Technical Report

- Draft -
2nd Revision

User's Guide for
Sketcho V1.1b

University of Maine

Department of
Spatial Information Science and Engineering
and
*National Center for Geographic Information and Analysis*

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
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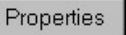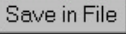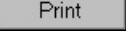
Orono, October 29th, 1999   TR99-2b

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DRAFT, FOR VERSION 1.1B[◇] :

User's Guide for *Sketcho*

This User's Guide provides useful information about the prototype application of sketch-based query user interface for GIS, called *Sketcho.* The document is intended for people who want to experiment with our prototype application. It shows various facets of how to draw a sketch, how to manipulate objects and relations, and finally how to query a sketch against a simple database consisting of previously drawn or some other way generated sketches.

An easy way to find a particular topic is to browse through the table of content and then go directly to the specified page. There are essentially eight sections, covering everything from installation to advanced functions. For information concerning applied data models or methods used we refer to the technical report (Blaser, 1999) and other publications that have been published in this context (Section 8). This second edition of the draft includes a first description for a host of new functions, notably concerning the new module that allows a user to build and query a simple sketch database.

As stated in the title, this is a first working draft, made public because of numerous requests. We are fully aware of the fact that this guide is neither complete nor in its final format and that certain parts need some more work, mostly because the prototype and its computational models are being modified and further developed. However, we think it is necessary to provide such a first, rough draft at this point, because our prototype has already developed into a small application and the number of functions and features has increased considerably.

1   Getting Started

1.1   System Requirements

Sketcho is a Windows32 application that runs under the Microsoft Windows operating system (95/98/NT). A system with a 100MHz Pentium processor and 24MB of RAM provides sufficient resources to run the prototype satisfactorily. We have not experimented with lower performance PC's; however, for querying a sketch database it is advantageous to have a faster configuration, notably with more RAM (See also the provisional performance index at the end of this guide)

The prototype can be run with a standard PC configuration using a mouse for sketching. However, the use of a drawing tablet or a device where the user can sketch directly onto the monitor provides a more natural feeling. The prototype runs with various screen resolutions, however for good legibility and because some dialog boxes require a lot of screen real estate we recommend a resolution of 1024x768pixel or above.

[◇] Second Edition, revised: 10/29/1999 by @abl

1.2　Installation

Sketcho is available on CD-ROM and as downloadable file from the Internet:

Download Web-Page:　　　http://www.spatial.maine.edu/~abl/SQBS/Prototype.htm

Version 1.0c:　　　　　　ftp://mustang.spatial.maine.edu/pub/SQbS/SketchoV1.0c.zip　　　~1.5 MB

Version 1.1b:　　　　　　ftp://mustang.spatial.maine.edu/pub/SQbS/SketchoCD.zip　　　~21.2 MB
(Comprehensive setup with interactive mockups)

Version 1.1b:　　　　　　ftp://mustang.spatial.maine.edu/pub/SQbS/SketchoV1.1b.zip　　　~2.9 MB
(Standard setup with Toy Database (100 sketches))

Additional Toy Database:　ftp://mustang.spatial.maine.edu/pub/SQbS/ToyDB_5r.zip　　　~2.2 MB
(Database with 1000 randomly generated sketches)

1.2.1　From CD-ROM

The CD-ROM contains a setup program (setup.exe) that installs all necessary components on your hard drive. By default the main program and its components are installed into the windows program directory (`C:\Program Files\Sketcho`). The program location can be changed during the execution of the setup program. The installation program creates a folder and a short-cut to the executable on your desktop. The folder contains short-cuts to animated, interactive movies (mockups) of a sketch-based user-interfaces for GIS and some information about the prototype. These have been developed as a project study before the prototype was developed.

1.2.2　From ZIP File

The installation file obtained from the Web is similar to that from CD, though smaller. The program and all components necessary are stored in a self-extractable file. This files unpacks the application components (in the default temp directory) and initiates the setup program. Once the program has installed itself the temporary files are being deleted.

1.2.3　Uninstall the application

To uninstall all application components go into the *Windows Control Panel*, choose *Add/Remove Programs*, and select to uninstall *Sketcho*. This uninstall procedure is standard in Windows 95/98/NT.

1.2.4　The use of a drawing tablet

The prototype can be used with a drawing tablet and a pen as primary input device. To enhance the functionality of the pen we recommend using a pen with configurable buttons. One button should be configured as Shift-Button and another button as Right-Mouse Button. If no such buttons are present on the pen the keyboard can be used for this purpose as well.

2 Basic Functions

2.1 Simple Definitions

Before we start here some simple definitions:

2.1.1 What is a sketched "Stroke?"

A stroke is created when the user starts to sketch and completed when he or she "lifts" the pen from the drawing surface. A stroke can intersect itself. The only minimum requirement is that it has at least two points and a certain minimum length. A stroke is defined, therefore, as a non-interruptedly drawn line.

Figure 1   Example of a simple stroke.

2.1.2 What is a sketched "Object?"

An object consists of one or more strokes that are considered to be affiliated with each other. The process of affiliation is done automatically, but it can be manually overruled as well. An object can be a set of any combination of strokes.
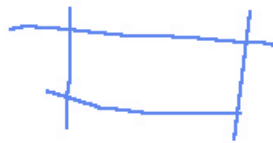
Figure 2   Example of a simple object consisting of four strokes.

2.2 Sketching Objects

Like with many computer-drawing programs, pressing the left mouse button and holding it down while drawing initiates the drawing process. When using a pen the same effect is obtained, when the pen is slightly pressed on the drawing device and stopped when the pen is lifted.

Strokes and objects can have different colors. The currently active object/stroke is always blue, while the previous object has a green color. All other objects/strokes are black. It is possible to go through the list of all objects by pressing the Tab key (or Shift-Tab) on the keyboard what causes the next (previous) object to be selected as the current object.
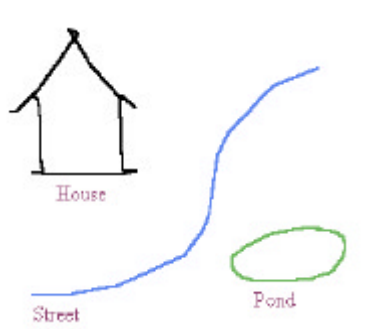
Figure 3   Example of a three simple objects drawn in sequence.

In Figure 3 above the house was the first object to be drawn (black). The actual object is the street and the object drawn before that is the pond. (Sequence: House-Pond-Street). The prototype determines automatically which strokes have to be aggregated (affiliated) to an object and when a new object has to be created. This decision can be overruled manually (Section 3.5)

The mechanism that determines the affiliation of strokes to objects is based on the time interval between strokes and the location of the start and end points of strokes. To personalize these parameters see the section about the user preferences.

2.2.1 The Influence of the drawing speed

If the time interval between the previous and the current stroke is below a certain threshold, then the current stroke is automatically affiliated to the last drawn object. This threshold can be adjusted in the user preferences (3.10). If the user makes a longer pause, only geometrical parameters are considered for the process of affiliation.

2.2.2 The influence of the start and end point of a stroke

To affiliate a stroke with a previously drawn object the user has to start or end the new stroke close enough a previous object. This works also if the time interval has passed the threshold.
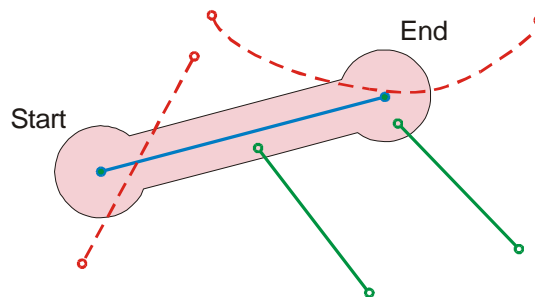
Figure 4   Stroke (blue) with its influence buffer zone and

The green strokes in the example in Figure 4 above get connected with the initial stroke (blue), while the red-dashed strokes are not (not considering time). This is because, the green strokes start or end within the buffer of the initial stroke. This buffer-zone can be adjusted manually (3.10) and it is increased around the start and end points of strokes.

2.3 Digitizing Mode

Beside the sketching mode there is a digitizing mode that lets a user draw connected polygons. These polygons can be open or closed. Starting from the initial point, points are connected with straight lines until the initial start and actual end point of the polygon are close enough (closed polygon), or until the user double-clicks the same point (open polygon). If the application is in the digitize mode, the automatic stroke association is turned off that is, each stroke becomes a new individual object, even if e.g. start and end point of digitize strokes match. However, and because digitized objects are treated like common objects, they can be grouped or ungrouped, or combined with conventionally sketched objects to more complex entities.

The digitizing mode is practical, for instance, when the user wants to digitize from digital photos and add these sketches to a sketch database.

2.4   Selecting Objects and Strokes

A selected object becomes the current object and can, therefore, be distinguished from other objects by its blue color. The current object is always the selected object, to select another than the current object there are four possible approaches.

Remark: If we refer to clicking the left mouse button, then this is equal to applying some pressure with the point of a pen.

2.4.1   Simple Select

Change the pen mode from drawing ✎ into selecting ☝. This can be done by double-clicking the left mouse button (pen) or by selecting the appropriate tool from the toolbar ▱.

To select an object by simply pointing the cursor to this object and click the mouse button over the object. If an already selected object is selected then the stroke below the cursor is selected (if the object has more than one stroke). A selected stroke has a slightly different color (light blue) than the rest of the selected object.

2.4.2   Box Select

Pressing the left mouse button over no object invokes a standard box select feature. Such, it is possible to select one or more strokes of an object (the selection box may only contain strokes from one object), or one or more objects (one or more objects are fully contained in the selection box). Selected entities must always be completely inside the box.
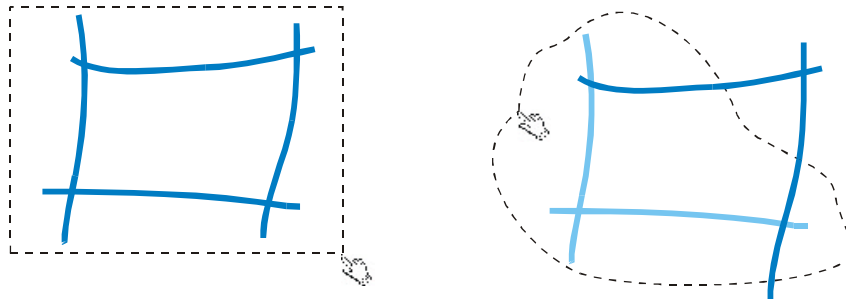
Figure 5   Box select on the left and lasso select on the right

2.4.3   Lasso Select

Similar to the Box Selection method this approach lets you select groups of strokes or objects. The difference is the shape of the selection tool. This mode is invoked by pressing the left mouse button (cursor not over any object) and simultaneously pressing the shift button (keyboard or pen). From there on the user can freely draw the selection hull (Lasso). In the example of Figure 5 right, two strokes of an object are selected using a lasso.

2.4.4   Keyboard Select

Instead using a pointing device, it is also possible to select objects using the tab key of the keyboard. By repeatedly applying the Tab key (Shift-Tab for reverse order) objects are selected one after another.

2.5   Annotating drawn Objects

An annotation can be a textual description or extension of a drawn object. Annotations can be made for objects and for the sketch itself. It is possible to make multiple annotations per object or sketch. Only the topmost annotation is visible by default.

Remark: The current version of the prototype is not focused on the semantics of objects or the sketch. Therefore, the annotation capabilities are relatively limited at present; however, this may change, when verbal input can be processed as well.

(→ Sketch-and-Talk Project, http://www.spatial.maine.edu/~max/UIforGIS.html).

2.5.1 Annotating a sketch

To annotate a sketch the user must press the right mouse button over an empty space (not over an object) and select the *Annotate Sketch* option from the context menu. An alternative way to do the same is to start typing in an empty sketch, pressing the Enter key closes the annotation. The sketch annotation can also be created, edited, or deleted using the annotation toolbar on the Figure below.

Figure 6   Annotation Toolbar

The topmost annotation of a sketch is always visible in the edit box of the annotation toolbar. The delete button at the right side of the toolbar deletes the topmost sketch annotation and displays the next following, if there is any annotation left.

Remark: By now only the topmost annotation is used and preserved when the sketch is saved.

2.5.2 Annotating sketch objects

The current version of *Sketcho* does neither store, analyze, nor process object annotations. Only a selected object can be annotated. There are three ways to annotate an object:

a) Handwritten annotations

If the automatic text detection is enabled, then the prototype will recognize written text and associates this text with the closest object. To overrule this automatic detection the user can also chose to select the explicit handwriting mode 𝒜 . The automatic text detection is turned off by default; to invoke it chose the appropriate parameter in the application preferences (described below).

Figure 7   Automatic text detection

Detected text changes its color (purple) and when the associated object is selected it highlights the associated text using a back-filled hatch pattern (Figure 7).

b) Typed annotations

If an object is selected the user may immediately start to type an annotation. Pressing the *Enter* key closes the annotation and adds the annotation to the bottom of the list of annotations of the object.

c) Annotation dialog box

An alternative way to add/edit annotations is over the context menu of an object. This menu is invoked by pressing the right mouse button over an object. To close the dialog box press the *OK button*, or type a point at the first position of a new line.
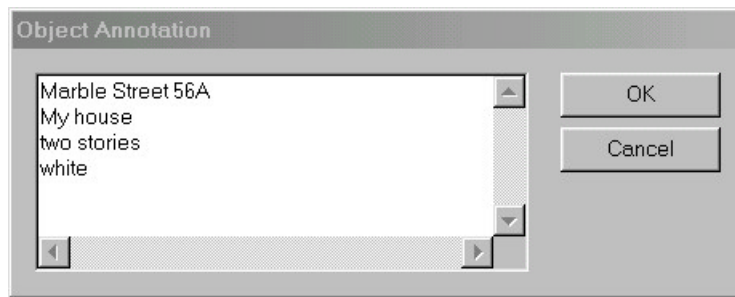
Figure 8   Text annotation dialog box

Remark: Object annotations are not preserved when a sketch is stored and handwritten text objects are not further processed.

2.5.3   Changing the association of handwritten text

Written annotations are automatically associated to objects. To change the affiliation of an annotation, select the annotation by clicking at it–the annotation is now the current object. Now press and hold the shift key and select the appropriate object that must be associated with the annotation with. By repeatedly selecting the same object, an association is toggled.

2.6   Modifying Sketched Objects

To modify an object or a stroke it must be the currently selected object (e.g. by using one of methods described above).

