

IBM MULTIMEDIA ANALYSIS AND RETRIEVAL

IBM T. J. Watson Research Center

User Guide

<http://www.alphaworks.ibm.com/tech/imars>

IBM MULTIMEDIA ANALYSIS AND RETRIEVAL SYSTEM

User and Installation Guide

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Introduction

IBM Multimedia Analysis and Retrieval System (IMARS) is an automated tool for content-based indexing, classification and search for digital image and video collections being developed by IBM Research.

IBM® Multimedia Analysis and Retrieval System (IMARS) is a powerful system for automatic indexing, classification and searching of large collections of digital images and videos. IMARS works by applying computer-based algorithms that analyze visual features of the images and videos, and subsequently allows them to be automatically organized and searched based on their visual content. IMARS is comprised of the **IMARS extraction tool** and the **IMARS search tool**, as shown in Figure 1. The IMARS extraction tool takes a collection of images and videos from the user, and produces indexes based on mathematical analyses of each piece of content. These indexes organize the results of the analyses for the IMARS search tool. The IMARS search tool provides a graphical interface which allows the user to search, browse and navigate the collection based on the values produced by the analyses performed by the IMARS extraction tool.

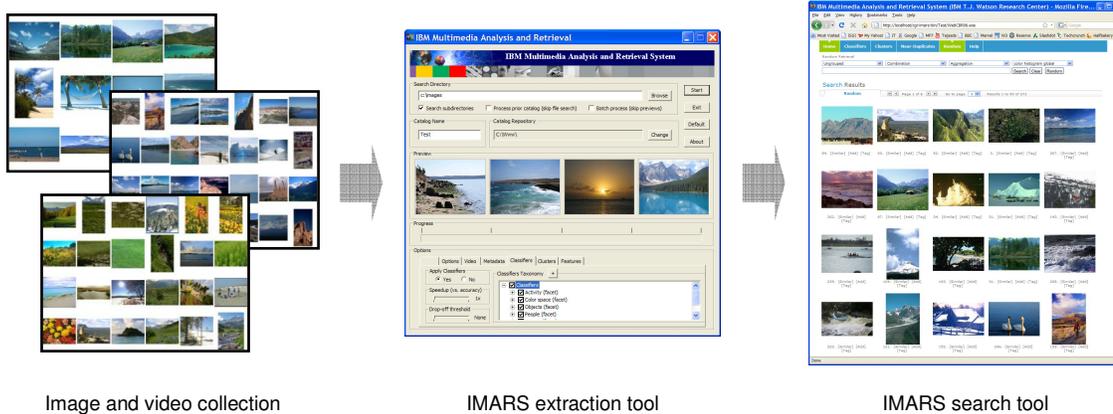


Figure 1 The IBM Multimedia Analysis and Retrieval System (IMARS) consist of the IMARS extraction tool and the IMARS search tool.

In addition to searching and browsing the collection, IMARS provides capabilities for (1) automatically identifying and optionally removing exact duplicates from large collections of images and videos, (2) automatically identifying near-duplicates, (3) automatically clustering images into groups of similar images based on visual content, (4) automatically classifying images and videos as belonging or not to a pre-defined set (hereafter called taxonomy) of semantic categories (such as ‘Beach’, ‘Car’, etc.), (5) performing content-based retrieval to search for similar images based on one or more query images, (6) tagging images to create user defined categories within the collection, (7) performing text based and metadata based searches.

How Does It Work?

The IMARS extraction functionality is enabled by two main categories of computer algorithms that work together to bridge the “**semantic gap**” for images and videos. The first category is **visual feature extraction**, which works by using the computer to analyze the pixel-level contents of each image and video, and create a multi-dimensional vector description of its visual features. Since there are many important dimensions of visual contents, such as color, texture, shape and spatial layout, IMARS utilizes a large set of visual feature extraction algorithms that extract descriptors across a wide array of visual dimensions.

The second category is **visual semantic extraction**, which works by applying machine learning techniques to the extracted visual descriptors. IMARS is supported by a broad array of **pre-trained semantic classifiers** that automatically identify whether each new image and video belongs to one or more of the pre-defined semantic categories in the taxonomy based on its extracted visual descriptors. IMARS provides additional capabilities based on **unsupervised classification** that cluster the images and videos purely based on their extracted visual descriptors, without assigning them any label, and allow searching based on visual similarity.

IMARS consists of two main tools: (1) the IMARS extraction tool, and (2) the IMARS search tool. The IMARS extraction tool, shown in Figure 2, is applied in practice to a collection of images and videos by simply pointing the tool to a folder where the image and video files are stored. For the fastest operation, the folder should be on a local disk, but shared network folders are also supported in the case where disks are not local. The IMARS user interface allows the selection of different options for indexing, classification and search. These options are described in detail in the following sections.

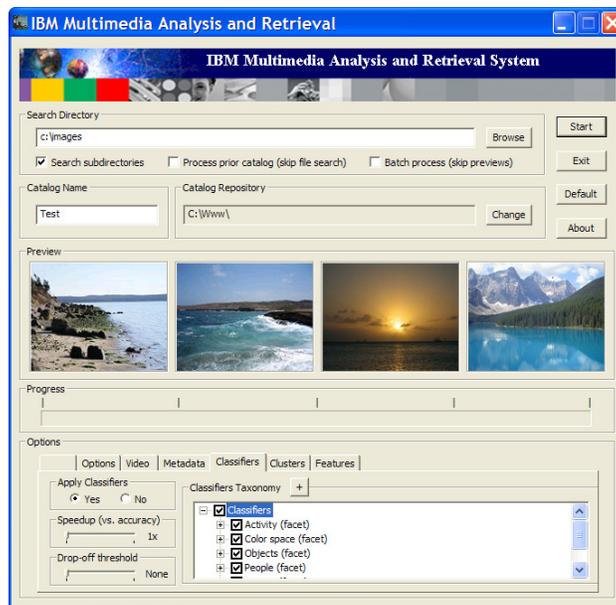


Figure 2 The IMARS extraction tool processes and analyzes the input image and video collection and organizes the results for subsequent searching, browsing and navigation using the IMARS search tool.

Once these options are set, the extraction process is launched by the user pressing the “Start” button. IMARS will then go through the following process: (1) crawls the input folder and optionally sub-folders to find image and video files for indexing, (2) parses each found video file and extracts key-frames or optionally extracts frames sampled at fixed temporal intervals, (3) processes the full set of images and key-frames and optionally extracts visual descriptors, optionally extracts metadata and creates thumbnail versions of each for later searching, (4) optionally identifies duplicates and near-duplicates, (5) optionally clusters the images and key-frames into groups of visually similar items, (6) optionally classifies the images and key-frames into semantic categories, (7) organizes all extracted information into an index for later searching.

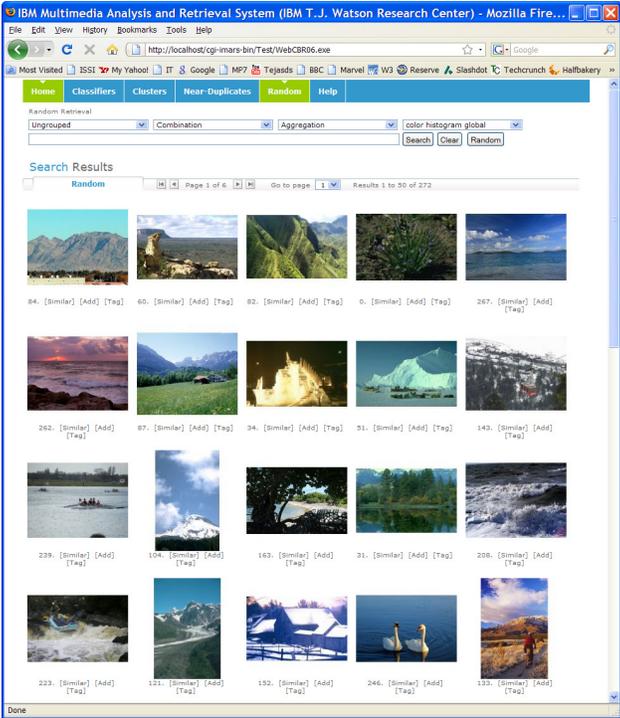


Figure 3. The IMARS search tool allows searching, browsing and navigation of the results of processing image and video collections using the IMARS extraction tool.

Once the IMARS extraction process is complete, the results can be searched and browsed using the IMARS search tool, shown in Figure 3, using a Web browser. The IMARS search tool relies on a Web server such as Apache being installed and configured on the computer. Later sections describe how to set up the Web server. The IMARS search tool allows the browsing and searching of the extraction results as well as content-based similarity search.

The IMARS search tool presents the results of a query in different formats, among which the user can decide and switch according to his preferences. One consists of mosaic overview images that provide a simple at-a-glance summary of each of the main categories extracted. Another is a word based representation. See the ‘IMARS Search Tool’ Section for more details. The tool also allows drilling-down for more details, for example, to provide a sorted list of matches for each semantic category, or to provide the full set of extracted semantics for each image or video key-frame.

Hardware Requirements:

The IMARS extraction tool provides a Windows-based graphical user interface and requires Windows (XP, 2003, Vista). A command-line version is available for Linux. Please contact us for more details.

The IMARS search tool operates along with a Web server using common gateway interface (CGI) to run the IMARS search program. The IMARS search tool also requires Windows (XP, 2003, Vista) for the server machine. A Linux version is also available. The client machine can be any computer that has a Web browser and does not require specific operating system.

Overall, the following hardware is required:

- Operating System (OS): Windows (XP, 2003, Vista); please contact for Linux.
- Disk drive space: 10MB for IMARS tools and up to 10GB for pre-built packaged classifiers; additional drive space is required for storing results of processing image and video collections, which depends on the size of the collections.
- RAM: > 512MB
- CPU: > Pentium IV, 2.4GHZ

Software Requirements:

In order to fully operate the IMARS search tool, the following software is required to be installed on the server and/or client machines:

- **Server:** HTTP Web Server - If a HTTP Web Server is already installed on the server machine, it will need to be configured to support the IMARS search tool (instructions provided in following sections). If a HTTP Web Server is not installed, then one must be installed, such as Apache (see <http://httpd.apache.org/>) and configured for IMARS prior to using the IMARS search tool. Instructions for installing and configuring the IMARS search tool for Apache are provided in the Section HTTP Server Setup on page 8.
- **Client:** Any Web browser (i.e. Internet Explorer or Mozilla Firefox) is required to be able to use the IMARS search tool to access the extraction results for an image and video collection

NOTE: the server and client can be installed on the same machine or on different ones, according to the needs of the user.

Optional Software:

By default, IMARS supports a wide range of digital image formats (such as JPEG, GIF, PNG, TIFF and PNM). IMARS can be extended to operate on video using the FFmpeg decoder (see <http://ffmpeg.mplayerhq.hu/>). Please refer to Section “Optional Software Installation” on page 7.

Installation Guide

Installation Package

The IMARS Installation Package can be downloaded at the following Web site:

<http://www.alphaworks.ibm.com/tech/imars/download>

The IMARS package consists in a series of zip files, as listed below:

- **imars.zip** – contains the IMARS extraction tool and the IMARS search tool
- **classifiers.zip** – contains a sample set of classifiers that automatically categorize images into a pre-defined set of categories (taxonomy) covering settings, color contents and visual types.

Please refer to the “IMARS Extraction Tool Installation” for instructions on how and where to download and extract the zip files.

IMARS Extraction Tool Installation

Installation Steps

- IMARS installation files can be downloaded from the IBM alphaWorks site: <http://www.alphaworks.ibm.com/tech/imars>, download tab.
- Download **imars.zip** unzip it to a directory of your choice (i.e. C:\Program Files\Imars\) - hereafter referred to as <DIR>.
- Download **classifiers.zip** and unzip it to <DIR>\bin\
 - NOTE: at this point, the <DIR>\bin\classifiers\ folder should contain a hierarchy of subfolders, where the top-most of them containing the string “(facet)” in their name, e.g. “Setting (facet)” or “People (facet)”.

Optional Software Installation

- The IMARS extraction tool natively supports many image formats. The IMARS extraction tool can be extended to handle video by downloading and installing the FFmpeg video decoder. FFmpeg is an open-source project that supports encoding and decoding of a large number of video formats across multiple operating systems. If the FFmpeg decoder program is copied to the IMARS installation folder, it will be used by IMARS to decode any videos found that match the formats supported by FFmpeg.
- **Step 1:** Download FFmpeg.exe. The official site for FFmpeg is <http://ffmpeg.mplayerhq.hu/>. IMARS uses the binary executable version of the FFmpeg decoder. It can be obtained by following instructions for building it from the FFmpeg source code. Alternatively, a pre-built version can be simply downloaded directly from sites that provide an FFmpeg.exe binary distribution, i.e. http://arrozcru.no-ip.org/ffmpeg_wiki/tiki-index.php?page=Links.
- **Step 2:** Select the FFmpeg.exe executable and copy it to the installation folder <DIR>\bin (i.e. C:\Program Files\IMARS\bin).

HTTP Server Setup

If a HTTP Web Server is not currently installed on the server machine, then one must be installed and configured for IMARS prior to using the IMARS search tool. The following instructions described how to download, install and configure the Apache Web Server for IMARS. The configuration for other HTTP Web Servers is similar.

1. DOWNLOAD

Download Apache Server Setup from <http://httpd.apache.org/> if it is not already installed on the server machine.

2. INSTALL

Install Apache into a directory of your choice (hereafter referred to as [APACHEROOT]; on Windows PCs, it is usually C:\Program Files\Apache Software Foundation.

3. CONFIGURE AND ADD ALIAS FOR IMARS

Configure the httpd.conf file. If you already have the Apache HTTP server installed, and you are not sure where the conf directory is, try searching for the httpd.conf file. For example, httpd.conf file for Apache 2.2 is in the [APACHEROOT]\Apache2.2\conf directory.

Catalog Repository

At this point, you must select a directory to be used as the “Catalog Repository” or CATALOGROOT. In most cases, it should be a new directory, and it will be used to store information generated by the IMARS Extraction Tool. The configuration steps that follow under “Add Alias” will make the Catalog Repository directory (and all its subdirectories) readable via HTTP, so you should not place sensitive data in this sub-tree. When you run the IMARS Extraction Tool later, you will be creating a subdirectory of the Catalog Repository for each collection.

If the directory CATALOGROOT is set to C:\WWW, you need to specify C:\WWW in step 2 of the “add alias” procedure and make sure that the Catalog Repository folder in the IMARS extraction tool is: C:\WWW. You can choose a name for the collection, such as Travels, when using the IMARS Extraction Tool. Once indexed, the collection will be accessible via a browser at the following link: <http://localhost/imars/Travels/>

The following paragraph explains in detail how to add the alias to Apache HTTPD.

