Quantitative Microscopy Applied to Cytology and Material Microstructure

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Abstract

This paper introduces the project SQOPE: Software in Quantitative OPtical and Electron microscopy, which aims to establish a collaborative group of researchers in the development of a computer framework to process and analyze microscopic images. The main requirements are the ability to deal with images from different microscopes, customization facilities and two execution modes: sequential and parallel. The parallel version will be available through the Internet, by means of a service portal. This tool will permit computer-aided identification of pathologies in medical images, even so we intend to extend it to other sectors of technical-scientific research. The commercial potential of this software attracted the company Associated Scientists to intervene in the project.

1. Introduction

The developments of the past decades have offered new mechanisms for examining biological and material samples using quantitative microscopy [6]. Chemistry and hardware technology to acquire medical information provide opportunities for developing more sophisticated image processing and analysis tools to report exam results. Thus, more attention should be payed in creating softwares with some flexibility to deal with the huge variability of microscopy images. Most of the companies offer their own software packages dedicated to specific microscopes, a worth strategy to them, but not to the end-user. Microscope users also need customized softwares to automate their repetitive routines, according to their specific requirements.

Microscope users lack computer tools that ally flexibility both to customize routines and to process images from different microscopes. A group of researchers from North to South Brazil, including foreign institutions, proposed the development of a vanguard project in quantitative microscopy. It involves a framework implementation with available components to assemble specific computer applications, delivered under Lesser General Public License (LGPL) and developed in Java. In addition to these facilities, we want to use parallel processing [5] to speed up measurement routines. The framework development will focus on medical image and material microstructure processing and analysis. The project involves software engineering and computational configuration of grid (portal service provider) adapted to schedule tasks for parallelizing microscopical picture processing, as well as the extraction of measurements.

Dr. d'Ornellas and Dr. Ushizima have recently approved individual proposals to deal with quantitative microscopy, one supported by CNPq-CT-Info (2004), in Federal University of Santa Maria and other supported by FAPESP, Young Researcher (2005), in Catholic University of Santos. Their collaboration can synergically carry out integration of image processing and recognition algorithms for mutual benefit. In addition, Associated Scientists [1] is a company involved in Scope project, interested in exploring web portal technologies for processing experiments using a high performance computing infrastructure, as well as customization services and/or training. The collaboration of this company is strategically important for its experience in software business.

2. Material and methods

This multidisciplinary research involves basically Biology, Material Science and Computer Science. The following sections will describe each area according to the adopted approach in the current project.

2.1. Biology

Aiming to contribute to Health sector, digital micrographies will be processed and analysed from (i) optical microscopy: pathology characterization to aid leukemia and buccal cancer diagnosis and (ii) transmission electron microscopy (TEM) image processing to reconstruct viral structure. Beyond the image acquisition, the collaboration with pathologists is mandatory to create meaningful tools to the users, so they can actually interpret microscopic exams faster and more accurately.

2.2. Material Science

The idea is to research material microstructure in such a way it takes advantage of the implemented tools to analyze microscopical medical images. Measurements such as porosity, granularity, amongst others are involved in the quality control process of finished products. Particularly, the steel corrosion automated inspection to infer the material resistance would allow more precise quantitative evaluations regarding the samples.

2.3. Computer Science

This project encloses Software Engineering, focusing on Computer Vision, Parallel Processing and High Performance Computing areas.

We intend to extend human perception in diagnosis, offering a framework to deal with digital micrographies. The main activities can be summarized as follows: (i) to implement algorithms to process, segment and analyze images, applied to quantitative microscopy [3], ranging from basic operations to filtering, segmentation, feature extraction, mathematical morphology and calibration tools for multiscale approach (variable magnification); (ii) to use techniques of software engineering, allowing reusable routines; (iii) to offer computational tools for the pathology sector and metallurgy, improving the qualification of processes and products, combining computer vision to the efficiency of the parallel processing [4]; (iv) to evaluate the benefits of parallel processing for quantitative microscopy applications; (v) to spread new technologies over areas as Health (e.g. Medicine, Dentistry, Pharmacy, Biomedical Engineering, etc.) as an element of differentiation and competitiveness in the market; (vi) to intensify partnerships and integration among national and international institutions and Brazilian companies.

The technical difficulties of the proposed framework are also the challenging features. We propose to design a system which deals with variability to process images from different microscopes, incorporating parallel processing to reduce computing time in batch routines. Several drawbacks must be taken into account related to the microscope (illumination, magnification, staining protocol and qualilty, slide preparation, specimen, etc.) and the camera (sensitivity, resolution, thermal noise, exposure time, color depth, etc.).

A differential characteristic of Scope is the usage of idle computational resources (PCs, servers, workstations, etc.) to run applications [2] in quantitative microscopy. One can probably increase the throughput for some routines in image processing and feature extraction since many more computational resources are available, mainly considering experiments with a batch of samples. The computational resources can belong to an institution, multiple institutions and/or isolated collaborators, who want to donate idle time of their computers. The grid computing idea will permit access virtualization to complex computational infrastructures to execute quantitative microscopy applications: one of the biggest benefits is that it allows users to share resources geographically distributed and from different organizations to be accessed under controlled procedures of security.

3. Conclusions

The overall project is based on multidisciplinary efforts of research collaborators with a well-defined purpose of making a software to microscope users, with a user-friendly interface, which will allow customizations of routines and parallel processing.

The main educational institutions will donate computational time using their existent machine resources to make grid computing available to run applications of quantitative microscopy. The access control to the Grid will be implemented through Service Portals. This service will allow users/researchers who do not possess computational infrastructure for parallel processing to use remote computational resources in an easy and cheap way.

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