Using the Fuzzy Classification Procedures in IDRISI 2.0

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Note: The following directions describe how to produce a fuzzy classification of remotely sensed imagery. Text in black was taken directly from the help section of IDRISI for Windows, version 2.0. The text in green are helpful comments and procedures from researchers at the Idaho State University GIS Training and Research Center (ISU GIS TReC) who were using fuzzy classification techniques to classify sagebrush-steppe areas on the Upper Snake River Plain. The IDRISI for Windows: version 2.0 User's Guide ©1997 is a useful source of information on application and function of hard and soft (including fuzzy) classifiers. It also contains more information about fuzzy classification than what is reported here, the reader is encouraged to read and use it; particularly the sections on: Fuzzy Sets (9-33, 11-17) and Hard/Soft Classifiers (11-2, 11-7, 11-11).

FUZSIG Operation

FUZSIG operates in a manner very similar to MAKESIG. However, the use of FUZSIG requires that a specific sequence of operations be followed:

1.Define Training Sites
This stage proceeds much the same as usual: training sites are digitized using the on-screen digitizing facility. However, there is no requirement that training sites be as homogeneous as possible -- only that the relative proportions of cover types within each training site pixel can be estimated.

- We imported an ungenerated polygon coverage (ungenerated as line from ArcInfo) using the software specific format: ARCIDRISI module. An alternative method would be to use the POLYGRID and GRIDIMAGE commands in Arc to output an image for import into IDRISI.
- Note: if you have multiple training sites for one class type, you must edit the ungenetated file so that all polygons representing the same class type have the same identification number.

2.Rasterize Training Sites
Although this stage is not strictly necessary, It can make the next stage much easier if the Training sites are collected into a single raster image. This is done by running INITIAL to create a blank byte binary image (i.e., one initialized with zeros), and then rasterizing the digitized polygons with POLYRAS.

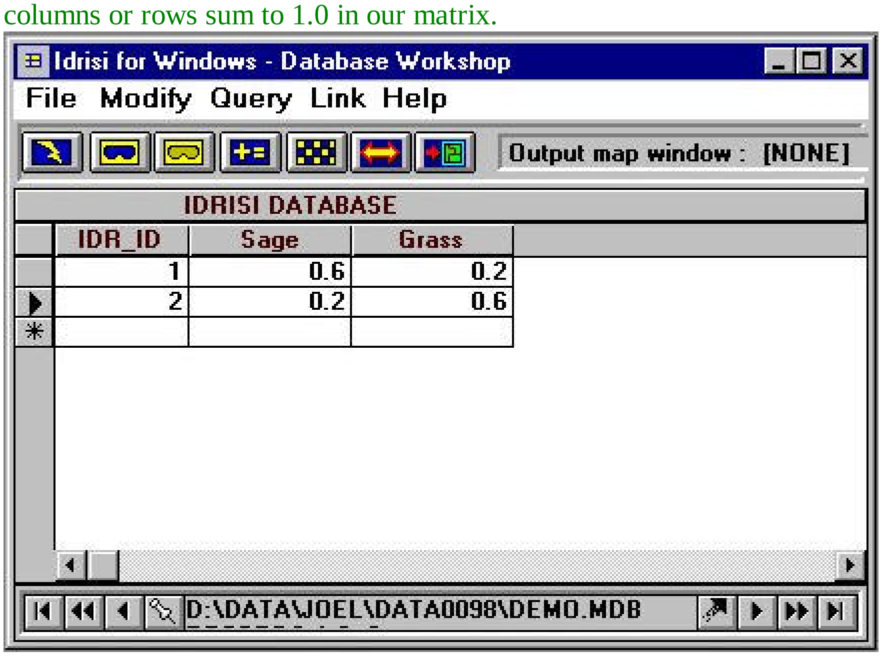
- We initialized a blank layer (this tool is found under the Data entry: Initial tab) using the spatial extents of the imagery we would be classifying and the updated it using POLYRAS.

3.Create Fuzzy Partition Matrix in Database Workshop
The next stop is to create a *fuzzy partition matrix* in Database Workshop. A fuzzy partition matrix indicates the membership grades of each training site in each class. To do this, first setup a database with an integer identifier field and one field (column) per information class in 4-byte real number format. Then put numeric identifiers in the ID field corresponding to each of the training sites (or training site groups if more than one polygon is used per class). For N classes, then, an *N x N* matrix Is formed.

The next step is to fill out the fuzzy partition matrix with values to indicate the membership grades of each training site (or training site group) in the candidate classes. This is best filled out by working across the columns of each row in turn. Since each row represents a training site (or training site group), estimate the proportions of each class that occur within the training site and enter that value (as a real number from 0.0 to 1.0). In this context, the numbers should add to 1.0 along each row, but typically will not along each column.

Once the fuzzy partition matrix is complete, use the ASSIGN option under the LINK menu of Database Workshop to create a series of raster Images expressing the membership grades for each class. In this case, the feature definition image is the training site raster image created in the previous step. Create an output image for each class using a name that is a concatenation of the letters "fz" plus the name of the class (where the result will be truncated, if necessary, to a maximum of 8 characters). For example, if the class is named "conifer", the output produced with the ASSIGN operation should be named "fzconife". This "fz" prefix is a requirement for the next stage.

