IndiFrag v2.1: An Object-based Fragmentation Analysis Software Tool

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Introduction

IndiFrag is a processing tool used for the extraction of a set of indices and variables that describe the level of fragmentation and spatial distribution of land uses in response to morphological, spatial and typological properties of cartographic objects. Moreover, it also quantifies changes over a period of time. It works with land use and land cover (LULC) maps in vector format. Thus, topological relationships are used, easing the interpretation and analysis of fragmentation in different objects or regions of a particular area of study.

The tool calculates a large number of indices according to several levels of hierarchy. On the one hand, fragmentation indices are divided into five groups based on the described attributes: area and perimeter, shape, aggregation, diversity and contrast. They are also divided into three levels based on the calculation scale: super-object, class and object. On the other hand, multi-temporal indices are also divided into three levels: super-object, class and object.

The outcomes are stored in the attribute table of the input data, thus they can be interpreted directly and easily by means of variable maps.

Tool description

This tool was created to automatically calculate fragmentation and multi-temporal indices, initially for application in urban areas. It consists of a toolbox with geoprocessing scripts in Python (a programming language) using several libraries, (e.g., *arcpy, numpy…).* The tool is executed using the software ArcGis Desktop (ESRI). It is easy to use and fully automatic by only providing the input data. It is intended to be a generic tool, in order to extend its range of applications. Thus, this tool is not restricted to urban fragmentation analysis, but it may also be used to analyse the spatial distribution and change of any image classification result.

IndiFrag does not need installation. However, it needs ArcGIS software installed in the computer. Up to now, it has been tested with ArcGis version 10.1 (and with Windows OS 7 and 10, with 32

and 64 bits), but it is expected to work in higher versions. The tool consists of a compressed file with the following subfolders or files:

- **IndiFrag_v2.1:** the toolbox.
- **IndiFrag_v2.1/IF_library:** specific library for IndiFrag. This folder has to be placed in the same path as the toolbox.
- **Other_Libraries:** Python libraries needed to compute specific functions, they have to be installed only the first time that the tool is used.
- **UserGuide:** manual of use (currently in Spanish, we are working on the English version).
- **Help_Documents:** html help documents of the windows and boxes.
- **Tutorial_Shapes**: Shapefiles used in the tutorial guide and their results.
- **Licensing**: document with the license and disclaimer.
- **README**: basic steps for using IndiFrag.

IndiFrag v2.1 is divided in two tool sets. The first one, "Fragmentation Analysis", computes the fragmentation metrics for one date, and the second, "Multi-temporal Analysis", multi-temporal metrics (Figure 1).
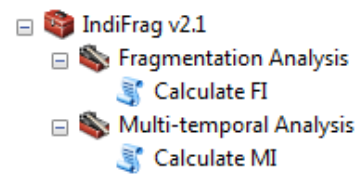

Figure 1. IndiFrag v2.1 toolbox and tool sets

Input data

A classified polygon vector shapefile is required. For the multi-temporal module, two shapefiles are needed. These polygons are the "objects" and they represent the minimum unit of assessment, the object level. Polygons with the same class constitute the second level of assessment, class level. Optionally, another shapefile may be used to define boundaries and a higher level of assessment, the third and super-object level. For a few metrics, a centre point shapefile is requested. It should be taken into account that the coordinate systems of the input data have to be the same.

- *Shapefile with objects*

This shapefile contains the objects or entities; it has as many rows as objects, and each one has to be classified or categorised. Some examples are: limits of cadastre plots or blocks with their associated use or land use/land cover (LULC) data (e.g: CLC, SIOSE, Urban Atlas, etc.), among others. A field with the classification is required and optionally, it is recommended another field
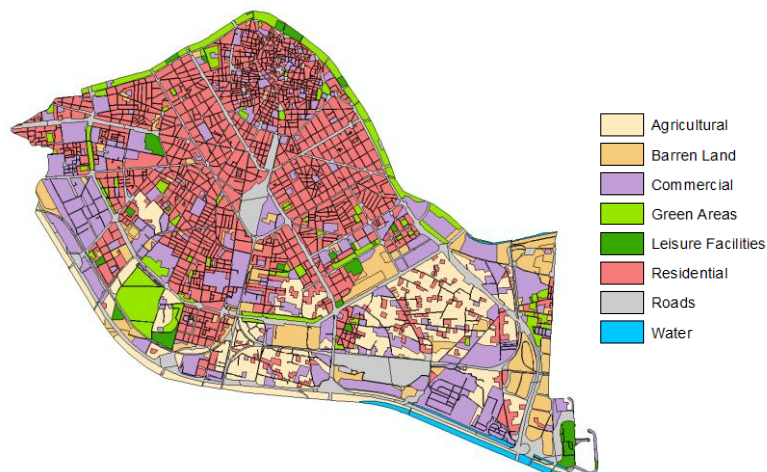

Figure 2. Shapefile with objects (urban blocks) and their clbasses (LULC). Source: Urban Atlas 2006 - Valencia

that contains the typology of the class, whether it is considered urban or not (Figure 2).