2.6.1   Modifying the location of objects or strokes

The selected object or stroke can be moved by pressing and holding the shift-key while in the selection mode,

and grabbing the object/stroke on an edge. The original position of the object or stroke will be marked with a shadow during the movement.
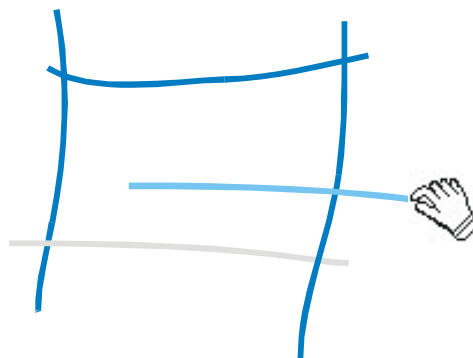
Figure 9   Moving a stroke within an object.

2.6.2 Deleting objects or strokes

To delete an object or a stroke the user may press the delete button in the menu bar or the delete key on the keyboard. Both approaches have the same effect, namely that the object or stroke is put onto the undo stack. In order to delete the entire sketch the shift-key has to pressed in addition to the delete button/key.

An alternative method to delete an object is to cross it out (cross out gesture) like shown in the Figure 8 below.

(a)   (b)
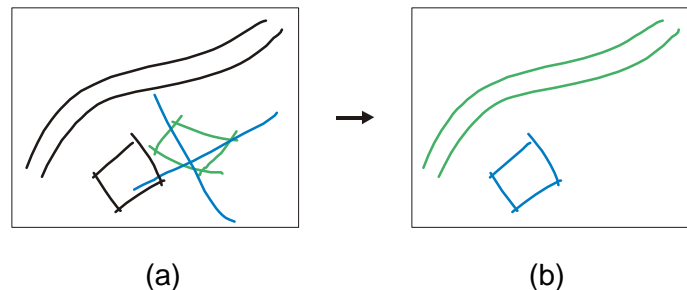
Figure 10   Example of a delete gesture applied on a drawn object in a sketch.

The delete gesture is used to eliminate a previously drawn object from the sketch and to put its elements (strokes) onto the drawing stack. The gesture consists of two crossing strokes that intersect at an angle of around 90°. The affected sketch object is determined based on the gesture's location and on a temporal factor. That is, if more than one object are candidates for a deletion, then the most recently drawn object will be eliminated.

2.6.3 Changing between text object and non-text object

If an object has mistakenly been classified as text object it can be reclassified as non-text object by pressing the text/no-text button. The inverse action is of course possible as well.

2.6.4 Detach strokes from an object

By pressing the detach button it is possible to detach a stroke that has been incorrectly associated to the previous object from this object. Pressing this button breaks the last stroke (or the currently selected stroke) from the currently active object and creates a new object based on this stroke.

2.6.5 Attach strokes to an object

The converse operation to *detach* is *attach*, which connects a non-associated stroke or object to the previously active object (green color). Repeatedly pressing the button rotates the association trough all available objects. The association is final, when another action is taken, e.g. when the user restarts to draw.

2.6.6 Group/Ungroup strokes

This button can break objects apart into the strokes (groups of strokes) and it can group selected strokes or objects to one object.

2.6.7 Rotate objects

Objects can be rotated around the geometric center of their MBR, by selecting an object (pressing and holding the left mouse button over an object) and pressing and holding the Ctrl-button. The center point is visible and the object is rotated as long as the mouse- and Ctrl-button are pressed (See Figure 10 below). The original location is drawn light gray and the new current location is marked light blue.
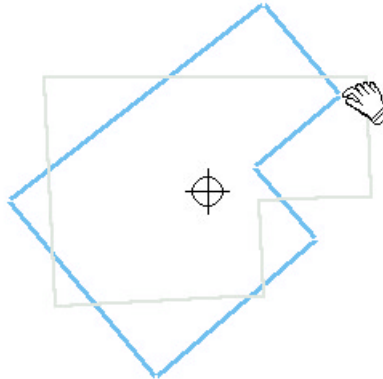
Figure 11   Rotating an object

Only single objects can be rotated. If multiple objects must be rotated then the advised procedure is to group, rotate, and ungroup the objects.

2.6.8 Cut, copy, paste and duplicate objects

Sketcho has an internal clipboard that allows to store and retrieve a copy of an object's geometrical properties–annotations and affiliations are not copied. To copy an object into the clipboard there are two ways: one is to press Ctrl-C the other is to chose *Edit-Copy* from the Main Menu. The cut function (Ctrl-X) has the same effect, except that the original object is deleted, when it is copied onto the clipboard.

Once there is a copy of an object on the clipboard it can be reproduced as many times as necessary. Functions to reproduce an object from the clipboard are:

- Paste (Ctrl-V), this pastes a new object from the clipboard at the location of the original object. (Note, if the object was copied (Ctrl-C) into the clipboard then there are two geometrically identically objects on top of each other).

- Duplicate (Ctrl-D), this copies a new object from the clipboard at a location slightly offset from the location of the original object.

2.6.9 Undo-/Redo button

The undo/redo functions behave only partially like typical undo/redo functions. This is primarily, because the functions give a user basically access to the stack of deleted objects and strokes but not to previously executed operations. Hence pressing the undo button will only put the last drawn stroke onto the stack and conversely pressing the redo button will retrieve the newest stack element onto the sketch.

2.7 Zoom Tool

The zoom tool of the prototype is an alternative to the standard zoom that enlarges the area that is selected within a box. By making movements towards the center of the drawing area the tool zooms out and by making the converse movement the tool can be used to zoom in.
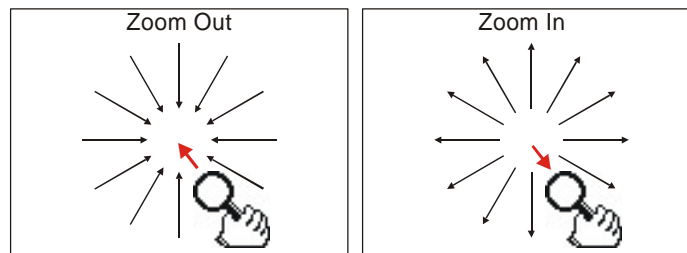
Figure 12   Interactive zoom tool

The other way to zoom is to use the zoom dialog box provided through the context menu (→ right mouse button).
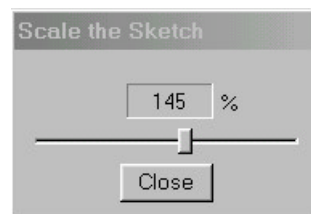
Figure 13   Zoom dialog box

Remark: The zoom function is unavailable in the Formal View and when a background image is displayed in the Sketch and Object View.

2.8 Saving a Sketch

Saving a sketch is done by pressing the save button of the toolbar or selecting the *Save*, respectively *Save As* option from the File menu. The generated file is currently the ASCII debug format of *Sketcho*. The file extension of these files is `*.dmp` and the description of this format can be found in Chapter 5. Saved values are geometry, pen-size, the temporal aspect of each point and a point specific flag. All other information, such as object annotations or text objects is currently not preserved. The sketch's topmost annotation, however, is saved (See also the section about the `*.dmp` format).

2.9 Retrieving a Sketch

Currently only sketches stored in the debug sketch file format (`*.dmp`) can be retrieved. These files do not contain certain information from the original sketch, such as explained in the previous section. Pressing the open file button when already a sketch is opened results in loading the content of the dump-file into the current open sketch (this is not a bug but a feature ☺). If a sketch has to be retrieved into another than the currently open sketch, then the user has to create a new sketch first and then load the sketch.

2.10 Put a sketch into the Current Database

The name of the currently selected database is shown in the right lower corner of the user interface next to the status lights on the status bar. The default name of the database is "`database\`" and the location is right under the program root.

Figure 14   Status bar with indication of the current database

The term *database* is used, for any directory that stores sketches (also referred to as individual datasets or data records of the database) in the standard `*.dmp` formal. The current database can be changed under the main menu option: *Edit-Preferences-Application-DB Query*.

To put the current sketch into the current database the user simply has to press the ⬇ button. If the sketch has not yet been processed then this is done before the sketch is stored. The sketch is stored in the normal `*.dmp` format; the dataset name is generated automatically. Any sketch can be stored as dataset in a sketch database and it is also possible to retrieve, edit, delete, or move previously stored sketches in the database. The database in this context consists of a set of files with the proper extension and the proper format and its access table (index) is the directory's file listing.

2.11 Attach files to a Sketch

In order to link a sketch with other documents, *Sketcho* provides a function to attach files to a sketch. It is possible to store any number of documents to a sketch. When a sketch is saved also the links to the attached documents are saved. These links are absolute that is, the sketch record can be moved or copied from one database to another and the attached links are still intact. If attached files are moved, however, they are not recognized any more and their links are being disregarded.

It is possible to attach image or text-document files to a sketch. However, only image files are currently operational. The topmost image can be displayed as a background of the sketch 🖼. This is practical, for instance, for digitizing purposes or when sketches have been generated automatically based on image data (e.g. feature extraction and aggregation of orthophotos). Pressing the 🔳 button, invokes the *Attach Files to Sketch* Dialog Box shown on the Figure below.
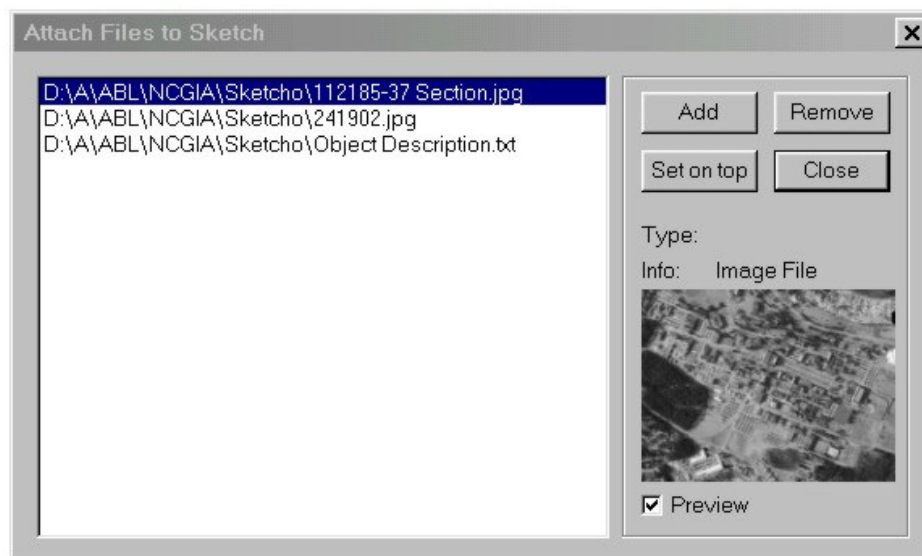
Figure 15   Attached Files Dialog Box

The dialog box of Figure 15 above shows that the sketch is associated with two image- and one text-document. The topmost image file is highlighted and shown in the preview window. To change the order of the files, specifically to set/change the topmost file there is a button (*Set on top*) that sets the highlighted file on top of the list. Similarly, attached files can also be deleted from the list (using the *Remove* button). When a new sketch is created, this box is empty. To populate the box the user may press the *Add* button, which opens a standard Windows open-file dialog box. Multiple selections are possible as well.

2.12 Hiding Text Objects

Pressing the ⊞ button toggles the show/hide status of all annotations and text objects. This includes annotations that are drawn (objects that have been recognized or designated as text-objects) and typed annotations.

2.13 **Show/Hide the Background Image**

If an image is associated with a sketch, then this image can be displayed in the background of the sketch by pressing the ⊞ button. This can be helpful if an image has to be digitized manually or if a sketch must be referenced to a picture. Images are always displayed with their original size and centered within the sketch document. If an image is used as a background, then the sketch is zoomed to 100% and the zoom tool is temporally disabled. However, it is still possible to pan the sketch and the image. The reference points of the image in relation to the sketch are stored in the *.dmp file. If an image is available as a background that is, if the attached file list is not empty, then this is shown on the status bar by a small blue rectangle between the database name and the status lights, such as shown in the Figure below.
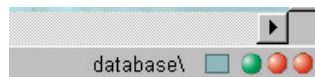
Figure 16   The status bar indicates that an image is ready to be displayed.

2.13.1 Changing image properties

Images, notably orthophotos, are often relatively dark so that it becomes difficult to see the sketch on top of the image. Sketcho provides an option that allows altering an image visually. However, this alteration is limited to the displayed image that is, the original file is not changed. To change the appearance of an image the user has to open the application preferences (*Edit-Preferences-Application-Image Preferences*) from the main menu bar. This will open the dialog box below.
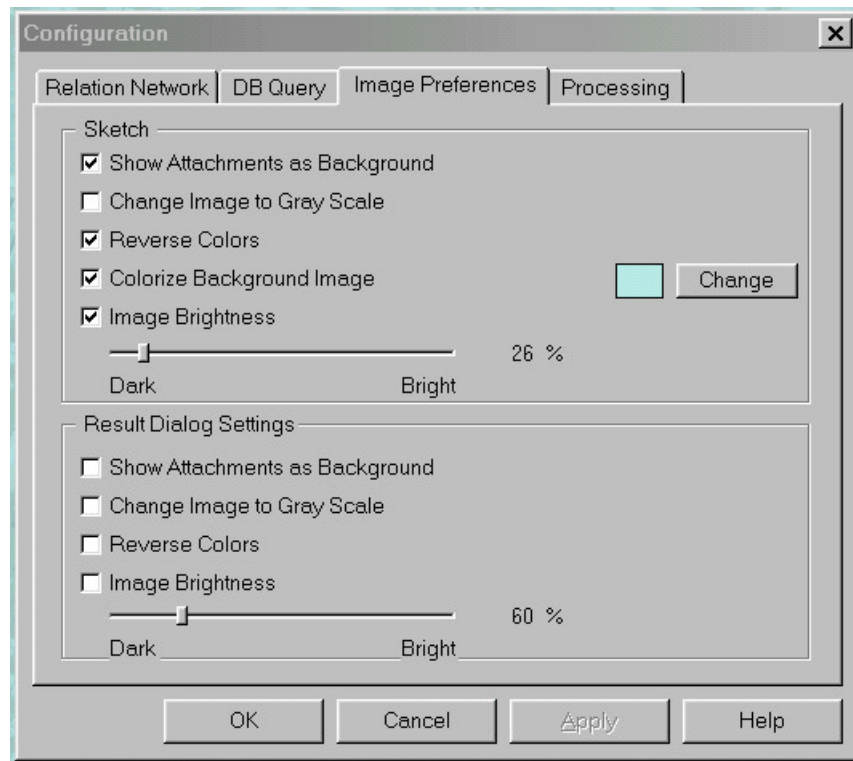
Figure 17   Change image preferences dialog box

The set of provided options is relatively simple but it may help increase the visibility. The image can be converted to gray scale, it can be colorized with a specific color, its colors can be reversed, or the image brightness can be adjusted. The image provides also an option to do the same manipulations for the result dialog box that will be discussed later on.

