Manipulator Reference Manual

Team ISE
Image Selective Encryption

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Introduction

The ISE JPEG Manipulator is an application designed to allow the user to examine, manipulate and create images from the data of pre-existing JPEG images. Team ISE, at the University of Colorado at Boulder, developed this software in conjunction with a research on the topic of JPEG Image Selective Encryption. The Manipulator was employed by the team to evaluate data from different JPEG images and provide support in testing different encryption schemes.

The purpose of this manual is to inform the user about the functionality of the JPEG Manipulator. Throughout the course of this manual, there will be a lot of terminology related to JPEG images. Unfortunately, this manual does not explain in-depth the about how JPEG compression formats work and assumes that the user has some prior knowledge of these concepts. If you do not have any previous experience with these types of compression formats, Team ISE recommends reviewing some of the reference material included at the end of this manual.

This software is provided by Team ISE and the University of Colorado AS IS and although it is believed to be in good working order, said members provide no guarantees and/or warranties about the Usage, Quality, Stability and/or Correctness of this software. Neither Team ISE nor the University of Colorado shall be held liable for any damages what-so-ever, arising out of or related to the use of or the inability to use the ISE JPEG Manipulator software. Anyone installing, using, or having previously installed or used the JPEG Manipulator agrees to all of these conditions. Any user should properly back-up all data before using it in conjunction with the ISE JPEG Manipulator software.

Chapter 1: Getting Started

Before the user can begin using the JPEG Manipulator, there are a number of tasks that must be accomplished. This section of the user manual is to explain the system requirements, provide installation instructions and opening the application. Please read over the following information for a description of these details.

1.1 ISE Manipulator Minimum System Requirements:

The Manipulator has several system requirements needed as a minimum to properly install and run the Manipulator. These requirements are as follows:

1. Microsoft Windows NT/2000/XP Operating System.
2. Microsoft .NET framework version 1.1.
3. A monitor, mouse and keyboard for the host computer.
4. 100 MB of free Hard Disk space.
5. 300 MHz or faster CPU.
6. 64 MB of RAM.

1.2 ISE Manipulator Recommended System Requirements:

In addition to the minimum system requirements needed for the ISE Manipulator, Team ISE also recommends several minimum system requirements, to ensure performance. These requirements are as follows:

1. 1 GHz or faster CPU.
2. 256 MB of RAM.

1.3 Installing the ISE JPEG Manipulator:

The Manipulator comes prepackaged with a full installation script that performs all necessary functions to properly install the Manipulator with a minimal degree of user effort. If a previous version of the Manipulator was installed prior to this installation, be sure to completely remove the previous version before preceding with this installation, otherwise this installation will not complete properly. Uninstalling the Manipulator is covered under section 1.4 of this manual.

If your system meets all minimum system requirements and there is no previous version of the Manipulator installed, you are now ready to begin the installation process. To install the ISE JPEG Manipulator, complete the following steps:

1. If the ISE Manipulator has not been previously downloaded, be sure to download it to the computer where it is to be installed to. Be sure to save it some place that can be easily remembered, like your "Desktop."

