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# INTERNATIONAL DATABASE PROJECT FOR SPECTRAL OBSERVATIONS ON ASTEROIDS

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32 bit database application for Windows has been created using a client–server model. Object-oriented design of a multiple-document interface allows us to accumulate spectra in the database and to operate with different kinds of spectral information. All stored spectra are wavelength calibrated and passed through instrumental reductions such as flat-fielding and sky background subtraction. Stream socket interface facilities allows us to exchange by spectral information between different computers on the Internet and to organize a uniform system of international banks of spectral information. The application is developed as a dynamic data exchange server. It also uses Microsoft exchange communication facilities.

Keywords: Database application; Client–server model; Multiple-document interface; Asteroid

## 1   INTRODUCTION

Spectral observations of asteroids contain important information about the chemical–mineral composition of asteroid matter and their origins. Asteroid spectral information acquisition and systematization allow us to resolve some problems such as asteroid classification and definition of the surface composition and structure of asteroids. On the other hand, the problem of spectral data exchange between researchers and observers working in various parts of the world is very real. The modern level of research requires the analysis of a large number of observed and other data. So using a unique information system to exchange, to store portably, to restructure, to visualize and to analyse data by computation methods is preferable.

## 2   DATABASE STRUCTURE

The individual database is located on a hard disk in a subdirectory, called a root database directory. The root directory contains a set of subdirectories each of which stores spectra obtained at the same night. The name of this subdirectory contains the date (year, month, day) on which a selected night was begun. The database root directory also contains a sub-directories list text file and a database system summary binary .IDX file containing statistical

information about all subdirectories and their access types through the net. The names of these two files coincide with the database root directory.

An identifier for each spectrum is a set of symbols that includes time (hours, minutes, seconds) of its recording during observations. Time-independent spectral distributions such as catalogue data can also be stored in the database. Spectra are considered as time independent if hours or minutes or seconds of their identifiers record times left for frames of possible corresponding time values or they are stored in the subdirectory whose month or day contained in its name is left for frames of possible corresponding date values. Every subdirectory contains our observations log text file, a database subdirectory system summary binary .IDX file and a number of spectral data binary .JTV files. A log file contains spectra identifiers and their description (arbitrary commentary inputted by the observer). A subdirectory .IDX file contains spectra identifiers, their access types through the net and their subdirectory indices obtained during indexing. A new structure of the .JTV file was developed to store standard errors of individual intensity values. The .JTV file consists of two parts: general information and individual spectra information. In the new version of the .JTV file the individual spectrum information now includes the array of intensity standard errors. Old and new format .JTV files are distinguished with the first byte of general information.

All text files such as observations logs, worksheet, databases list and dates list contain the particular line that stores the line index at which the cursor must be positioned after opening the corresponding view.

## 2.1  Database List File

A file containing a list of databases of spectral observations is located in the same subdirectory as the database application. Every line in this file contains a pointing database letter identifier and the address of the individual database. The address can contain the path to the file if it is located in the Windows address space or it can contain the IP address of the remote server and letter identifier of the selected database. For example

<div style="text-align:center">

computer     a d:\DB1\R}CrAO asteroids spectral observations2000
              A10.10.10.10cR}SAI asteroids spectral observations2000

</div>

where a and A are letter identifiers of various databases, d:\DB1\ is the path to the local database, 10.10.10.10 c is the remote database path containing the IP address (10.10.10.10) and database letter identifier c and R is the type of access to shared database resources through the computer network. The text beginning from the quotes is the commentary inputted by user.

## 3  DATABASE APPLICATION

A 32 bit database application for Windows is developed to provide access to database of spectra and to perform various kinds of spectral data analysis. The application has a multiple-document interface that is created on the base of C++ Object Oriented Library for Windows. The View–Document model is used to develop the interface. According to this model the Document objects are provided access to database but the View objects are responsible for presenting data on the screen. The Document Manager object forms and controls the multiple-document interface structure (Fig. 1).
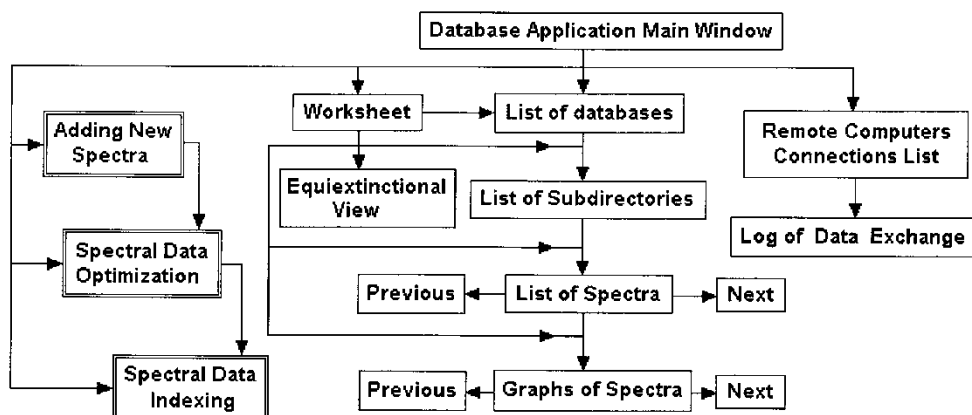
FIGURE 1    Multiple-document interface scheme.

