Creating a Methodology to Elaborate High-Resolution Digital Outcrop for Virtual Reality Models with Hyperspectral and LIDAR Data

Douglas B. de Castro(✉) and Diego Fernando Ducart

Universidade Estadual de Campinas (UNICAMP), Campinas, São Paulo, Brazil
castrodouglasdev@gmail.com

Abstract. Outcrops are essential for geological interpretation on the surface, with the advancement of technology, outcrops can also be studied in the office through three-dimensional outcrop models. Photogrammetry and laser scanning techniques allow the creation of a three-dimensional digital outcrop model (DOM) for out-of-field analysis. Virtual reality technology is a human-computer interface that allows direct user interaction with a virtual environment. In geosciences, virtual reality (VR) is currently widely used to overcome difficulties encountered in the field, the quality of the analysis increases by allowing the collection of a greater number of qualitative and quantitative data in the office. The combination of DOM and RV is used in geosciences to make data extraction more accurate and intuitive for the geologist, but photogrammetry and LIDAR data can reach millions of points and present an excessive density for processing when collected on large scales by airborne platforms. Although some areas of science such as engineering have techniques for optimizing 3D models, geosciences do not yet have an optimization protocol that allows integration between DOM and VR without loss of relevant resolution aspects for geological interpretation. Given the present scenario, the proposal of this project is to develop a valid and replicable method for creating and optimizing a high-resolution three-dimensional outcrop model, using LIDAR and hyperspectral readings of the mining front of the Au Córrego do Sítio deposit as a database.

Keywords: geotechnology · geoprocessing · scan data · geo interpretation · digital interpretation

1 Introduction

Outcrops are bodies of rock that are exposed on the surface by natural events on the planet or anthropological events. Outcrops in general are a way of visualizing and interpreting surface and subsurface geology [1]. Collecting quantitative information in three dimensions (3D) in the field is a fundamental requirement in many geological, structural, stratigraphic, sedimentological, geomorphological, and geotechnical studies [2].

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Rock exposures can be represented by 3D digital models generated from photogrammetric or laser scanning methods [3]. These models are known as Digital Outcropping Models or DOM [4]. The spatial analysis process can be carried out from measurements in the same field or from DOM in an office [5].

DOM has become much more accessible and used in modern geosciences [6]. Although it does not replace geological field activities, DOM is a powerful additional tool for geosciences. The possibility of "bringing" the outcrop to the laboratory allows a great optimization of time and money, in addition to allowing more complex analyses to be carried out with a greater level of detail [7].

Many areas of geosciences have adopted the use of the digital outcrop model [5]. In the hydrocarbon industry, it is used to provide a qualitative check that validates reservoir models [8]. The field of use of Digital Models has also expanded to geological mapping, with the aim of defining patterns of lithological, mineralogical and chemical alteration characteristics [2]. Collecting data from three-dimensional models allows measurements to be carried out remotely in the office.

DOMs can be generated from photogrammetric or laser scanning (LIDAR - Light Detection and Ranging) methods [4]. When DOM is fused with hyperspectral images collected from the same outcrop, the result can help with lithological and mineral mapping. Hartzell [9] combined hyperspectral reading data with models generated via LIDAR, thus being able to identify different lithologies after orthogonally projecting hyperspectral images onto the digital outcrop model.

DOMs can be analyzed and interpreted with the support of Virtual Reality (VR) tools. Digital files generated by these methods may have sizes that are unfeasible for processing in virtual reality, overloading computers when placed on viewing platforms for data collection [6]. However, in the construction area, some mesh optimization techniques are used to reduce the need for processing the 3D model [10].

According to Chen [10], 3D models generated from point clouds can be optimized through different reconstruction techniques. Although there are appropriate proposals for digital model optimization processes, none have yet been applied and validated for digital outcrop models. This project aims to test and validate different methods of creating an optimized DOM for geological studies through virtual reality, preserving precision for its application within geosciences. For this, hyperspectral and LIDAR data already collected on a mining front of the Au Córrego do Sítio deposit will be used. The Córrego do Sítio Gold Deposit is situated in the eastern region of the Brumal district, within the municipality of Santa Bárbara, Minas Gerais, Brazil.

2 General Results

2.1 Main Results

This project's general objective is to create and test a valid and replicable method for creating and optimizing digital outcrop models. The method must allow the extraction of qualitative and quantitative geological information with precision and high resolution from virtual reality.

2.2 Specific Results

Between the specific objectives, we can find the creation of hyperspectral and LIDAR data processing with interactive protocols between hyperspectral data. The test of different mesh optimization methods on the DOM, so that the model becomes lighter and still has a level of detail and accuracy sufficient for data collection through virtual reality. The data must be validated in optimized models within virtual reality with field data. Using C++ mesh programming we expect to train a GPU code so that the optimization process can be done in an automated manner.

3 Methods

The methods used for data processing are parallel processing techniques such as MPI, CUDA, and OpenMP. The model used will be the SIMT (Single Instruction Multiple Threads) type, where SM (Stream Multiprocessors) is used to share memory. In the memory sharing model envisaged, the CPU and RAM store variables and code. RAM memory is slow compared to the CPU and creates the need for cache memory.

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