2. Once the file has completed downloading, double-click on the file to begin the installation process.

3. Follow through on-screen installation instructions of the installer to successfully complete the installation (see figure 1.3.1). Team ISE recommends using all of the default settings for installation.
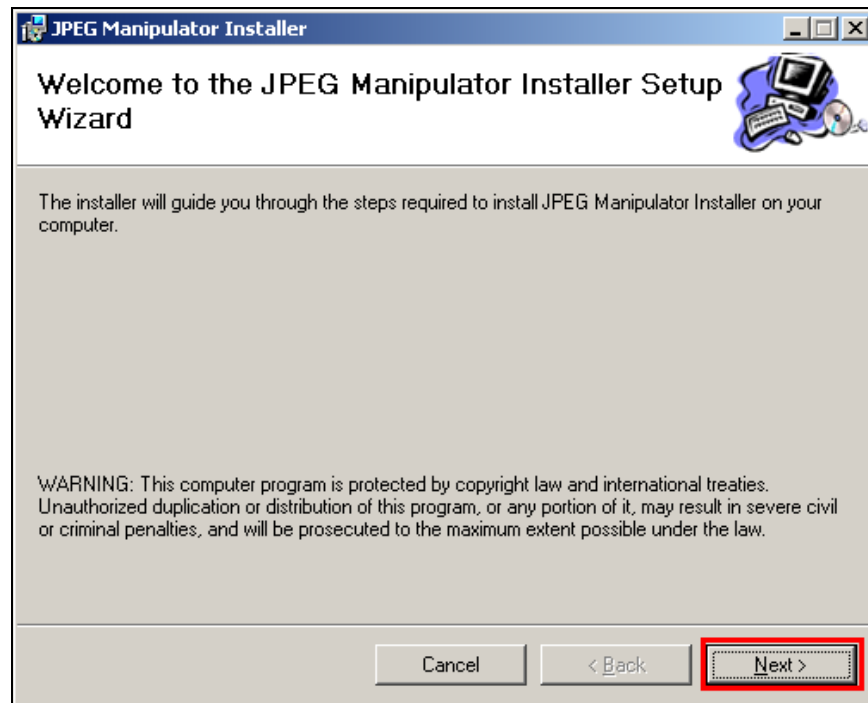

Figure 1.3.1 – JPEG Manipulator Installer Start Screen

1.4 Uninstalling the ISE JPEG Manipulator:
The Manipulator installation package also includes an uninstall script to remove all of the application files, if the need arises. The uninstaller will remove all data copied and created during the installation process. Please note that images created by the user or any original JPEG pictures used will not be removed, unless they are saved within the ISE program folder (the folder created in the programs files during installation). To perform the uninstall process, complete the following steps:

1. Go to Start >> Settings >> Control Panel

2. Once you click on the "Control Panel," you should see the contents of the Control Panel folder. Double-click on the "Add/Remove Programs" icon (See figure 1.4.1).

3. Within the Add/Remove Programs utility, find the "JPEG Manipulator" entry and click on it to highlight it in blue and then click on the "Remove" button next to it.

