TOLOMEO
TOoLs for Open Multi-risk assessment using Earth Observation data

WP5 - FLOV

Original FLOV Processing chain

The following figure presents the general workflow of the processing chain. This processing chain can be decomposed in 3 modules:

1. Image change detection
   - This module uses images pre- and post-event in order to produce a change detection with 2 information layers: the flooded area extent and the damaged objects (buildings, roads)
   - Flood area extraction is performed by pixel-based change detection either using statistical similarity measures or by supervised SVM classification provided by OTB. GeoAIDA contains s classification method that is based on Conditional Random Fields. CRFs consider like MRFs a neighbourhood around a pixel. In contrast to MRFs, CRFs have access to the feature vectors of neighbouring pixel. The CRF implementation in GeoAIDA has been expanded to handle multi-temporal imagery. For change detection the method has been modified to detect class changes.
   - Damaged object map will be based on:building and road extraction.
     - InterIMAGE can provide different ways for object extraction. The object extraction processes could be carried out entirely within InterIMAGE – such processes would have basically 3 steps, following the object-based paradigm: segmentation; feature/attribute extraction; and classification.
       - For the segmentation process, InterIMAGE contains currently two very robust region growing segmentation operators. Both of them have parameters that need to be adjusted to the specific characteristics of the image (spatial and spectral resolutions) and to the characteristics of the class of interest (in this case, buildings and roads). This can be done manually or in a semiautomatic, supervised way in which the user provides a shapefile with a few buildings delineated. The algorithm then proposes the best segmentation parameters for the particular

image/class. There is also segmentation operators based thresholding. Such operators support the creation of artificial image bands through band arithmetic and thresholding over the synthetic band.

- For the feature/attribute extraction, more than 65 attributes (spectral, textural, morphological and topological) can be calculated for image segments. We could force the segments to be equal to a single pixel (using the Chessboard segmentation), but we do not recommend that alternative due to its computational cost.

- Classification can be performed in InterIMAGE in a supervised way, through a decision tree classifier (C4.5). The user would need to indicate which segments are actually associated to the classes of interest. Classification could also be performed through a knowledge-based approach, that is, the user would have to define rules over the features extracted for the segments, based on prior knowledge. Such rules can be structures over fuzzy sets, and deliver class membership values that will be used to resolve eventual spatial conflicts among objects from different classes.

- BREC also provides routines for road and building extraction

  - Road extraction: It's a routine able to extract urban road network in high resolution Optical/SAR images. It is based on a novel multi-scale detection of street candidates, followed by optimization using a Markov Random Field description of the road network. Deals with image up to 4000 x 4000 pixels and 8 bit spectral resolution. Results is represented by an ASCII file listing road coordinates. It's supported by a routine able to generate a raster image starting from the ASCII file.

  - Building extraction: In BREC is possible to perform building extraction using a classification routine (for example Fuzzy Artmap) followed by a contour regularization. Since buildings do not usually have small holes in their bodies, and they are either isolated or clustered into blocks that inherit the same geometrical characteristics of the single element, this procedures can be applied to the object recognized as "buildings" in a classification map, to improve their geometrical regularity. The routine is devoted to obtain a better edge delineation and to improve building separation, filling gaps inside a building, jointly preserving details and reducing local classification errors.

- This module can be complemented by thresholding routines working on a single post-event image. These routines are available in OTB and TerraLib.

2. Data-base/image change detection

    - This module performs 2 instances of change detection between images and topographical data-bases. The 2 instances correspond to the use of images pre- and post-event. The pre-event change detection allows to build an updated version of the data-base (assuming that the pre-event imagery is more recent than the data-base). The post-event change detection focuses on the infrastructures impacted by the flood.
    - Both types of change detection are based on an extraction of roads and buildings from the images in order to build object hypotheses to be checked against the data-base (probably using the Dempster-Shafer tools available in OTB).
    - There is also the possibility of using post-classification analysis for change detection as provided by InterIMAGE.
    - BREC provides tools which could be adapted for the image to data-base change detection, as for instance the road change detector (an algorithm able to compute differences between two segments sets), the alignment routine (allows to connect segments where reasonable, based on their mutual position).

3. Flooded area prediction

    - This module is independent of EO image availability and uses a DEM for flooded area simulation (use of level curves) and possibly a data-base in order to take into account for obstacles to water flow. It will be implemented using TerraLib's Local flow extraction routines use G-GCS (Geographically Aware Graph Coupling Structure for GIS Water Flow), which is compatible with regular grids, TINs, Voronoi triangulation, and contour lines. The G-GCS should enable the extraction of local flows by means of terrain digital models, the correction of terrain digital models, the generation of graphs representing the flows network, and finally, upscaling of drainage directions, which is a process of scale refinement.