- *Super-objects shapefile (optional)*

When this shapefile is introduced in the analysis, the assessment is conducted separately for each super-object, easing the subsequent comparison of results. If this shapefile is not introduced, a new shape is created with only one super-object, in order to store the super-object level results for the whole study area, which corresponds to the total extension of the objects. Some examples of this shapefile are: administrative boundaries, neighbours, districts, etc. They define the boundaries in which the study area is subdivided for the analysis. A field with the name or the identifier of the super-object is required (Figure 3).
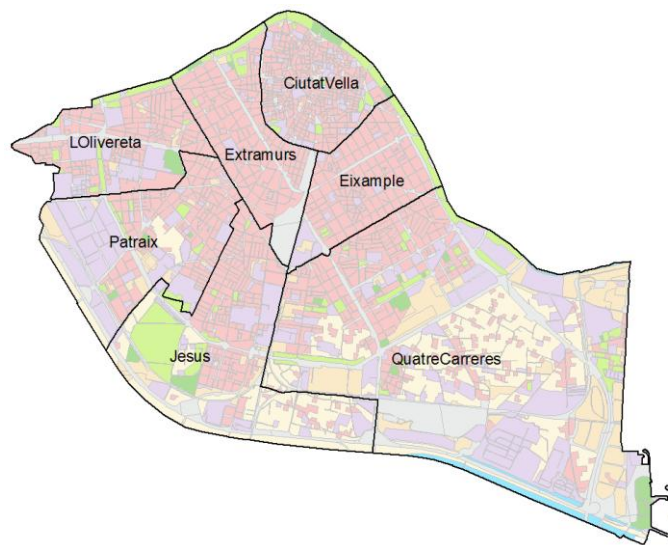

Figure 3. Shapefile with Super-Objects (districts). Source: Spanish National Institute of Statistics (INE)

- *Centre point shapefile (optional)*

This shapefile is needed for computing some indices, it contains only one point located in the centre of the study area, it may be the geometric centroid or not.

Interface

- *Fragmentation Analysis*

This module computes the fragmentation metrics for one date, and they can be selected expanding the groups of metrics and checking the checkboxes. Following the directions in the "Tool Help" will guide the user to correctly introduce the input data (Figure 4).
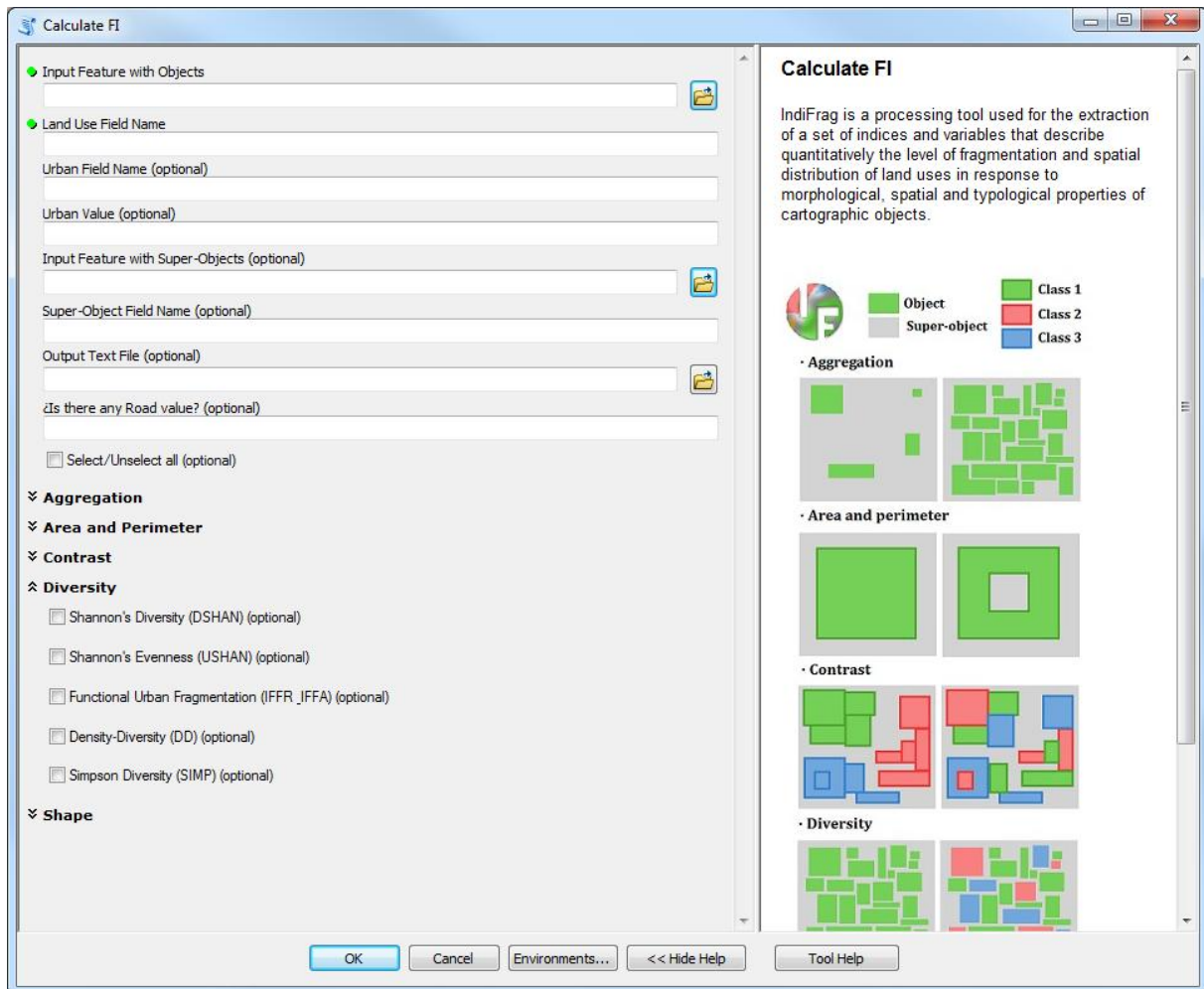
Figure 4. Interface of the Fragmentation Indices (FI) module