4. Follow through the on-screen instructions to successfully complete removal of the application.

Please note that you must uninstall any previous versions of the ISE JPEG Manipulator before installing any updated versions.
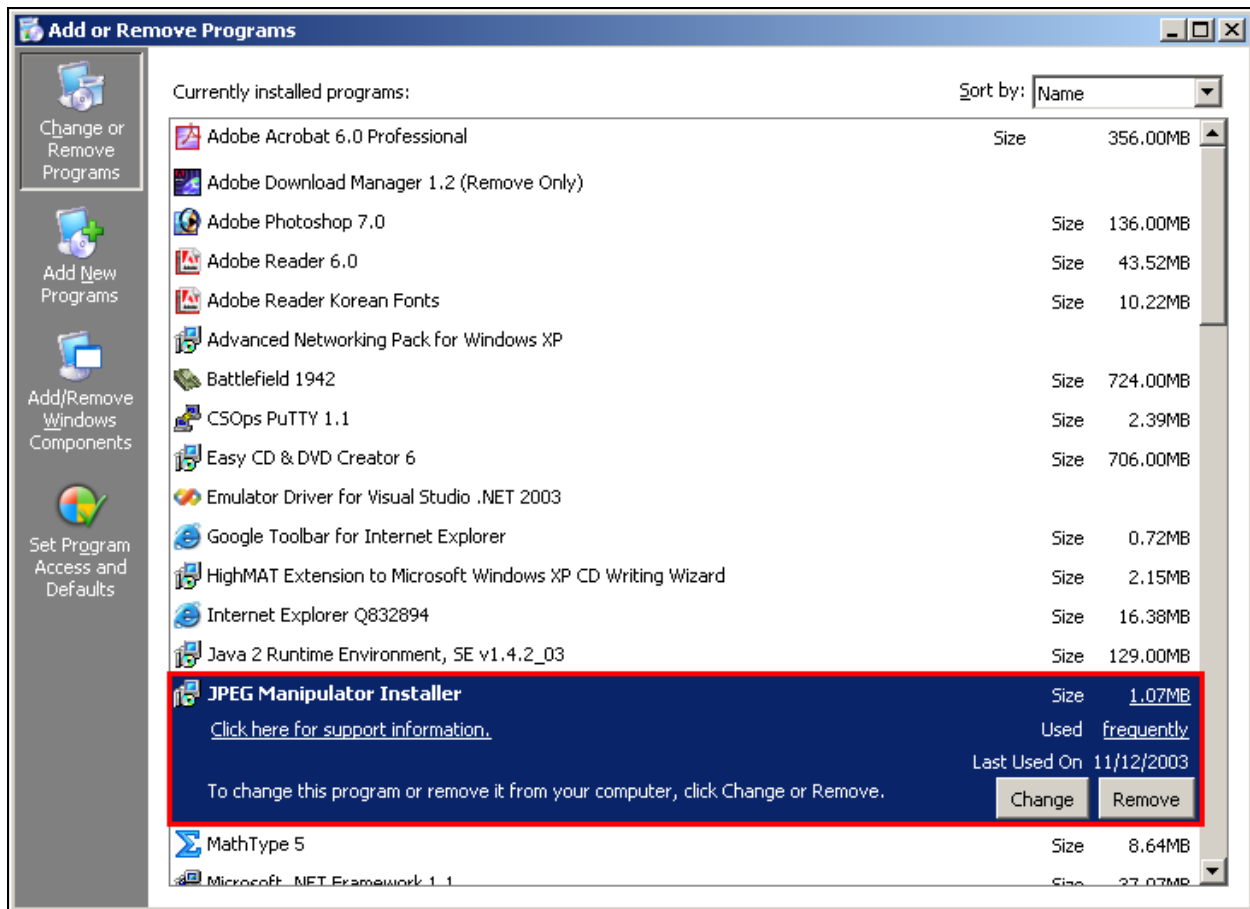
Figure 1.4.1 – Add/Remove Program Example

1.5 Running the ISE JPEG Manipulator Application:
Once the Manipulator has successfully completed installation, you should be able to instantiate the application without further delay. If the default installation was chosen, then the program can be invoked by going to:

    Start Button >> Programs >> ISE >> JPEG >> JPEG Manipulator

Otherwise, if a different location for the program menu has been chosen, then go to the folder where the program was installed and then go to:

    ISE >> JPEG >> JPEG Manipulator

Once the JPEG Manipulator icon has been clicked, the program will begin execution.

Chapter 2: JPEG Manipulator Functionality

Once you've successfully installed the ISE JPEG Manipulator application, you can begin to work with different types of JPEG images. Although the application is designed to work specifically with the Baseline compression standard for JPEG images, the application should work with other JPEG formats as well. This section of the manual is devoted to describing the interface and functionality of the JPEG Manipulator.

2.1 Understanding How Data is Represented in the Application:

Understanding the way JPEG image data is represented in the application is extremely important to use this as an effective tool. When the Manipulator loads a JPEG image, the data is broken down into each of the frames of data and then distributes to its corresponding text box on the interface. When each text box is loaded, the byte data is converted to its hexadecimal value in ASCII characters. For example, if a byte has the value of: 1111 1111 binary (0xff in Hexadecimal), then in the interface, the data will be displayed as "ff." If we look at an actual example of a Huffman table (shown in figure 2.1.1), we see that the data is loaded as 2 characters followed by a space for each byte of data in the table.
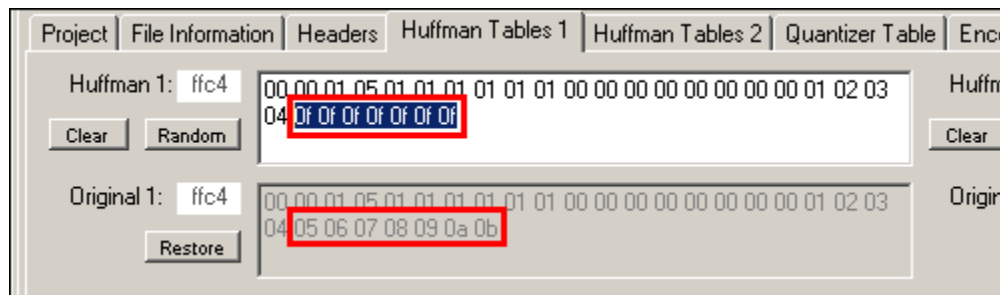