- For our analysis we had sage and grass training sites. Thus there were 2 rows to our fuzzy partition matrix. Because of the mixed nature of sagebrush-steppe vegetation our sage training sites has .60 membership to sage, and .20 to grass. The grass training sites had .60 membership to grass and .20 to sage. These membership grades reflect how spectrally pure the sites were. In the example below, notice that neither the columns or rows sum to 1.0 in our matrix.



4. Extract Fuzzy Signatures

The next stage is to create the fuzzy signatures. This is done with the FUZSIG module. As mentioned above, the operation of FUZSIG is identical to MAKESIG. You will need to specify the name of the file that defines your training sites (if you followed the steps above, this will be the image file you created in Step 2), the number of bands to use in the signature development, the names of those bands and the names of the signatures to be created. It is very important, however, that the signature names you specify coordinate with the names of the fuzzy membership grade images you created in Step 3. Continuing with the previous example, this means that if you specify a signature name of 'conifer", FUZSIG will expect to find an image named "fzconife" in your working directory. Similarly, a signature named "urban" would be associated with a fuzzy membership grade image named "fzurban".

The output from FUZSIG Is a set of signature (“.sig") files of identical format to those output from MAKESIG. FUZSIG gives each pixel a weight proportional to its membership grade in the determination of the mean, variance and covariance of each band for each class (see Wang, 1990). Thus a pixel that is predominantly composed of conifer will have a large weight in the determination of the conifer signature, but only a low weight in determining the signature for other constituents.

FUZSIG Notes

1. Because these signature files are of identical format to those produced by MAKESIG, they can thus be used with any of the classifiers supported by IDRISI for Windows, both hard and soft. However, there are some important points to note about these files:

   a) The minimum and maximum reflectances on each band cannot meaningfully be evaluated using the weighting procedure of FUZSIG. As a consequence, the minimum and maximum value recorded is derived from consideration of only those pixels where the membership grade for the signature of concern is greater than 0.5. This will typically produce a result that is identical to that output by MAKESIG. However, it is recommended that if the PIPED classifier is to be used with these signatures, the parallelepipeds should be defined by standard deviation units rather than the minimum and maximum.

   b) Unlike MAKESIG, FUZSIG does not output a corresponding set of signature pixel files (".spf") to the signature files produced. As a consequence, EDITSIG cannot be used to examine or modify the signature files produced. However, since the signature files are simple ascii text files, they can be examined in EDIT. Their simple structure is explained in the *File Structures Appendix in* the User's Guide.

2. This module is based upon the following:

Wang, F., (1990) "Fuzzy Supervised Classification of Remote Sensing Images", *IEEE Transactions on Geoscience and Remote Sensing*, 28, 2, 194-201.

FUZCLASS Operation

FUZCLASS classifies an image based on the information contained in a series of signature files. These need to have been previously created either with MAKESIG or FUZSIG. You may then indicate whether you wish to enter each signature separately or use a Signature Group File to specify the entire group at once. Signature Group Files are created with the EDIT module.

Regardless of the manner in which signatures will be entered, the opening dialog will require that the user specify the number of signatures and their names, the Z-score at which fuzzy membership decreases to zero (see Note 1), whether calculations should use un-normalized or normalized distances (see Note 3), and a prefix to be used in constructing the names of the output images (maximum 3 characters).

- The Z-score is a user defined parameter (see FUZCLASS Notes below) and will vary depending on your training site characteristics. As Z is increased, the uncertainty of the output classification increases (similar to increasing the probability of a Type 2 statistical error), but as it decreased, the uncertainty of the output classification decreased increases (similar to increasing the probability of a Type 1 statistical error).

- We tested Z-scores between 1.2 and 0.6 for our analysis and found that 0.85 seemed to be the best based on known attributes of the study area.

When all of the above have been answered, press the Continue button. The final dialog will present you with a list of the bands to be used in the classification. You can de-select any of the bands you do not wish to use.

The module produces a set of images. This set consists of one fuzzy membership image for each of the signature classes, and a classification uncertainty image. Names for the fuzzy membership images are created by concatenating the prefix specified and the names of the signatures. Any name longer than 8 characters is truncated. The classification uncertainty image is given a name produced by concatenating the prefix and the letters "clu" (an acronym for classification uncertainty). In addition, FUZCLASS also outputs an Image Group File (".igf") which can be used with the extended cursor inquiry feature available under DISPLAY PREFERENCES.

FUZCLASS Notes

1. The Z-score for 0 fuzzy set membership can be decided by two parameters: quality of your signature, and width of each class. If the signature is pure and the class width is small, a small Z-score should be selected. If the signature is mixed and the class width is large, a large Z-score should be selected.

2. The fuzzy Set Membership is calculated based on standardized Euclidean distance from the mean of the signature, using a sigmoidal membership function (see FUZZY). The underlying logic is that the mean of a signature represents the Ideal point for the class, where fuzzy set membership is 1. When distance increases, fuzzy set membership decreases, until it reaches the user-defined Z-score distance where fuzzy set membership decreases to 0.

3. The un-normalized procedure assumes that the fuzzy set membership for each class is derived independently, and incomplete information or overlapping signatures may exist. The sum of values for a pixel for all class images may be other than 1 in this case. The normalized procedure assumes that full information is achieved and signatures do not overlap, thus the fuzzy set membership for a pixel for all class images sums to 1.

4. The formula for the calculation of classification uncertainty is the same as that used in BAYCLASS (see BAYCLASS Note 4).