2.14 User Preferences

Some characteristics of the user interface can be controlled through the User Preferences dialog box accessible via the main menu bar (*Edit-Preferences-User*).
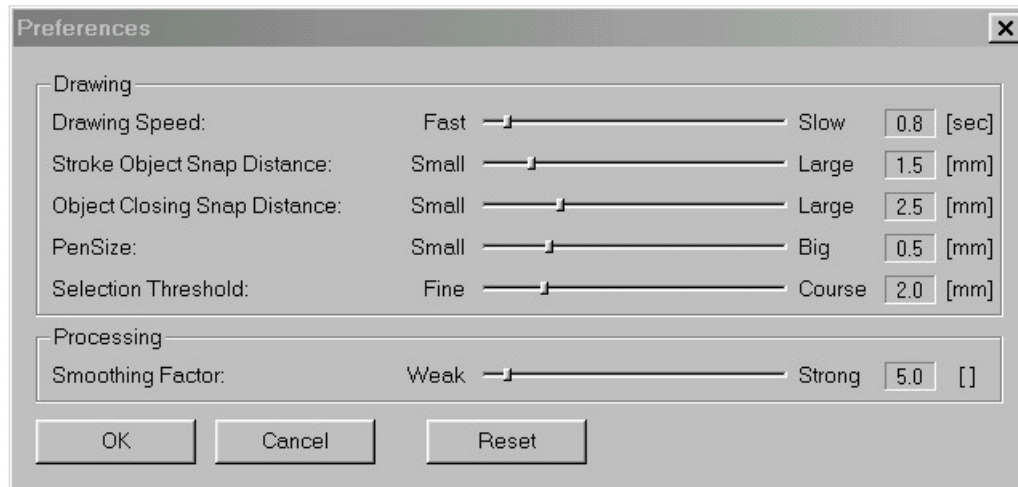
Figure 18   User Preferences Dialog Box

The parameters that can be modified are self-explanatory:

- *Drawing Speed* specifies the time maximal interval between strokes that can pass so that the new stroke is considered to belong to the previously drawn object (even without considering the stroke's location)
- *Stroke Object Snap Distance* is the maximal distance that a stroke can have from an edge so that it is still consider belonging to this object.
    → This distance is bigger around the vertices of an object.
- *Object Closing Snap Distance* is the maximal gap that is closed between vertices of strokes of the same object.
- *Pen Size* is the pen size with that an object/stroke is drawn.
- *Selection threshold* is the maximal distance that the cursor may be away from an edge of an object so that this is still selected.
- *Smoothing Factor* is the value that is used for the secondary smoothening of strokes. A higher value leads to a reduced number of points, but also in a more course representation of the sketched objects.

2.15 Application Preferences

There are numerous application parameters that can be set in the application preferences dialog box. This box is accessible through the main menu bar (*Edit-Preferences-Application*) or through the application preferences button . Preferences are, so far, divided into the following four categories:

- Relation network configuration (Association network)
- Database query configuration
- Image preferences
- Processing preferences

This division has some program historical reasons and is, therefore, provisional and might change over time and for future versions of the prototype.
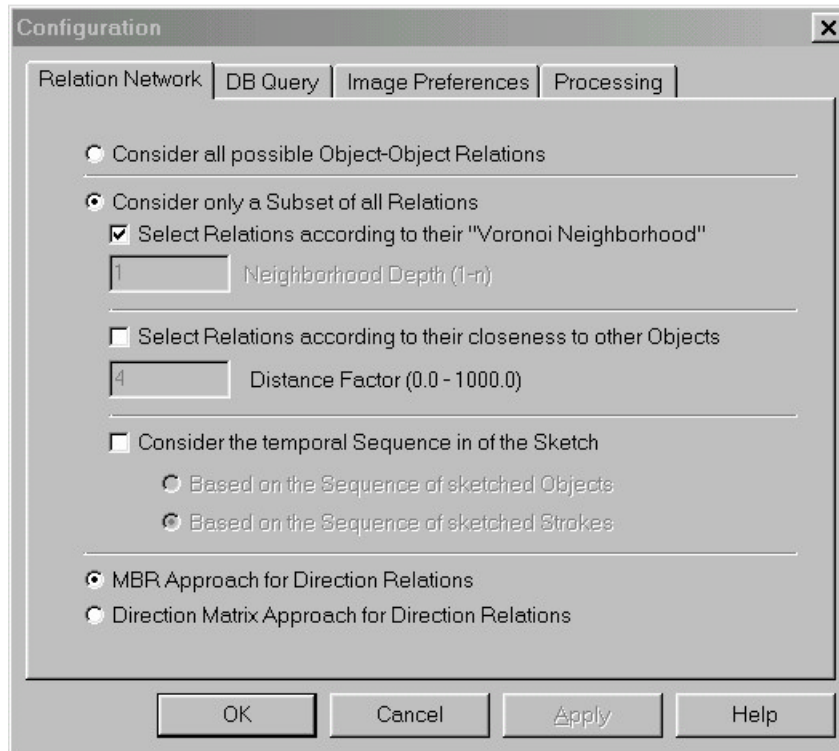
Figure 19   Application Preferences, Relation Network Dialog Box

This dialog box specifies the method that is used to generate the relation network of a sketch. There are principally two approaches to create this network. The first is based on the entire set of binary relations between all non-text objects in the sketch (first option); the other approaches use only a subset of the entire set. In order for the application to decide which relations to take into account and which relations to disregard, there are three methods:

- The first method is based on the Voronoi Neighbor approach described in [Blaser, 1999 (to be completed) #1910]. In short, this approach considers only relations between an object and its immediate neighbors, which reduces the number of relations to compute and analyze, while keeping a set of most relevant relations.

- The second approach is based on a relative primitive algorithm that determines relations between objects based on the size of the two involved objects and on their distance to each other. Increasing the factor increases the range of an object and such the number of relations used in the model (See the technical report for details (Blaser, 1999)).

- The third method finally considers only the temporal sequence in which objects have been drawn. That is, objects that have been drawn after each other are connected. This method has a further option: if objects are drawn initially in an incomplete fashion and finished later (e.g. some strokes are added later to the object) then it is appropriate to select the second temporal option. This option is based on observations in our sketching report (Blaser, 1998).

The three latter methods can be combined, however, relations that have been selected multiple times are only considered once.

Currently the application provides two different methods to compute the directional component of the model. The first approach is based on a model that uses the objects MBR's (Papadias and others, 1995; Papadias, Egenhofer and Sharma, 1996). The second approach uses MBR's as well, although in a more sophisticated manner (Goyal and Egenhofer, 1997). At the moment the second method is not operational, because research for this specific approach is still ongoing. The set of metric descriptors that is used to describe the metric relationship between object pairs has been formulated and described by (Shariff, 1996) in his PhD thesis. The formalization of the topological component of a relation, finally, is based on the 9-intersection model of (Egenhofer and Franzosa, 1991).
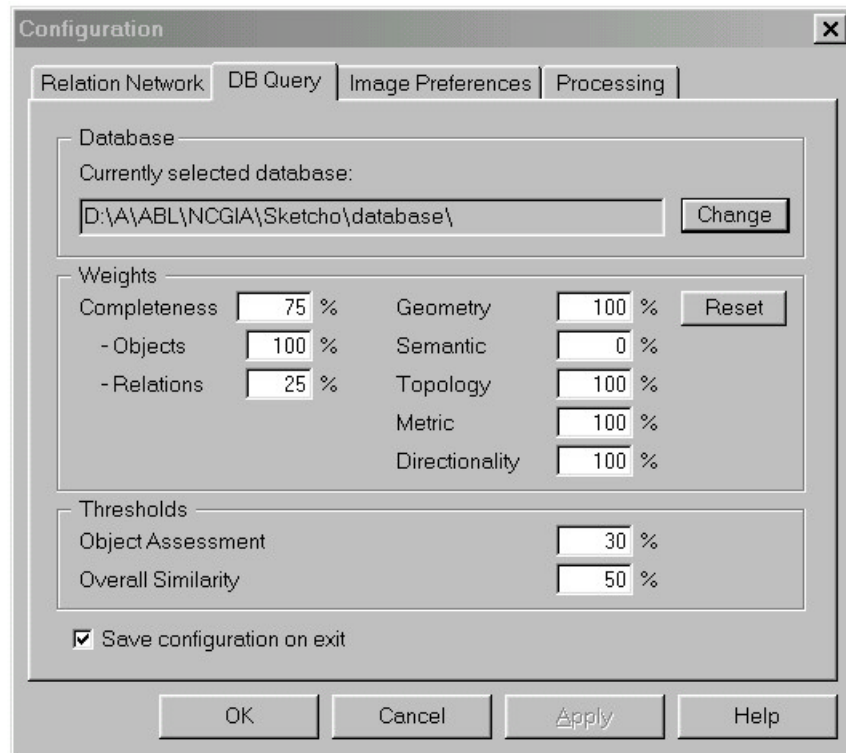
Figure 20   Application Preferences, Database Query Dialog Box

The database query dialog box allows a user to specify the current database. The current database is the directory that stores processed sketches and their representation (called datasets or database records) when the button is pressed. It is also the database that is used when sketches are queried. The name of the current database is visible on the right side of the status bar (Figure 16).

Beside the name of the database, the user may also specify different global weights for the individual components used in the formal model of the sketch. Completeness is a measure to describe the wholeness of the retrieved result. For instance, if the query sketch contains 4 objects but the retrieved sketch contains only three objects, then the total similarity of the two representations may not exceed 75% (assuming a 100% completeness weight). The relational completeness works in a similar manner. However, it can only be applied when subsets of the complete relation set are used for the model.

The geometry component takes object attributes, such as shape or size into consideration. Semantic is not yet used. Geometry and semantic are object-specific, while the values for topology, metric, and directionality refer each to the properties of binary object-object relations. The similarity between two scenes is computed using the weighted similarities of the components stated above. The value for completeness is used to limit the maximal possible similarity as shown in the Formula below.

$$SceneSimilarity = Similarity * (p_{Comp} * Completeness + (1.0 - p_{Comp}))$$ Formula 1

with $Similarity$:= The weighted similarity of all other scene attributes

p_{Comp} := The weight for Completeness

$Completeness$:= The averaged value for completeness computed based on objects and relations.

The threshold for the object assignment is used in the process of automatically assigning objects in the query sketch to objects in individual database records. The threshold marks the minimum object-object similarity that must be present (for each individual object-object couple) so that these specific objects can be associated with each other. Such, using a low threshold increases the likelihood that objects can be associated, however this might also lead to objects being mistakenly associated with each other.

The overall similarity is used to exclude data records from being ranked and presented to the user. That is, if the value for the overall similarity threshold is set to 75%, then only data records with at least such a scene similarity are being considered.

The processing dialog box contains by now just one parameter: the automatic text detection. This option is turned off by default. If this option is chosen, then freshly drawn objects are tested upon being handwritten text.
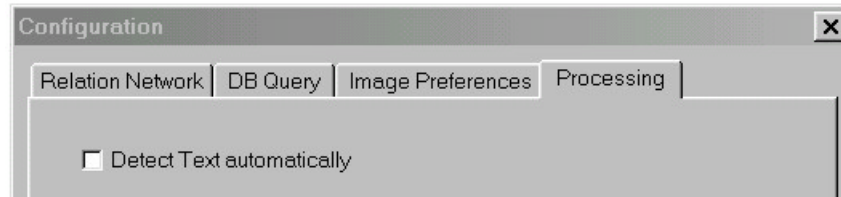
Figure 21   Application Preferences, Processing Dialog Box

The set of configurable parameters is stored in the `sketcho.ini` file. However, it is not recommended to modify this file manually, in part also because many parameters are not yet documented. If the file should get corrupted, delete the file and restart *Sketcho*, this will create a new `sketcho.ini` file with the default values.

2.16 View Preferences

The View Preferences dialog box is available for the Sketch- and Object View. Settings in this dialog box allow the user to enable or disable specific visual elements and processing by-products for verification and debugging purposes.
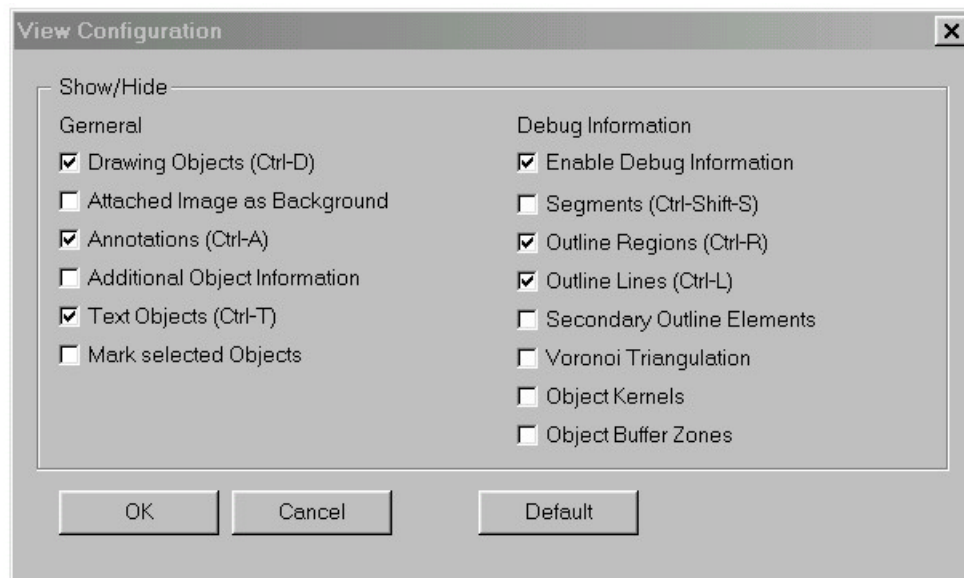
Figure 22   View Preferences Dialog Box

Checking, respectively un-checking options in this dialog box are immediately interpreted that is, their effect is instantaneously visible. Pressing the *Default* button will reset all options.

3   Advanced Functions

3.1   Changing Views

Sketcho has three different levels of abstraction for the same data. These levels are called *Views* according to the Microsoft's MFC terminology. The primary data view is the *Sketch View*, this is the place where the sketch is generated and edited and this is also the only mandatory view. The other two views can be used to examine the intermediate results of the sketch interpretation.

To change between views there are three possibilities:

- Select the button from the toolbar
- Press Ctrl-Tab on the keyboard
- Select the desired view from the view menu (*Views-Change View*)

Selecting the *Sketch View* is always possible; *Object View* and *Formal View* can only be chosen if certain conditions are met.

3.2   Sketch View

All functions described so far are geared towards the *Sketch View*. The two last functions that need a description focus on processing objects and establishing relations between these objects. Both functions can be invoked from the Sketch View.