Figure 2.1.1 – Example Data in the Manipulator

As you can see by the picture above, there has been a change to 7 bytes of data in this particular Huffman table. Note that when we make a change to the data, we must represent it as a character of '0' to '9' or 'a' to 'f' for the Manipulator to properly interpret the data we have changed. Now that it has been said that data is represented in this way, we should mention that this is true for MOST of the text boxes, but not all. Certain text boxes, like the File Comments text box, outputs the data as its byte value, which allows the user to see what the data actually says, not just the byte data itself. In the following sections, each of the different text fields will be defined as to which way data is represented. In most cases, the text fields will contain the byte data converted to the ASCII representation of its value.

2.2 The Manipulator's Main Window:

Upon invoking the JPEG Manipulator application, the main window will be displayed for the user to see. The main window is also known as the Console tab (which is described in depth in section 2.6) and will provide the user access to almost every function of the Manipulator. The main window is designed to look and feel like a standard, Windows-style application. Notice that there is a main menu, tab controls to switch between the different components of the interface and closing and sizing controls for the window itself.

2.3 The Main Menu of the Manipulator:

The JPEG manipulator contains a Windows-style application menu bar for performing common tasks within the Manipulator. This main menu consists of four sub-menus: File, Edit, View and Help sub-menus. Each of these sub-menus is defined in this section of the manual.

2.3.1 The File Menu:

The File menu is the leftmost menu on the main window of the JPEG Manipulator application. This menu provides the user with options to Load a Picture, Update a Picture, Create a New Project, Save a Project, Load a Project and Exit the application. Please note that all of these functions (except exiting the application) can be preformed on the Project sub-tab by using the buttons available. In addition, the application can also be exited at any time by clicking on the "X" button on the top right of the main window of the application. Figure 2.3.1 shows an example of the File menu and the following is a description of each of the File menu options:

1. **Load Picture** - Allows the user to Load a new JPEG image into the manipulator as an original image for editing. If there is an existing picture previously open, the user will be warned before the Load Picture action is taken.
2. **Update Picture** - Allows the user to create a new manipulated image, based upon the current data in the Manipulator data fields.
3. **New Project** - Clears out the current project data and picture data in the Manipulator.
4. **Open Project** - Allows the user to open an existing project. If a project is already open, then the user will be warned before the Open Project action is taken.
5. **Save Project** - Allows the user to save all of the data currently loaded in the Manipulator in an SEP project file for future use.
6. **Exit** - Allows the User to close the JPEG Manipulator at any time.
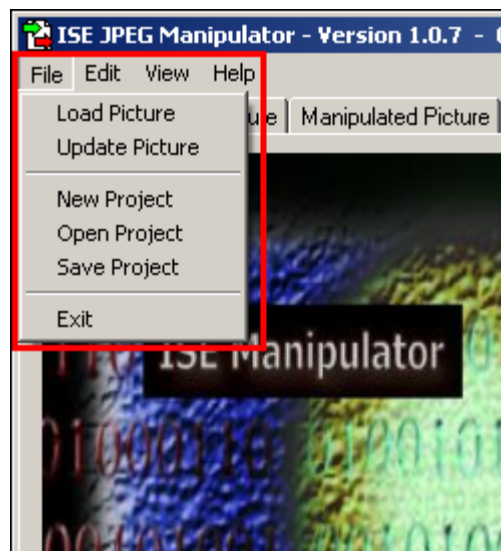

