WP2 - HUEX

Contents

1. Original HUEX Processing chain

The HUEX tool is implemented as an application of the InterIMAGE system.

The objective of the HUEX tool is to recognize human settlements from different sources of data – optical and SAR – with different resolutions.

Most of the functionality needed to fully implement the processing chain is already present in the InterIMAGE.

The processes involved in the processing chain of WP2 will vary depending on data availability. The most general processing chain is the one depicted on Figure 1, when all possible input data is available. Naturally, either optical or SAR input data is mandatory, but knowledge/interpretation models can be created as to consider different sources of input data.

The main processes/components involved in WP2 processing chain are listed below.

- Segmentation:

    Identification of homogeneous regions in the input images.

- Feature extraction:

    Creation of numerical description of primitives (pixel or segment).

- Interpretation

    Execution of a knowledge/interpretation model for the classification of the image objects (segments) defined during the segmentation process.

- Import Raster

    Import DEM data into InterIMAGE's internal raster format.

- Import Vector

    Import GIS data (*shapefiles*) into InterIMAGE's internal raster format.
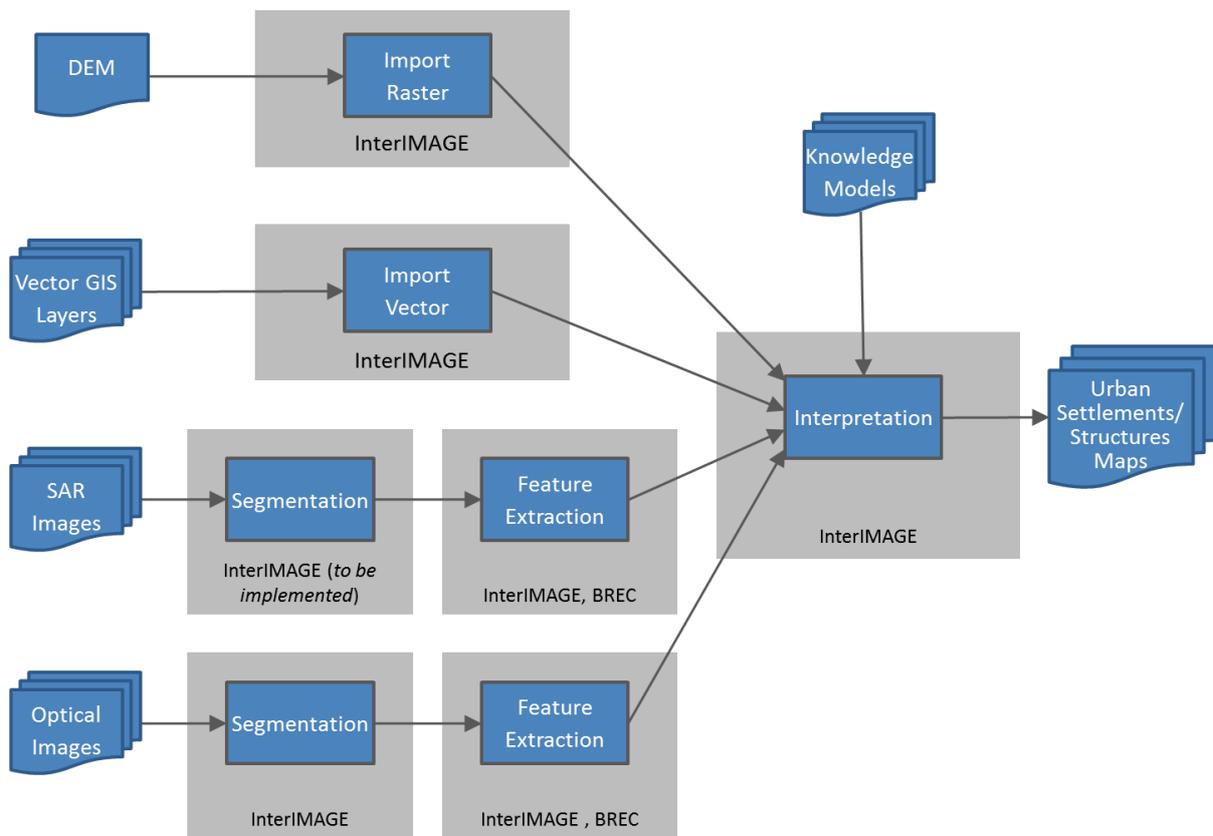
Figure 1. WP2 processing chain