Step 1: Copy and paste the following segment to the end of the **httpd.conf** file:

(NOTE: remove trailing and preceding white spaces that may occur if you copy and paste this segment from the .pdf file)

```
# Add IMARS aliases
AliasMatch ^/IMARS/([^/]*)(.*)$ "CATALOGROOT/$1/docs/$2"
AliasMatch ^/imars/([^/]*)(.*)$ "CATALOGROOT/$1/docs/$2"
ScriptAliasMatch ^/cgi-imars-bin/([^/]*)(.*)$ "CATALOGROOT/$1/cgi-bin/$2"
ScriptAliasMatch ^/cgi-IMARS-bin/([^/]*)(.*)$ "CATALOGROOT/$1/cgi-bin/$2"
Alias /IMARS "CATALOGROOT"
Alias /imars "CATALOGROOT"
<Directory "CATALOGROOT">
    Options Indexes MultiViews
    AllowOverride All
    Order allow,deny
    Allow from all
</Directory>
<Directory "CATALOGROOT/*/docs">
    Options Indexes MultiViews
    AllowOverride All
    Order allow,deny
    Allow from all
</Directory>
# End IMARS aliases
```

Step 2: Replace CATALOGROOT with your Catalog Repository physical location i.e. C:/WWW

Step 3: Save the changes to the httpd.conf file

EXAMPLE: If CATALOGROOT is C:\WWW, the end of the httpd.conf file looks like:

```
#Add IMARS aliases
AliasMatch ^/IMARS/([^/]*)(.*)$ "C:/WWW/$1/docs/$2"
AliasMatch ^/imars/([^/]*)(.*)$ "C:/WWW/$1/docs/$2"
ScriptAliasMatch ^/cgi-imars-bin/([^/]*)(.*)$ "C:/WWW/$1/cgi-bin/$2"
ScriptAliasMatch ^/cgi-IMARS-bin/([^/]*)(.*)$ "C:/WWW/$1/cgi-bin/$2"
Alias /IMARS "C:/WWW"
Alias /imars "C:/WWW"
<Directory "C:/WWW">
    Options Indexes MultiViews
    AllowOverride All
    Order allow,deny
    Allow from all
</Directory>
<Directory "C:/WWW/*/docs">
    Options Indexes MultiViews
    AllowOverride All
```

```
    Order allow,deny
    Allow from all
</Directory>
# End IMARS aliases
```

Step 4: RESTART the Apache HTTP server for the changes to take effect.

Next section will describe the use of the IMARS extraction tool.

IMARS Extraction Tool

The IBM Multimedia Analysis and Retrieval System (IMARS) extraction tool analyzes input image and video collections and organizes the results for subsequent searching, browsing and navigation using the IMARS search tool

The IMARS extraction tool is an integral part of the IBM® Multimedia Analysis and Retrieval System. The IMARS extraction tool automatically analyzes the visual content of the images and videos in the collection and extracts and organizes the results to allow efficient and effective access and searching of image and video collections.



Figure 4 Example screen-shot of the IMARS extraction tool during processing of an image and video collection.

IMARS Extraction Tool Interface Overview

To start the IMARS extraction tool, double click on IMARS.exe. The IMARS extraction tool will load the variables specified in `prefdfilt.txt` in `<DIR>\bin`. The user needs to (i) specify the location of the image and video collection to be indexed (Search Directory), the location where to store the processing results (for all the collections) which will be used by the IMARS Search Tool (Catalog repository) and the name of the subfolder, within the Catalog repository, where the results of the current collection will be stored (Catalog Name), (ii) customize the IMARS extraction tool options and tabs, and (iii) press the START button to initialize the collection processing. Each option in the IMARS.exe tool corresponds to a variable setting (**in parentheses**) in `prefdfilt.txt` – see the “Manual Configuration Example” Section for more information on manual configuration.

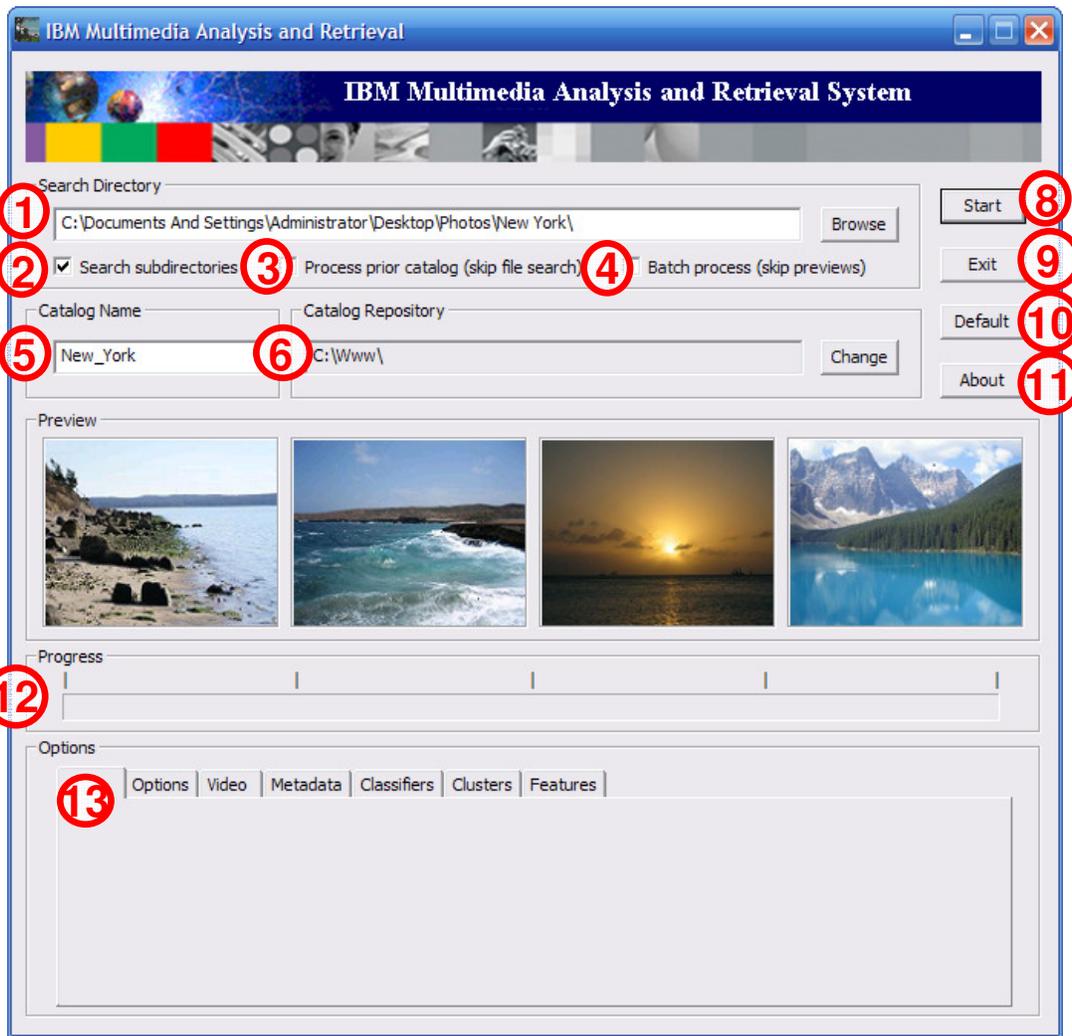


Figure 5 Search and Results Directory in the IMARS extraction tool

- 1) **Search Directory** – Specifies the full path to the folder containing the collection to be indexed. The IMARS extraction tool will not create any new files in this directory but will only read from this directory. The user can browse the hard drive(s) (using the browse button) to find the location of the collection (SEARCHDIR).
- 2) **Search all subdirectories** – If selected, IMARS will search subdirectories within the Search Directory. It will search subdirectories up to 12 levels deep (SUBDIRS).
- 3) **Process prior catalog (skip file search)** – If selected, IMARS will not search in the file system for images but will only re-index a catalog previously processed. NOTE: IMARS will reuse already extracted metadata and extract new metadata to create a final index. Enable all indexing and extraction options in the incremental run that you want to see in the final index, as indexing is not incremental. (NOCRAWL). For more on the incremental processing, see Advanced Topics.
- 4) **Batch process (skip previews)** – If selected, no preview images are displayed while processing. It saves processing time in case of large image sets (BATCH).
- 5) **Catalog Name** – unique repository name inside a given Catalog Repository. If the current Catalog Name matches with an existing one, then IMARS will prompt the user, asking whether she wants to overwrite the existing

one. If the user does not specify Catalog Name (i.e. it is left blank), the tool will also display a warning (CATALOGNAME).

6) Catalog Repository – is set to C:\WWW by default (this is the variable CATALOGROOT from the “Add Alias” section above). See “Manual setup” section on how to change the values manually. The Catalog Repository setting is connected with your Apache server configuration – if you change the value of the CATALOGROOT variable make sure that the IMARS segment of http.conf file reflects the same change (CATALOGROOT in the Apache HTTP Web Server). Once indexed, all Collections will then be accessible via a browser at the following link: <http://localhost/imars/>

7) Catalog Directory - Location where the IBM Multimedia Analysis and Retrieval System will store and index data collected from the Search Directory. The Catalog Directory is built as <Catalog Repository>/<Catalog Name>. The Catalog Directory should not be the same as the Search Directory, be read only, and be write protected. (CATALOGDIR)

8) “Start” Button - Once the user has selected all the above options, she can hit the START button. This will begin the process of indexing the image collection. Progress will be displayed in the progress bar (see point 13) at the bottom of the screen. The system will first extract features and then extract clusters and concepts, as needed. This will be followed by preparing indices and web pages to be shown during the search phase.

9) Exit – Once indexing is completed and the user does not plan to index any more images or video, she can select the EXIT button to close the IBM Multimedia Analysis and Retrieval System (IMARS) extraction tool.

10) “Default” Button -- Pressing this button will make IMARS Extraction Tool to set all directories and options (button 13) to their respective default values as specified in prefdeflt.txt, see the next section for details.

11) “About” Button -- displays copyright information about the IMARS Extraction Tool.

12) Progress bar – displays processing status and progress estimates when the IMARS Extraction Tool is running.

13) Option tabs – lets user set advanced processing options for content search, processing, feature extraction, and classifiers. See the next section for details.

IMARS Extraction Tool Interface Advanced Configurations

IMARS Setting and Manual Configuration:

The system default values for IMARS variables are set in the configuration file <DIR>\bin\prefdflt.txt, and they are loaded in the first run of IMARS.exe. Once the tool completes the indexing, or if user chooses to exit, user specifications in the IMARS extraction tool are saved to <DIR>\bin\preflast.txt. All subsequent IMARS extraction tool runs will load/write variable values from/to <DIR>\bin\preflast.txt file.

The user can manually change the values of the variables in the preflast.txt file, as shown in the following example. The manual configuration is equivalent to setting the variables from the IMARS Extraction tool interface.

Step 1: Close the IMARS application.

Step 2: Change the default variables in preflast.txt

From:

```
SEARCHDIR=C:\Photos\  
CATALOGDIR=C:\Www\Travels  
CATALOGROOT=C:\Www\  
CATALOGNAME=Travels
```

To:

```
SEARCHDIR=C:\Photos  
CATALOGDIR= C:\myUser\myFolder \Holiday  
CATALOGROOT= C:\myUser\myFolder  
CATALOGNAME=Holiday
```

Step 3: Save preflast.txt

Step 4: If you change CATALOGROOT in preflast.txt, make sure to change the variable CATALOGROOT in http.conf in the Apache setting (see Apache HTTP Server setup section) to the same value i.e. CATALOGROOT is not C:\myUser\myFolder. Save httpd.conf and restart Apache server.

Step 5: Run IMARS.exe - changes will be reflected. If there was an error or typo in preflast.txt, you may receive a warning dialog box, as in figure 6.

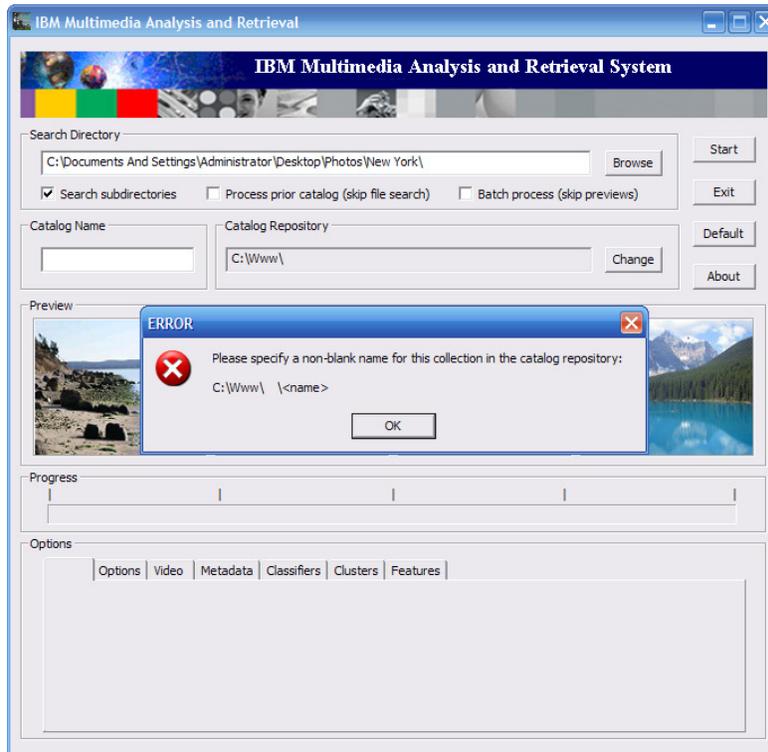


Figure 6 IMARS extraction tool - Warning for invalid Category Name directory entry

Multiple Collections

Each collection needs to have a unique collection name, and the tool remembers and displays the last Catalog Repository and Catalog Name will be remembered and displayed. Note that, if user does not want to overwrite the previous collection results, she needs to CHANGE the subdirectory (catalog name) before running the tool.

Advanced Settings on the Parameters tabs - The IMARS extraction tool has multiple tabs where the user can fine-tune the parameters used for collection indexing, metadata and semantic information extraction. Each tab is explained in detail in the following Sections.

1. Options Tab

The Options Tab allows the user to specify the data formats that will be processed, the size of the dataset, and some advanced image processing methods.

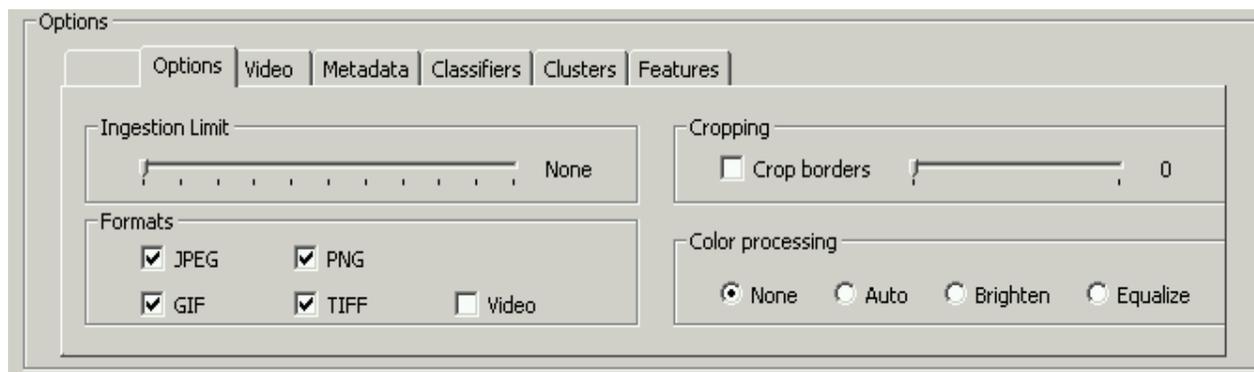


Figure 7 IMARS extraction tool – Options Tab

Ingestion Limit – Allows an upper limit on the number of indexed images, up to MAX=70000 of the images in the collection. This option allows the user to limit the number of images to be indexed. Images are selected in alphabetical order. The trial version of IMARS limits the number of images and videos that can be processed but should be generous enough for most non-commercial testing of the system. The full version of IMARS is limited only by the available disk space. (MAX)

Target Formats – This release of IBM Multimedia Analysis and Retrieval System natively reads JPEG, GIF, TIFF, and PNG images. The user can choose which formats will be processed using the corresponding check boxes. The IBM IMARS extraction tool can also index videos if ffmpeg binary is present, see “Optional Software Installation” section of this guide. If the external FFmpeg software is installed, the system will also be able to process a wide variety of other video formats, such as MPEG, WMV, AVI, and FLV.