Figure 2.3.1 – The File Menu

2.3.2 The Edit Menu:

The Edit menu is the second from the leftmost menu on the main window of the JPEG Manipulator application. This menu provides the user with options to Copy, Cut and Paste data to and from the system clipboard. Please note that all of these functions can be preformed by keying in the combinations: 'ctrl+c', 'ctrl+x' or 'ctrl+v' respectively. Figure 2.3.2 shows an example of the Edit menu and the following is a description of each of the Edit menu options:

1. **Copy** - Copies the currently highlighted text to the system clipboard.
2. **Cut** - Cut the currently highlighted text and copies it to the system clipboard.
3. **Paste** - Pastes any text currently on the system clipboard into the field currently indicated by the text cursor.
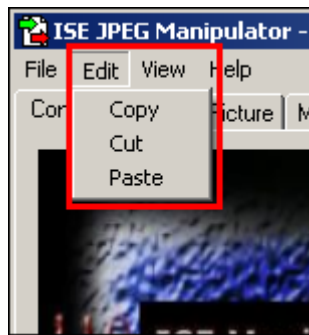

Figure 2.3.2 – The Edit Menu

2.3.3 The View Menu:

The View menu is the second from the rightmost menu on the main window of the JPEG Manipulator application. Under the View menu is the Stretch Mode sub-menu. This sub-menu provides the user with options to toggle each of the picture box controls between normal and stretch mode. Figure 2.3.3 shows an example of the View menu and Stretch Mode sub-menu and the following is a description of each of the options:

1. **Large Original** - Toggles the stretch mode for the picture box on the Original Picture tab.
2. **Large Manipulated** - Toggles the stretch mode for the picture box on the Manipulated Picture tab.
3. **Small Original** - Toggles the stretch mode for the Original picture box on the Console tab.
4. **Small Manipulated** - Toggles the stretch mode for the Manipulated picture box on the Console tab.
5. **All Pictures** - Toggles the stretch mode for each of the picture box controls in the Manipulator application.
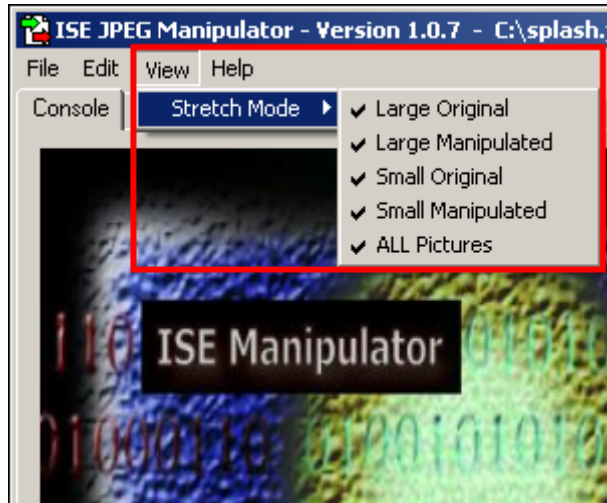
Figure 2.3.3 – The View Menu

2.3.4 The Help Menu:

The Help menu is the rightmost menu on the main window of the JPEG Manipulator application. This menu provides the user with options to view the Manipulator Tutorial, Manipulator User Manual (this document) and the About window. Figure 2.3.4 shows an example of the Help menu and the following is a description of each of the Help menu options:

1. **Tutorial** - Opens a new window containing the Manipulator's user tutorial document.
2. **Manual** - Opens a new window containing the Manipulator's user manual document (i.e. this document).
3. **About** - Opens a new window containing the Manipulator's about window to display the application and project information.

Figure 2.3.4 – The Help Menu

2.4 The Original Picture Tab:

The Original Picture tab allows the user to see, in a large window, the JPEG image that is currently loaded in the Manipulator. Also, this picture can be viewed in its actual size, or stretched to fit the exact size of the picture box control on this tab, by making changes in the

View menu settings (as described in section 2.3). An example image is shown in figure 2.4.1 (shown in stretch mode):