2. HUEX version 1 implementation (May 2013)

2.1.   Introduction

In this framework, a method was developed to detect human settlements on Remote Sensing (RS) images. This method has the advantage to rely on a model which can be described using simple features related to the ontology of an urban area.

The next section describes the steps to follow that permit the detection of human settlements.

2.2.   Methodology

The software used for this protocol is InterIMAGE v1.36. The method that will be described permits to detect the urban area using two parameters related to the ontology of an urban area. The first parameter is the area (Square Meters) that define each agglomerate of buildings. The second parameter is the number of buildings for each agglomerate. In this protocol, the model used to describe the human settlements has an area of at least 100'000 square meters within at least 100 buildings.

The dataset used for this protocol is composed by one optical CBERS 2B High Resolution Camera (HRC) panchromatic image which has 2.5m of spatial resolution.

New Project

First of all, it is necessary to define a new project:

1) Start InterIMAGE.
2) In the toolbar click on *File/New Project*.
3) In the 'Project' section, type a name for the project then, click the *Browse Folder* icon
   🔍 and set a folder.
   NOTE: Make sure the keys, names and paths in your project don't have white spaces or non-ASCII characters, otherwise InterIMAGE won't run properly.
4) In the 'Resources' section, click the *Browse Resources* icon 🔍 and select the input image then, type 'image' as name that will identify it in *'key'*. Check the box named 'Default Image'. Once complete click the *Add* icon ➕ in 'Resource List'.
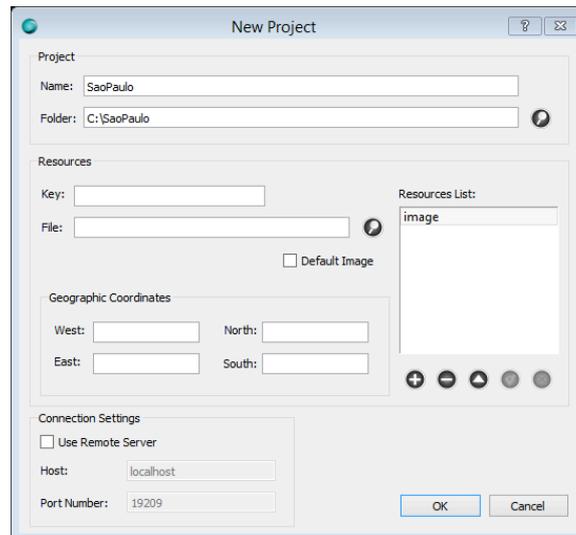
5) Click 'OK'.

Figure 2. 'New Project' window.

Define the Semantic Network – 'Urban Focus' node

Now that the project is defined, we can define the semantic network. Firstly, we set up the 'Urban Focus' (UF) node:

1) In the 'Semantic Net' window, right click on the 'Scene' brick [Scene] and select *Insert Child/Node.*

2) Select the node just created with left click.

3) In the 'Node Editor' window, type 'UF' as name for the 'Class' and select the red color on 'Color'.

4) Select the 'BREC Urban Focus' operator from the 'TopDown Operator' list.

5) In the 'TopDown' sub-section of the 'Semantic Net' section must be defined the parameter of the operator:

    a. Select 'image' as 'Input Image';

    b. Type '31' as 'Low-Pass Filter Kernel';.

    c. Type '2.5' as 'Threshold';

        NOTE: The threshold is optimized for CBERS 2B HRC data. For different sensors, a different threshold must be researched.

