**: ART, ML-EM and OS-EM.
- **CUDA Toolkit** (version 6.0): taking advantage of some functions of the **Thrust library**.
- Every iterative algorithm applied to DBT can be explained by Figure 2.

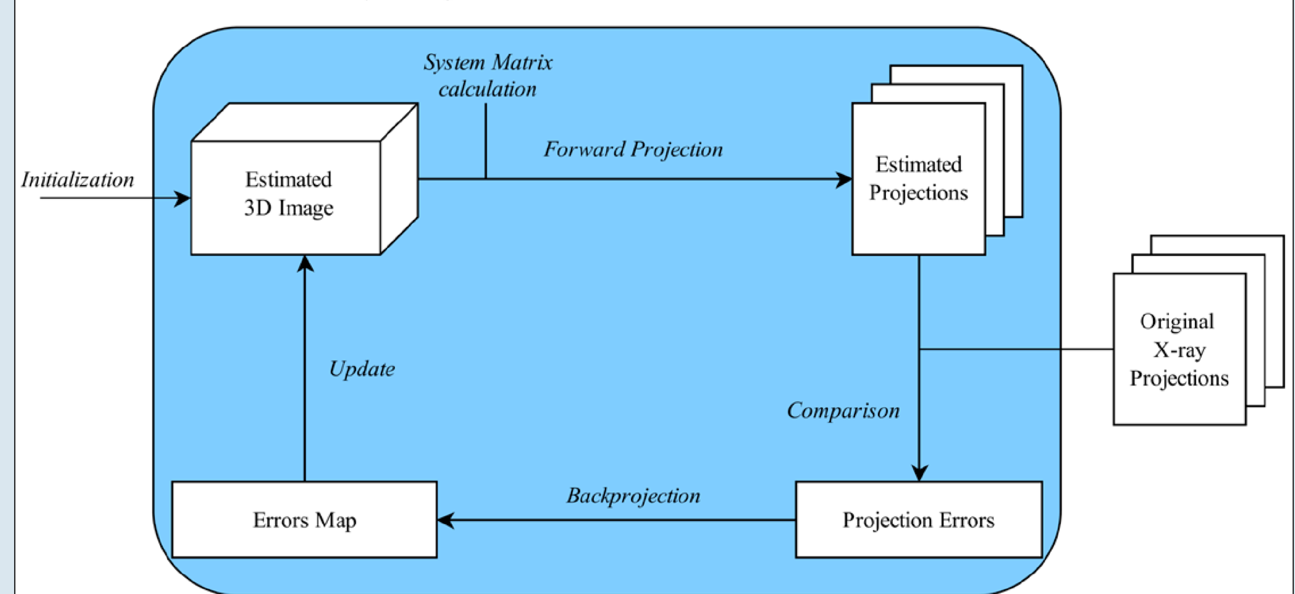


Figure 2. In both the *Forward Projection* and the *Backprojection* processes, a system matrix is used to model the radiation transmission and detection process for DBT.

- This work **paralllelizes the system matrix calculation** using a **ray driven approach**.
- A heterogeneous **CPU+GPU configuration** is proposed with an **integration of CUDA in IDL**, as shown in Figure 3.