3.2.1   Processing sketched Objects

This step is necessary in order to bring all objects up to date. If the object-processing button is pressed, all objects that have not yet been processed will be processed. During normal sketching operations, this includes only the last current object, because all previously drawn objects have already been pre-processed. Such we do not have to process all objects at once, but can do it incrementally. However in some cases it is necessary to process the entire sketch (all objects) this can be initiated by pressing the shift key and the object-processing button simultaneously. To assess if the entire sketch has to be processed, there are three status lights on the right side of the status bar. The left light indicates the object status, the light in the middle that of the set of relations, and the light on the right indicates the readiness of the entire sketch.

Figure 23   Status indicator lights on the lower right corner of the user interface (Status bar)

The lights can have the following colors:

- Red: Not Ready
- Yellow: Partially Ready
- Green: Ready
- Blue: Currently Processing

In order to be able to switch to the next view, it is necessary that we have a green object indicator light (left light). If it is yellow or red the user has to press the object-processing button before he or she can continue. However, if the change view button is pressed and not all objects have been processed, then the application automatically updates all objects.

3.2.2   Processing spatial Relations

The functionality of this button is similar to the one described above. The difference is that pressing this button will always result in processing the entire set of model relations. Upon pressing the button the indicator light turns blue while the application is processing and then green after the task has been completed.

3.2.3   Querying a database

Sub-Chapter 4.8 provides an in-depth look at querying a sketch database

3.2.4   Debugging View

Please see the Sub-Chapter about View Preferences 3.16.

3.3   Object View

The *Object View* shows what the application has detected considering sketched objects. The view shows a simplified and interpreted outline of each object and it conveys—using different colors—each object's type. Should an object have been misinterpreted, for instance a region has been considered as a line because it was not automatically closed, then this can be reversed by a simple push of a button 🐾. (*) It is also possible to move, delete, and edit objects at this stage, all without changing the initial sketch. That is, modifications on this level are only passed forwards to the next level of abstraction, but not backwards.

Hence, the major purpose of this view is to provide a tool that allows to check what the object detection engine has detected so far and to modify the representation if this should be necessary.

In this context there are three basic functions available:

(*) These features are currently disabled (Version 1.1a)

3.3.1   (*) Move an object or parts of an object

If the location of an object is not satisfactory then the object can be grabbed and moved to a new location. This is possible with single and multiple outline objects. Like in the *Sketch View* individual parts of objects can be moved separately.

3.3.2   (*) Delete an object or parts of an object

If parts of an object have been misinterpreted, then this is the time for a correction. Besides moving it is also possible to delete detected line or region sub-objects form objects. Entire objects can be deleted as well.

3.3.3   Changing an Object's Type

An important function is that to change an object's type between region and line and vice versa. To change the type of an object the user has to select the object and then to press the change type button 🐾. This function is reversible and also available in the *Sketch View*.

The *Formal View* is the third and last view of our prototype application. This view represents the highest level of abstraction where every object or relation is solely represented by a symbol that is connected to other entities according to the application setup and to current situation. Currently there are four different symbols implemented. These symbols cover current the data model of the prototype (region and line objects, and binary relations) and possible future extension such as multiple relations. However, although it is possible to establish multiple relations they are not yet operational (e.g. stored or processed).

Despite the relative simple and abstract look of this view, the user has some powerful tools to further edit the sketch in this phase. For instance, it is possible to disable or (re)-enable objects or relations, and it is also possible to create new relations between objects if there is no previous automatically generated relation.

3.4.1 Symbolic description

All objects and relations in the *Formal View* are represented by symbolic icons that can be freely rearranged. By now there are four different symbolic representations possible, covering lines, regions, binary relations, and multiple relations. As stated before, multiple relations are not generated automatically. Model objects to be implemented in future version of the prototype include: derived points, lines, and regions.
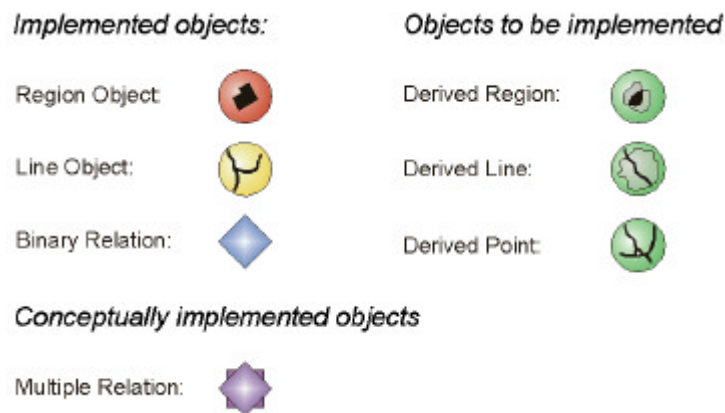
Figure 24   Currently implemented (left) and projected (right) symbols for objects and relations in the Formal View.

3.4.2 Viewing the neighbors of an object

To view all neighbors of an object or the two objects of a relation, the symbol in question has to be selected. This will highlight the appropriate set of symbols using an alternative color.

3.4.3 Arranging objects and relations

To move an icon it has to be selected and dragged to the new location. This is slightly different from the two other views, where the shift key has to be pressed to obtain the same result.

3.4.4   Browse/Edit object properties

The object dialog box is invoked by pressing the right mouse button over an object. The box shows a variety of object properties, some of them are modifiable (white) and others are not (gray).

Figure 25   Object property dialog box.

Most dialog entries are self-explanatory. Properties that are automatically evaluated are: Type, area/length, and orientation. The annotation reflects what the user has annotated earlier during the sketching phase. All other parameters are not yet operational and are not used for any calculation. The overall weight of an object is the parameter that decides how important an object is within the context of the sketch. This value should be assigned by the application during the sketch evaluation process but it can also be adjusted manually. However, because we do not yet evaluate objects in this sense, the overall weight is 100% for all objects.

Figure 26   Object property dialog box with object and TMBR and interpreted Object View.

To view the interpreted outline of an object the user can to double-click the object in the lower right corner (Figure 26). This will result in the representation of the object's outline and its TMBR.

Figure 27   Changing the direction of an object.

If the object has a direction, then this direction can also be viewed or changed graphically by moving the direction indicator (a small black line) in the white object area (Figure 27). Alternatively, the direction can also be changed using the appropriate edit box.

3.4.5 Browse/Edit relation properties

Relations can be browsed or edited the same way as objects that is, the right mouse button has to be pressed over a relation symbol and the relation dialog is invoked. The dialog works for all binary relations, though the full functionality is only implemented for region-region relations. However, some functions are implemented for line-region and line-line relations as well. (By now line objects are treated as long region objects)
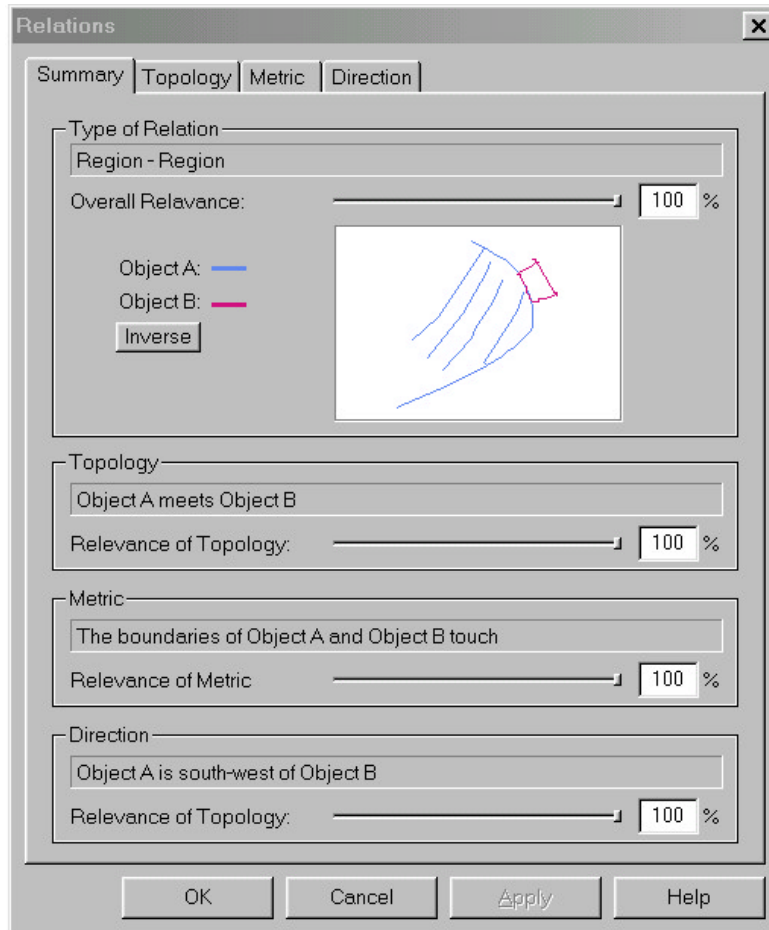
Figure 28   Summary information dialog box.

The first page of the dialog provides summary information about the selected relation. Similar to the object properties dialog box, weights that can be assigned on a general level and for all model components. The inverse button switches Object A and Object B.
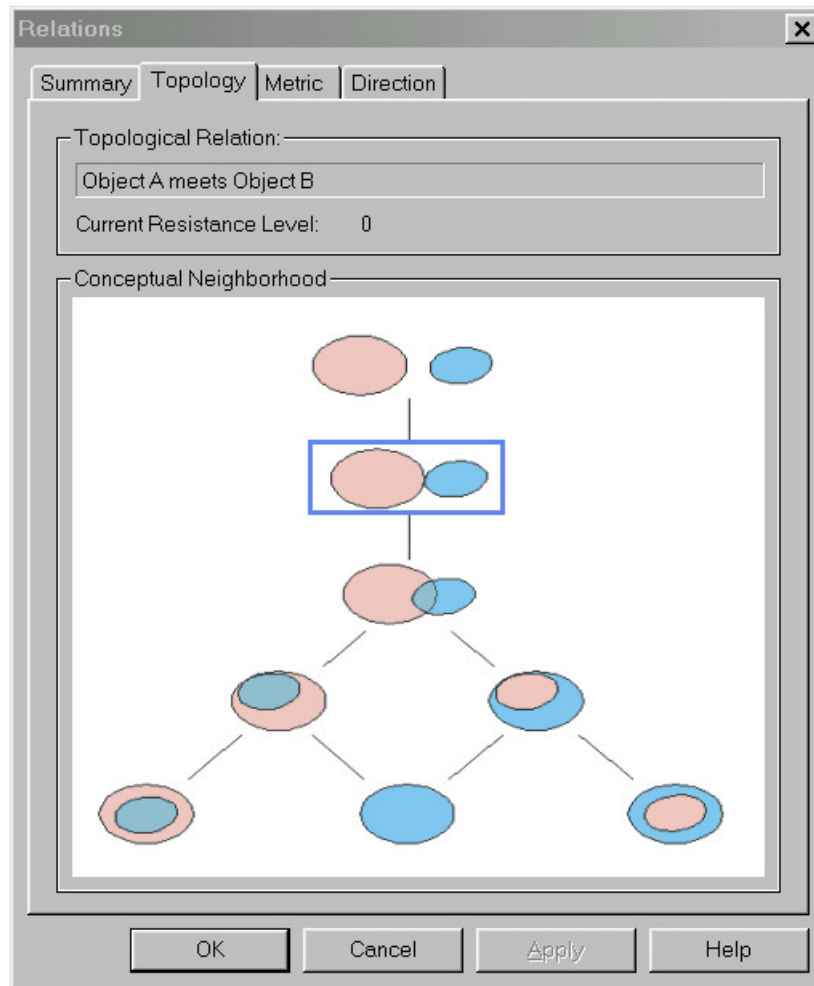
Figure 29   The topology page of a binary region-region relation.

The first page shows visually how the topology of a relation has been classified. To change the topological state of a relation it is possible to click on other topological states. This moves the blue rectangle, indicating the current state and leaves a gray shadow at the original place. The current resistance level indicates how far the selected relation is from the original relation (0 being no resistance). However, this has by now no effect on later calculations.

Figure 30 Property page with information about the metrical components of a region-region relation. This example shows an overlap situation.

The next property page is concerned about metrical relations. Depending on the relation's topology, different parameters are evaluated. This dialog box has a mere display function because these parameters cannot be changed. However it is possible to assign and change the relevance of each metric variable. This relevance is not yet considered in the formal model of the application.
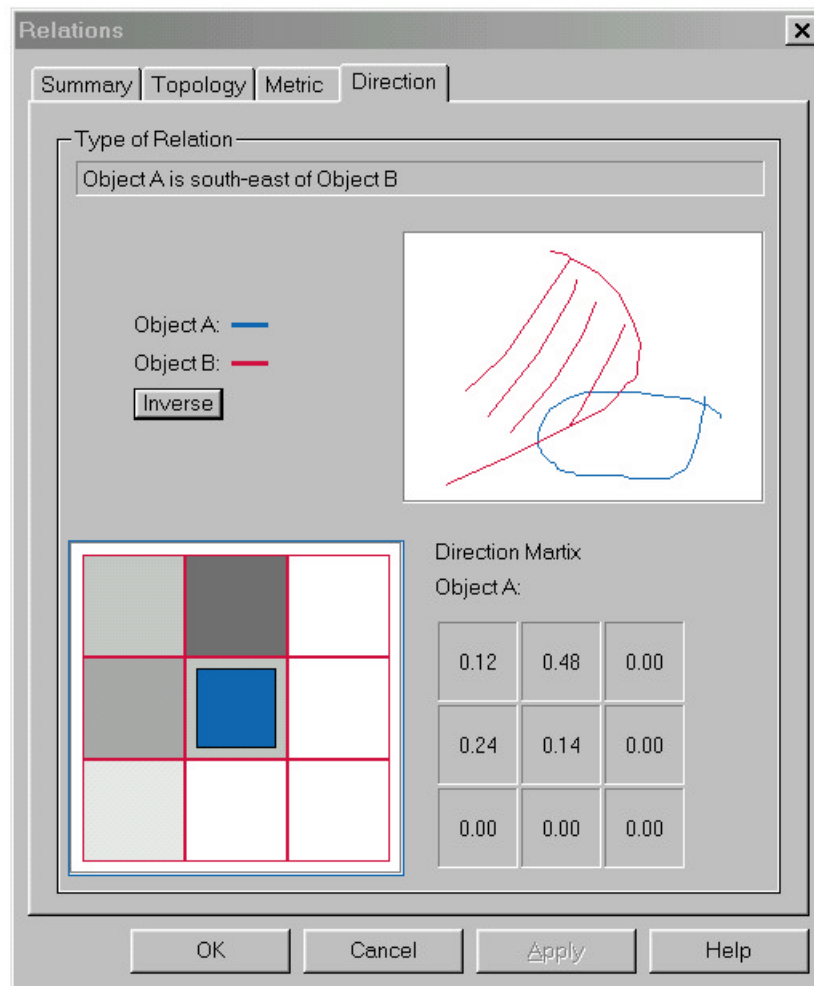
Figure 31   Property page with information about the directional component of a binary relation.

