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3D Medical Image Reconstruction Based on PYNQ

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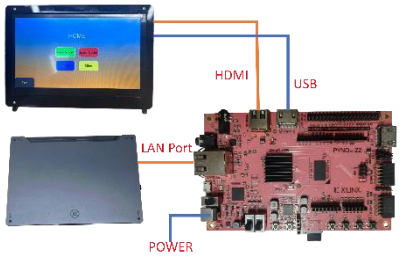
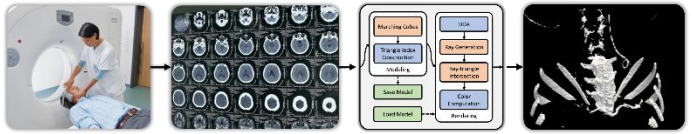


On board test by PYNQ-Z2

INTRODUCTION

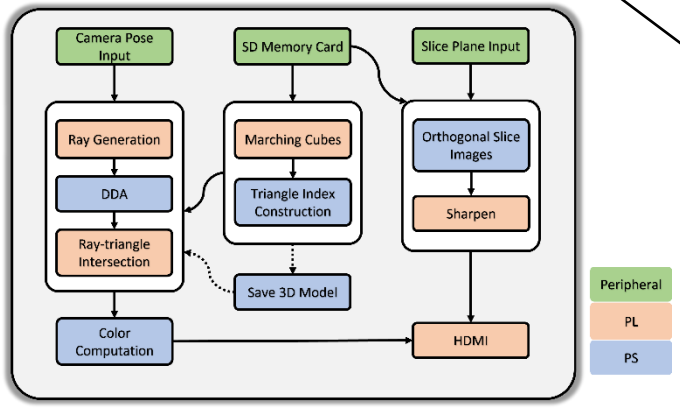
Medical imaging technology, using high-precision images obtained from devices such as CT, plays a vital role in fields like disease diagnosis.



Typical application case

However, conventional two-dimensional tomographic images struggle to comprehensively display the three-dimensional anatomical structures of the human body, making it less convenient for observing and analyzing lesions.

Key technical issues addressed:
1. Dataset Processing: Sharpening input images through convolution processing.
2. 3D Reconstruction of 2D Slices: Reconstructing 2D slice data into 3D models using the Marching Cubes algorithm.
3. Real-time Rendering: Rendering the model in real time based on the ray tracing algorithm.
4. Virtual 2D Slicing: Re-slicing the model in different directions.



System Architecture

Medical Image 3D Reconstruction:
1. Preprocess medical images on ARM core and send to PL for spatial triangulation
2. Return data to PS for 3D model construction
3. Input camera pose to PL for ray generation module.
4. Use DDA algorithm to extract the corresponding triangle for each ray
5. PL ray intersection module computes closest intersecting triangle's normal vector per ray
6. PS renders the 3D reconstruction result

Medical Image Reslicing:
1.Construct a 3D dataset from 2D CT images
2. input re-slicing direction to process longitudinal slices
3. Process sliced images on the PL sharpening module
4.Output the processed images to the display device via the HDMI interface.

CREATIVE DESING

RESULT

Our work achieves the construction of high-quality, highly flexible-viewpoint, and high-speed-rendering medical 3D models, as well as the generation of longitudinal reslicing.

Based on the PYNQ-Z2 FPGA development board, we utilize the dual-core A9 processors on the PS side, along with the PL-side image processing module, spatial triangulation module, ray generation module, and ray-triangle intersection module for 3D modeling.

The medical image acquisition and 3D reconstruction ensure the generation of 3D models that accurately reflect real anatomical structures while addressing issues such as noise, artifacts, and inter-slice misalignment.

The system integrates practical functionalities for medical image processing, including image enhancement, object detection, and segmentation. These features are efficiently implemented on the FPGA and seamlessly integrated with the 3D reconstruction and rendering modules, offering a comprehensive solution for medical image processing.