## 3.1    List View Base Class Inheritance

The functionality of each of the elements of the interface, namely Databases List, Subdirectories List, Spectra List, Worksheet, Remote Computers Connections List, Data Exchange Log, is provided with corresponding class inherited from List View (Object Windows Reference Help, 1995) base class.

The Databases List view is developed to assist the user to arrange all references to databases used in the work in a unique list and to provide a user quick access to spectral or other data from a selected database. The list of databases can be sorted with database paths or commentaries or letter identifiers of databases. The user can open the dates list of selected database from the view. It is also possible to delete any line in the view or to add a new database address to the list. The Databases List window allows the user to create new databases and to delete empty databases in the local Windows workspace.

A selected database Subdirectories List allows one to create new subdirectories, to delete empty subdirectories and to sort existing subdirectories by the name or corresponding commentaries. It also opens the Spectra List window of the specified subdirectory and the Databases List window. A selected subdirectory Spectra List allows one to delete selected spectra, to create references to spectra, to write them to the worksheet file, to open the Graph window to draw spectra and to open the Databases List and Subdirectories List windows. While exchanging spectral data through the computer network the main window opens the Remote Computers Connections List window, allowing one to break connections with selected IP addresses on user demand and the Data Exchange Log window showing the list of requested and transferred database resources.

## 3.2    Worksheet

Worksheet is a text file containing references to spectra from various databases. That is helpful while performing an analysis of spectral data placed in various subdirectories or databases. Individual lines in the worksheet can contain commentaries or references to spectral data. The line containing the spectrum reference has the following format:

computeraYYYYMMDD HHMMSS(I) ObjectName Commentary

where the first letter a is a letter identifier of the selected spectral database, YYYYMMDD specifies the name of the selected subdirectory, HHMMSS(I) points out the selected spectrum, and the Commentary is inputted by the user.

### 3.3  WindowView Base Class Inheritance

The Graph and Equiextinctional view windows base their functionality on classes inherited from WindowView (ObjectWindows Reference Help, 1995) base class. The Graph window is developed to show spectral data in the graph form in which wavelengths are along the abscissa axis, and intensities along the ordinate axis. It is possible to draw at once up to 300 spectra in the same Graph window. Two cursors can be used in the Graph window. One cursor is moved from one spectrum to another and is used to activate any spectrum and to select a subgroup of spectra in the window. The other cursor is moved from one point to another in the selected spectrum. The spectra in the Graph window can be displayed in overlay mode or in so-called waterfall mode (one under the other). On user demand, axes with ticks and grids can also be displayed in the Graph window. Spectra can be drawn with various symbols: lines connecting nearby points, crosses, circles, etc. An Equiextinctional view window (Bochkov and Shumko, 2002) is developed to display monotonic extinction variations in time.

### 3.4  Processes: Input, Optimization and Indexing of Spectral Data

Three processes (Bochkov, 2000a) are developed to input spectral data to the database, optimizing placement of the spectra in the database subdirectories and indexing spectra in the subdirectories. The classes realized by these processes are joined to the general heritage scheme which allows one to run an optimization process after inputting new spectral data to the database and after that running the indexing process automatically. Indexing must be run after every execution of inputting or optimizing, but optimization of the spectral data in subdirectory is usually run after inputting a large volume of data or after a significant change in the database content.

### 3.5  Communication Facilities

The user can access the database of spectra by inserting its path in the databases list if one is placed in the Windows workspace. Alternatively the user can perform spectral data exchange using the application in client or server mode of the Windows stream socket communication based on the TCP–IP protocol. In the last case the same application must be installed and run on the destination computer.

The program interface provides a user with facilities for spectral information exchange between two computers included in the network in two modes: browsing mode and dialogue mode.