- ***Multi-temporal Analysis***

Similar to the previous module, it calculates multi-temporal metrics by using two input data from the same area at different dates. The "Tool help" describes the required data to be introduced in each box (Figure 5).
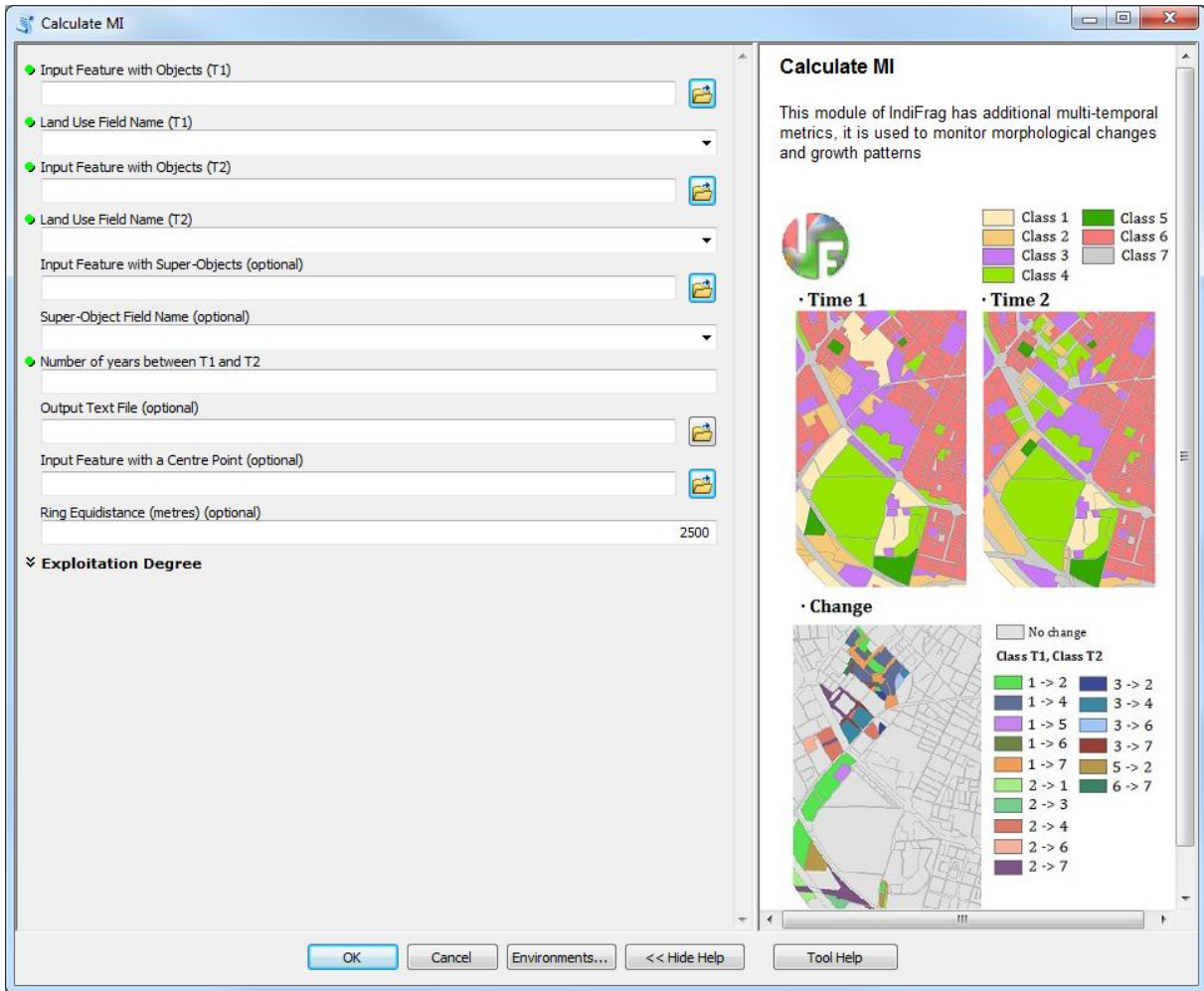
Figure 5. Interface of the Multi-temporal Indices (MI) module