Image Processing Options

IMARS extraction tool has two image processing options. These options allow the user to edit the appearance of the collection, not the source images or key-frames.

Cropping – Allows the user to apply universal cropping of image borders. It crops borders on all sides by x pixels, where x is determined by the sliding scale. This option is very useful if images and videos in the collection have damaged sides, black borders (i.e. letterboxed videos, where top and bottom are padded with black stripes), or images and videos presenting header or footer (i.e. news channels) that are not relevant for the content extraction (CROP, CROPSIZE).

Color Processing – If images are too dark, or the results are not satisfactory, the user can pick any of the image pre-processing options to improve the appearance of images and videos.

- 1.1. **“Auto”** option lets system decide if range normalization is needed for an image histogram.
- 1.2. **“Brighten”** option performs brightness adjustment in the image histogram, and can clarify the content if the image collection is too dark (BRIGHTEN).
- 1.3. **“Equalize”** performs contrast adjustment in the collection using the image's histogram. This method usually increases the local contrast of many images, especially when the usable data of the image is represented by close contrast values (EQUALIZE).
- 1.4. **“None”** option is set as a default. Color Processing can significantly change the characteristics of the content. For typical user collection of digital photos and personal videos, no color processing is usually needed.

2. Video Tab

The Video Tab allows the user to specify video-specific parameters for key-frame extraction.

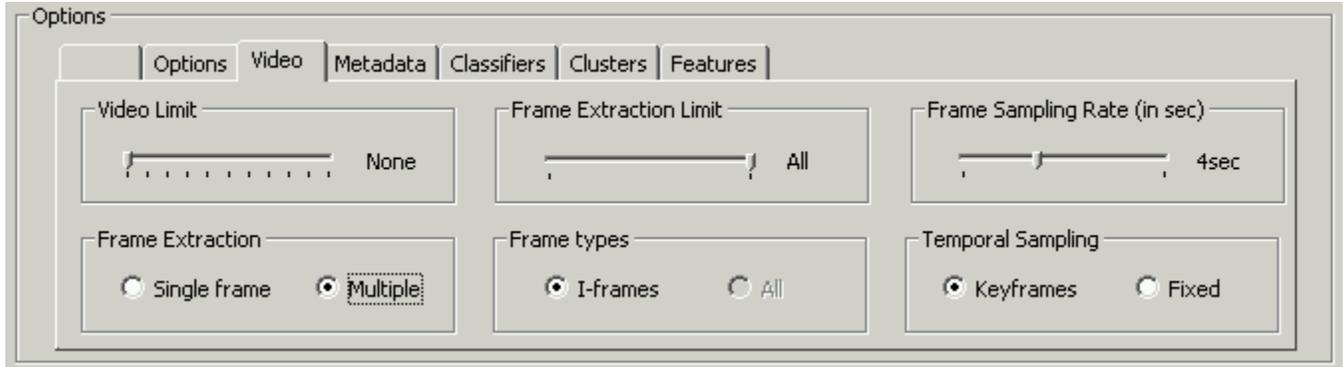


Figure 8 IMARS extraction tool - Video tab

Video Limit – upper limit on the number of indexed videos. If it is set to None (extreme right), the tool will index up to $\text{VIDEOLIMIT}=20000$ videos in the collection (VIDEOLIMIT).

Frame Extraction Limit – limits number of frames extracted per video. The default option is All. The user might want to exercise this option if the collection has too many videos, and for a quick overview only a couple of frames per video are needed (VIDEOFRAMELIMIT).

Frame Sampling Rate (in sec)- set the number of seconds to be skipped after each processed frame (higher number corresponds to faster processing). It influences the behavior of the Temporal Sampling method selected (see below). If the Frame Sampling Rate is set to n , then Temporal Sampling is applied every n -th second in the video. The default is set to 4 seconds, as this gives a good balance between key-frame sampling and processing speed (VIDEOSKIPFACTOR).

Frame Extraction – allows the user to specify if she wants multiple key-frames or a single, most representative key-frame to represent an input video in the Search Tool. The default is set to multiple, as the level of detail is greater ($\text{VIDEOFRAMEEXTRACTION}$).

Frame Types – determines the type of frames to keep after MPEG decoding. Currently only the I-frames are used, since they are not compressed in the temporal domain and therefore provide a more accurate representation (VIDEOFRAMETYPE).

Temporal Sampling – allows the user to choose the method for selecting frames to be processed (VIDEOSAMPLING). Fixed frame sampling simply extracts every n -th frame in the video. This approach is faster than Key-frame sampling, but results in a larger number of frames, many of which may look very similar. Key-frame sampling compares successive frames and extracts a key-frame when the visual difference between them is above a threshold. Successive frames are spaced according to the Frame Skip Factor. (VIDEOSKIPFACTOR). The default value is set to key-frames. This processing is more complex, but the results are much better, as it selects a representative key-frame for each distinct shot in the video stream.

3. Metadata Tab

The Metadata Tab allows the user to specify what metadata should be extracted from images.

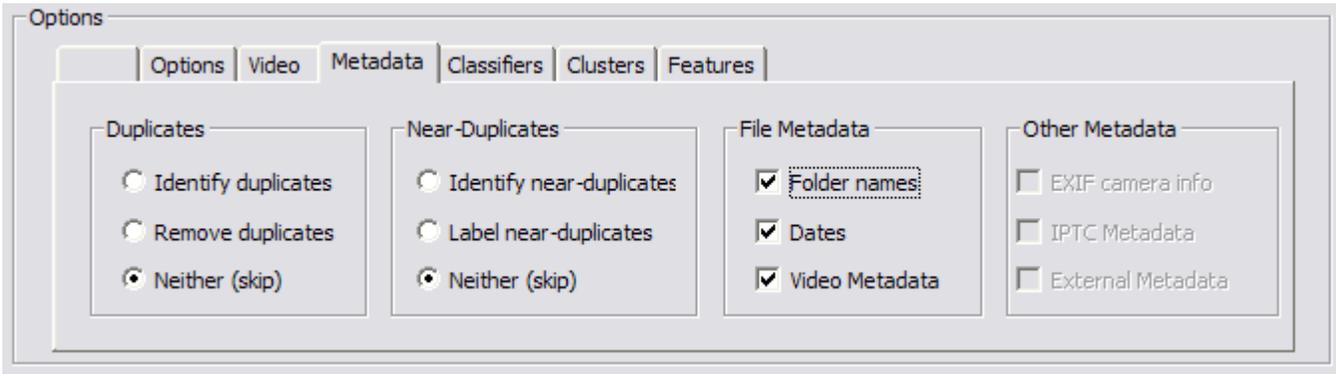


Figure 9 IMARS extraction tool - Metadata tab

Duplicates – are defined as images with the same MD5 hash values. They can have different names or come from different sources, but have the same content. This option gives the user a capability to identify duplicates (IDENTIFYDUPLICATES) and to remove duplicate files (REMOVEDUPLICATES) in its collection. **Duplicates** tab in the IMARS search tool allows users to access the list of identified duplicates, if IDENTIFYDUPLICATES is on.

Near-duplicates - are images and key-frames that have almost the same appearance, but are not identical i.e. picture of the same scene from slightly different angle, 2 keyframes from a still video, etc. The IMARS extraction tool can identify near-duplicates (IDENTIFYNEARDUPLICATES) and label them using the pre-defined set of classifiers (LABELNEARDUPLICATES) - more on labeling under “Clusters” tab.

File metadata – allows the user to save the pathname of the folder where the original images (videos) are stored (“Folder names” option). The “Dates” option lets the system extract the date when each image was created. For videos, the IMARS Extraction tool extracts metadata information on the key-frame level of the video. Therefore, “Date” will reflect the time and date the key-frame was extracted. (METADATAFILENAMES, METADATADATES)

Other Metadata – in future versions, IMARS may extract EXIF and / or IPTC Camera information from the searched images, if such information exists. Presently, this function is not available. NOTE: Various image processing programs tend to change original EXIF information (i.e. cropping, web publishing, red eye removal). IMARS will display whatever is in the camera info field of the source image specified. (METADATAEXIF).

4. Classifiers Tab

The Classifier Tab lets the user determine if the system needs to do an automatic semantic classification of content and if so, the user can select from the provided taxonomy which classifiers should be applied.

Fully-automatic approaches based on statistical modeling of low-level visual content features have been applied for detecting the semantic concepts in our pre-defined taxonomy such as sky, party, etc. Statistical modeling requires large amounts of annotated examples for training. Since this scenario is not applicable to unlabeled content in the user collection, we adopt an approach based on automatic semantic tagging. We re-use our existing semantic models, which were trained on various multimedia content, and automatically associate confidence scores to unseen data with the cross-domain concept models. To enable cross-domain usability, we chose the general semantic models from our taxonomy, preserving consistent definitions of concepts across different multimedia and video domains (albums, blogs, web video).

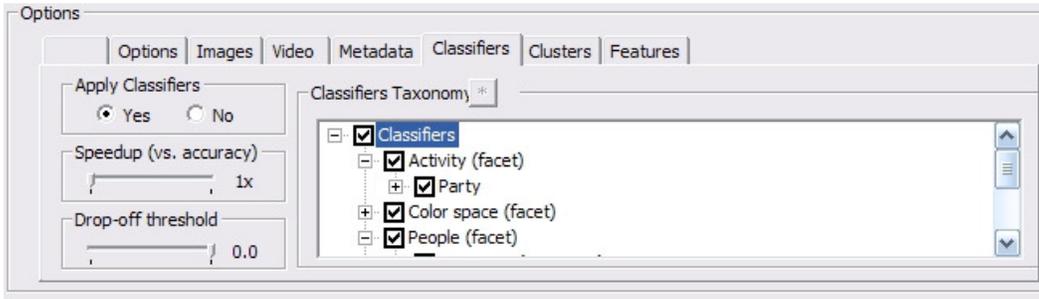


Figure 10 IMARS extraction tool - Classifier tab

Apply Classifiers – index the image or video collection with a list of semantic classifiers. If the “Yes” radio button is selected, the tool will automatically classify the multimedia set to allow browsing and searching of the collection with the selected classifiers. The classification output can be browsed by clicking on the “Classifiers” button in the IBM Search Tool. (EXTRACTCLASSIFIERS). Classification model evaluation can be sped-up by setting the speed-up and drop-off threshold value, as defined below:

Speedup (vs. accuracy) – sets the trade-off between speed and quality of classification. If the speedup is 1x (default), the accuracy (that is, the quality of the classification) is the highest possible, as the system is using the full classifier models in the evaluation step. If the speedup is set to a higher value (20x is highest) the system performs a faster evaluation of the classifier model on the dataset by sampling the model. This can result in reduced accuracy since the full model is not used as a trade-off for the increased evaluation speed. (CLASSSPEEDUP).

Drop-off threshold – determines a classification threshold under which the classification results are discarded. The classifiers determine whether an image belongs to a specific category in the taxonomy by processing it and returning a score. If the drop-off threshold is set to a value other than none, it indicates that all the images with intermediate scores in the classification model evaluation that are below the threshold should be discarded. If it has value ‘None’ (far left), no drop-off threshold is used and all the scores are kept. 0.0 is the default threshold (PROGRESSIVETHRESHOLD).

Classifiers Taxonomy – if classification is selected, the IMARS extraction tool will evaluate the user’s collection against all concepts selected from the default concept taxonomy. The full taxonomy currently consists of 126 concepts split into 7 main categories: Objects, People, Settings, Types, Colors, Activity and Domain. It was created according to the following criteria. The user can choose to use a subset of the concepts in the taxonomy by checking the boxes in front of the corresponding concepts. NOTE: Concept selection is propagated to the entire sub-tree of selected nodes. The automatic classification output can be browsed by clicking on the “taxonomy” option in the IBM Search

5. Clusters Tab

The Clusters Tab allows the user to specify what kind of data clustering, if any; they want to see in the Search Tool.

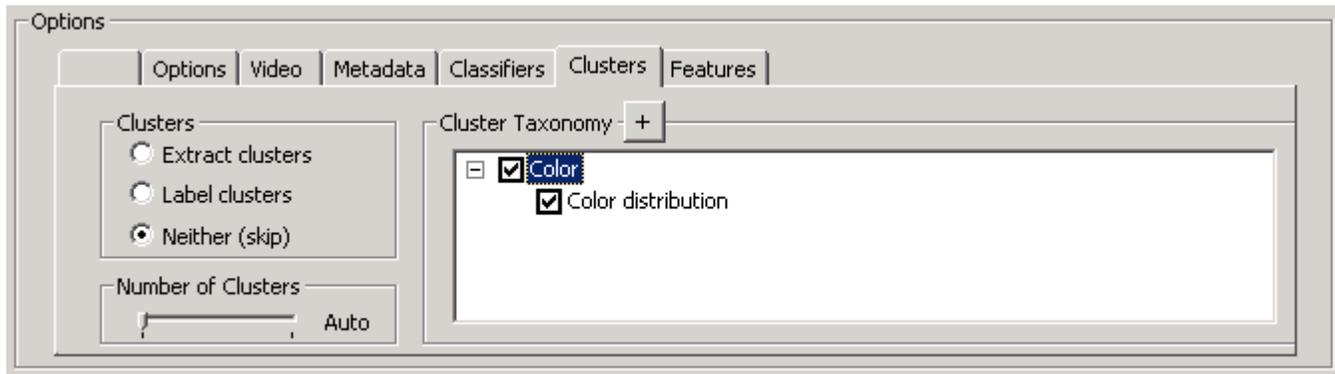


Figure 11 IMARS extraction tool - Clusters tab

Extract Clusters – the IBM Multimedia Analysis and Retrieval System allows users to cluster their image collection using visual similarity. The user must select the “Yes” radio button to extract clusters, as “No” is the default. (EXTRACTCLUSTERS)

Label Clusters – if cluster labeling is selected, the IMARS extraction tool will extract clusters based on checked visual descriptor listed in the clusters taxonomy. (LABELCLUSTERS)

Number of clusters – the default number of clusters is determined based on data size, visual feature, and data point distribution in the visual space. If the collection is heterogenic in content, more clusters will be created. (NUMCLUSTERS)

6. Features Tab

By default, the tool extracts a range of visual features, which can be used later on for a visual content-based similarity search. The user can use this tab to specify only a subset of the features to be extracted.