Finally there is the direction property page that shows the directional relation between two objects based on the direction-relation matrix. The dialog shows this information in graphical, textual, and in matrix form. By pressing the inverse button the converse relation can be browsed. There is no possibility to change the relevance of this relation component, because this is already covered on the general relation page.

3.4.6   Adding a binary relation

A new binary relation can be created when two objects are selected and the group/ungroup button ⌗ is pressed. To select multiple objects the user has to press and hold the Shift-key, while clicking on the desired objects. The relation is created and treated like any other automatically created relations that is, it can be browsed edited and so on.

3.4.7   Adding a multiple relation

To create a new multiple relation the user has to select three or more objects the same way as when a new binary relation is created. The symbol of a multiple relation will differ and there is until now no functionality behind this relation.

3.4.8   Disabling objects or relations

Objects and relations can be disabled or re-enabled by selecting a symbol and then pressing the delete button.
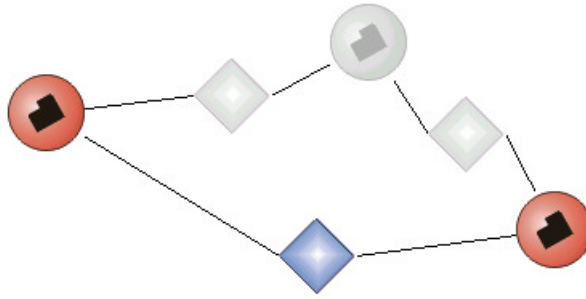
Figure 32   Three region-objects, one of them is disabled.

3.4.9   Deleting objects/relations

In order to delete a relation or an object that user has to press the Shift-key in addition to the delete button. Similar to the Object View, objects are not deleted in the previous views but only in this, the Formal View.

3.4.10 Show/Hide the legend

Clicking somewhere onto the screen of the *Formal View* invokes a modeless legend (dialog) that can be closed by clicking on another part of the screen.

3.5   Printing Sketches

Sketches and their background can be printed using the standard Windows printing facilities. This includes the selection of the printing device (*File-Print Setup*), the print preview (*File-Print Preview*), and the printing dialog as well (*File-Print*). These functions are all accessible through the main menu. This facility works for all versions of the prototype (also Windows NT).

3.6   Sketch Manipulation

By now the only sketch manipulation implemented is the rotation. This function is accessible through the main menu (*Tools-Rotate-Sketch*). The function to moving and scale sketches is prepared but not yet implemented.

3.6.1 Rotating a sketch

An entire sketch can be rotated in increments of 1° (1/360 of 2Π); the sketch can be rotated in both directions. This function is accessible through the main menu (*Tools-Rotate-Sketch*).
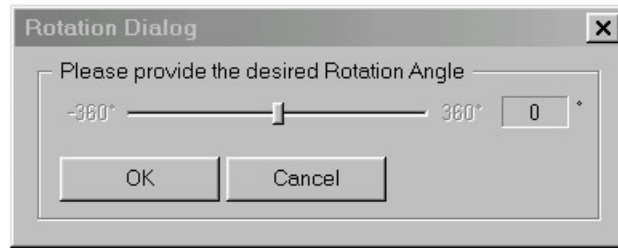
Figure 33   The rotation dialog box.

3.7   Database Manipulation

So far there are three basic functions to manipulate a database. The first function computes and displays a set of statistical information about a database, the second lets a user reprocess a selected database, and the third function generates a random database based on the current sketch.

3.7.1 Analyze a database

This function computes some statistical information of the selected database and its contained data records. The function is accessible through the main menu (*Tools-Database Tools-Analyze Datasets*) and allows the user to pick any database available.
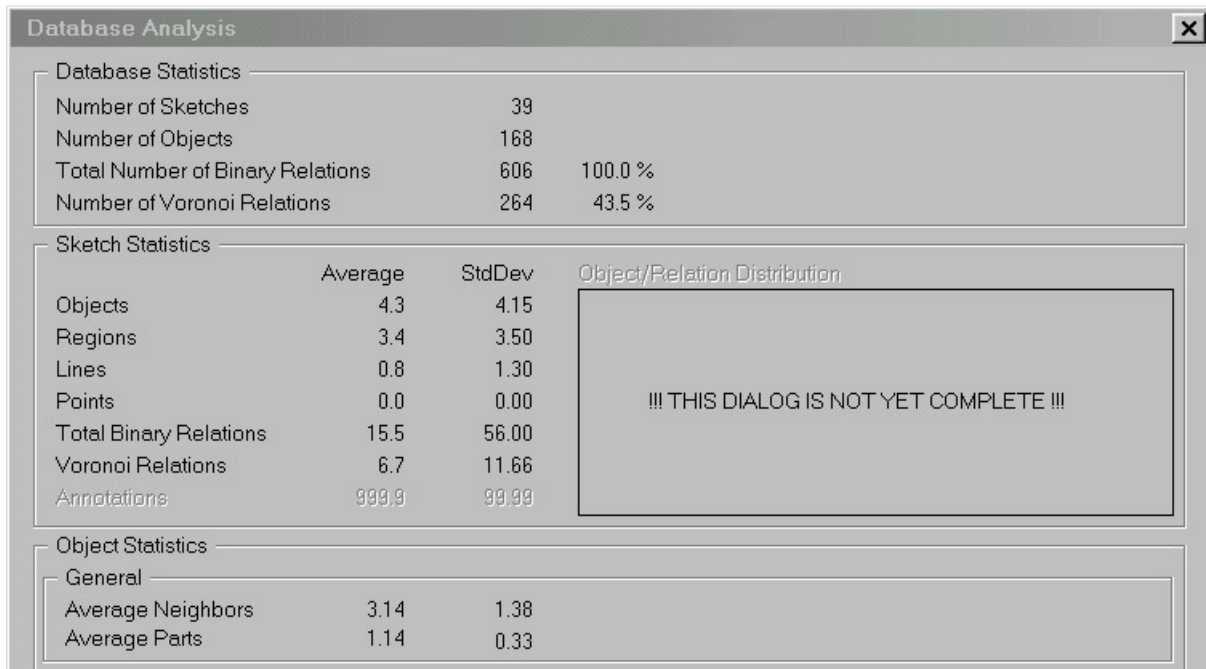
Figure 34   This figure shows a section of the database analysis dialog box.

Figure 34 shows a section of the database analysis dialog box. By now only a small set of statistical values is computed. This section will, eventually, be expanded in future versions of the prototype.

3.7.2 Reprocess a database

Reprocessing a database becomes necessary, when sketches have been recorded with a different program than *Sketcho* or if computational methods of *Sketcho* have changed since the database was generated. Reprocessing is possible, because the `*.dmp` format consists of multiple sections and because only one section–the sketches geometry–is mandatory. Such, it is also possible to "record" a sketch with a different program and solely writing the geometry of a sketch in the correct format into the `*.dmp` file. The necessary computations can then be done using the reprocessing option of *Sketcho*. Like the other database function this function is accessible through the main menu (*Tools-Database Tools-Reprocess Datasets*).
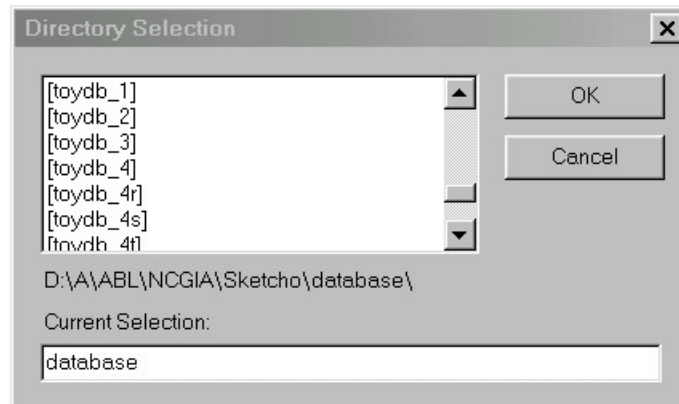
Figure 35   Database selection dialog box.

3.7.3 Create a random database

In order to investigate larger sketch databases *Sketcho* has a designated function that allows a user to create an entire database of sketches from one initial sketch. The user can specify the number of data records (sketches) of the database (to build) and the methods how the individual data records are created. These methods focus on moving, rotating, and scaling individual objects within a given random interval and rotating the entire sketch with a random angle. The intervals can be specified as indicated in the dialog box below. If a method's interval is set to zero, then this method is not applied.
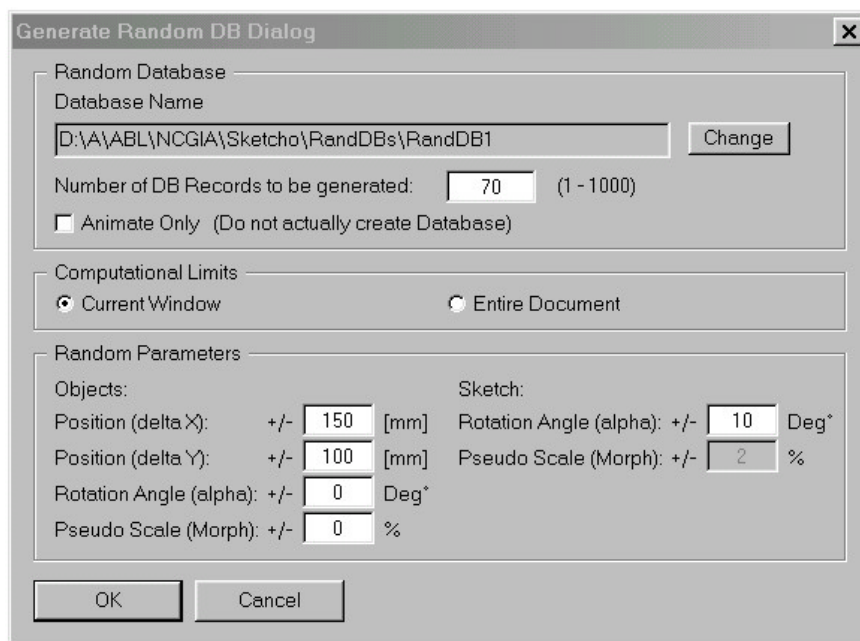
Figure 36   The random database generation dialog box

The new position of objects can be controlled by selecting appropriate computational limits. The limits available constrain new object positions (the center of the object's MBR is considered the object's location) either to the visible field of the user interface (Current Window) or to the entire document that is, objects stay always inside the document (Entire Document).

In order to estimate a possible outcome of a randomly generated database, the dialog box includes an option that lets a user check the chosen random parameters, before creating the database (*Animate Only*). With this option enabled, the user is able to follow the random sketch generation without actually producing a database. This method is much faster, because no sketch parameters have to be computed.

Caution: The original sketch will not be saved! – If you want to keep the original sketch then this has to be done manually (e.g. by choosing the menu option *File-Save*, or by pressing the save button 🗖).

The default path for random databases is `\RandDBs\RandDBx` with "x" being an automatically increased number. However, because a database is just an ordinary directory with sketches stored as files in the standard `*.dmp` format, a database can be created at any place of the file structure (the use of a network is also possible). The default name of randomly created data records is `dbx.dmp`, with "x" being an automatically increased and unique number. A database can, therefore, also be created in multiple steps. The maximum number of datasets per database is 1'000'000. Individual sketches of a database can also be freely deleted (e.g. using Windows' explorer) and new sketches can be added manually if this is necessary. There is no naming convention in the database. The database is consistent, as long as the dataset files have the appropriate extension and the correct format.

3.8   Database Query

Once a sketch is drawn it can be queried against a database. The database used for this purpose is always the currently selected database (as indicated at the right side of the status bar). The default database can be changed by modifying the appropriate entries in the application preferences settings. A sketched query must consist of at least one object (Remark: In this particular case the weight of the *geometry* component may not be zero, because with only one object there are no binary relations to be established), on the other hand, there is no upper limit for the number of objects in the query sketch. However, sketches with large object numbers queried against large databases may result in prolonged computation times (see section about the current performance). The sketched query may consist of any combination of line and region objects, multiple sub-objects are allowed as well. Objects and relations can have individual weights and they may be disabled (e.g. using the tools provided in the *Formal View*).

The result of the query is a ranked list of sketches (Data records). Different computational models are available and many factors influencing a query can be visually modified. The following sections describe the main functionality of the query interface, they also show, how the results can be analyzed, exported, and printed.

To initiate a database query the user has to press the query button 🔍 at any time of the sketching process that is, it is *not necessary* to select the object-processing 🚦 or relation-processing 🔀 button beforehand.

3.8.1   Result dialog

The main query interface is the result dialog box shown on the figure below. This dialog box includes all necessary interaction tools to browse through the results and to modify the query, if this is necessary.
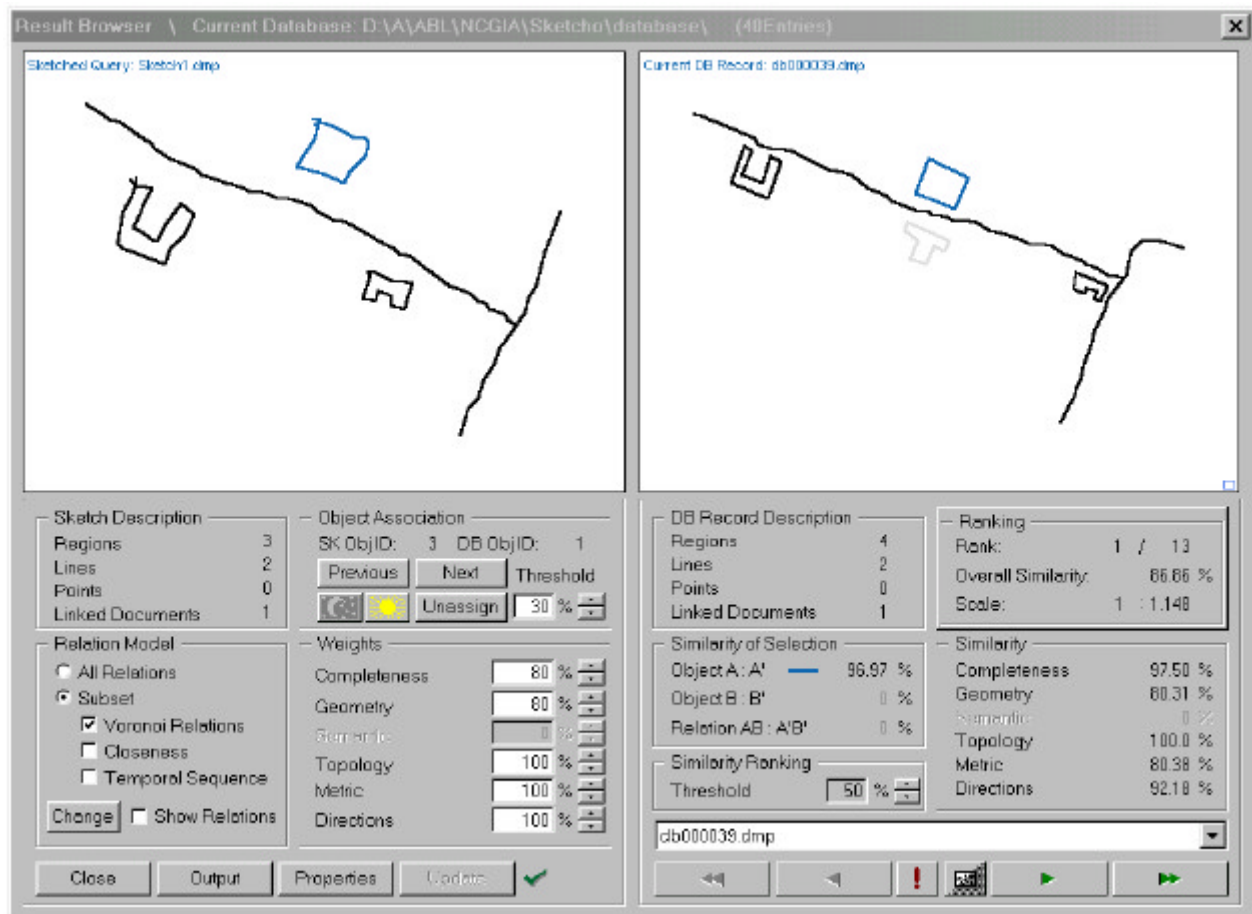
Figure 37   The result dialog box