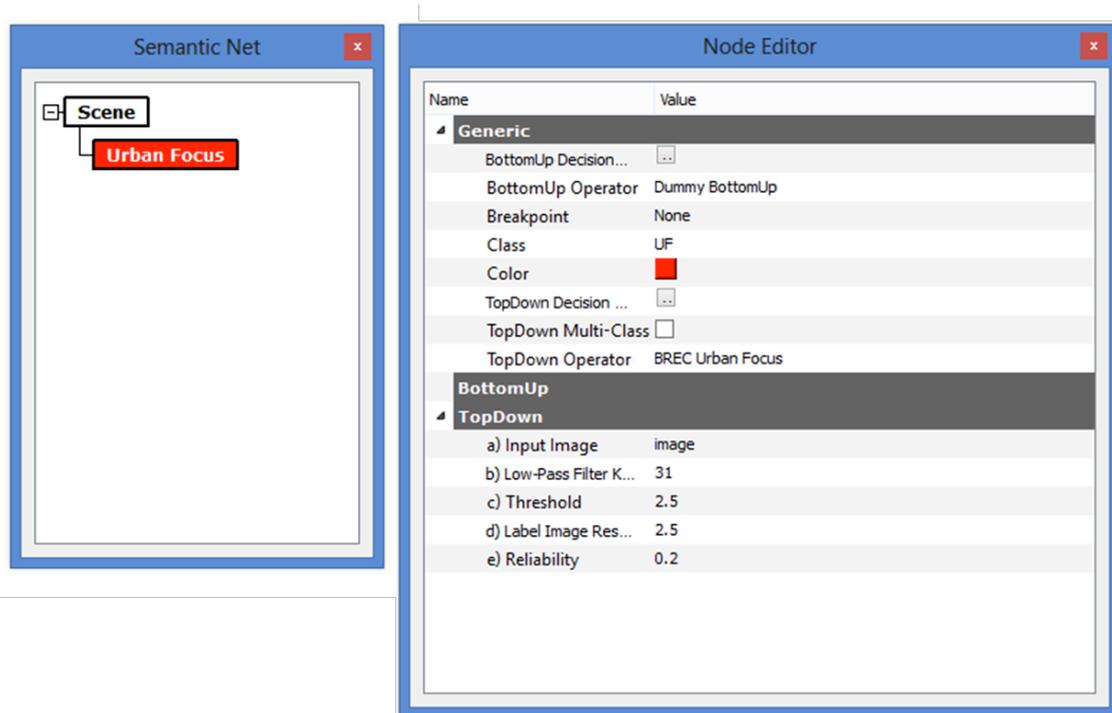   d. Type the resolution of the image in 'Label Image Resolution'.

Figure 3. Urban Focus node.

The 'Urban Focus' node exploits a per-pixel feature extraction procedure and, it is designed to detect groups of buildings and structures on panchromatic remotely sensed data.

Define the Semantic Network – 'Segmentation' node

The second node that we are going to create is the 'Segmentation' node:

1) In the 'Semantic Net' window, right click on the 'Urban Focus' brick and select *Insert Child/Node.*

2) Select the node just created with left click.

3) In the 'Node Editor' window, type 'Segmentation' as name for the 'Class' and select the blue color on 'Color'.

4) Select the 'TA_Baatz_Segmenter' operator from the 'TopDown Operator' list.

5) In the 'TopDown' sub-section of the 'Semantic Net' section must be defined the parameter of the operator:

   - Select 'image' as 'Input Image';
   - Type '0' as 'Input Bands';
   - Type '1' as 'Input Weights';

- Type '0.6' as 'Compactness Weight';
- Type '0.8' as 'Color Weight';
- Type '10' as 'Scale Parameter'.