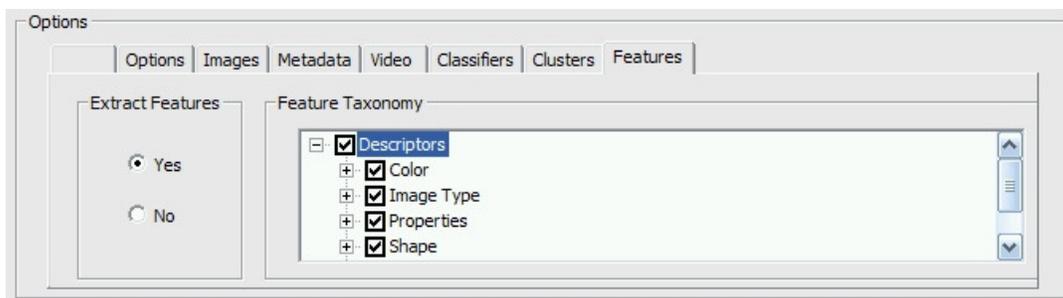


Figure 12 IMARS extraction tool - Features tab

Extract Features – the IBM Multimedia Analysis and Retrieval System allows users to index their image collection with a list of visual features capturing visual characteristics of the content, such as color, texture and shape. The “Yes” radio button must be selected to force the system to extract all possible features; otherwise the system will only extract the minimum set of features necessary for the selected classifiers. The user may wish to extract all possible features so that they are available for similarity searches in the Search tool later.

Feature Taxonomy – if feature extraction is selected, the IBM Multimedia Analysis and Retrieval System will extract all the features listed in the features taxonomy by default. The user can choose a subset of features to be extracted by using the corresponding check boxes.

On Low-level Visual Descriptors

The system extracts different visual descriptors at various granularities for each representative key-frame of the video shots. Relative importance of one feature modality vs. another may change from

one concept/topic to another. Although the used visual descriptors are very similar to the MPEG-7 visual descriptors, they differ in that they have been primarily optimized for retrieval and concept modeling purposes. We performed extensive experiments to select the best feature type and granularity for content search and modeling. Here are some of the low-level visual descriptors (features) the IBM IMARS extraction tool extracts from the collection.

Color Histogram - color represented as a 166-dimensional histogram in HSV color space.

Color Correlogram - color and structure represented as a 166-dimensional single-banded auto-correlogram in HSV space using 8 radii depths.

Color Moments - the first 3 color moments in Lab color space as a normalized 225-dimensional vector.

Wavelet Texture - the normalized variances in 12 Haar wavelet sub-bands

Edge Histogram - edge histograms with 8 edge direction bins and 8 edge magnitude bins, based on a Sobel filter

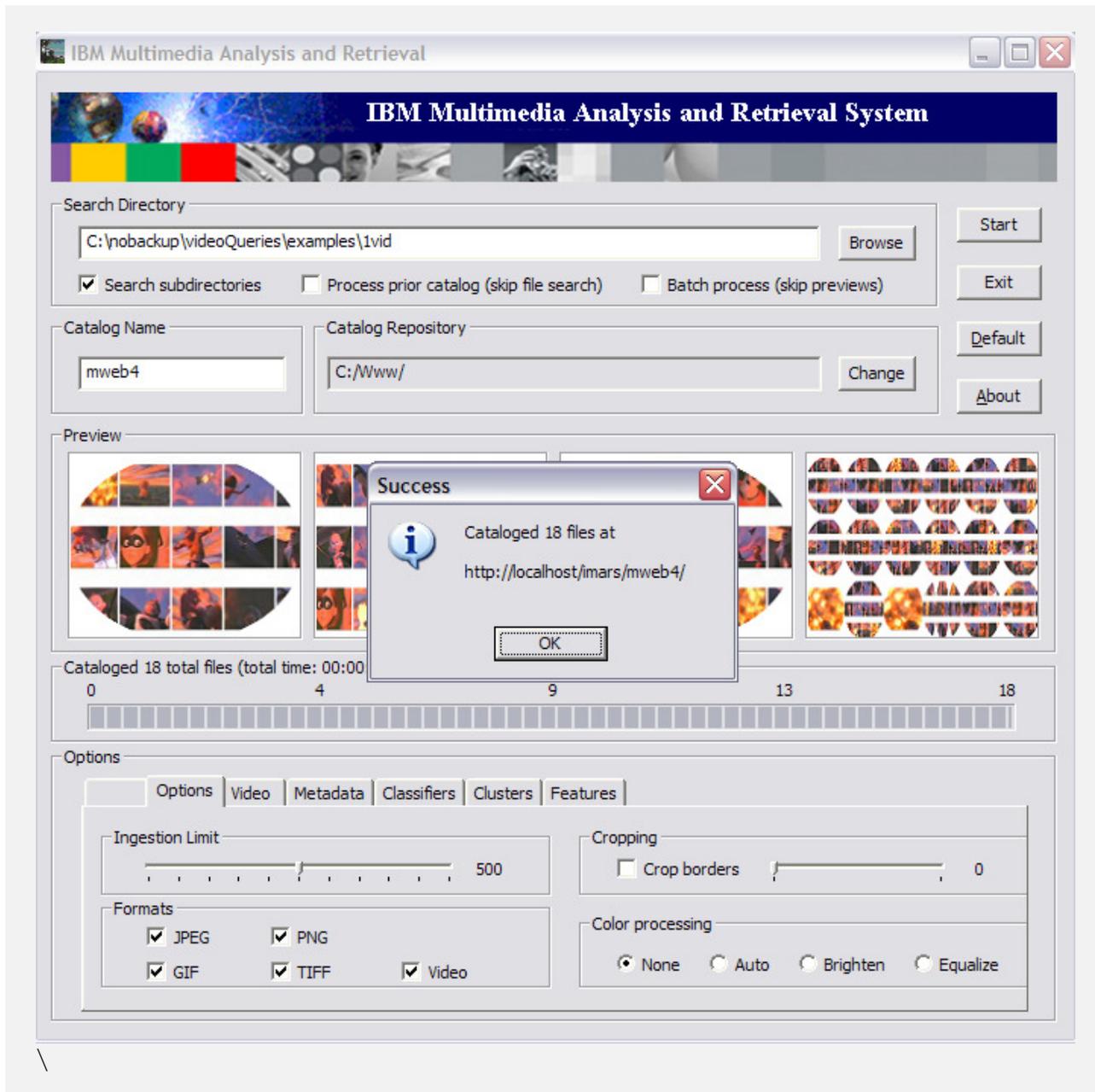


Figure 13 IMARS extraction tool - Indexing complete message

When the indexing is completed

When the IMARS extraction tool completes the collection processing, the user will get a Run Time Screen notification in the separate window: To view the indexing results in a browser, click on the right-most image in the preview section, or open the following link directly in the browser <http://localhost/imars/>. See Part 3 of this manual for a description of the IMARS Search Tool.

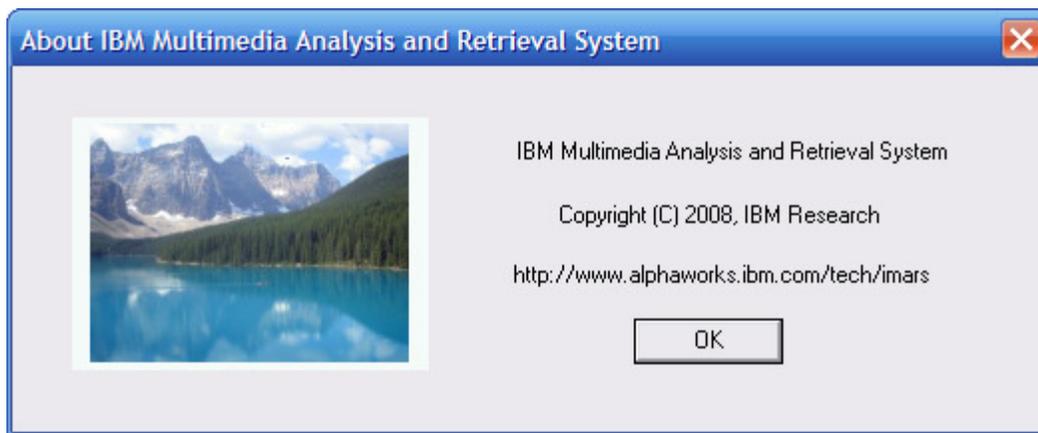


Figure 14 Search tool – Information Screen

IMARS Search Tool

The IMARS search tool allows searching, browsing and navigation of the results of processing image and video collections using the IMARS extraction tool

he **T** IBM® Multimedia Analysis and Retrieval System (IMARS) search tool allows the efficient and effective searching, browsing and navigation of the results of the IMARS extraction on image and video collections. The IMARS search tool allows the user to easily explore the results found for duplicates, near-duplicates, clustering, classifiers and other metadata, when selected for extraction using the IMARS extraction tool. The IMARS search tool also allows content-based similarity searching, whereby the tool finds the images that best match a query image in terms of visual similarity or semantic relatedness. Furthermore, the tool provides the user with the capability of easily tagging images with labels chosen by the user itself, in order to create user-defined clusters of images.

The IMARS search tool works with a Web browser interface to access and display the results obtained by running the IMARS extraction tool on one or more image and video collections. The IMARS search tool can access each collection by simply typing its Web address (which consists in the prefix <http://localhost/Imars/> plus the Catalog name chosen for the collection in the extraction tool interface) into a browser. For example, given the default IMARS configuration and case where the client and server are on the same machine, the results for a collection named “Vacation” can be accessed by typing <http://localhost/Imars/Vacation> into the Web browser.

IMARS Search Tool Interface

The user can browse different views of the indexed collection. Images and key-frames are organized in buckets using extracted metadata, grouped by visual similarity into clusters, and sorted by semantic label confidence. Users can access all views using the search tool tabs, as described below.

1. Tabs

1.1. Home Tab

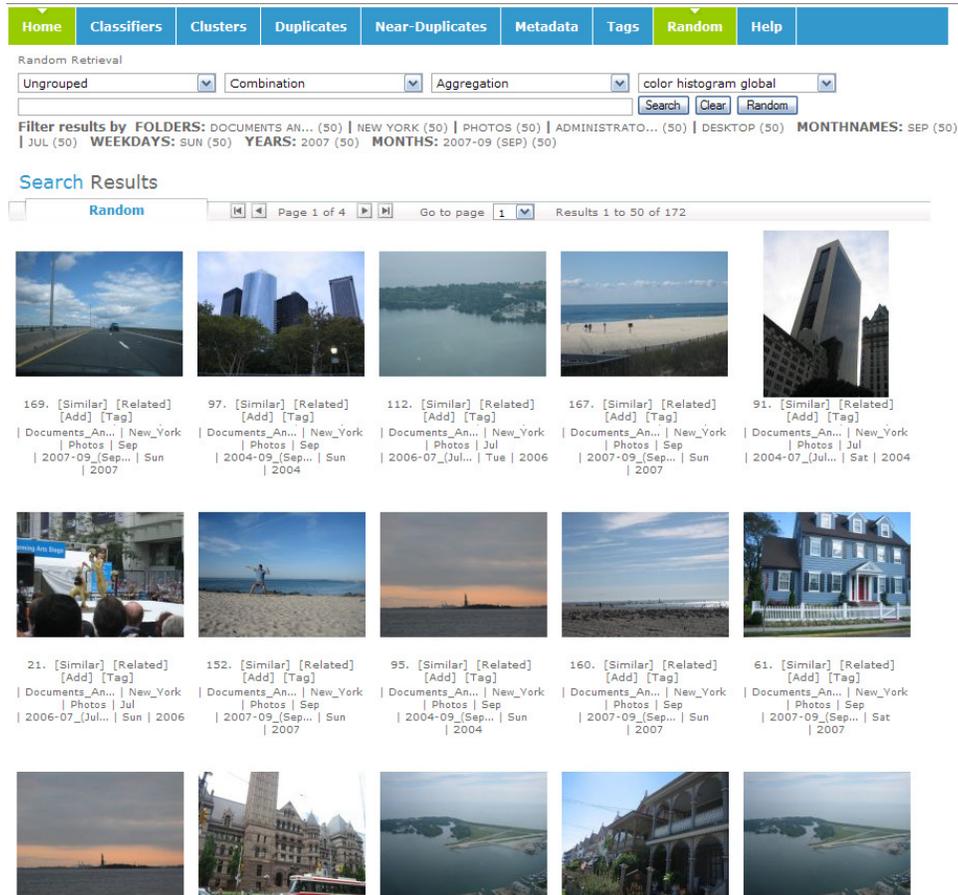


Figure 15 Search tool - Collection browsing

The Home Tab of the Search interface displays a random set of images or video key-frames from the indexed collection. This collection overview shows a set of images, where for each item the following information and links are provided:

- Thumbnail image depicting the contents of each processed image and video key-frame
- Assigned id # for the image or key-frame (for example, the image on the top left corner in Figure 15 has been assigned id # 169);
- Link called **[Similar]** that allows content-based visual similarity search (see the ‘Content-based Search’ Section)
- Link called **[Related]** that allows content-based search based on semantic relatedness – retrieves all images/key-frames that have similar metadata information as the image of interest
- Link called **[Add]** that adds the item for subsequent multi-example content-based search (see the ‘Content-based Search’ Section)

- Link called **[Tag]** that allows the assignment of tag to the item (see the ‘Tagging’ Section)
- Excerpt of the information extracted for corresponding image or key-frame.

If the user selects a thumbnail, it will lead him to a more detailed view of the image, as described in the “Detailed Image View” Section.

1.2. Classifiers Tab

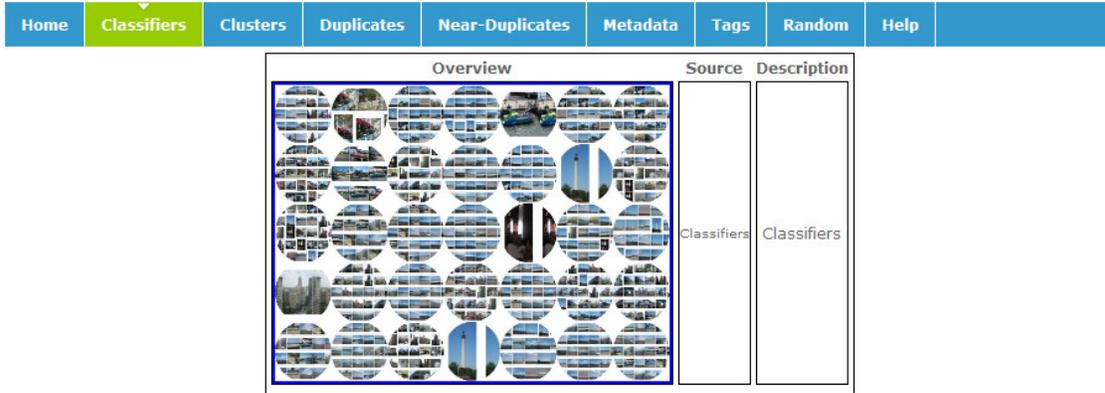


Figure 16 IMARS Search tool - Classifiers tab

If the user selected the YES radio button in the Classifiers tab of IMARS extraction tool, this tab points to the classification results. Such results consist in scores, associated to every image in the collection, expressing the degree to which such image belongs or not to each concept in our predefined taxonomy. Clicking on the image or the link in the table leads to the list of available classified concepts. Users have a choice of 3 (three) different ways to display the concept view of the collection: Tag space, Mosaic Images and Taxonomy.