The left side of the dialog box (graphical section) shows the sketched query and on the right side there is, initially, the best match from the database–if the query was successful. Object that the application could associate automatically are outlined in black, while objects with no corresponding pair are drawn in a light gray shade. The dialog box informs a user about the overall ranking (overall rank and scene similarity), about individual similarities of model components, such as completeness or topology, and about individual similarities between (selected) matching object- or relation-pairs. The left, text-oriented section of the dialog box is configuration-oriented, while the left side is oriented towards the result of the query in regard of the currently selected database record.

a) Scene Information

Both, the sketched query and the currently selected database record have a section that describes the individual scenes quantitatively. These sections are entitled *Sketch-* respectively *DB Record Description* and they contain information about the number of line, point and region objects per scene. The Figure below shows this section for the sketched query in the example above (Figure 37).

Sketch Description
Regions	3
Lines	2
Points	0
Linked Documents	1

Figure 38   A simple quantitative scene description of the sketched query.

b) Navigating the results

To navigate the results the user may either push one of the green navigation buttons (shown above), or directly select the desired database record in the list box on the right side of the dialog box. This list-box contains the names of all database records that have a similarity above the provided scene similarity. If a database record has a sketch annotation, then this annotation is preferred before the actual database record name. The list is ordered alphabetically (conversely to the ranking list which is ordered by rank). Switching data records, will results in the dialog box being refreshed with the new database record specific values.

c) Updating the query
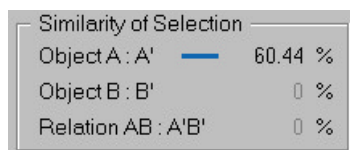
Certain actions, for instance, if a user changes weights or if objects are manually associated will require the query to be recomputed. The prototype logs all modifications and informs the user when a re-computation is necessary. The application uses a green check mark ✔ for a consistent up-to-date query result and a red cross for a query that has to be updated ✖ (Update indicator). In the case that the query must be update, the user simply has to press the update button next to the update indicator and all necessary steps are automatically initiated. Pressing the update button does not change the selected data record on the right side. It can, however, change the similarity values and/or the ranking. For the case that with the new evaluation the old current database record falls under the given scene similarity threshold, the best match is again selected.

d) Checking out object information

Object information can be checked by right clicking an object or by selecting the object (using the left mouse button) and pressing the properties button (object is now drawn in blue, the current object color). At this point it is, for instance, possible to change an object's weight. The similarity between the query object and its corresponding object in the data record is provided on the right side of the dialog box and the corresponding object is depict in blue as well (See Figure below).

Similarity of Selection
Object A : A'	▬	60.44 %
Object B : B'		0 %
Relation AB : A'B'		0 %

Figure 39   The individual similarity section of the dialog box when an object (-pair) is selected.

Another way to select an object is pressing the next or previous button, which will toggle rotate the currently selected object through all objects of the sketched query.

e) Checking out relation information

Similarly to checking out object properties it is also possible to browse through relation properties. There are two ways to do this. The first is pressing the next or previous button while holding down the Shift key. The second method is to enable the display of relations and to select a specific relation (double diamond).

Figure 40   A line and a region object connected through a binary relation. The relation is selected.

Selecting a relation will color the two involved objects of both the sketched query and the retrieved dataset in two different shades of blue, this will also provide access to the similarity values of this relation and the to object pairs (Shown in the Figure below).

Figure 41   The individual similarity section of the dialog box when a relation is selected.

Pressing the properties button or right clicking a relation will open the relation properties dialog box. At this point it is possible to change the weights or simply to browse through the topological, metrical, or directional parameters of the relation.

f) Re-associating objects

When the query is initiated each object of the sketched query is automatically assigned to the geometrically most similar object in each data record. For this to happen both objects must be of the same type and the object's similarity must be above the provided object similarity threshold, which is 30% in the example of Figure 37 above. The set of algorithms used for this automatic object association are relatively primitive; it can, therefore, happen that objects are assigned incorrectly. There are basically three scenarios:

    An object has been associated with the wrong object

    An object has not been associated at all, although it should have been

    An object has been associated although it should not have been.

To remedy case i), select the object that has been incorrectly associated in the sketched query (the wrong associated object is highlighted in the data record). Now click at the outline of the correct corresponding object on the left, this will re-associate the objects. Note that this will also shift the association of the two remaining objects together (see the two Figures below).
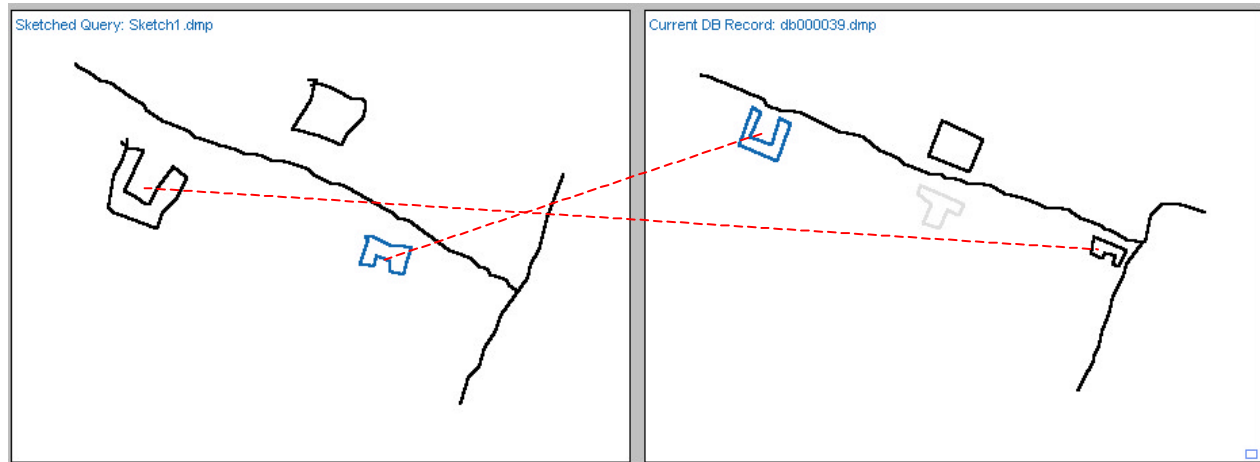
Figure 42a   The selected object is incorrectly associated.
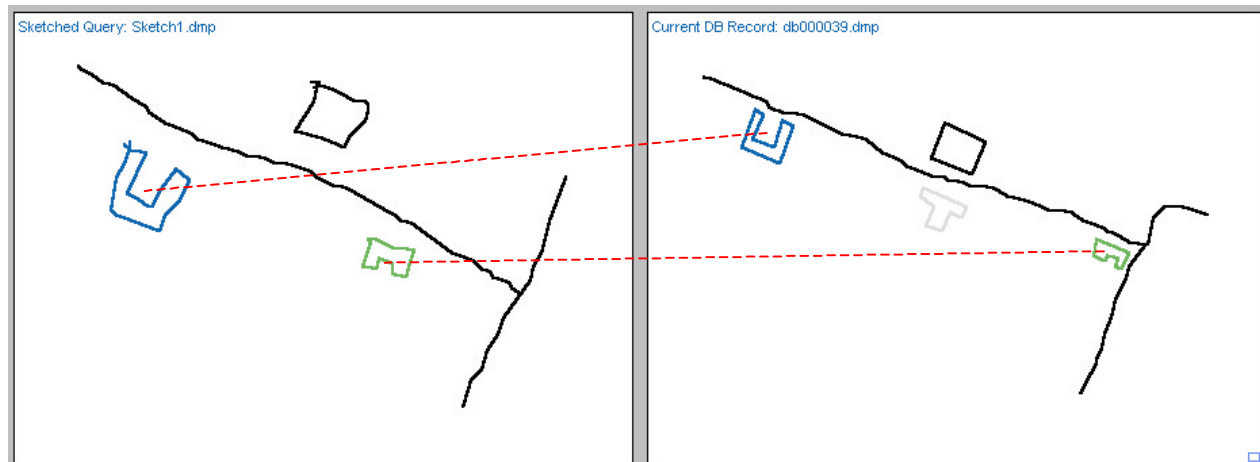
Figure 42b   The incorrectly associated object has now the correct pear and the remaining object pair is selected as the current object pair.

Figures 42a and b show the re-association process for case i). The red dashed lines are added for comprehensibility. If the situation is not satisfying, the user can continue to re-assign objects until all objects have found their correct partner.

Case two ii) involves two different strategies: the first applies when the target object on the left is already (but wrongly) assigned with an object on the right. In this case we proceed as in case one, however, because only three objects are involved one sketch object will be unassigned (light gray shade). The second sub-case is simpler, as the target object on the left has not yet been assigned to any object on the right. Here we just assign the two corresponding objects.

For the third case iii) we simply un-associate the object that has no corresponding object in this particular data record. To do so we select the object on the right and press the unassign button.

If objects are re-associated the update indicator will indicate that an update is necessary. However, as the update does only concern this specific configuration, the update procedure will be relatively quick.

g) Disabling and enabling objects

Objects can be disabled for the entire query (without deleting the object itself). In such a case the object is simply not considered when the relation network and when the similarity are computed. To disable an object, the user can either double-click the object or select the object and then press the disable button . A red cross over the disabled object will visually indicate that the object is disabled.

Figure 43   A disabled object

To enable the formerly disabled object, it is enough to double click the object in question, to associate it with another object on the left side, or to press the enable button . After disabling or enabling objects the query has to be updated (the update button has to be pressed) and *all* data records will be reevaluated.

h) Disabling and enabling relations

Disabling a relation works after the same principle as disabling an object. That is, the user can either double-click a relation (to see the relation diamonds the *Show Relations* option has to be checked) or he can select a relation and press the disable button . Note: when a relation is disabled then its primary weight is set to zero and if it is again enabled then this weight is set back to 100%. Therefore, if the user has specified a relation weight different from 100%, then this weight has to be reestablished manually.

Figure 44   A disabled relation

To enable a relation the user has to once again double-click the relation, select the relation and then press the enable button , or change the primary weight of the relation to a value different from 0%.

i) Changing weights

We have already seen how to change weights for individual objects or relations. However, we can also change the weights of components in our model. By now five of six primary weights are implemented–semantical aspects are not yet treated–and the user is free to chose any combination of weights. These weights refer to three different levels. The highest level is that of the completeness (See the formalization in the section about application preferences). On the object specific level there is the geometry component weight and on the relation specific level there are weights for the topology, metric, and direction components of the model.
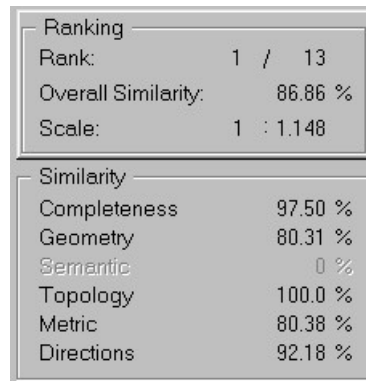
Figure 45   The weights section of the dialog box

If weights are changed the query has to be updated. Depending on which weight has been changed the processing time may vary.

j) Ranking and similarity result display

For each database record the application computes a similarity value; however, only those data records that are above the scene similarity threshold are included in the ranking list. Each ranked database record has a unique rank, a similarity value, a scale, and individual component similarities and those values are displayed when the data record is selected.

```
┌ Ranking ─────────────────────┐
│ Rank:              1  /    13 │
│ Overall Similarity:     86.86 %│
│ Scale:             1   : 1.148 │
└──────────────────────────────┘
┌ Similarity ──────────────────┐
│ Completeness        97.50 %   │
│ Geometry            80.31 %   │
│ Semantic                0 %   │
│ Topology            100.0 %   │
│ Metric              80.38 %   │
│ Directions          92.18 %   │
└──────────────────────────────┘
```
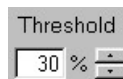
Figure 46   The ranking and similarity section of the dialog box

Figure 46 shows the ranking and similarity section of the dialog box. The overall similarity is the weighted end result of the similarity evaluation. The individual similarity components reflect the values before the component's weights are applied, therefore, even if, for instance, the completeness weight is 0% there will be a value for the completeness of a scene.

The scale is computed based on the size and the scale of corresponding object pairs of the query scene and each specific database record.

k) Changing thresholds

There are two thresholds that can be set: The first specifies the minimum geometric similarity value that must exist between two objects so that they can be automatically associated (see Figure below).

```
Threshold
┌──────┐
│ 30 │ % ▲▼
└──────┘
```

Figure 47   The object similarity threshold section of the dialog box

The second threshold specifies the minimum scene similarity value that is necessary to include this specific data record in the ranking list. Note: It is a common mistake, to have the scene similarity threshold too high and such getting no results. The Figure below shows the scene similarity threshold section of the result dialog box.

```
┌ Similarity Ranking ──────────┐
│ Threshold          ┌────┐     │
│                    │ 50 │ % ▲▼│
│                    └────┘     │
└──────────────────────────────┘
```

Figure 48   The scene similarity threshold section of the result dialog box

l) Changing the relation network parameters

As stated above, there are different methods to compute the association graph (relation network) of our computational model for a sketch. The major parameters can be selected right in the result dialog box itself (See the Figure below).
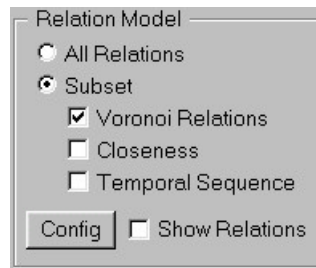
Figure 49   The relation network section of the dialog box

However, the user can also press the configuration button Config in order to change additional model parameters. Pressing this button will open the application preferences (See this section for further information).

m) Show/hide the background image

Attached images can be displayed for the received data record only. If there is an attached image available then this is indicated by a small blue rectangle in the lower left corner of the database record window such as shown in the Figure below.

