TRIOS - an open source toolbox for training image operators from samples

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***Abstract*—Image processing is a valuable tool in many areas, including medical image analysis, document processing and bioinformatics. However, designing good image operators requires deep knowledge in both image processing and the area of application, and the designed operator might not be the best possible. Automatic training of image operators allows people with little knowledge in Image Processing to design good (sometimes optimal) image operators by providing pairs of images that contains examples of the input and the output of the desired operator. However, to the best of our knowledge, there is no toolbox that makes the design of such image operators an easier task for non-specialists. In this work, we present TRIOS, an in development research toolbox that contains algorithms to train morphological image operators from samples in an easy and unobtrusive way.**

***Keywords*-Mathematical morphology; Image Operators; Supervised learning; Toolbox**

I. Introduction

Digital image processing (DIP) provides methods and algorithms that help to solve many complex problems, from document processing [1] to medical image analysis [2]. Mathematical Morphology [3] (MM), a subarea of DIP, approaches images as lattice points and image operators as operators between lattices. Operators in MM are generally parametrized by structuring elements (a subset of the image domain) that probe the image locally to analyse the image structure [4]. Complex image analysis problems can be solved by combining basic morphological operators into more complex ones. However, selecting adequate structuring elements and the correct workflow of operators requires experience in DIP and some degree of trial and error.

An alternative approach is to provide a set of samples of the expected input and the respective desired output and to estimate an operator that minimizes an error function. Dougherty [5] describes a procedure to automatically build morphological operators based on the canonical decomposition [6]. Other works [7], [8], [9] improve and extend that approach.

Open source implementations of several MM operators can be found but no implemention of a system to automatically design image operators can be found so far.

Contributions: This work presents TRIOS, an in development open source toolbox to researchers in DIP and Machine Learning that will allow nonspecialists in DIP to build complex image operators from pairs of input and respective ideal output samples of the desired operator. The toolbox contains TRIOSlib, a library of machine learning algorithms designed to automatically build image operators, and TRIOS-auto, an easy to use GUI tool that makes the building process easier to nonprogrammers.

Organization: The rest of this paper is organized as follows. In Section II the toolbox's structure is described. Section III gives an overview of the GUI tool to build image operators. Section IV gives an overview of the library that supports the toolbox and Section V discusses future works.

II. TRIOS - training image operators from samples

TRIOS[10] is an open source toolbox of algorithms and tools to mitigate the design of image operators from samples. The automatic design of an image operator follows the workflow in Fig. 1.

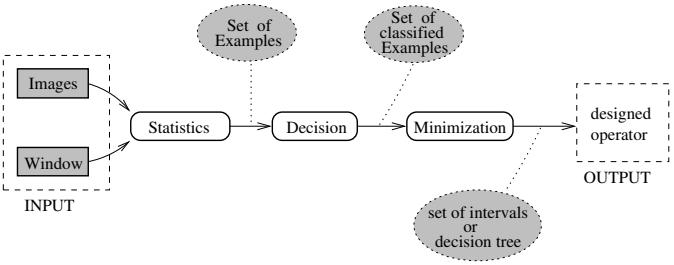

Fig. 1. Workflow of TRIOS

The process starts with the creation of an image set consisting of pairs of input-desired output images and, also, the definition of an observation window [5]. The next step, *Statistics*, probes the image set throught the observation window and builds a set of window configurations (patterns) and a histogram of output desired values. The third step, *Decision*, assigns a unique output value for every observed window configuration. Finally, *Minimization*, is a step to generalize the output to non observed window configurations and to build an efficient representation of the resulting operator. At this point, the trained operator can be saved and applied to other images at the user's will.

III. TRIOS-auto - an easy to use tool to train image operators

TRIOS-auto is a GUI tool that uses TRIOSlib to build image operators from samples. It helps nonprogrammers to build image operators in just a few steps. The user can easily select sample images, define the observation window, and fine tune the parameters of the *Decision* and *Minimization* steps. It is also possible to load an already trained operator and apply it to an image. See Fig. 2 for a screenshot of the tool.

The *Welcome* tab presents the user with tutorials and news about TRIOS. The *Project* tab loads and saves samples sets and observation windows and load pre-trained operators.

An image operator is built interacting with the main tabs: *Window*, *Samples* and *Build*.

In the first, *Window*, the user sets the size of the observation window and chooses the format of the window by clicking on the points that must not be in the window. The *Samples* tab is used to load, or create the image set by choosing images like any file manager tool. All image pairs are shown side by side and can be inspected simultaneously, i.e., the user will always look at the same regions on both images. Finally, the *Build* tab shows the available training algorithms and its parameters and lets the user start the building proccess. See Fig. 2.

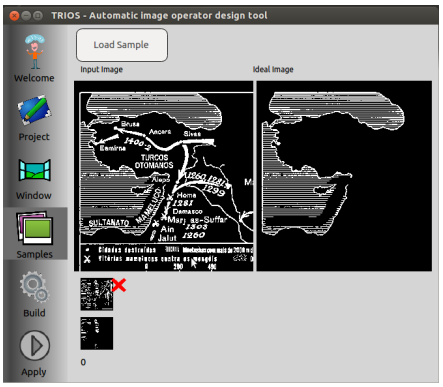

Fig. 2. Screenshot of the *Samples* tab.

A saved image operator can be applied to an image by first loading the operator from the *Project* tab and then selecting an image to be processed from the *Apply* tab. The result is shown side by side with the input image. Saving the result is also possible using the *Save* button (Fig. 3).

IV. TRIOSlib - the research library behind TRIOS

The library is implemented in C language, organized in modules of related functions and documented with Doxygen [11] (a tool to extract documentation from the source code). The minimization module is one of the main modules for researching in Machine Learning applied to DIP. It is designed to allow easy implementation and testing of new alternatives of learning algorithms. To extend the toolbox to grayscale or color images, for instance, a larger intervention is necessary.

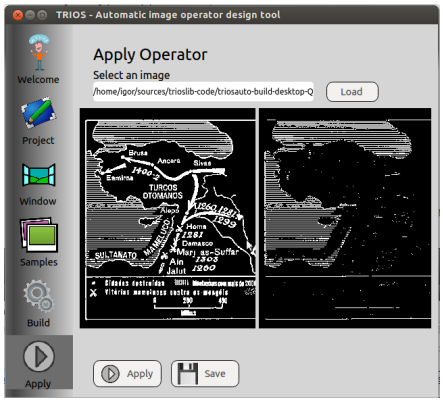

Fig. 3. Screenshot of the *Apply* tab.

V. Future Works

Currently, TRIOSlib supports only binary image operators. However it is designed to support general image types in the future. Our next goal is to include support to the design of stack filters and also grayscale image operators in the next few months. Also, the *Minimization* step is very time consuming. We would like to provide an estimative of the time needed and the ability to build the operator remotely.

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