Tag space view (below) allows the user to quickly identify how many images in the collection belong to a certain semantic concept, with respect to the whole collection. Each concept is represented by its name, and the size of the font is proportional to the amount of images belonging to it. When hovering over a tag within the cloud, a tool-tip appears informing how many pictures are associated with this tag. This feature enables smooth browsing and simplified view of a collection when there is a high number of elements in the list, and mosaic images contain too many small thumbnails to be intuitive.



Figure 17 Search tool - Tag space view

Mosaic Images view (below) allows the user to visualize the effectiveness of a specific classifier on the indexed collection. Each mosaic contains thumbnails of the images classified as belonging to the specific concept. The more images belonging to a concepts, the smaller the size of each thumbnail in its mosaic image representation.

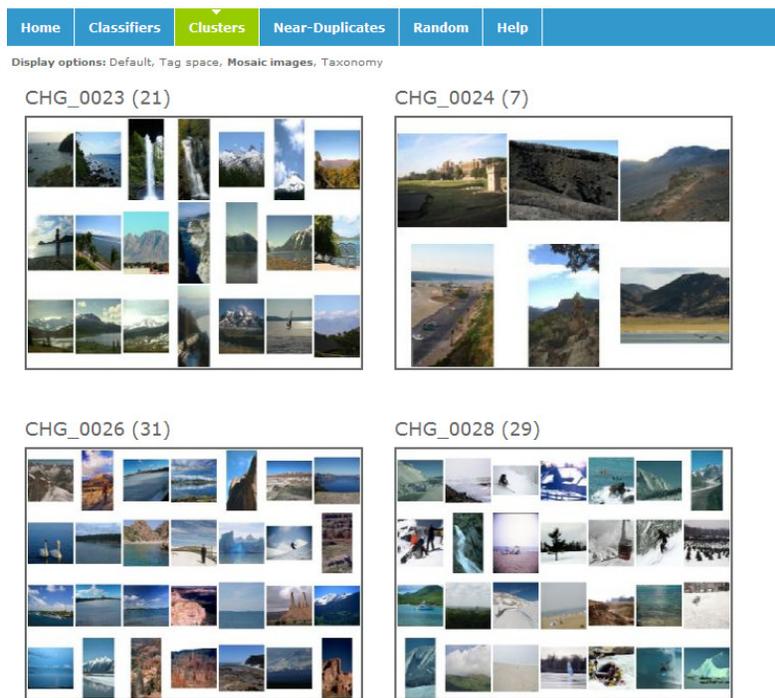


Figure 18 IMARS search tool – Example mosaic image view depicting results for set of clusters

Taxonomy view (below) allows the user to browse classifiers sorted according to the Classifiers Taxonomy in the IMARS extraction tool. This feature enables a hierarchical view of a collection when there is a high number of elements in the list that are co-related.

PREVIEW	NAME	COUNT	%	CATEGORY
	Black	2	0.046%	Color space (facet)/Dominant color (facet)/Black
	Blue	56	1.3%	Color space (facet)/Dominant color (facet)/Blue
	Brown	52	1.2%	Color space (facet)/Dominant color (facet)/Brown
	Green	6	0.14%	Color space (facet)/Dominant color (facet)/Green

Figure 19 IMARS search tool – Example taxonomy view of classification results

By selecting an individual classifier in any of the available views, the user is prompted to a page containing images indexed in a ranked order. The order is such that the images most likely to belong to the selected concept will appear at the top of the sorted collection, while the least likely images will appear towards the bottom, as shown in the ‘Beach’ example below: As can be seen, the system can automatically select relevant images (i.e. representing a beach scene) from the collection. Under each thumbnail is reported a highlighted number, representing the confidence score on the likelihood of the image to belong to the concept.

The screenshot displays the IMARS search tool interface. At the top, there is a navigation bar with tabs: Home, Classifiers, Clusters, Duplicates, Near-Duplicates, Metadata, Tags, Random, and Help. Below this, a search bar shows 'Semantic search "Beach" (84)'. The search criteria are set to 'Ungrouped', 'Combination', 'Aggregation', and 'color histogram global'. The search results are filtered by 'Folders: DESKTOP (50) | DOCUMENTS AN... (50) | NEW YORK (50) | PHOTOS (50) | ADMINISTRATO... (50)' and 'Weekdays: SUN (50) | SAT (50) | MONTHS: 2007-09 (SEP) (50) | YEARS: 2007 (50) | MONTHNAMES: SEP (50)'. The search results are displayed in a grid of 10 thumbnails, each with a confidence score in a yellow box: [0.19], [0.19], [0.158], [0.158], [0.157], [0.157], [0.156], [0.156], [0.149], and [0.149]. Each thumbnail includes links for [Similar], [Related], [Add], and [Tag], and a breadcrumb trail: | Documents_An... | New_York | Photos | Sep | 2007-09_(Sep... | Sun | 2007.

Figure 20 IMARS search tool – Example of view of classification results ranking images and video key-frames images for category of “Beach”.

Note on the Classifiers

The automatic semantic classification will not produce perfect results. Given the tremendous variety of visual content for any category, the computer will likely produce some misclassified results. The IMARS classifiers have been designed to work as well as possible across a wide range of domains and have not been fine-tuned for nuances of individual domains such as broadcast news, consumer photos, cell phone cameras, and so on.

1.3. Clusters Tab

The Clusters Tab shows the whole dataset clustered using one or more visual features (listed on the entry page), based on user selection in the Clusters tab of the IMARS extraction tool (see the Clusters Tab Section of the IMARS extraction tool). Images are grouped into buckets based on their visual similarity within the cluster and dissimilarity with respect to other clusters in the visual descriptor domain (i.e. color, texture, edge, shape). The mosaic image of a specific cluster category shows the aggregated collection view where grouping is done with respect to visual similarity of the collection content.

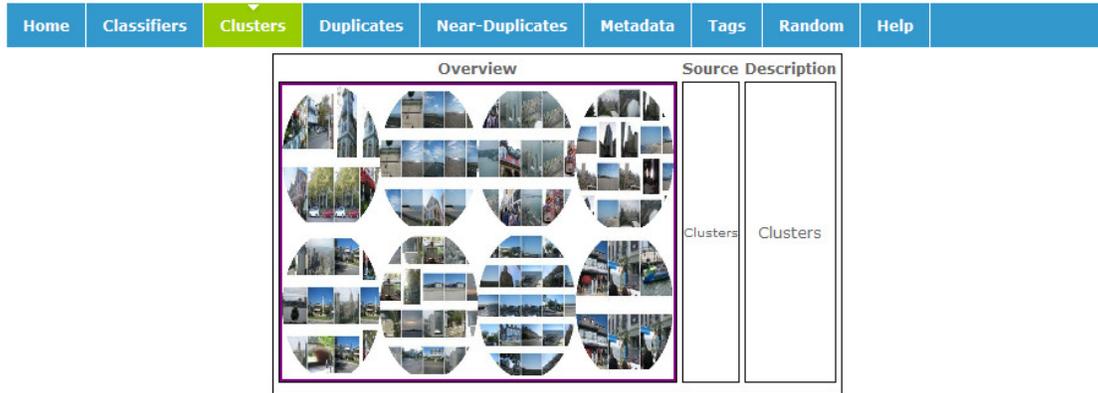


Figure 21 IMARS search tool - Example for Clusters tab

Note

The functionality of the Metadata, Cluster and Classifiers tabs are essentially the same. The first page gives an overview of available metadata/clusters and classifiers for the collection. By choosing the specific view within the tab, the user is led to a collection space overview that can be tag-based ('Tag Space'), image-based ('Mosaic Images') or more general ('Taxonomy')

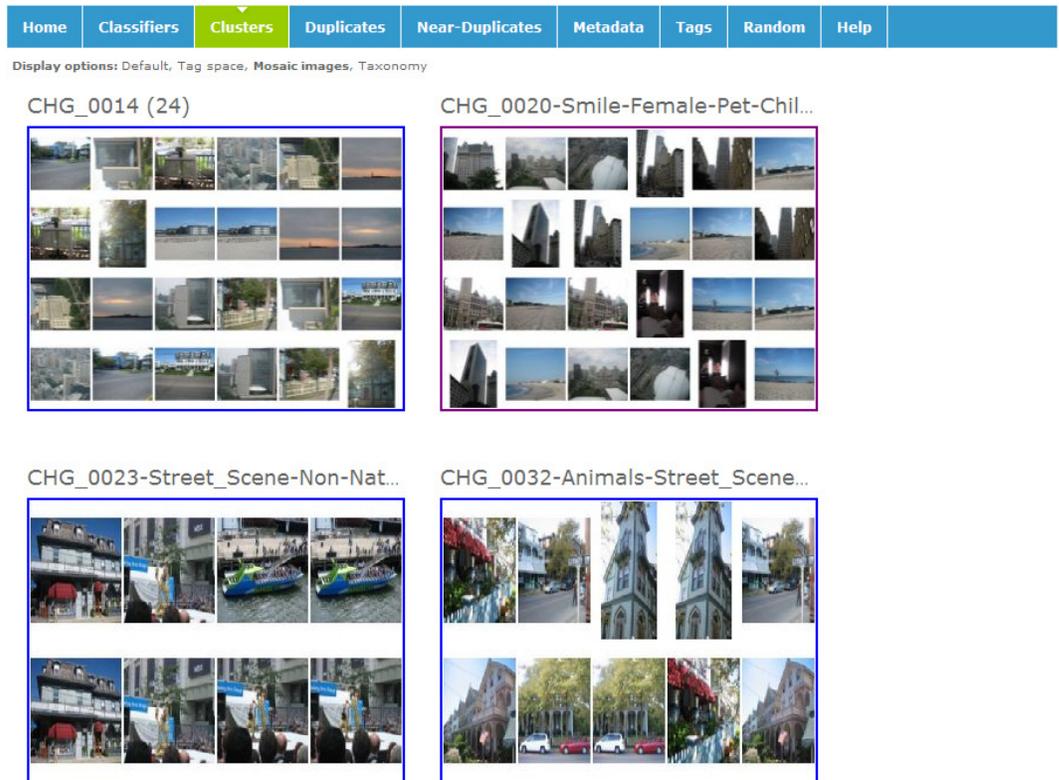


Figure 22 IMARS search tool – Example mosaic view of clusters.

1.4. Duplicates tab

Duplicates are exact copies of the same image. The system allows the user to find such repetitions by extracting and comparing their unique hash MD5 value, and eventually erase them.

1.5. Near-Duplicates tab

Near-Duplicates Tab shows grouping of the images or key-frames in the collection which are visually similar, but not exact copies

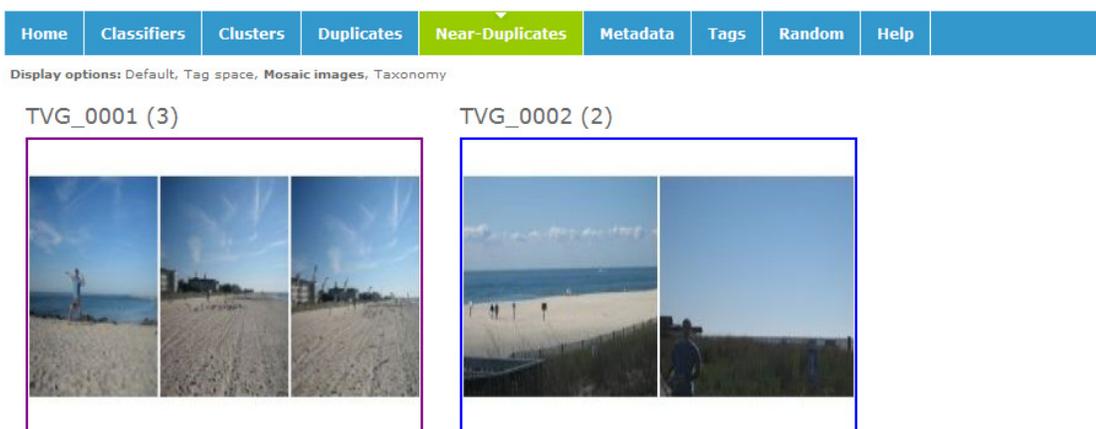


Figure 23 IMARS search tool – Example for Near-Duplicates tab

1.6. Metadata tab

Metadata Tab has the exact same functionalities as other Tabs (see Note). Metadata information about digital images and videos plays a crucial role in the management of multimedia repositories. It enables cataloging and maintaining large collections, and facilitates the search and discovery of relevant information. Moreover, describing a digital image

with defined metadata schemes allows multiple systems with different platforms and interfaces to access and process image metadata. Depending of the selection in the Metadata tab of the IMARS extraction tool, the Metadata folder can contain information on the folders the collection belongs to, or time and date when images were taken. The Metadata tag space of years is shown in the image below:



Figure 24 IMARS search tool – Example for Metadata tab

1.7. Tags tab

Tags tab are somewhat different from the Metadata Tab as all the Tags are summarized together and there is only one view of the data. Tag space is automatically populated as users tag images or group of images (see more under system functionalities in the next section). The size of each tag is proportional to the number of images which were tagged accordingly within the collection.



Figure 25 IMARS search tool – Example for Tags tab

1.8. Random

The Random tag produces a display (similar to the Home tag one) of images randomly selected from the collection.

1.9. Help tag

By clicking the Help tag, the user is presented with an html version of this Guide.

2. Detailed Image View

The user can access a detailed view of the image by clicking on an image thumbnail in any of the non-summarizing collection views in the Search Tool.

Figure 24 shows an example of detailed view of the image, presenting

- Image Info: the Name and ID assigned to the image or key-frame
- Corresponding metadata
- Classification results
- Feature Search box: enables user to a more advanced option of searching in different visual feature spaces. The user can do a content-based search by clicking on any of the features listed.

<<Previous | Next>>

Image Info

Name: ihn-C68D75EDB795FE0B303FCC0A6C8
Shot ID: 40877

Metadata

- Source@sunset_Ask

Auto-Tagged Concepts (Confidence)

- Classifiers@Beach (0.26)
- Classifiers@Blue (0.086)
- Classifiers@Blue_Sky (0.21)
- Classifiers@Generic_Setting (0.72)
- Classifiers@Known_Setting (0.72)
- Classifiers@Natural_Photo (0.37)
- Classifiers@Nature (0.28)
- Classifiers@Nature_Scene (0.72)
- Classifiers@Outdoors (0.37)
- Classifiers@Setting (0.72)
- Classifiers@Sky (0.21)
- Classifiers@Violet (0.36)
- Classifiers@Water_Scene (0.72)
- Clusters@CHG_0464-Green-Violet-Nature-Blue_Sk (0.99)

Feature Search

- color histogram global
- color histogram layout
- color histogram center
- color histogram horizontalcenter
- color histogram verticalcenter
- color histogram cross
- color histogram horizontalparts

Add Tag

Figure 26 Search tool - Detailed image view

Video playback

Home Classifiers Clusters Duplicates Near-Duplicates Metadata Tags Random Help

Saved Results: View |

<<Previous | Next>>

Image Info

Name: 000135
Shot ID: 25504
Shot span: 00:04:28:00 ~ 00:04:30:00

Metadata

- Author@Unknown
- Date@Unknown
- Month@Unknown
- Near-Duplicates@TVG_0132
- Videos@pbi8yGyGNxg.flv

Auto-Tagged Concepts (Confidence)

- Classifiers@Activity (0.18)

Download Video (.flv, 16MB) | Play Video | Stream Video |

Figure 27 Search tool - Detailed video shot view with video playback option

If IMARS extraction tool processed the video, the detailed view of each key-frame contains the video playback links to the video. Video shot metadata are extracted and processed in the IMARS extraction tool.