NOTE: The parameters are optimized for CBERS 2B HRC data. For different sensors, different parameters must be researched.
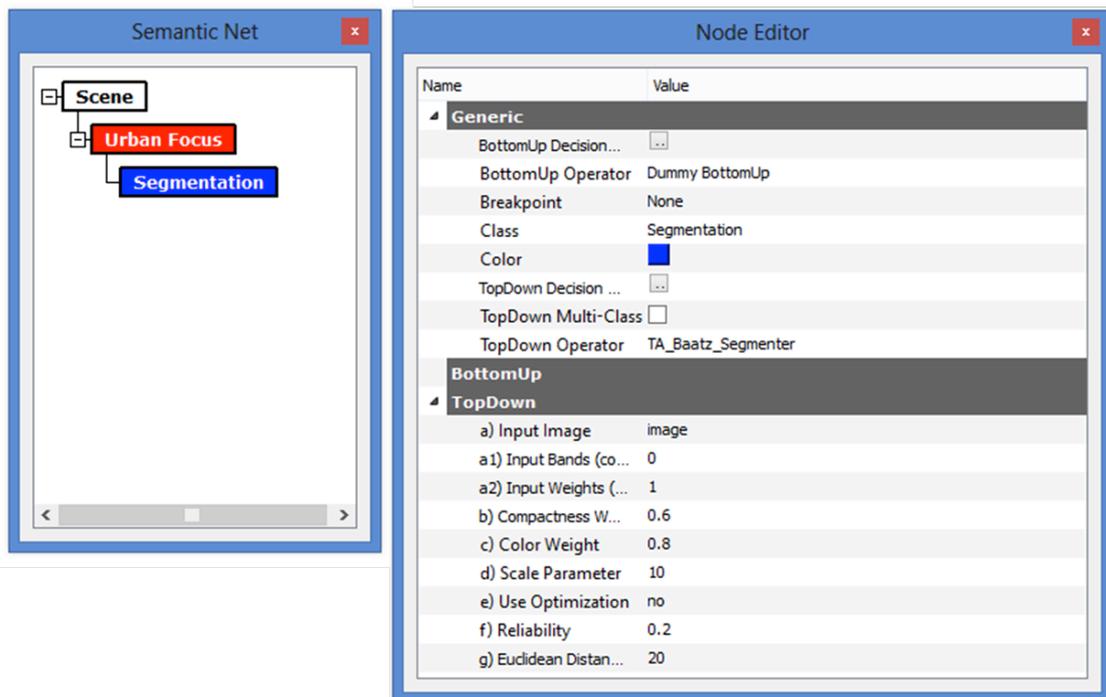

Figure 4. Segmentation node.

The 'Segmentation' node apply a segmentation within the 'Urban Focus' region. The segments could be classified in order to get image-objects representing buildings. The classification will be done in the next section applying a decision rule to the output of the segmentation node.

Define the Decision Rules

The last step to achieve the result is to define the decision rules for the two node:

1) Select the 'UF' node, in the 'Semantic Net' window, with left click.

2) In the 'Note Editor' window, click on the 'Decision Rule for TopDown Operator' icon [..] in 'TopDown Decision Rule'. A new window with name 'Decision Rule for UF - TopDown' will pop-up.

3) Click the 'Expression' brick `Expression` then type 'SUFarea' as 'New Attribute' then, type 'area' as 'Expression' then, click 'OK'.

4) Click the 'Selection' brick `Selection` then type 'SUFarea' as 'Expression 1' then, select the 'Greater than' symbol in 'Operator' then, type '100'000' as 'Expression 2' then, click 'OK'.
   NOTE: the segments with an area higher than 100'000 Square Meters are kept, lower are deleted.

5) Click 'OK'.

6) In the 'Note Editor' window, click on the 'Decision Rule for Bottomup Operator' icon [..] in 'BottomUp Decision Rule'. A new window with name 'Decision Rule for UF – BottomUp' will pop-up.

7) Right-Click on the 'All' brick and select *Insert Child/Aggregation*. Type 'nsegments' as 'New attribute' then, select 'Count' as 'Type' then, check the 'For parent' box then, click 'OK'.

8) Click the 'Expression' brick `Expression` then, type 'setAttributesForParent' as 'New attribute' then, click 'OK'.

9) Click 'OK'.

10) Select the 'Segmentation' node, in the 'Semantic Net' window, with left click.

