Change Detection Toolbox in *Python* (v2)

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CONTENTS

HOW TO RUN PYTHON TOOLBOX GUI

1. Install Required Python Version and Libraries

The following libraries are required to run the GUI. Make sure all the following libraries are installed and linked with the installed Python and relevant Python interpreter.

PACKAGE	VERSION REQUIRED	SOURCE
PYTHON	3.0 or greater	https://www.python.org/
OPENCV	3.0 or greater	https://pypi.python.org/pypi/opencv-python
Numpy	-	https://pypi.python.org/pypi/numpy
PIL (Python Imaging Libarary)	-	http://www.pythonware.com/products/pil/
time	-	Python default
sys	-	Python default
Spectral Python	-	http://www.spectralpython.net/
Matplotlib	-	https://matplotlib.org/
TKInter	-	https://docs.python.org/3/library/tk.html

2. Load the following Python files into the Python interpreter

The following four files contains the algorithm codes and related functions. These are required for the running of the toolbox. The first file is the main file, which is to be run for starting the Toolbox GUI.

PYTHON FILE NAME	FUNCTIONALITY
PyCDTv2_GUI_jmcis**.py**	MAIN file for starting the GUI
PyCDTv2_Functions_jmcis**.py**	Includes functions such as read_envi_image, add_noise, etc.
PyCDTv2_Algorithms_jmcis**.py**	Includes Algorithms and related functions
PyCDTv2_GTEvaluation_jmcis**.py**	Quantitative analysis: Comparison with Ground Truth(GT)

3. INPUT MULTI-BAND IMAGES ARE READ IN ENVI FORMAT

The toolbox currently works only on multi-band images of 3 or more bands. The ENVI file format, (.IMG and .HDR) is used for input images.

- There is an option inside the toolbox to browse to a file location and select files. The first and second input images should be selected like-wise.
- Use the file explorer to browse to the folder containing the ENVI multi-band files and SELECT THE **.HDR** file (and not the .IMG file).

4. STEP BY STEP PROCEDURE TO RUN THE TOOLBOX

The following steps can be used to run the toolbox and visualize the change detection outputs.

a. Make sure all the functions in SECTION 2 are in the Running folder of your Python interpreter.
b. Check if all the required packages and libraries (in SECTION 1) are installed and working. The first few lines of the python file imports these libraries and should show no errors.
c. Run the MAIN file in SECTION 2.
d. Top left on the Input image 1 and Input Image 2 sections, click on 'Browse' and use your file explorer to select the .HDR multi-band file. Do this for Input image 1 and 2.
e. Using the third Browse button, browse the 'Ground-truth' file from the file explorer.
f. Select the required Change Detection algorithms to run by checking the individual boxes. (Selecting all algorithms takes longer to run; to check if the toolbox is working correctly, SELECT 2 algorithms (Image differencing, Image ratioing are the fastest) and run them. Any compatibility issues or missing packages/libraries can be found out in this way).
g. Tile-size is another parameter. Default is 20; selecting values of 10 – 50 in increments of 10 is advised. With the increase in tile-size, it is computationally expensive to run the algorithms.
h. Add-noise: This can be used for making the simulated images more complex by adding Gaussian noise. The SNR can be specified here. Default is zero or no noise.
i. Output Images: One of the output is the binary image where 1s represent the changes, and 0s represent no-changes. The second output images merge this *change-map* with the input images; the magenta shade shows the input image, and the green shows the *output changes*.
j. Quantitative analysis: The second-last plot shows the ROC curves of the selected run algorithms on top of each other/merged on to a single plot. The last plot lists the AUC or Area under the ROC curve as a quantitative number, derived from the ROC curve, to judge on how well the algorithm performed on the respective two input images.

Any problems with running the code or errors, please email the author with a screenshot of the error at jjm3282@rit.edu.

Thanks

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INTRODUCTION

The RIT-CD toolbox is a Python programming-language based GUI (Graphical User Interface) for the running and evaluation of various change detection algorithms from the literature, on user-defined input image pairs. Twelve different algorithms are included in this toolbox, which applies various detection criteria on the image pairs and outputs the *changes* between the target and reference images. The algorithms currently included in this toolbox are:

a. Point density tail length Estimation (PDTL)
b. Simplex-Volume Estimation/Complexity
c. Mean-shift metric
d. Outlier-distance metric
e. Graph-based NEV change detection
f. Chronochrome change detection (CC)
g. Covariance equalization (CE)
h. Principal component analysis (PCA)
i. Image differencing (ID)
j. Image rationing (IR)
k. Change vector analysis (CVA)
l. Spectral mixture analysis (SMA)

All the above algorithms are designed to operate on *multi-spectral* images with multiple bands of spectral data. The various spectral bands of the input image pairs are utilized by these algorithms to detect the changes. The running of the change detection process yields output images, output-input merged images, Receiver operating characteristics (ROC) curves, and area under the ROC curve (AUC). The ROC curves and AUCs can only be obtained if the *truth-images,* indicating the actual *changes* between the image pairs, are provided for the algorithm.

FUNCTIONALITIES

A. CURRENT

The features included the toolbox are:

Tile-size: The size of tile used by the tile-based algorithms can be defined by the user. The default is set to 20.

Add noise: Add a Gaussian noise with user-defined SNR to evaluate algorithm performances in cases of noise. It also aids to add complexity to the input images, especially in case of simulated images.

ROC & AUC: The Receiver operating characteristic (ROC) curves and area under the ROC curve (AUC) can be obtained. The user needs to select this option in the GUI window and provide the ground-truth file using the browse button in GUI. Details on the input file formats are described in the following sections.

B. FUTURE

WINDOW SELECTION: The Tile/Sliding window option determines the window selection or image division into tiles for various algorithm processing. The Tile-window option (default) would divide the images into *non-overlapping* tiles starting from the origin or (0, 0) coordinates of the image; the algorithm compares between tiles from respective pixel-coordinates of the image pairs.

The sliding-window approach, on the other hand, operates on the images using *overlapping* tile windows (with a minimum of 1-pixel overlap), where the user can define the required pixel overlap (same overlap in horizontal/vertical directions to create a square-image-tile). This feature will be added on the toolbox in the future. Currently, the default option is 'Tile-window' non-overlapping approach.

INPUT

Two types of input files are required by the algorithm, while one of them is optional:

1. Input-image pairs: The two input images, both target and reference image files should be of the ENVI file format (.img & .hdr). The input image pairs should have equal height, width, and the number of spectral bands. There is a *browse* option in the toolbox GUI to select the input image 1 and image 2 using file explorer. The input files with the '.img' extension should be selected while selecting the files.
2. Ground-truth image (optional): The ground-truth image can be an 8-bit one-band image preferably of TIFF file format. The algorithm expects only *two image classes* in this input file, with 0 representing *no-changes* and 255 representing *valid-changes*. There is an option to browse this file from the toolbox GUI. After uploading the image, the ground-truth-evaluation button (yes/no) in the GUI will automatically change to Yes. If the ground-truth evaluation is not required, no file needs to be selected. The default option is set to No.

OUTPUT

The output image with the changes marked as 255s and non-changes as 0s is written as an 8-bit single-band TIFF format to the same location of the input images.

ROC curves and AUC: The ROC curves and AUC are displayed in the GUI and are not written to an outside file. [Although writing these outputs can be added, if required].