Download video (<ext>, <size>) - allow user to download and save the entire video, or play from the beginning (based on the browser setting).

Play video – IMARS Search Tool plays it within a HTML embedded windows media player. NOTE: only works for video formats that are compatible with WMP (e.g. mpeg, some avi, not flv).

Stream video – seek and play the video from the current shot using existing video player

- Generate playlist in .asx format
- Seeks and plays the video from the current shot ((e.g. 00:04:28:00 in this example) - seeking is approximate and may fail depending on how the original video is encoded
- If the seeking fails then it would play from a best-effort-guess, or the beginning of the entire video (this varies depending on player)
- Existing video player needs to: (a) be linked to the default web browser, (b) be able to handle both .asx format and the actual video format,\
- We recommend to install VLC player - see <http://www.videolan.org/vlc/> for more details.

Video playback option can be manually setup in the <CATALOGDIR>\cgi-bin\vars.txt file (i.e. C:\WWW\Travels\cgi-bin\vars.txt)

ALLOW_VIDEO=1 - variable that allows video access from IMARS Search Tool (enabled by default)

DOWNLOAD_VIDEO=1 – variable to display Download Video link in Detailed Image View (enabled by default)

PLAY_VIDEO_FILE=1 – variable to display Play Video link in Detailed Image View (enabled by default).

PLAY_VIDEO_PLAYLIST=1 - variable to allow playlist creation and streaming (enabled by default)

VIDEO_MAX_SIZE_KB=20480 – caps the maximum size in KB allowed for video playback or download

3. IMARS Search Options

The IMARS search tool supports searching by visual features, metadata, tags and classification categories. Although these automatic techniques are very powerful, it is important to keep the user in-the-loop to support a most effective interactive search experience. The IMARS search tool supports search capabilities that can combine text based, visual appearance based, and classifier based searching.

3.1. Content-based Search

Content-based search or ‘query by example’ search is a query technique that involves providing the system with an example image that it will then base its search upon. The system retrieves the closest images to the example image in low-level visual descriptor space and retrieves a result list where images are sorted by the ascending distance from the query example. Content-based search in IMARS can be invoked in three ways.

In the first scenario, the user selects the [Similar] button under the example query. In the second scenario, the user can either type LIKE@<Shot ID> in the search bar, where <Shot ID> is the index of the desired example in the database, or click the [Add] button below the example query, and press search. In both scenarios, the user can select the specific visual space to conduct the similarity search in the feature box (“color histogram global” by default). Figure 25 shows the resulting page of these two scenarios using the default visual space.

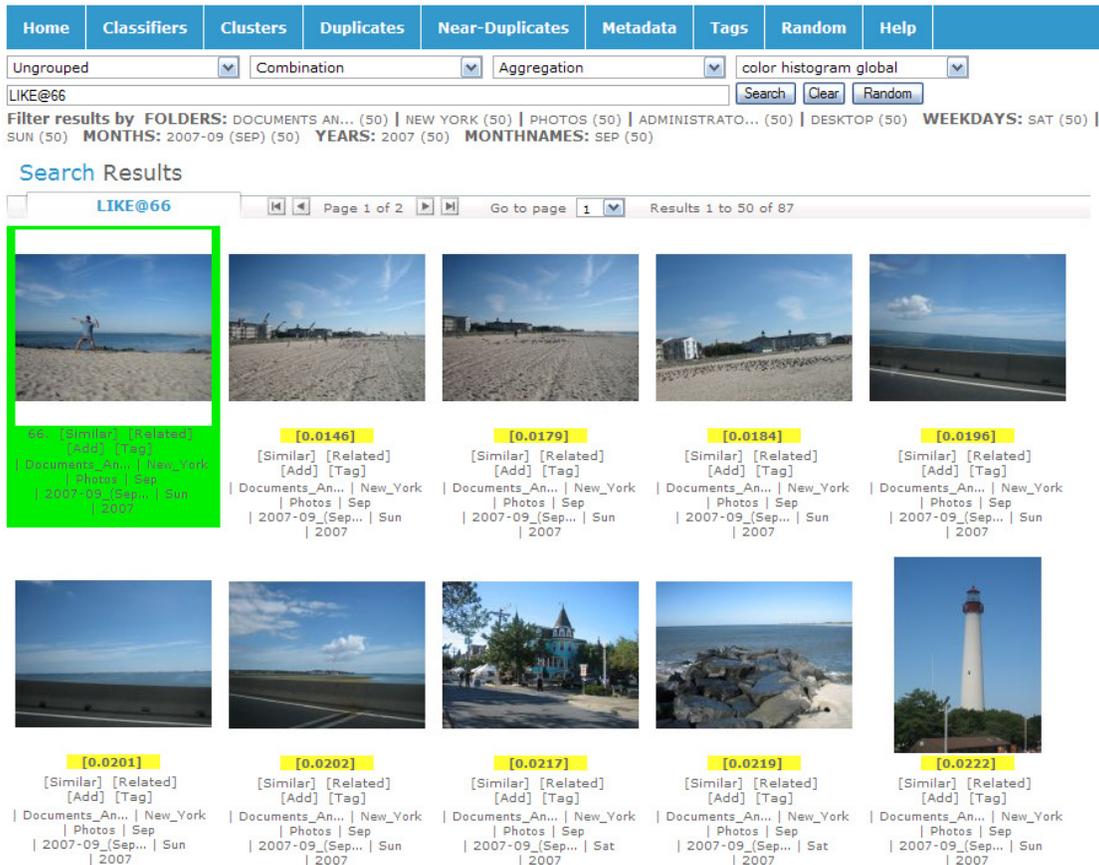


Figure 28 IMARS search tool – Example of content based visual similarity search.

In the third scenario user can invoke a specific similarity search from the image view page by selecting a visual space she wants to query in. If the use selects a default feature space, the result page will be the same with the previous Figure 25. In other cases the result will be different. The following image (Figure 26) shows a result page when search is done in wavelet texture feature space, where the relevant result set is ranked differently from Figure 25.

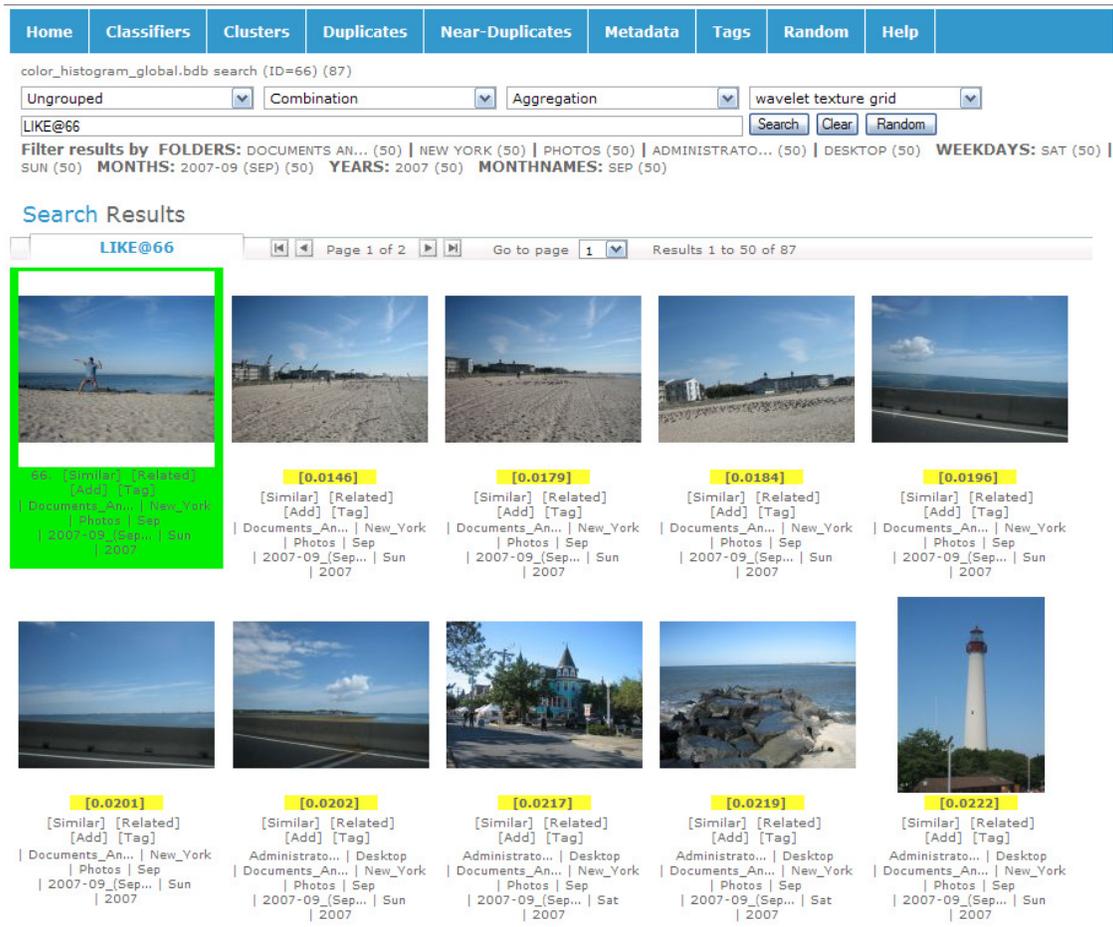


Figure 29 IMARS search tool – Example content based search using color wavelet texture descriptors.

3.2. Search Bar

The Search Bar allows the user to access and search substrings of all labels connected to the key-frame (this extends to metadata and classifiers). All Browsing functionalities can be accessed through a Search bar using the correct prefix, i.e. FOLDERS@ is the prefix for Folders Metadata CLASSIFIERS@ is the prefix for auto-tagged semantic models, and TAGS@ is the prefix for user-assigned tags. Search bar has an auto-complete functionality to enable easier browsing through possible matches, as illustrated in the screenshot below:

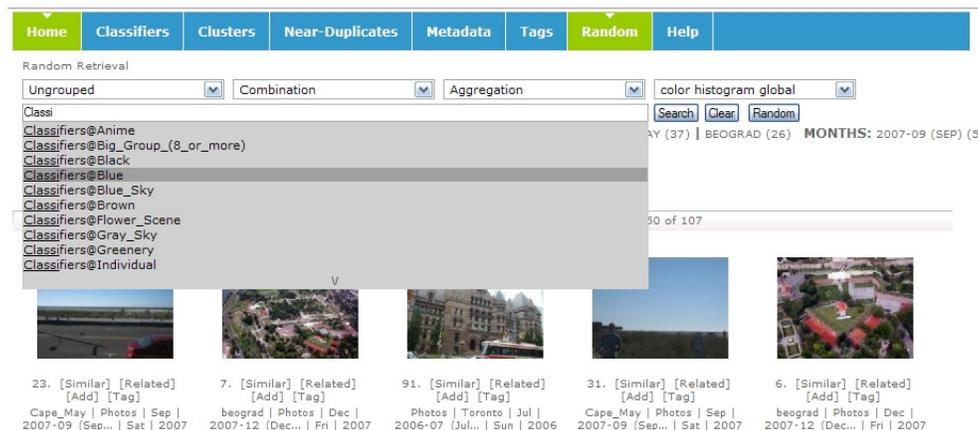


Figure 30 IMARS search tool – Example of search bar.

The search bar also enables content-based search: typing Like@<Shot_ID>, where <Shot ID> is the index of the desired example in the database and press search, will result in query-by-example search over the collection. In the same manner, the search bar enables multi-modal search using BOOLEAN type of expressions. In the example below, we filter the content-based search with classifier 'Blue_Sky', and final search expression Like@<Shot_ID> AND CLASSIFIERS@Blue_Sky gives us a more precise result set:

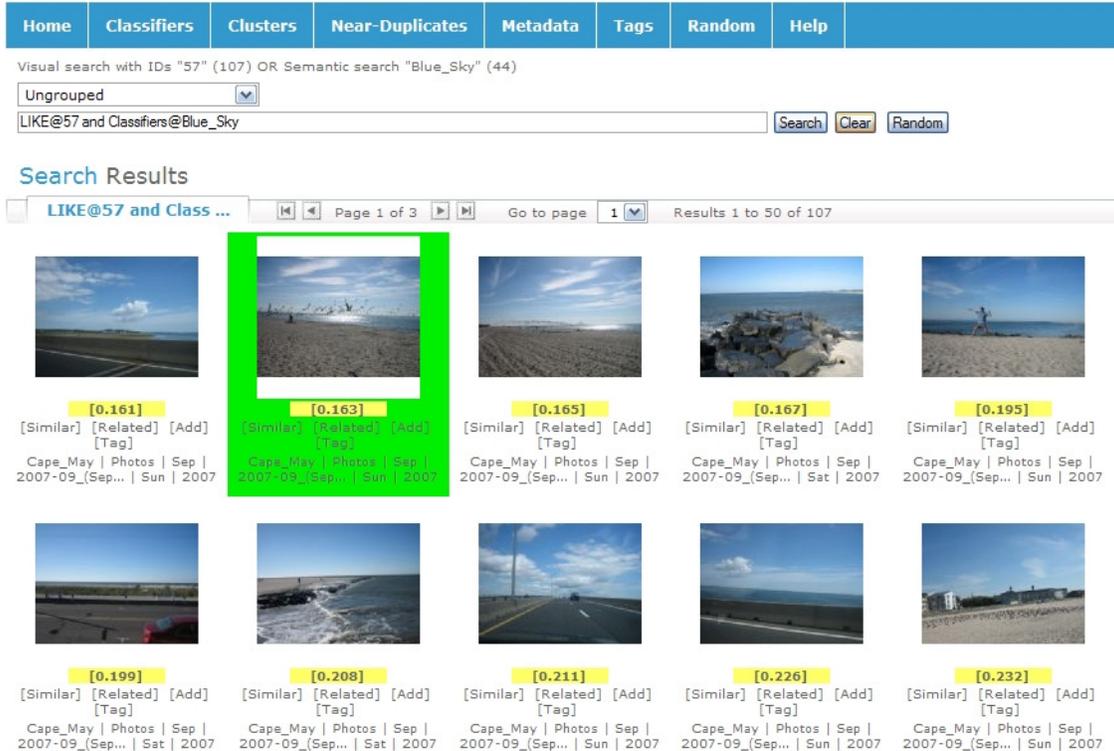


Figure 31 IMARS search tool – Example of multi-modal search using content-based search combined with classifier-based search.