Using the local computer database application in the client mode and the remote computer database in the server mode user can load those resources of a remote database which are intended at least once for reading. Loaded data can be written to the local hard disk in existing or new databases. Also the user can send and write any resource from a local database to remote computer database while writing access is permitted. Browsing mode is realized without participation of the remote computer operator.

Unlike the browsing mode, the dialogue mode demands the participation of both the local and the remote computers operators. In that mode, operators can send to and receive from each other individual text messages, spectral or other data from their active windows.

Receiving or sending data through the network can also be applied to the selected data in the active window.

The database application is developed as dynamic data exchange server. Spectral data can be obtained from the server by specifying the database identifier, subdirectory and spectrum identifier which is the creation time while observing. Also spectral data from the active window can be requested. The dynamic data exchange server facilities of the program can be used from such programs as for example Origin 5.0 or MatLab.

Transfer operations (cut, copy and paste) for spectra are also available. Spectral data can be copied to the clipboard also in Excel tables form to paste them later, for example in the Origin Worksheet. Using the facilities of Microsoft exchange graphs of spectra and other text information can be sent by Email. The contents of each window can be forwarded from the program to printer.

## 4   FACILITIES TO ANALYSE SPECTRAL INFORMATION

A special interface to perform algebraic operations (Bochkov, 2000b) (addition, subtraction, multiplication, division and involution) with one-dimensional arrays (first operand) and a constant value (second operand) was developed for various kinds of analysis of spectral data. Selected operations can be applied to wavelengths and intensities. The air mass value of the spectrum can be used as the second operand.

Some algebraic operations such as addition, subtraction, multiplication and division can be performed with two spectrum operands. Before the operation both selected spectra are adjusted to the same wavelength array by means of linear interpolation. One operand must be placed in the Graph window, but another must be specified in a special dialogue box called the Algebraic Operations Tool Box and containing references to database spectra. Only one spectrum can be selected in the Tool Box. If the Graph window contains more than one spectrum, then selected algebraic operation will be repeated for each pair of spectra formed in the stated above manner. The active spectrum of a Graph window can be specified in the Tool Box as the second operand. The Tool Box allows one to specify the operand type (minuend, subtrahend, dividend or divisor) of a selected spectrum for such algebraic operations as subtraction and division not having commutative properties. Before an operation the spectrum selected in the Tool Box can be raised to a certain degree. The degree can be set equal to a user inputted value or to the air mass of the Graph window spectrum or to the air mass of the Tool Box selected spectrum. That can be useful when comparing various observations or obtaining special spectral distributions from observations.

Each algebraic operation set of parameters such as type of operation, degree, or reference to selected spectrum can be memorized in a special window of the Tool Box. The sets of macro commands (so-called macros) can be automatically applied for any group of spectra specified by the user. Macros can be saved to the file.

Such algebraic operation settings can be created and written to the commentary of individual spectra references of the Worksheet. It allows one to load immediately to the Graph window the spectral distribution being the result of combinations of various operations.

Using a number of developed functions (program procedures) to realize known calculation methods we have created facilities of the algebraic operations interface application package. The method of dispersion analysis of group of spectra calculates the intensity standard errors for selected wavelength values. That allows one to find the spectral range containing considerable intensity variations. Methods of differential and absolute spectrophotometry allow one to obtain extra atmospheric spectral distribution. Smoothing and polynomial interpolation of spectral data methods are also available from the database application.

Convolution and deconvolution operations (Bochkov and Shumko, 2002) based on the fast Fourier transformations can be applied to spectral data with a user-defined point spread function.

A system of N equations of type of $\Theta_i = C\theta_i^{X_i}$ having $N+1$ unknown parameters ($C$, $\theta_i$) can be solved by means of approximation method when the mean value $\bar{\Theta} = \sum \theta_i$ is known, $C$ is a constant and $X_i$ is a set of known parameters (Bochkov and Shumko, 2002).

## 5 CONCLUSIONS

The new international database project of the spectra of asteroids being considered is sufficiently simplified, but it can store, systematize and analyse observed spectral data by means of computational methods and provides facilities for their exchange between researchers. The database can be useful for storing any additional information (e.g. obtained under laboratory measurements) and used in investigations of the physical properties of asteroids. Personal computers of different investigators may be used to accommodate the databases of spectra while their volume remains relatively small. It may be useful for researchers investigating the physical characteristics of asteroids by spectral methods but, as the number of spectral data increases, the exchange volume of spectral information should be centralized. Using more powerful computers will be needed to service the increasing number of a client's requests.

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