High-throughput imaging flow cytometry real-time analysis system based on time-stretch

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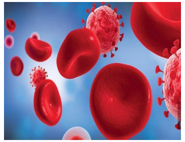
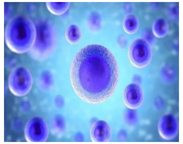
AMD XILINX

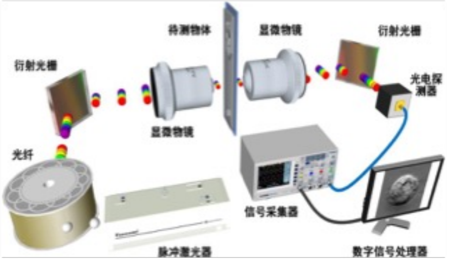
On board test by XCKU085

INTRODUCTION

The massive single-cell images, from human blood to algae, captured by **high-throughput imaging flow cytometry real-time analysis system** with optical time-stretch imaging technology, can be used for single-cell analysis, which plays a significant role in biological, medical, pharmaceutical, and green energy applications. **Optical time-stretch imaging technology** brings a continuous high-speed serial data stream, equivalent to generating up to one million frames of cell images per second. Massive data put forward strict requirements for the back-end **data acquisition and processing system**. In order to fully use time-stretch imaging technology for continuous high-throughput single-cell detection, we independently design a data acquisition, processing, and storage system.

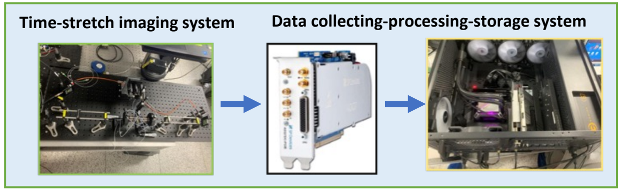






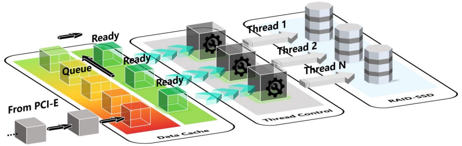
High-throughput imaging flow cytometry real-time analysis system

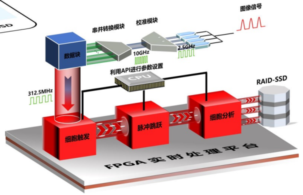
Design of the analysis system



CREATIVE DESING

The system composed by **time-stretch imaging system and data collecting-processing-storage system** and it takes FPGA as the core. The processed data is finally transmitted to the PC host through the PCI-E 3.0 X8 interface. Moreover, the **image analysis algorithm** is also applied in the FPGA, which can analyze morphological information such as size, roughness, and opacity in the cell image in real time. Both morphological information and data are transmitted to the back end for further analysis. Use FPGA to carry out real-time preliminary analysis and preprocessing of cell images, and then input pictures into the **AI model** to accelerate the whole process, which leads to 5.6GB/s data transfer rate. **Memory pools, multithreading and high-performance queues** ensure that cell data can be **stored in RAID-SSD** in real time, which increase the continuous writing speed of the data by 8 times.

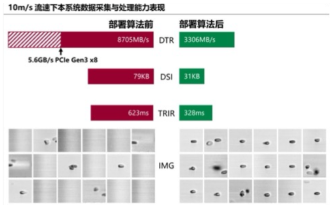




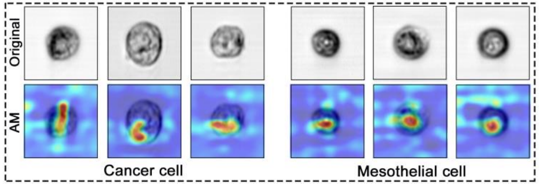
Design of FPGA board and multithreading storage system(right)

RESULT

In our experiment, we can capture up to 320,000 frames of cell images per second with a **0.78 μm spatial resolution** at the sampling rate of 10GS/s, which translates into a data transfer rate of 5625MB/s. Data transfer rate (DTR), data size per image (DSI), time of recovering image resolution (TRIR) shows great change by adding algorithm. Using CNN model to analyze detection of malignant chest and abdominal effusion cancer cells, **the accuracy of detecting malignant cells is 90.58%.**



Compare of performance of data collecting and processing



Distinguish cancer cells and mesothelial cells by the system