Regular expressions in the Search bar allow the combining of multiple modalities of extracted information to better model the information need and to ultimately find the relevant shot within the collection.

3.3. Results Grouping

The IMARS search tool offers the possibility to improve the visualization of query results by grouping them using existing metadata and clusters. The groups are computed dynamically, by initiating on the result set which is currently displayed on the screen, and the following steps are taken:

- Select the grouping category i.e. metadata or visual cluster from the dropdown menu over the Search bar
- Collect group labels for every key-frame in the result set that matches the selected category
- Group images/shots in the result list by common label.
- Create visual containers for all images/shots labeled with the group label.

Groups are ordered based on their aggregate scores, and then items are ordered within groups based on their original query match scores. The figure shows an example of how a user can easily filter the meaningful results in the retrieved list by grouping the top matches using visual clusters.

Visual search with IDs "57" (107) OR Semantic search "Blue_Sky" (44)

Group by Clusters

LIKE@57 and Classifiers@Blue_Sky

Search Results

Displaying 50 Images in 9 Group(s) (Collapse all, Expand all).

LIKE@57 and Class ... Page 1 of 3 Go to page 1 Results 1 to 50 of 107

Group 1 [0.768]: Clusters@CHG_0057-Water_Scene-Nature-Gray_Sky-Outdoors-Blue_Sky (5 items) [Tag group]

[0.163] [Similar] [Related] [Add] Cape_May | Photos | Sep | 2007-09_(Sep... | Sun | 2007

[0.165] [Similar] [Related] [Add] Cape_May | Photos | Sep | 2007-09_(Sep... | Sun | 2007

[0.167] [Similar] [Related] [Add] Cape_May | Photos | Sep | 2007-09_(Sep... | Sat | 2007

[0.315] [Similar] [Related] [Add] Cape_May | Photos | Sep | 2007-09_(Sep... | Sun | 2007

[0.35] [Similar] [Related] [Add] Cape_May | Photos | Sep | 2007-09_(Sep... | Sun | 2007

Group 2 [0.707]: Clusters@CHG_0017-Sky_Scene-Outdoors-Blue_Sky-Blue-Nature (9 items) [Tag group]

[0.161] [Similar] [Related] [Add] Cape_May | Photos | Sep | 2007-09_(Sep... | Sun | 2007

[0.211] [Similar] [Related] [Add] Cape_May | Photos | Sep | 2007-09_(Sep... | Sun | 2007

[0.226] [Similar] [Related] [Add] Cape_May | Photos | Sep | 2007-09_(Sep... | Sun | 2007

[0.244] [Similar] [Related] [Add] Cape_May | Photos | Sep | 2007-09_(Sep... | Sun | 2007

[0.297] [Similar] [Related] [Add] Cape_May | Photos | Sep | 2007-09_(Sep... | Sat | 2007

Figure 32 IMARS search tool – Example of grouping of query results.

3.4. Tagging

Tags are freely chosen labels that help to improve a search engine's effectiveness because content is categorized using a familiar, accessible and shared vocabulary. The IMARS search tool offers several ways to retrieve items that match the topic of interest. The tagging feature enables the user to assign subjective tags to multimedia content. Specific key-frames can be tagged from the collection view using the button [Tag] under the thumbnails. The system allows for a group tagging i.e. simultaneous assignment of the same label to a group of key-frames. This allows the user to define specific events across different content sources that were not specified in the system. In the single item view, we use different confidence values, to distinguish such “group tags” from tags that were assigned to a single shot. Once a reasonable number of tags have been assigned to the multimedia collection, the collection can be viewed as a Tag cloud using Tags tab in the search system.

IMARS ADVANCED TOPICS

IMARS allows for the parallelization of the process using multithreading of collection processing and metadata extractions. IMARS supports incremental collection and processing updates in the experimental form..

Throughput Performance

1. Performance Time Analysis

The IBM Multimedia Indexing and Search System (IMARS) provide setup options in the IMARS extraction tool that determine the throughput of the extraction process. The following table summarizes a sample configuration of options in the IMARS extraction tool:

Tab	Video Tab		Classifiers Tab		Features tab
Option	Video Frame Sampling	Skip Frame Rate	Classifiers taxonomy	Speedup vs. Accuracy	Feature taxonomy
Setting 1	Regular	4s	10 selected	20x (max)	All selected
Setting 2	Regular	4s	100 selected	20x (max)	All selected

The following charts are based on Windows Server 2003 SP2 CPU: Intel Xeon 3.20 GHz CPU RAM: 3.75 GB and processing 10 visual classifiers (concepts). As shown, in this case the IMARS extraction tool processing time is 12 times faster than real time with respect to video content.

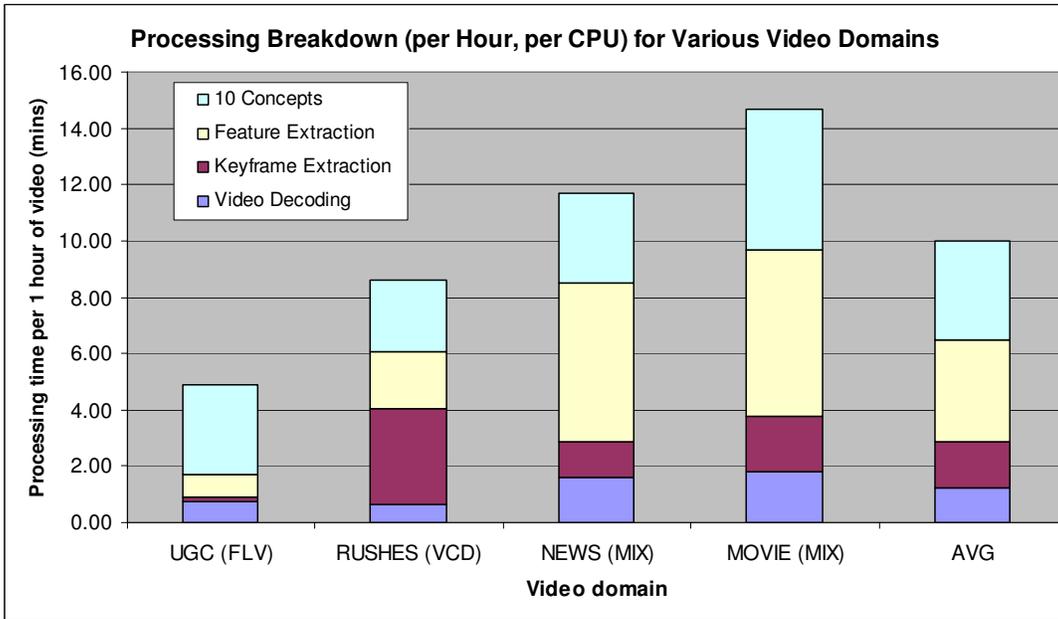


Figure 33 IMARS extraction tool - Processing breakdown statistics for 10 concepts (per Hour, per CPU) for various Video Domains

As the number of classifiers is increased from 10 to 100, the IMARS extraction tool processing mix involves increase in time spent on classification compared to the functions of video decoding, key-frame extraction and feature extraction, as shown in the figure below (light blue bar). The processing time for the video data set increases to half real time.

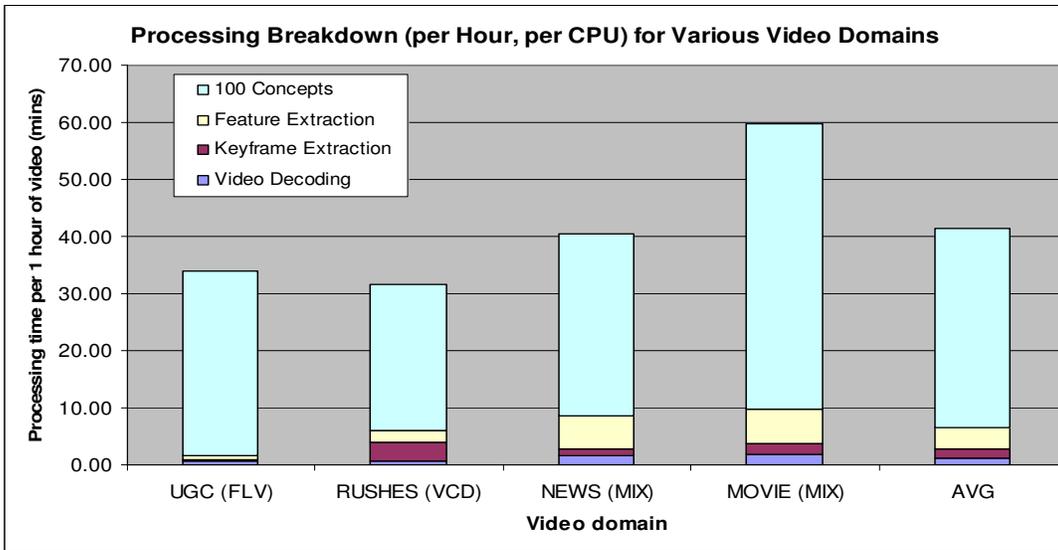


Figure 34 IMARS extraction tool - Processing breakdown statistics for 100 concepts (per Hour, per CPU) for various Video Domains

The following table summarizes the IMARS extraction tool processing of large collection of videos based on unit of 1TB of videos from mixed sources.

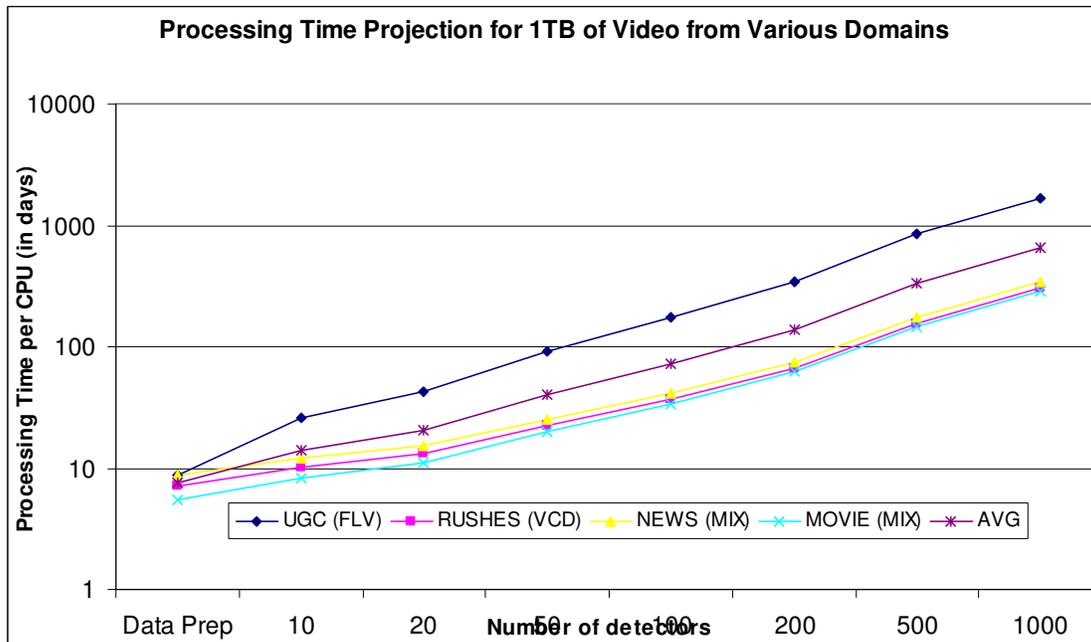


Figure 35 IMARS extraction tool - Processing time projection for 1TB of video from various Domains

Actual performance will depend on specific setup and platform. Using IMARS report, users can get an insight into an actual throughput of the process and ways to control it.

1.1. IMARS Reporting

IMARS report provides user with a detailed output summary on IMARS Extraction Tool processing, and it is stored in <CATALOGDIR>\log.txt file (i.e. C:\WWW\Travels\log.txt). Summary at the end of the log file provides performance time statistics on each IMARS Extraction Tool flow. Sample log file output for IMARS run on 207 images, 23 classifiers,(Windows XP version 2.09 Intel® CPU T2600@2.16GHz, 2GB RAM)

PROCESSING TIME STATISTICS (HH:MM:SS.MMM)

```

-----
Crawling:           00:00:00.031 (0%)
Metadata:           00:00:00.078 (0%)
Features:           (49%)
Classifiers:        (45%)
Duplicates:         00:00:00.000 (0%)
Near-duplicates:   00:00:00.000 (0%)
Clusters:           00:00:00.719 (0%)
Indexing:           00:00:34.030 (4%)
-----
Total processing:   00:13:53.234 (100%)

```

User can control the IMARS processing throughput through several options

2. SETUP OPTIONS

The system default values for IMARS variables are set in the configuration file <DIR>\bin\prefdfilt.txt, and they are loaded in the first run of IMARS.exe. Once the tool completes the indexing, or if user chooses to exit, user specifications in the IMARS extraction tool are saved to <DIR>\bin\preflast.txt. All subsequent IMARS extraction tool runs will load/write variable values from/to <DIR>\bin\preflast.txt file.

2.1. Basic Manual Configuration

The user can manually change the values of the variables in the preflast.txt file, as shown in the following example. The manual configuration is equivalent to setting the variables from the IMARS Extraction tool interface.

Step 1: Close the IMARS application.

Step 2: Change the default variables in preflast.txt

From:

```
SEARCHDIR=C:\Photos\  
CATALOGDIR=C:\Www\Travels  
CATALOGROOT=C:\Www\  
CATALOGNAME=Travels
```

To:

```
SEARCHDIR=C:\Photos  
CATALOGDIR= C:\myUser\myFolder \Holiday  
CATALOGROOT= C:\myUser\myFolder  
CATALOGNAME=Holiday
```

Step 3: Save preflast.txt

Step 4: If you change CATALOGROOT in preflast.txt, make sure to change the variable CATALOGROOT in http.conf in the Apache setting (see Apache HTTP Server setup section) to the same value i.e. CATALOGROOT is not C:\myUser\myFolder. Save httpd.conf and restart Apache server.

Step 5: Run IMARS.exe - changes will be reflected. If there was an error or typo in preflast.txt, you may receive a warning dialog box, as in figure 6.

2.2. Advanced Manual Configuration

IMARS is an end-to-end tool that performs multiple tasks in cascade: shot segmentation, key-frame extraction, feature extraction, classification, metadata extraction, and clustering. During IMARS Extraction Tool processing, the steps that take the bulk of the processing time are (a) video logging (b) feature extraction, and (c) classification evaluation. User can speed up the processing by setting advanced options in <IMARS>\bin\preflast.txt file

NOTE: the following variables need to be set in the preflast.txt directly to take effect.

2.2.1. Multithreading

Indexing videos is time and CPU consuming. To index 50GB of video with 6 classifiers can take 36 hrs of processing on one CPU. IMARS takes advantage of the multiprocessing systems by allowing for multiple threads of processing running in parallel. This is controlled by NUMTHREADS variable in the parameter file preflast.txt.

NUMTHREADS=-1 (default)

If NUMTHREADS is larger than 1, IMARS takes advantage of the multiple processors, and parallelizes the process of video indexing, feature extraction and classification. This can result in significantly faster collection processing, as illustrated in Figure.