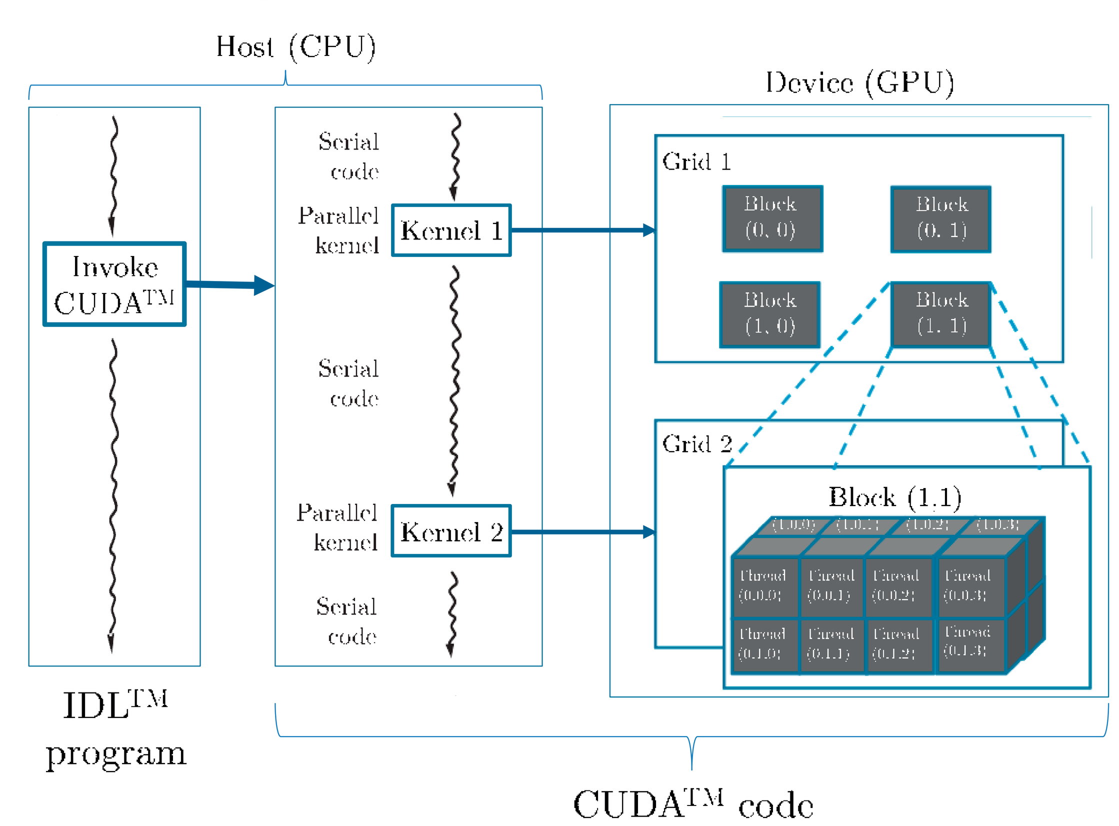


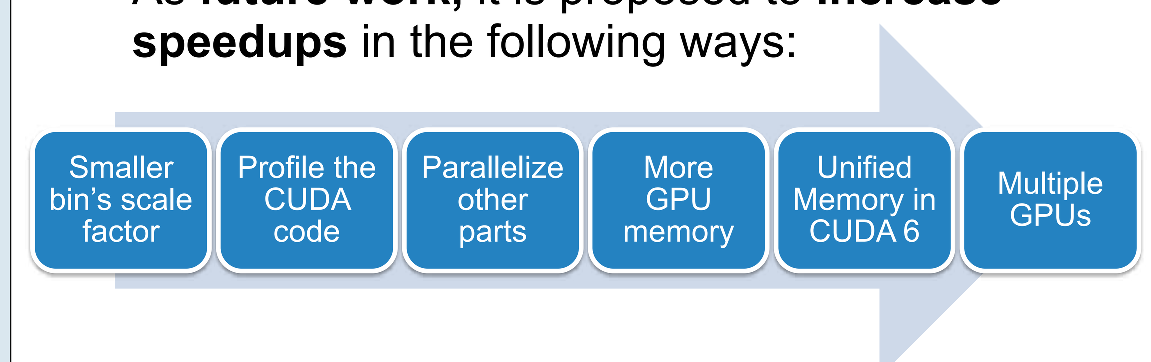
Figure 3. Methodology of the work: execution of an IDL program invoking CUDA and using a multidimensional example of a CUDA grid organization.

Results

- The **integration** of CUDA in IDL was **successfully accomplished**.
- Promising **speedups** of 1.6 were obtained when compared with the pure-IDL implementation.
- These results were obtained by **merging 16 bins of the detector** to decrease the reconstruction times.
- Without any scale factor, the speedups would be **significantly higher**.

Conclusions

- The method proposed in this work has never been attempted before. Its **advantages** include the fact that it allows:
  - an **incremental approach**;
  - the **quality of results assessment** by comparison with pure-IDL implementation.
- In this work the system matrix calculation was parallelized. Other possible parts include *Forward Projection* and *Backprojection*.
- As **future work,** it is proposed to **increase speedups** in the following ways:



- The developed implementation proved to be **computationally efficient**, allowing to reduce computation times when compared with the pure-IDL implementation.
- The obtained speedups might prompt the use of **GPUs** in a near future in **a real clinical setting**, reducing the radiation dose per exam.
- DBT machines may incorporate **embedded hardware** (powerful GPUs), producing images within a time compatible with its clinical use.
- This methodology may be **adapted to other medical imaging modalities**.

Acknowledgments

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