11) In the 'Note Editor' window, click on the 'Decision Rule for TopDown Operator' icon [..] in 'TopDown Decision Rule'. A new window with name 'Decision Rule for Segmentation - TopDown' will pop-up.

12) Click the 'Class' brick `Class` then, select 'Segmentation' then, click 'OK'.

13) Click the 'Expression' brick `Expression` then type 'SSEmean' as 'New Attribute' then, type 'mean(...)' as 'Expression' and select 'image_layer1' then, click 'OK'.

14) Click the 'Selection' brick `Selection` then type 'SSEmean' as 'Expression 1' then, select the 'Greater than' symbol in 'Operator' then, type '75' as 'Expression 2' then, click 'OK'.
    NOTE: the segments with a mean of the pixel values higher than 75 are kept, below are deleted. These values was selected using CBERS 2B data. For different sensors, a different threshold must be researched.

15) In the 'Lower-level Rule' section check the 'Merge Connected' option.

16) Click 'OK'.

17) Select the 'Scene' node, in the 'Semantic Net' window, with left click.

18) In the 'Note Editor' window, click on the 'Decision Rule for Bottomup Operator' icon ⊡ in 'BottomUp Decision Rule'. A new window with name 'Decision Rule for Scene – BottomUp' will pop-up.

19) Right-Click on the 'All' brick and select *Edit*. Select 'Urban Focus' then, click 'OK'.

20) Right-Click on the 'Urban Focus' brick and select *Insert Child/Selection*. Type 'nsegments' as 'Expression 1' then, select the 'Greater than' symbol in 'Operator' then, type '100' as 'Expression 2' then, click 'OK'.

NOTE: the urban areas which contain more than 100 buildings are kept, lower are deleted.
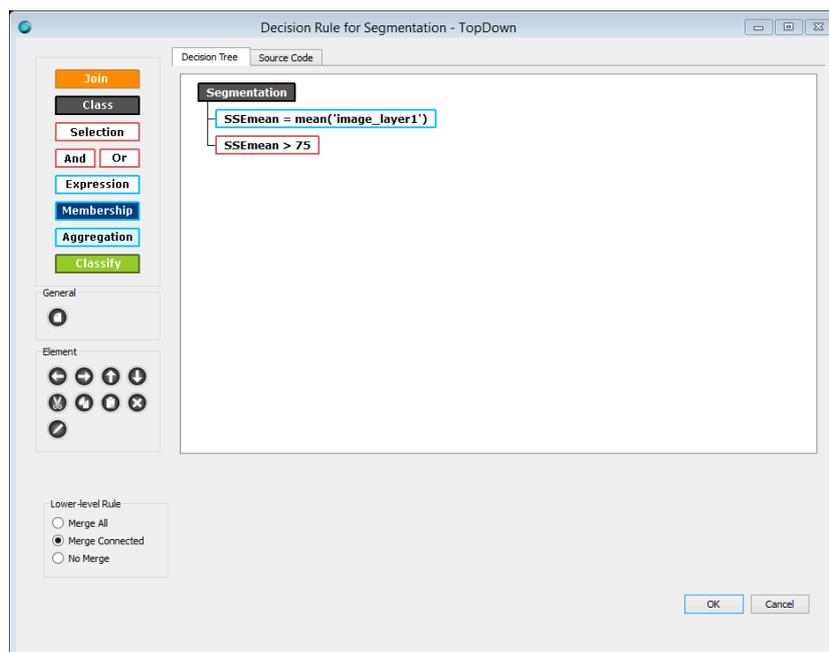
21) Click 'OK'.