2.2.2. Feature Store

Feature Store enables user to re-use extracted low-level descriptors. If the STORE is enabled, IMARS writes to the STORE during the feature extraction phase, and reads from it.

STORELOCATION=LOCAL
 STOREREADTYPE=1
 STOREWRITETYPE=1
 USESTORE=1

USESTORE - this variable in the parameter file preflast.txt controls the use of the STORE processing. If USESTORE=1, then IMARS uses STORE option for feature extraction, if USESTORE=0, it does not.

STORELOCATION – if this variable is set to local and USESTORE is enables, STORE folder will be created here <CATALOGDIR>\STORE (i.e. C:\WWW\Travels\STORE) to save all feature descriptors. STORELOCATION can be set to point to a fixed location i.e. STORELOCATION=C:\WWW\STORE. This is useful if user is processing lots of different collections that might overlap, or reprocessing the same collection.

The following table sums up the IMARS setting and processing times of 207 images, 23 classifiers on Windows XP version 2.09 Intel® CPU T2600@2.16GHz, 2GB RAM. The advantages of using multiple threads and feature store are realized on a small collection and on a personal laptop. If we utilize 2 processors and enable STORE , the processing time statistics is cut in half, see table:

Preflast.txt Settings	NUMTHREADS	USESTORE	Features: (MM:SS)	Classifiers: (MM:SS)	Total Processing (MM:SS)
Base	1	0	06:55	06:22	13:53
Advanced	2	1	03:02	04:26	07:34

The following statistics is based on time statistics obtained on IMARS processing of 1250 images and 119 videos, 23 classifiers on Microsoft Windows Server 2003, SP 2, Intel ® Xeon™ MP CPU 2.7Ghz, 3.5GB of RAM.

Preflast.txt Settings	NUMTHREADS	USESTORE	Features: (MM:SS)	Classifiers: (MM:SS)	Total Processing (MM:SS)
1 Thread	1	0	1:10:53	0:11:36	01:47:42
2 Threads	2	0	0:37:02	0:06:56	01:03:31
3 Threads	3	0	0:26:20	0:05:23	00:55:35
1 Thread + STORE	1	1	0:12:46	0:11:24	00:49:04
2 Threads + STORE	2	1	0:08:40	0:06:44	00:34:42
3 Threads + STORE	3	1	0:08:04	0:05:09	00:32:33

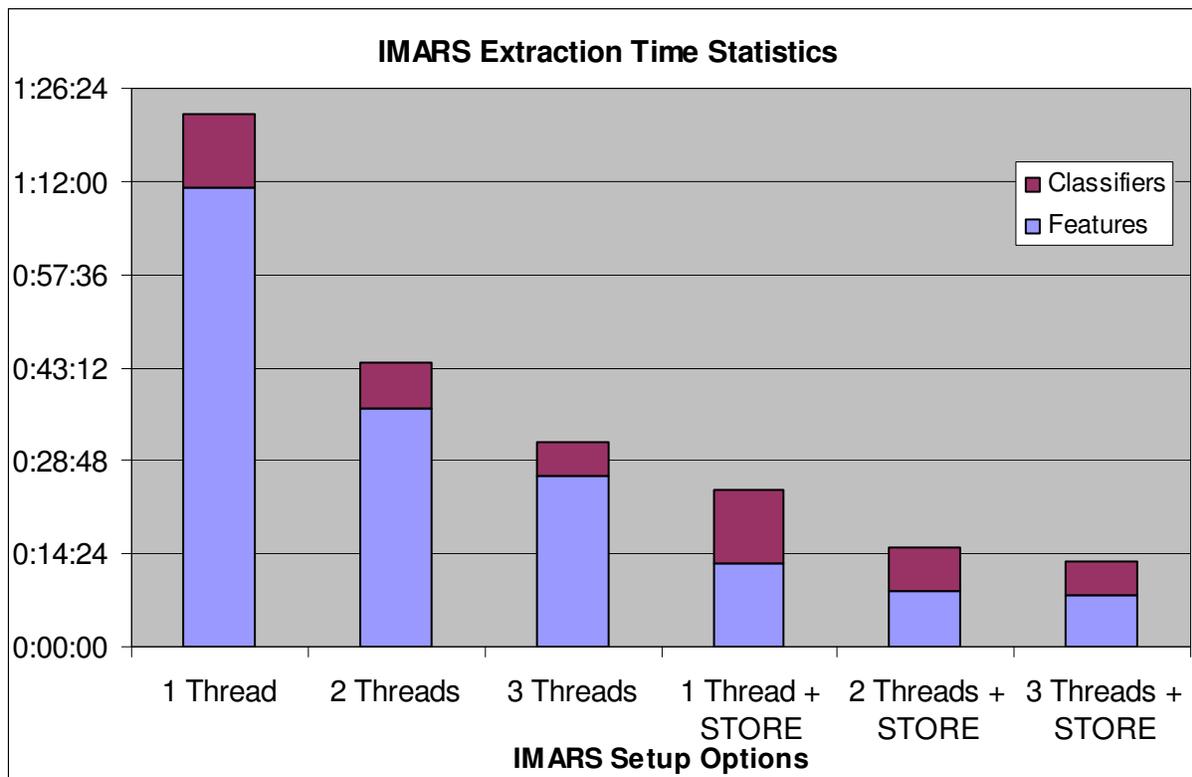


Figure 36 Comparison of various IMARS processing times for number of processing threads and use of STORE.

Feature extraction and classification evaluation take the most of the processing time. Figure 36 illustrates the speed up IMARS advanced options enable. As number of threads grows from 1 to 3, the amount of time needed to process a collection is significantly reduced as steps are parallelized.

Also, the figure demonstrates that the use of STORE use is helpful for the incremental processing (reprocess data IMARS has already accessed) in large collection scenarios, As shown in Figure 36, it can speed up the processing significantly (over 50% of the time). Note that use of STORE reduces processing burden, but it is disk I/O intensive and requires extra disk space for storing descriptors. User must carefully choose the right parameters for the specific scenario IMARS processing is used to obtain optimal processing time.

2.3. Incremental Processing (Experimental)

IMARS supports incremental collection and processing updates in the experimental form. IMARS interface allows users to re-use extracted information in collection re-processing if **Process prior catalog (skip file search)** is selected (NOCRAWL=1 in preflast.txt). IMARS will not search in the file system for images but will only re-index a catalog previously processed. NOTE: IMARS will reuse already extracted metadata and extract new metadata to create a final index. Enable all indexing and extraction options in the incremental run that you want to see in the final index, as indexing is not incremental.

IMARS supports collection append. If user selects the CATALOGDIR to be the same as the existing one (i.e. C:\WWW\Travels is already populated by a previous IMARS instance), IMARS will offer user an option to

- overwrite existing catalog (YES) - overwrite existing CATALOGDIR with new data. NOTE: if the Search Directory is different than the one used to populate CATALOGDIR before, all information will be overwritten. APPEND=0

- append existing catalog (NO) – this option allows user to append new images to the existing collection. IMARS will set the variable APPEND=1, and will reuse old metadata in the extraction process.
- change the location of CATALOGDIR (CANCEL)

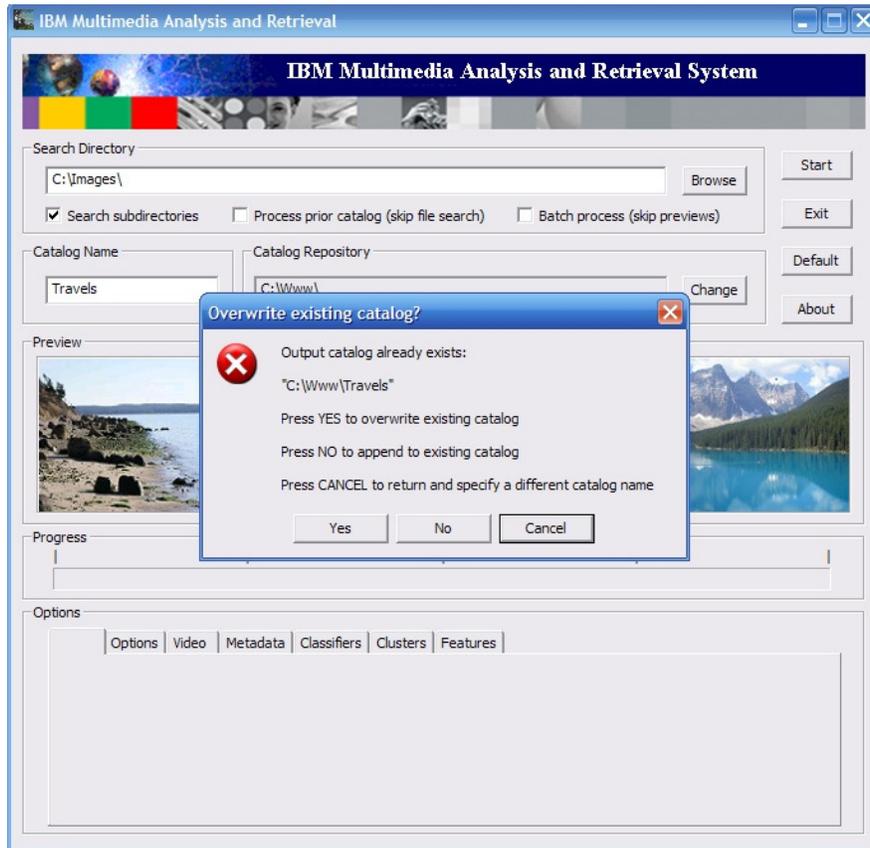


Figure 37 IMARS extraction tool warning allows user to overwrite or append existing catalog directory, or to change the catalog name.

FAQ

1. What is the IBM Multimedia Analysis and Retrieval System?

IBM Multimedia Analysis and Retrieval System (IMARS) is an automated tool for content-based indexing, classification and search for digital image and videos being developed by IBM Research.

2. What are the advantages of visual search over the common, text or tagged based ones?

IMARS enables the user to index, browse and search a collection of videos or images based on their visual content. This capability is much more powerful than the traditional text/tag based ones (which are also offered as part of IMARS and can be combined with the visual content one), since it relies on the actual information contained in an image or video, rather than on something that some people labeled. For example, when looking for images containing an orange, visual cues such as its color provide a means to get far more meaningful results than simply the name of the picture itself, which often carries no information about its content (i.e. PICT_001.jpg)

3. Does IBM Multimedia Analysis and Retrieval System work on videos?

Yes. The IMARS natively supports digital images of most prevalent image. Video formats can be supported using the FFmpeg video decoder. Instructions are provided in this guide.

4. What does IBM Multimedia Analysis and Retrieval System consist of?

IMARS is comprised of the **IMARS extraction tool** and the **IMARS search tool**. The IMARS extraction tool is run against a collection of images and videos, and it generates indices based on computer analysis of the collection and organizes the results for subsequent searching, browsing and navigation using the IMARS search tool.

5. Why is there a limitation on the number of images and videos that the system can process in a single batch?

The trial version of IMARS limits the number of images and videos that can be processed but should be generous enough for most non-commercial testing of the system. The full version of IMARS is limited only by the available disk space.

6. If I check the Search subdirectory box in the IMARS extraction tool, what is the maximum depth of subdirectories that will be visited?

Maximum depth for crawling subdirectories is 12.

7. Why does IBM Multimedia Analysis and Retrieval System work only on the Windows® XP platform?

The IMARS extraction tool of the IBM Multimedia Analysis and Retrieval system has been extensively tested on Windows® XP platform. It will run on any 32-bit Windows® Operating System, but we recommend Windows® XP. However, the IBM Multimedia Analysis and Retrieval System Search Tool can be accessed from any Web browser on any platform (Windows, Apple, Linux®, etc.)

8. Do I need to install a Web server? Why?

Yes. In order to use the IBM Multimedia Analysis and Retrieval System Search Tool, you do need to install the Apache http server, please refer to the “Apache HTTP Server Setup” section of the IMARSGuide for alphaWorks.pdf

9. Can I append another image collection to the one ingested in IBM Multimedia Analysis and Retrieval System?

Not at this time. This release allows you to run IBM Multimedia Analysis and Retrieval System on separate directories only. You can put two different photo collections in the same folder and run IBM Multimedia Analysis and Retrieval System on them (make sure to check the include subfolders option).

10. My instance of the IBM Multimedia Analysis and Retrieval System exits without warning; what should I do?

Please download the latest version of IBM Multimedia Analysis and Retrieval System from IBM alphaWorks website. If you cannot find answers in this guide, please contact us.

11. Why do I need to download and unzip classifiers.zip and/or factory.zip files?

The IMARS extraction tool uses semantic classifiers located in <DIR>/bin/classifiers to evaluate against the user’s multimedia collection. If these files are missing, the user will not be able to explore the full capability of the IBM Multimedia Analysis and Retrieval system which relies on automatic semantic classification.

12. What are the concepts present in the taxonomy, and therefore recognized by IMARS’s classifiers?

Fully-automatic approaches based on statistical modeling of low-level visual content features have been applied for detecting the semantic concepts in our pre-defined taxonomy such as sky, party, etc. Statistical modeling requires large amounts of annotated examples for training. Since this scenario is not applicable to unlabeled content in the user collection, we adopt an approach based on automatic semantic tagging. We re-use our existing semantic models, which were trained on various multimedia content, and automatically associate confidence scores to unseen data with the cross-domain concept models. To enable cross-domain usability, we chose the general semantic models from our taxonomy, preserving consistent definitions of concepts across different multimedia and video domains (albums, blogs, web video)..

Taxonomy structure organizes a set of general semantic category models, where each category corresponds to a node in the hierarchy that is connected to parent and children nodes. Parent-child links can correspond to relationship based on containment, for example, where each child node is a specialized variation of its parent. Our taxonomy structure allows for a different aspect for decomposing or hierarchically relating the categories corresponding to who, where, how description of the visual content, thus organizing category models according to Activity, People, Setting and Type,

13. Can I define my own category for the classifiers?

Currently IMARS classifiers work only on the categories pre-defined in our taxonomy, and does not allow the user to build classifiers for new categories. The user can choose, among the offered ones, the classifier referring to the concept which is most similar to what she is looking for. Furthermore, though tagging, the user can create and define its own clusters of images.

14. I have installed IMARS system with default CATALOGROOT location C:\WWW. Now I want my <http://localhost/imars> to point to a different location. How can I change this?

By default, the CATALOGROOT variable is C:\WWW. Refer to IMARS extraction tool Interface, Manual setup for more information on how to change the CATALOGROOT variable in the IMARS extraction tool setup, and refer to the Apache HTTP Web Server setup to learn how to change CATALOGROOT in the http.conf file to the new value.

15. I played with manual setup in preflast.txt and now the tool does not run correctly. How do I reset the tool to load default variables?

If you ran IMARS.exe, it will save the current state in <DIR>\bin\preflast.txt, and it will use it for subsequent runs. Do the following:

- a) EXIT Imars.exe
- b) Erase <DIR>\bin\prefdlast.txt so that the default options in <DIR>\bin\prefdflt.txt can take effect next time Imars.exe is run.

16. What directory should I install IMARS in?

We recommend a short directory name like c:\imars. The directory tree in which the classifiers are installed under your IMARS directory can be quite deep, and in extreme cases, you may experience errors if you have directory paths which are hundreds of characters long.