Aerial Image Mosaics Construction Using Heterogeneous Computing for Agricultural Applications

Leandro R. Candido
Embrapa Instrumentação
São Carlos, São Paulo 13560-970
Brazil
Email: l.candido@hotmail.com

Maximiliam Luppe
Electrical Department - EESC - USP
São Carlos, São Paulo 13566-590
Brazil
Email: maxluppe@sc.usp.br

Lúcio A. C. Jorge
Embrapa Instrumentação
São Carlos, São Paulo 13560-970
Brazil
Email: lucio.jorge@embrapa.br

***Abstract*—In agriculture, image mosaics of forest and crop areas help different applications in precision farming that need to answer quickly. This work aims to show a different idea about image mosaic construction using heterogeneous computing in order to decrease the computational cost and giving a faster answer to the farmer about his crop.**

Keywords–single board computer (SBC); ifc6540; mosaic; embedded system; sift; heterogeneous computing;

I. Introduction

Tarallo et al. [1] describe that by using mosaics in agriculture is possible to perform direct field inspections either during the growing cycle or days after the harvest, providing an accurate diagnosis of the growing area. From there, it is possible to draw recommendation maps: decompression, fertility and input application at variable rate.

The main problem for any image mosaic construction is associated with the images features. Scale Invariant Features Transform (SIFT) algorithm [2][3] is used to extract features from an image that it will be matching with features extracted form another image. This process has a higher computational effort in image mosaic construction. Heterogeneous computing can contribute to the mosaic construction by reducing the computational effort.

Advanced Micro Devices [4] defines heterogeneous computing as a system that is composed by one or more kind of processor, including Graphics Processing Units (GPU) and Field Programmable Gate Array (FPGA), besides conventional Central Processing Unit (CPU) and Digital Signal Processors (DSP). According to Kauer et al. [5], heterogeneous architecture has gained much space in the high performance computing area. This is due to the popularization of increasingly efficient graphics processors, that are every day more present in Single Board Computer (SBC). An SBC [6] is a computer where all necessary electronics components for its operation are on the same board. It is very useful in robotics applications, control system, automation and others.

This paper aims to introduce a new idea about image mosaic construction using heterogeneous computing, where SIFT algorithm will be implemented in GPU in order to reduce the computational effort. The paper is organized as follows. In Section II, it is described the Inforce 6540 SBC architecture and the Scale-Invariant Feature Transform. In Section III, the initial results are presented, and the conclusion and future works are described in Section IV.

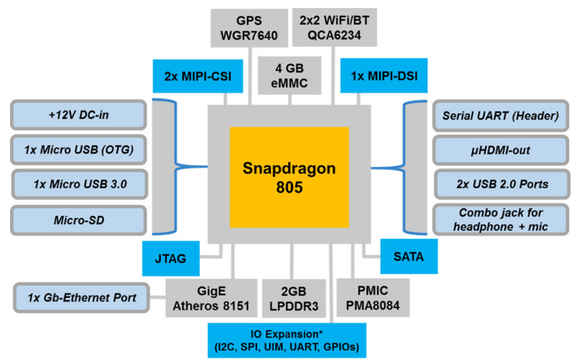

Figure 1. Inforce 6540 SBC Block Diagram

II. Material and Methods

A. Inforce 6540 SBC (IFC6540)

IFC6540 is an SBC manufactured by Inforce Computing [7]. It is based on the first commercial processor with support for 4k Ultra HD technology, the Snapdragon 805 (APQ8084).

Figure 1 shows all the electronic components that IFC6540 provides for user.

Snapdragon 805 (APQ8084) is a processor developed by Qualcomm [8] in order to work with the technology 4K Ultra HD with capture, reproduction and video output 4K on mobile devices. This chip integrates connectivity and heterogeneous computing. In heterogeneous computing encapsulated in this chip, stands out:

- Quad core Krait 450 CPU 2.7GHz per core
- Adreno 420 GPU @4.8 Pixels/second
- Hexagon DSP v50 @600MHz

Figure 2 shows the Snapdragon 805 processor and its main components.

B. Scale-invariant feature transform (SIFT)

SIFT [2][3] is a method for extracting distinctive invariant features from images that can be used to perform reliable matching between different views of an object or scene. The

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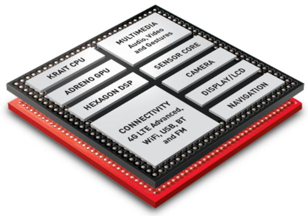

Figure 2. Snapdragon 805

features are invariant to image scale and rotation, and are shown to provide robust matching across a substantial range of affine distortion, change in 3D viewpoint, addition of noise, and change in illumination.

Lowe [2] describes four main steps used to generate the features in images. They are:

1) Scale-space extrema detection: This step aims to identify keyponts candidates that are invariant to scale and orientation. This is the most expensive process of all SIFT algorithm, because the original image is progressively blurred using Gaussian Blur and then the difference-of-Gaussian (DoG) function is applied.

2) Keypoint localization: By measuring the stability of keypoint, it is possible to determine the scale and location.

3) Orientation assignment: In this step, for each keypoint is assigned one or more orientation data based on local image gradient direction. This step aims to achieve invariance to rotation as the keypoint descriptor can be represented relative to this orientation.

4) Keypoint descriptor: Local gradients are measured around each keypoint to allow significant bright changes.

In this work, this method is used to attach different images where the keypoints are the same.

For this paper, there were two steps implemented based on Lowe's definition [2] as described early: step 1 (Scale-space extrema detection) and step 2 (Keypoint localization).

The partial implementation is shown in next section.

III. Initial Results

C++ programing language together with an open source computer vision library called OpenCV [9] were used for SIFT algorithm implementation. This library provides some ready image functions like Gaussian filter (image convolution) and others functions.

Figure 3a shows an agriculture aerial image, registered using an Unmanned Aerial Vehicle (UAV), and Figure 3b shows the partial SIFT algorithm implemented where it is possible see the keypoint candidates after execution using processor Quad core Krait 450 CPU 2.7GHz of the SBC IFC6540.

IV. Conclusion and Future Works

This work is at the beginning. The first two SIFT steps, based on Lowes definition [2], were implemented and tested on a SBC IFC6540 board. The partial results are promising and it was possible to determine the scale and location of keypoints candidates, as shown in Figure 3b.

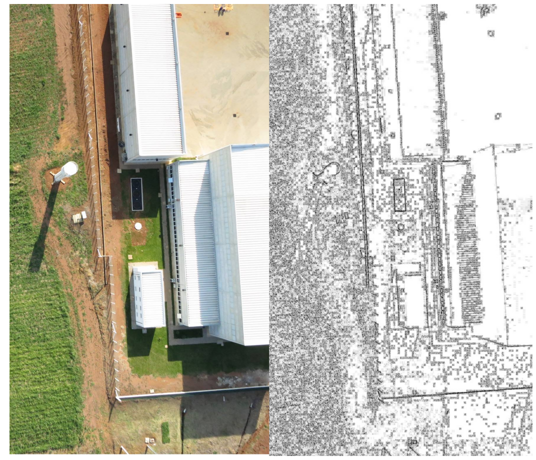

Figure 3. a) Original Image b) Keypoints Candidates.

All the steps will be implemented using the language OpenCL [10] to explore heterogeneous computing, transferring some functions to be processed on Adreno 420 GPU. The algorithm will also be optimized to improve performance, since the SIFT has higher computational cost in image mosaic construction, making it possible to obtain mosaic images on the fly.

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