Figure 50   The blue rectangle in the lower left corner indicates that an attached image is available.

To show respectively hide the background image the user may press the show/hide button, located between the navigation buttons. This will load the image and display it as a background, respectively hide the image depending on the state of the button.
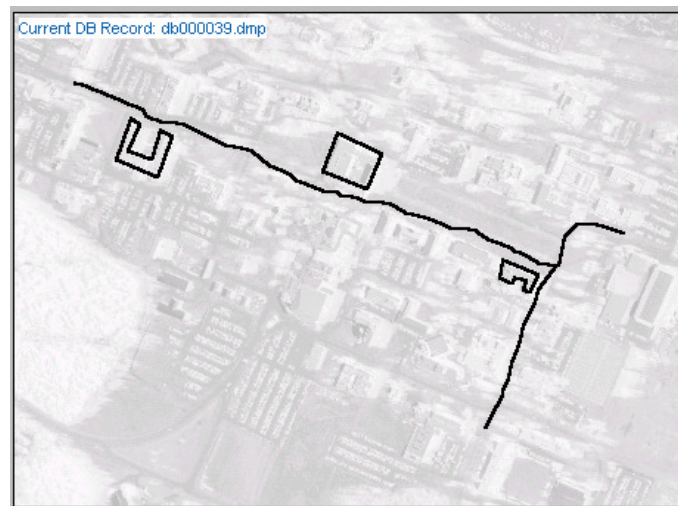
Figure 51   Database record with background image

Double clicking the image will show, respectively hide the sketched objects if a background image is loaded.

n) Change image attributes of the background image

Often background images are so dark or colorful that the sketch is barely visible. To change image attributes the user can right click the image button ![button], which will open the image attribute dialog box show below.
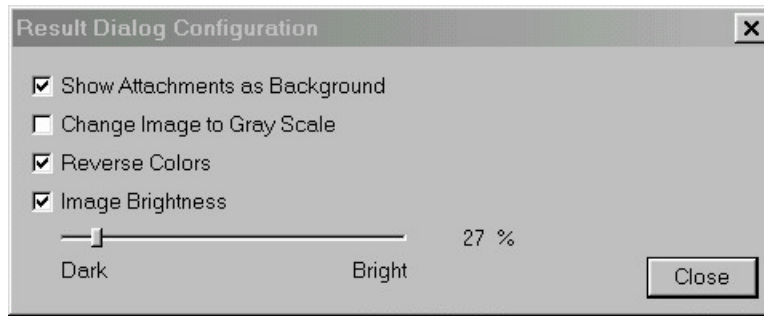
Figure 52   The image attribute dialog box is used to fine-tune the background image's appearance.

The configuration in Figure 52 above shows proven values for black and white images: the colors are revered and the image is brightened (because the colors are reversed we actually have to move the slider to the *Dark* side). Due to the (not in-house developed) image library used for *Sketcho*, simply increasing the image brightness does not lead to satisfying results (the black pixels remain black).

o) Additional information button

So far we have not implemented this feature, which will eventually enable the user to browse through objects that are linked to the currently selected database record.

3.8.2   Producing alternative output

The results of a query can be represented in four additional forms as:

- a sortable list on the computer,
- the printed equivalent to this on-screen listing,
- an ASCII text file, formatted for MS Excel, and
- a printed graphical listing of the ranked result list.

a) Sortable computer listing

Pressing the output button in the result dialog box opens the main output dialog box as shown on the Figure below.

Similarity Ranking

Rank	Record Description	Overall	Completeness	Geometry	Semantic	Topology	Metric	Direction
Weights	—	—	80.00	80.00	0.00	100.00	100.00	100.00
1	db000039.dmp	86.86	97.50	80.31	0.00	100.00	80.38	92.18
2	db000038.dmp	73.03	90.00	70.89	0.00	100.00	79.30	65.62
3	db000035.dmp	72.38	97.50	64.96	0.00	96.87	72.46	59.37
4	University of Maine, summer 85 12:05 Sewall Imagery	72.31	87.50	80.70	0.00	100.00	76.70	64.06
5	db000034.dmp	72.28	97.50	65.45	0.00	96.87	71.67	59.37
6	db000033.dmp	67.61	87.50	73.64	0.00	96.87	65.62	64.06
7	db000024.dmp	63.64	76.30	72.29	0.00	100.00	83.08	57.50
8	db000036.dmp	63.42	92.50	70.70	0.00	78.12	57.63	64.06
9	db000014.dmp	61.96	74.00	71.62	0.00	100.00	86.87	53.12
10	db000031.dmp	59.61	74.00	58.25	0.00	93.75	80.03	65.62
11	No Sketch Annotation	55.99	74.00	75.61	0.00	100.00	67.57	40.62
12	Sketched Query	50.69	56.88	66.79	0.00	100.00	71.89	68.75
13	db000026.dmp	50.39	53.00	67.48	0.00	100.00	77.92	75.00
14	db000032.dmp	48.64	53.00	69.27	0.00	100.00	90.79	50.00
15	Sketch Annotation	47.69	53.00	73.96	0.00	100.00	94.97	37.50
16	db000030.dmp	47.16	53.00	70.33	0.00	100.00	93.43	37.50
17	Sample with 3 region objects	47.04	53.00	65.89	0.00	100.00	83.75	50.00
18	db000001.dmp	45.30	56.88	74.82	0.00	75.00	52.91	75.00
19	db000002.dmp	45.03	53.00	72.65	0.00	100.00	91.12	25.00
20	University Park 25 Sketch 2-23-99	44.19	56.88	59.46	0.00	100.00	46.29	62.50
21	db000007.dmp	43.55	53.00	63.07	0.00	100.00	77.26	37.50
22	db000003.dmp	43.16	53.00	57.55	0.00	100.00	79.33	37.50
23	db000025.dmp	43.16	38.66	60.99	0.00	100.00	85.72	87.50
24	db000004.dmp	41.87	53.00	57.52	0.00	100.00	71.50	37.50
25	db000027.dmp	41.10	56.88	59.13	0.00	100.00	78.63	12.50
26	db000028.dmp	40.98	56.88	59.14	0.00	100.00	77.93	12.50
27	db000029.dmp	40.81	56.88	59.13	0.00	100.00	76.96	12.50
28	Annotation	36.90	32.00	80.93	0.00	0.00	0.00	0.00
29	Annotation	36.88	32.00	80.68	0.00	0.00	0.00	0.00
30	Annotation	36.88	32.00	80.88	0.00	0.00	0.00	0.00
31	db000000.dmp	36.47	32.00	79.99	0.00	0.00	0.00	0.00
32	db000023.dmp	34.54	32.00	75.76	0.00	0.00	0.00	0.00

Close   Save in File   Print   Annotation:

Figure 53   The main output dialog box

The main part of this dialog box is a ranking list of all classified database records that is, all sketches that have a similarity value above the user provided threshold. This list is initially sorted according to the rank, respectively the overall similarity of the individual database records. To obtain a different sorting, for instance, a ranking according to the metric similarity, the user has to press the appropriate column header, in this case the header titled *Metric*. Clicking a field twice results in an inverse ranking (least first).

The listing's header consists of two rows as show in the Figure below.

Similarity Ranking

Rank	Record Description	Overall	Completeness	Geometry	Semantic	Topology	Metric	Direction
Weights	—	—	80.00	80.00	0.00	100.00	100.00	100.00

Figure 54   Header of the main output dialog box

This first row is the title header, which allows the user to sort the list and to resize the columns. The second row indicates the weights of individual model components.

The edit box titled *Annotation* at the bottom of the dialog can be used to add a specific comment to the printed output (discussed below). Pressing the close button closes the dialog and returns to the result dialog box, pressing the save button opens a standard Windows file-save dialog box, and, finally, pressing the print button opens the print format selection dialog box.

b) Exporting results into a TXT file (Excel formatted)

Pressing the *Save in File* button invokes a standard Windows file-save dialog box. The produced file is in ASCII format but it is specially formatted (using tabs) for MS Excel. Hence, the file can be opened with Excel (using its *.txt filter) and directly imported into the standard Excel file.
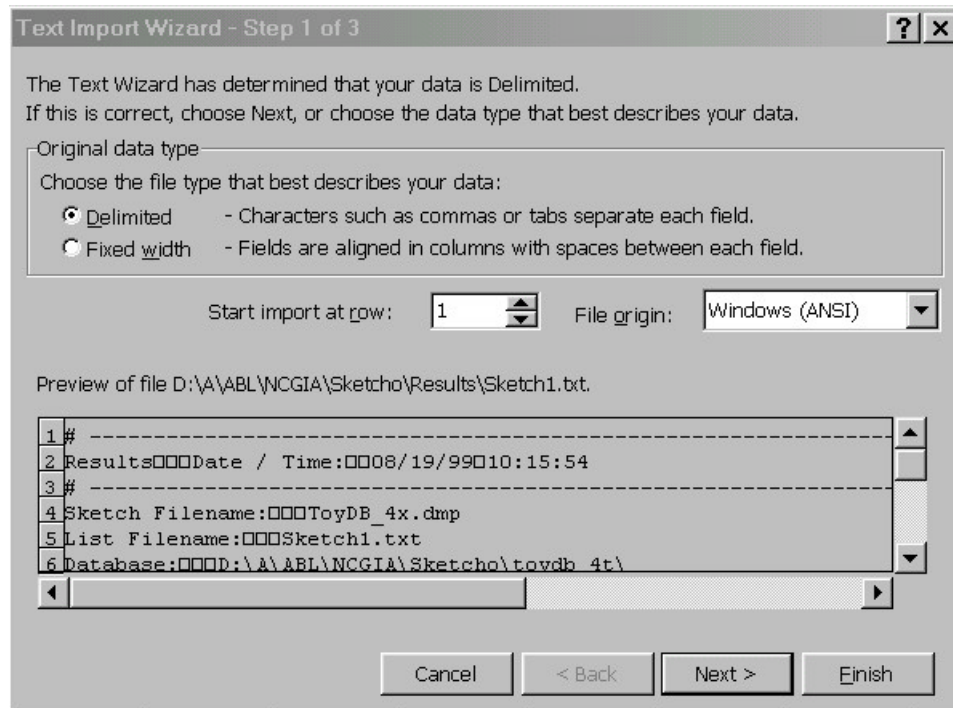
Figure 55   Text import dialog of MS Excel

After choosing the correct file the user can immediately proceed with the import procedure by pressing the *Finish* button as shown in Figure 55 above. The exported file contains essentially the same information as the initial output dialog box, plus some time stamp data.

c) Printing the listing

The print format dialog box appears after the print button is pressed. The default selection is the formatted listing of the result in text form.
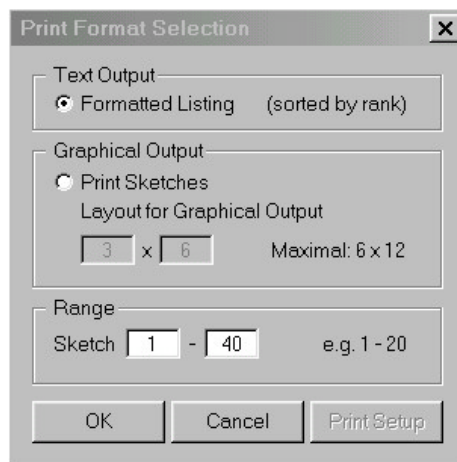
Figure 56   The print format dialog box

The user can chose the page range. By default all database records are printed. The listing is always by rank and the information provided is similar to that when the results are exported into a file (See section above).

Remark: By now listings can only be printed to the default printer. To direct the output to a different printer (e.g. to a PostScript file) the Windows settings have to be temporarily adapted so that the target device is the default device (Under Windows 95/98 chose *Start-Settings-Printer* and then right click the desired target device and select *Set as Default*). The second limitation concerns the supported paper format. By now only the US Letter (8.5"x11" or 21.6 x 27.9 cm) format is supported. The standard A4 format is currently not supported. If the output is directed to an A4-printer, then the document is centered horizontally and slightly cut off on the right hand side. To remedy this problem the user can change the default printer to *Default PostScript,* produce a PS file, and then open and manipulate this file with PostScript capable software. Another solution is to produce an Adobe `*.pdf` file. As of the time writing, the best printing results are obtained by using a HP660C color printer with US Letter paper.

d) Printing the graphical ranking list of

For many applications in the field of similarity assessment between spatial scenes it is important to provide the possibility of a visual comparison (reference) between queried and assessed scenes. This is, for instance, because people are very efficient in classifying scenes visually and because automatic classification algorithms like ours have to be checked for feasibility.
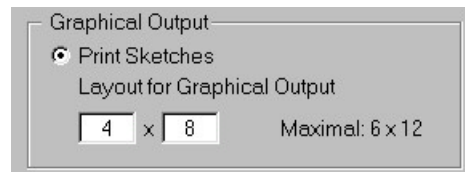
Figure 57   Graphical Output section of the print format dialog box.

When pressing the *Print* button in the *Output* dialog box the user can chose to print the graphical ranking list by selecting the *Print Sketches* option. Beside the range, the dialog allows to specify the number of sketches that will be printed on one page (columns x rows). The maximum is 6 x 12 sketches per page.
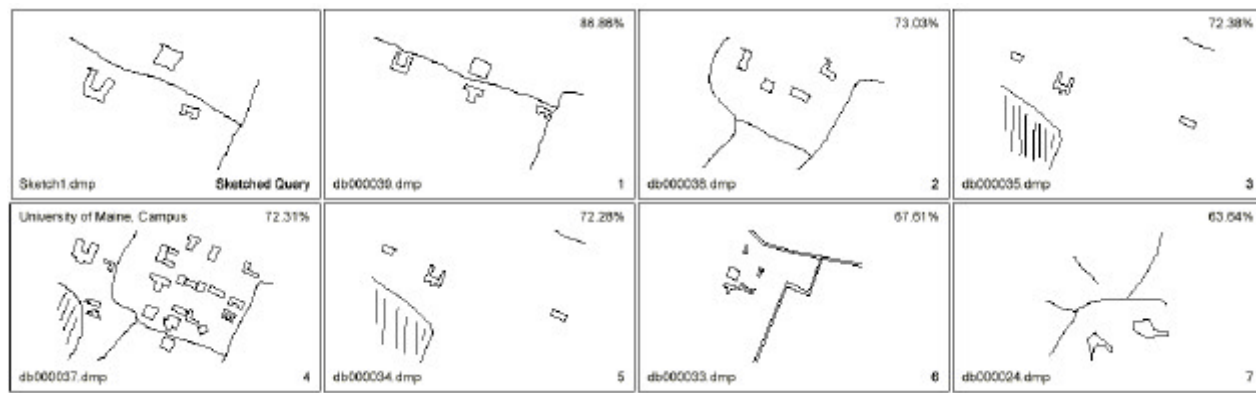
Figure 58   Section of the printed graphical raking list that can be generated (here a 4x8 sketch per page configuration).