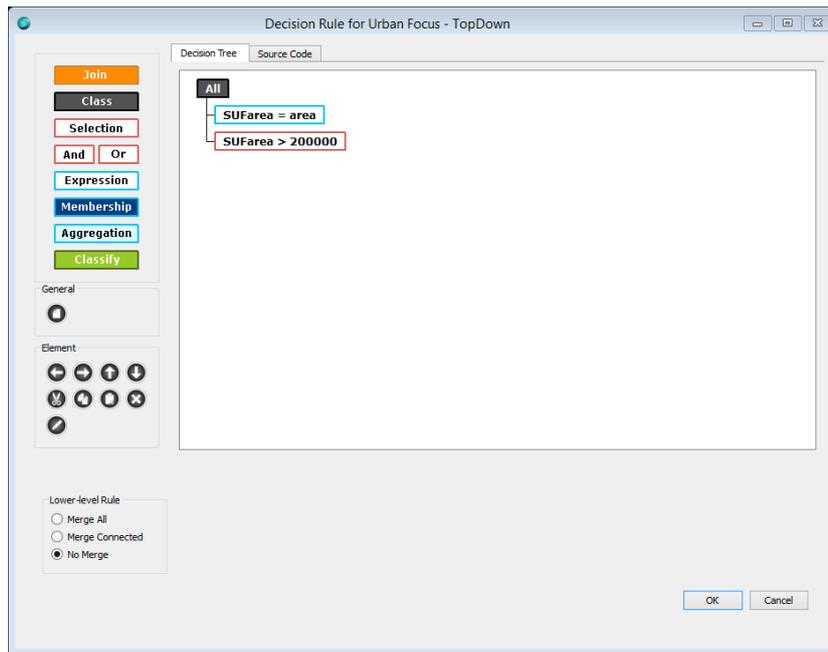**Figure 5. Top-Down Decision Rule for Segmentation Node**

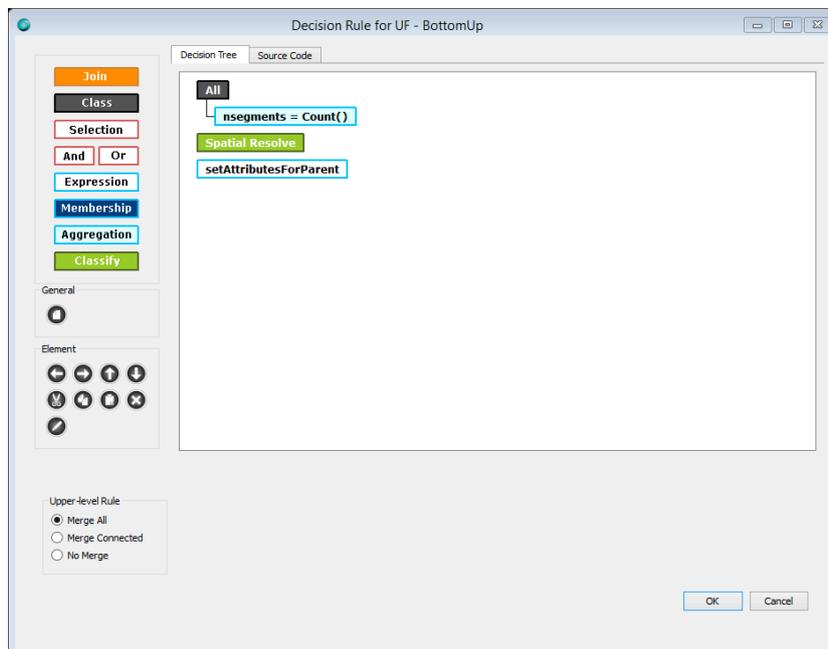**Figure 6. Top-Down Decision Rule for UF Node**

