Fast Parallel DRR Generator

Project Management and Software Development for Medical Applications

General Info
Contact Person: Matthias Grimm
Contact Email: grimmma@in.tum.de

Project Abstract
Students should develop a parallelized implementation of a Digitally Reconstructed Radiograph (DRR) generator. The inputs should be a CT (either in Dicom or Mhd format), a Pose encoded in a 4x4 Transformation matrix and a camera matrix as well as distortion coefficients. The output should be the digital radiograph, corresponding to the inputs. The output should be an OpenCV Matrix.

The DRR generator should be parallelized to allow for fast generation. This can be done for example by using multiple threads in the ray-casting, vectorized instruction sets such as Intel AVX or GPU shenanigans. The code should be able to run on a specific workstation in our lab.

Background and Motivation

A Digitally Reconstructed Radiograph (DRR) is an X-ray, simulated from a CT. In our specific case, we want to use DRRs for intensity-based registration of X-rays to CT. This requires the generation of a lot of DRRs. In our specific case, we are performing clinical trials, and the registration happens right before the intervention, so registration speed (and hence DRR generation speed) is crucial.

When DRRs are generated, the C-arm (“The X-ray Camera”) that is simulated is assumed to follow a pinhole geometry. Then, starting from a given pose of the C-arm, each ray between the radiation source (“Pinhole of the pinhole camera”) and the detector (“Image plane of the pinhole camera”) is traversed and the attenuation is computed as a function of the Hounsfield Units in the CT.

Since this process is independent for each ray, there is a large opportunity for speed up. This is where you come in.

Figure 2. A real X-ray (left) and a corresponding DRR (right). Ignore the red rectangle ;)

Student’s Tasks Description
Students should develop a parallelized implementation of a DRR generator. The inputs should be a CT (either in Dicom or Mhd format), a Pose encoded in a 4x4 Transformation matrix and a camera matrix as well as distortion coefficients. The output should be the digital radiograph, corresponding to the inputs. The output should be an OpenCV Matrix. The DRR generator should be usable in a C++ program. The code should be able to run on a specific workstation in our lab.

Please send the completed proposal to ardit.ramadani@tum.de, zl.jiang@tum.de, jennart.bastian@tum.de and tianyu.song@tum.de. Please note that this proposal will be evaluated by the BMC coordinators and will be assigned to a student only in case of acceptance.
Technical Prerequisites

Basic knowledge of parallel programming and optimization

Basic knowledge of X-rays and CTs and ideally of DRR generation.

Familiarity with Pinhole cameras and ray-tracing.

Some prior experience in working with Ubuntu

References

I would suggest looking at existing DRR generators such as
https://github.com/SeverineHabert/DRR-renderer or
https://github.com/arcadelab/deepdrr