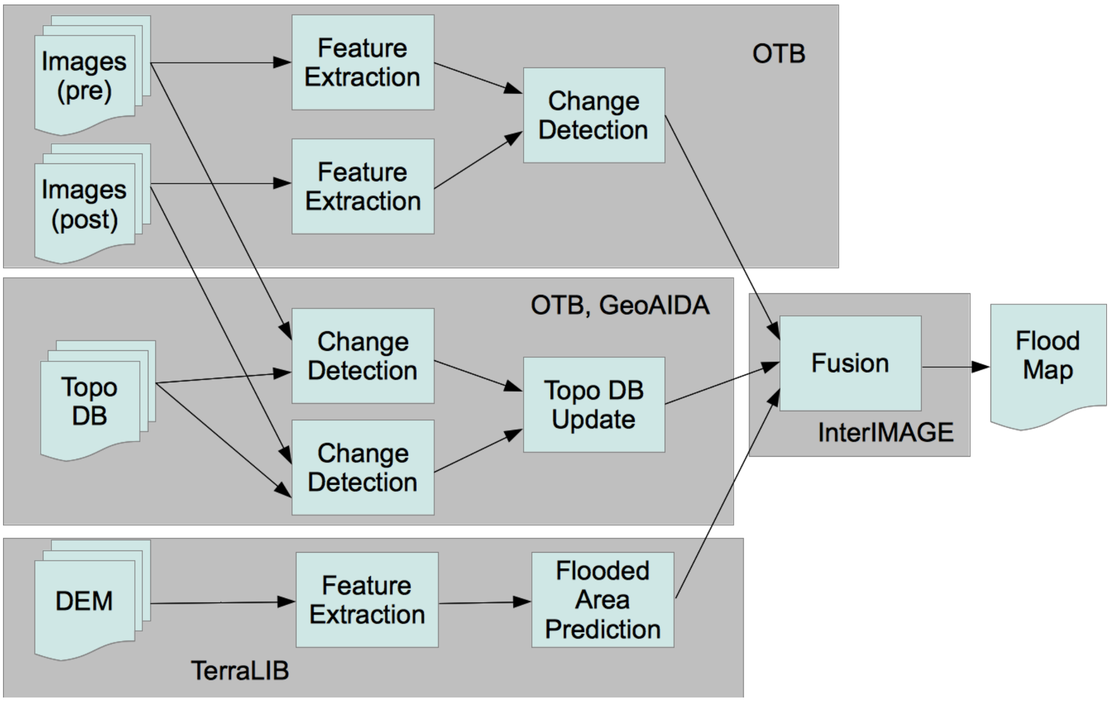
The output of these 3 modules can then be combined by a fusion module which will check for the consistency between:

1. The flood area extension detected by the image change detection and the one predicted from the DEM
2. The damage map obtained by image change detection and the one obtained using image/data-base change detection.

The fusion module produces 2 types of output: a flood extension map and a damage map. Comparison/Fusion is a basic function of InterIMAGE. The system can integrate vector and raster (labelled images) data and perform different analysis task, which would be coded/defined through a set of user defined rules, encode into knowledge models.

FLOV version 1 implementation (May 2013)

The initial design of the FLOV processing chain is illustrated in the following figure. It contains 3 processing paths: one for image change detection, one for image to database change detection and a final one for flood area extent forecasting using topographical information.



The first version of the tool provided the first processing path (image change detection) and the basic tools for the flooded area extent forecasting.

Improvements in FLOV version 2 (May 2014)

The architecture of the processing chain was achieved. The algorithms for optical to optical and SAR to SAR change detection were implemented. The basic version of the DEM thresholding method was prototyped. A parallel SVM learning algorithm was implemented. A region-growing segmentation technique able to process tiled images without artifacts has been implemented.

The integration of GeoAIDA was not performed, because of incompatibilities at the library level which make impossible to integrate it with OTB. Indeed, different versions of QT libraries used by OTB (a more recent one) and GeoAIDA (old QT v.3) would need GeoAIDA to update its dependencies, which is impossible within the scope of TOLOMEO.

This implies that the image to database change detection was not implemented.

Finally, due to cancelled secondments from PUC Rio to CNES, the fusion step using InterIMAGE was not implemented either.

Improvements in FLOV version 3 (November 2014)

We included the hydrological modeling in the risk assessment processing (work done by the secondments from INPE coming to CNES). All previous functionalities (version 2) were validated and documentation and tutorials are now available.

The evaluation of parallel segmentation algorithms was not done due to a cancelled secondment from PUC Rio to CNES.