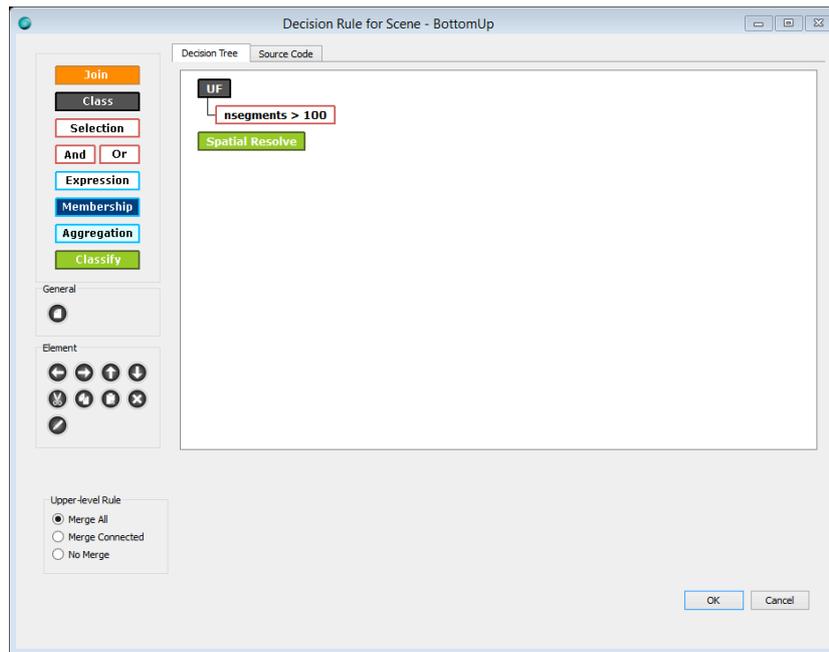**Figure 7. Bottom-Up Decision Rule for UF Node**

Figure 8. Bottom-Up Decision Rule for Scene Node

Execute the Project

Finally, the project can be execute:

1) In the toolbar click on *File/Save Project.*
2) Click the 'Execute' icon ⊚ (Top-Left) to run start the processing.

The result show the image-objects that represent the buildings which cover a region higher than 100'000 Square Meters (the area defined using the 'SUFarea' parameter) and that are in a minimum quantity of 100 for region (the value defined using the 'nsegments' parameter).

Export the Result

The result of the processing could be exported as ESRI Shapefile:

1) In the 'Layers' window, select the 'Result' layer with left click.
2) Click the 'Export' icon ⊙. A new window with name 'Export Shapefile' will pop-up.
3) Click the 'Class' brick [**Class**] then, select 'All' then, click 'OK'.

4) Click 'OK'. A new window with name 'Choose Shapefile' will pop-up.

5) Select the location and the name for the Shapefile that will be created.

6) Click 'OK'.

2.3. Conclusions

This protocol described a method that permits to detect urban area using the InterIMAGE software. The main advantage is that are used simply and easy to understand features, as area and number of buildings, related to the ontology of an urban area. Consequently, the method can be adjusted to different urban typologies by users with little background on RS.

3. Improvements in HUEX version 2 (May 2014)

1) Batch mode InterIMAGE version.

2) InterIMAGE operators based on the BREC Tools, from University of Pavia (integration between BREC and InterIMAGE):

- Urban Focus operator: identification of urban áreas;

- Road Extraction operator: identification of roads;

- Crossing Detection operator: identification of road crossings;

- Shadow Raiser operator: computation of building Heights based on their shadows and sun elevation;

- Raster Regularizer operator: regularizes borders of image segments; and

- Vector Regularizer operator: regularizes borders of vector polygons.

3) GUI optimization for visualization of 11 bits/band images.

4) Functions to save and load Decision Trees.

5) Functions to read and write BMP image formats.

Functions and operators available in InterIMAGE version 1.39.

4. Improvements in HUEX version 3 (November 2014)

1) A multitemporal classification operator based on the concepts of Bayesian networks.

2) SAR specific segmentation operator (based on TerraLib).

3) New segmentation operators implemented with the classes and functions present in the OTB (Orfeo Toolbox) Library:

- OTB_Connected_Component: based on the Connected Components algorithm implementation present in OTB.

- OTB_Baatz_Mutual: region growing segmentation procedure based on the Baatz and Shäpe multiresolution segmentation algorithm, using the concept of local mutual best fitting and OTB classes and functions.

4) Complementary software tool, SPT v.3 (Segmentation Parameter Tuning), for the automatic parameter tuning of the segmentation algorithms/operators included in the current InterIMAGE build.

Functions and operators available in InterIMAGE version 1.43.