Figure 58 shows a section of the output created in our example. The first sketch in this setup is always the sketched query. All ranked database records follow according to their overall similarity value. This similarity value is indicated for each sketch in the top left corner of the individual record boxes. The rank can be found in the lower right and the file name is in the lower left corner. If a database record has an annotation, then this annotation is printed on the upper left corner of the box instead of the dataset's filename.

Remark: The same limitations as specified in the previous paragraph apply for this output option as well.

4 Appendix

4.1 The *.dmp File Format

The *.dmp format was initially implemented as the debug file format that was used for developing the prototype. However, during time the format got amended and extended, so that it is currently the only file format supported by Sketcho. Eventually other vector formats, such as *.dxf or *.hp may follow. The main advantage of our format is that our format is based on simple ASCII text files that can be edited, modified, and most importantly easily created with any other application. The format is modular and only the geometrical part is mandatory. That is, the geometrical part (the polygons of objects) can be produced with a different program and Sketcho adds all other parts as necessary when the file is re-processed (See reprocessing a Sketcho database).

The following listings describe the basic *.dmp file format. The listings are color coded with the following semantics:

- blue: Crucial information that will be read by the prototype.
- green: Strings that are used as markers/references–do not omit or change.
- red: Comments that do not belong into the file, they are added for illustration purposes.
- black: Not crucial, needed for layout and at certain places for debugging purposes.

```
==============================================================
=== Dump File: Sketch1.dmp
==============================================================
===   3 Regions   2 Lines   0 Points   0 Text Objects ======
==============================================================
=== Test Sketch
==============================================================


     X      Y  PenSize   Time     Flag
==============================================================
Object ptr:   86a834 ===     1 ===========================
==============================================================
Stroke ptr:   958f40 ===    22 ===========================
  4398  -4629    5    206.300       3
  4391  -4652    5    206.360       9
  4374  -4707    5    206.410       0
  4338  -4761    5    206.470       0
  4317  -4897    5    206.850       0
  4338  -4916    5    206.910       0
  4519  -4982    5    207.230       0
  4536  -4912    5    207.450       0
  4585  -4858    5    207.510       0
  4636  -4778    5    207.670       0
  4636  -4773    5    207.780       0
  4577  -4733    5    208.170       0
  4509  -4820    5    208.390       0
  4483  -4878    5    208.610       0
  4472  -4878    5    208.720       0
  4430  -4856    5    208.770       0
  4381  -4827    5    208.940       0
  4462  -4663    5    209.600       0
  4398  -4654    5    209.760       0
  4391  -4652    5    209.760       9
  4381  -4648    5    209.760       0
  4372  -4633    5    209.930       5
Stroke end:   958f40 =================================
Object end:   86a834 =================================
==============================================================


==============================================================
Object ptr:   86adb8 ===     1 ===========================
==============================================================
Stroke ptr:   958da0 ===    33 ===========================
  4189  -4322    5    212.180       3
  4202  -4337    5    212.230       0
  4247  -4354    5    212.290       0
… Further points
```

File Header

→ Filename

→ Quantitative summary

→ Sketch annotation: "Test Sketch"

→ Object with 1 stroke

→ Stroke with 22 points

→ per point a line

First Object

Next Object

Listing 1   Header and single element object.

```
========================================================
Object ptr:   870288 ===    2 ============================
========================================================
Stroke ptr:   965930 ===   19 ============================
   5134  -4394   5    223.650     11
   5132  -4407   5    223.660      1
   5131  -4414   5    223.740      9
… Further points
   5146  -4398   5    225.310      9
   5134  -4394   5    225.410     11
   5115  -4388   5    225.630      5
Stroke end:   965930 =====================================
Stroke ptr:   95e680 ===    8 ============================
   5128  -4414   5    227.060      3
   5131  -4414   5    227.200      9
   5132  -4414   5    227.340      0
… Further points
   5145  -4401   5    227.560      0
   5146  -4398   5    227.750      9
   5149  -4392   5    227.940      5
Stroke end:   95e680 =====================================
Object end:   870288 =====================================
========================================================
```

→ Object with 2 strokes

→ 1st stroke has 19 points

Object consisting of two strokes

→ 2nd stroke has 8 points

Listing 2   Object with two elements

```
… Further points
   5368  -5016   5    235.360      0
   5336  -5014   5    235.740      5
   5346  -5020   5    235.750      9
Stroke end:   96a220 =====================================
Object end:   872cf0 =====================================
========================================================

… Scene Description Data

========================================================
= Sketch Attachments     1 ============================
========================================================
=    Width   Height   OrgXLP   OrgYLP  WidthLP HeightLP ====
=     1651     1306     3244    -3611     3513     2779
========================================================
D:\A\ABL\NCGIA\Sketcho\112185-37 Section.jpg
```

Last object

Scene description data

→ Sketch has one attachment

→ Coordinates of attachment (*)

→ Absolute path of the attachment

Listing 3   End of file with one sketch attachment

Remarks:

The coordinate system uses the third quadrant that is, the origin (0,0) is in the upper left corner of the coordinate system and the y-coordinate decreases from top to the bottom, such as shown in the Figure below.
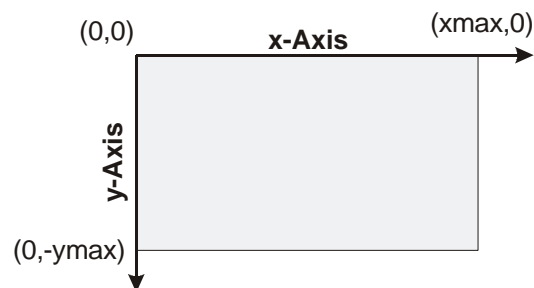
Figure 59   Section of the printed graphical output that can be produced (4x8 sketch per page configuration).

The extension of the sketching document is currently 10'000 x 10'000 units with one unit being 0.1 [mm] (hereof called the logical unit or LU). That is the actual drawing area is 1.0 x 1.0 [m]. The coordinates and the pen width in the *.dmp file are all in logical units. The only exception concerns width and height of the main attachment, which is in pixel; however, OrgXLP, OrgYLP, WidthLP, and HeightLP are again in LU.

Remark [(*)]: Because image support was added at the end of the project, it is, therefore, crucial to maintain the same screen resolution when database files with attached images are transferred from one computer to another. The time stamp of each point is measured in seconds plus fraction from the time when the sketch was opened. Considering the used flags. The first point of the polygon should have bit 0 and 1 set (decimal 3) and the last should have bit 0 and 2 set (decimal 5). Object self-intersections are in general flagged with bit 0 and 3 (decimal 9); however, intersections are again computed when the set of sketched objects is reprocessed , they must, therefore, not be flagged, or can even be omitted.

4.2   Provisional Performance Evaluation

Sketcho is a prototype application and, therefore, performance was not a major issue during the development. However, wherever it was feasible and in the scope of our possibilities we have tried to increase the efficiency of the prototype implementation.

Provisional Performance	Number of Objects per Sketch								*System Benchmark	*HD Benchmark MB/s	Installed RAM
Sketched Query:	6	12	6	18	6	6	6	6			
Sketch Database:	12	12	18	18	6	12	24	24			
Number of DB Records:	50	50	100	100	1000	1000	500	1000			
Performace:	Processing Time in seconds										
Pentium I 266 MHz	6.4	23.7	14.1	31.5	65.5	566.6	1192.2	0.0	66.0	4.0	64 MB
Cyrix II 300 MHz	8.5	39.3	17.4	46.6	91.1	136.4	170.9	704.6	80.9	5.7	128 MB
Pentium II 450 MHz	4.6	14.8	7.3	20.2	35.5	52.6	50.6	295.7	212.8	3.9	256 MB

Moderate, respectively heavy disk swapping activity   * Norton Utilities for Windows 3.0.9 rel.

Table 1   Provisional performance index of Sketch Version 1.1a with different configurations

Table 1 shows a comparison of the performance of Sketcho under different configurations. We have used three different platforms (all running Windows 98 with the same setup and no other applications running) and various complex scenarios. To measure the performance we have defined a *Complexity Index* which is the product of the number of objects in the query times the number of objects of a database record times the number of database records. The performance is quasi liner until the system runs out of RAM memory, as this is shown on the two Figures below.
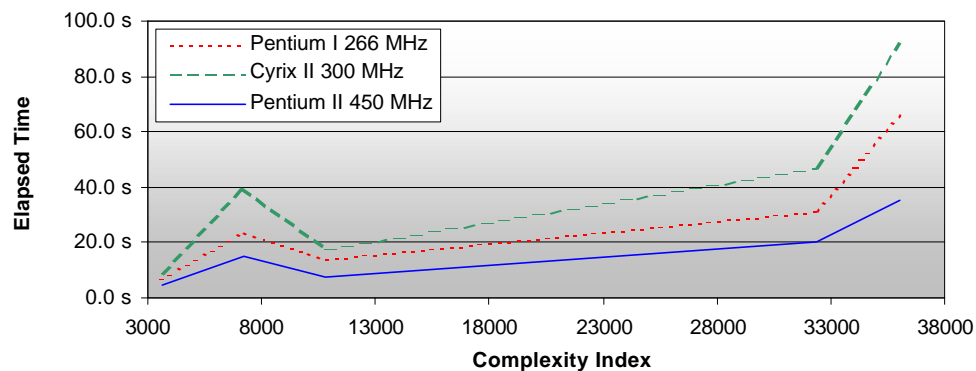
Figure 60   Plot of the provisional performance index for configurations that did *not* involve any disk activity.

Figure 61   Plot of the provisional performance index for all configurations in Table 1. This includes those configurations that *did* involve increased swap disk activity.

These figures show that one of the main shortcomings of the prototype is the use of the relative primitive data management system, which is solely based on directories and ASCII files.

4.3 Supported Short-Cuts

4.3.1 View/Hide:

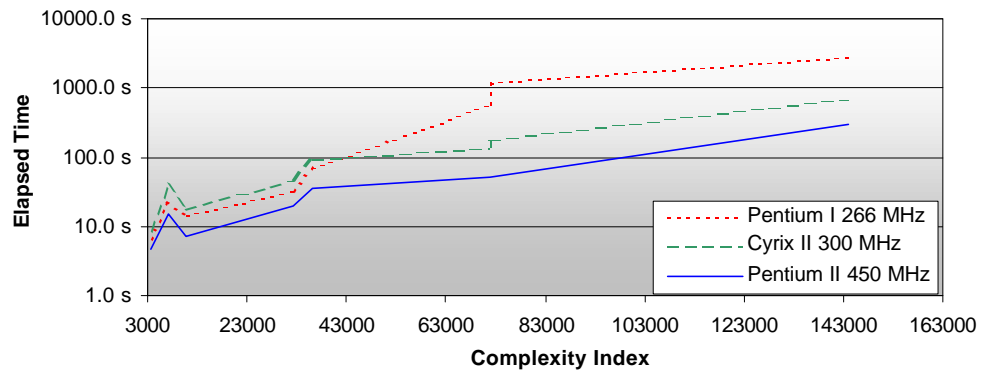|	
Ctrl-I:	Toggle View/Hide secondary Outline Elements (Regions & Lines)
Ctrl-T:	Toggle View/Hide as Text identified Objects
Ctrl-A:	Toggle View/Hide Object Annotations
Ctrl-Shift-S:	Toggle View/Hide Segments
Ctrl-R:	Toggle View/Hide Outline Regions
Ctrl-L:	Toggle View/Hide Object Lines
Ctrl-Shift-O:	Toggle View/Hide Object Outline (Lines and Regions)
Ctrl-Shift-D:	Toggle View/Hide Object Debug Information
Ctrl-Shift-L:	Highlight subsequent Outline Lines
Ctrl-Shift-R:	Highlight subsequent Outline Regions

4.3.2 View Settings:

F4:	Fit Sketch to the Current View

4.3.3 Application Wide Settings:

Ctrl-H:	Highlight Objects when the Mouse is over an Object

4.3.4 Recalculate and Reprocess:

|	
Alt-S:	Recalculate the Segmentation of the selected Elements/Objects
Shift-Alt-S:	Reset the Segmentation of the selected Elements/Objects
Alt-L:	Recalculate the Outline Lines of the currently selected Object
Shift-Alt-L:	Recalculate the Outline Lines of all Objects
Alt-R:	Recalculate the Outline Regions of the currently selected Object
Shift-Alt-R:	Recalculate the Outline Regions of all Objects
Alt-O:	Recalculate the entire Outline of the currently selected Object
Shift-Alt-O:	Recalculate the entire Outline of all Objects

4.3.5 Store and Retrieve (temporarily disabled)

Ctrl-P:	Put the current Object into the current Dump File (*.dmp)
Shift-Ctrl-P:	Put all Objects into the current Dump File (*.dmp)
Ctrl-G:	Get the first Object from the current Dump File (*.dmp)
Shift-Ctrl-G:	Get all Objects from the current Dump File (*.dmp)

4.3.6 Copy/Paste Functions

Ctrl-C:	Copy the currently selected object into the clipboard
Ctrl-X:	Copy the currently selected object into the clipboard and delete the original from the sketch
Ctrl-V:	Paste a copy the object on the clipboard (if there is any) at the same location as the original object.
Ctrl-D:	Paste a copy the object on the clipboard at a slightly offset location than the original object

4.4　Known Limitations and Bugs
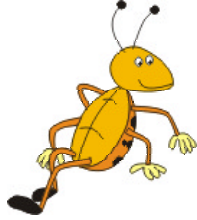
Hi, this is my section! – My name is Hugo, the friendly bug and I would like to guide you through this section.

i)　Windows NT cannot print the result sketches, neither list nor sketches

ii)　Undo and Redo → not intuitive

iii)　Formal View: icons do not well represent objects in standard formal view → show original sketch below icons.

iv)　Unmotivated "Hangers" in context with writing freehand text

v)　In some cases the green object-processing light will not turn green, even when shift- is pressed. Remedy: Press the query button 🔍, which will query the sketch and update all status indicators. If this does not work try to save the query and re-open it.

vi)　The symbols in the formal view are sometimes at odd positions.

vii)　The menu is only accessible though the keyboard when the mouse is not over the main drawing area.

viii)　Some short-keys do not work at certain occasions.

4.5　Literature

For further references concerning this prototype application, we refer to the Technical Report about the prototype that was written with a more in depth perspective in mind.

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