Figure 2.4.1 – The Original Picture Tab

2.5 The Manipulated Picture Tab:
The Manipulated Picture tab allows the user to see, in a large window, the altered JPEG image that is currently loaded in the Manipulator. Also, this picture can be viewed in its actual size, or stretched to fit the exact size of the picture box control on this tab, by making changes in the View menu settings (as described in section 2.3). An example image is shown in figure 2.4.1 (shown in stretch mode):
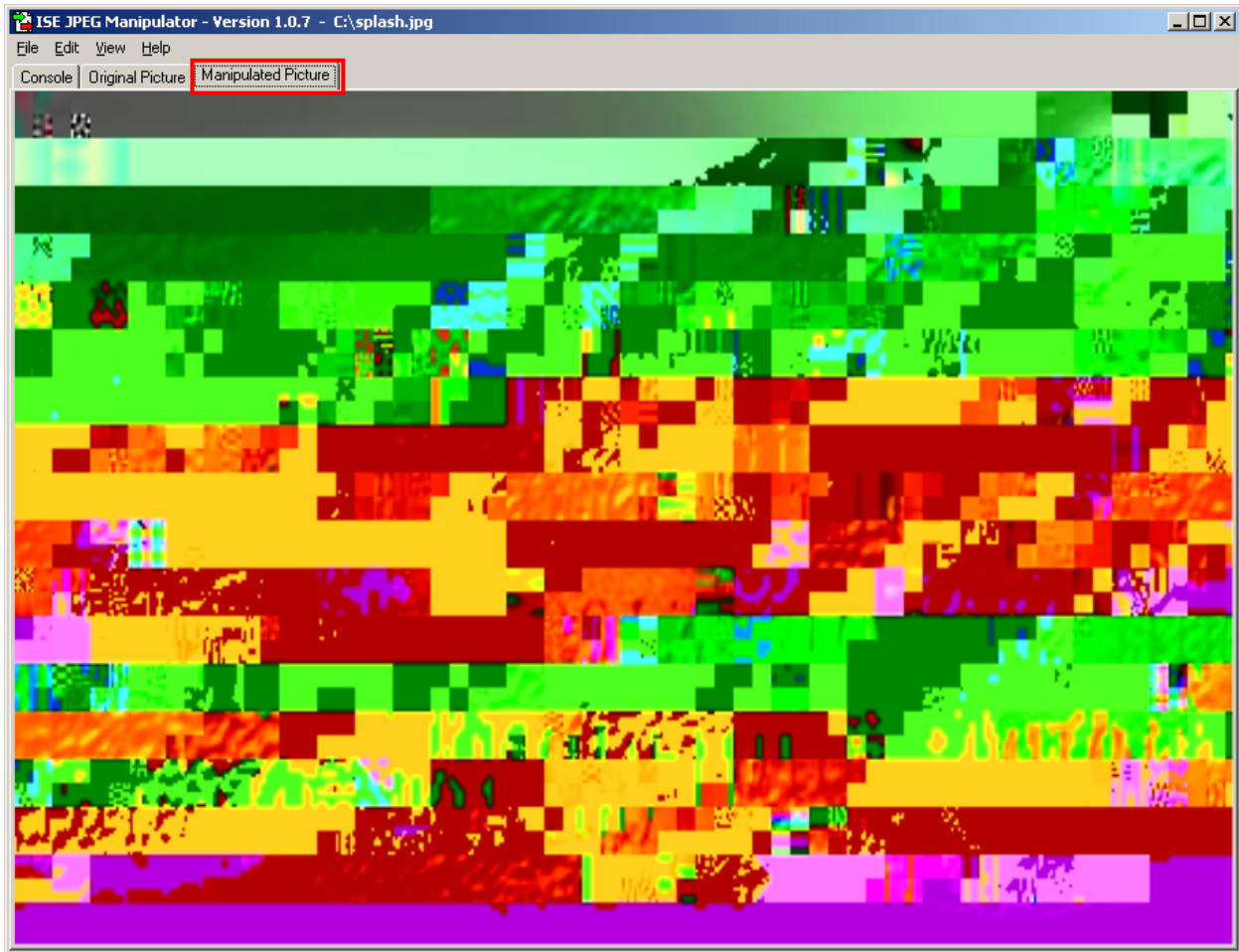
Figure 2.5.1 – The Manipulated Picture Tab

2.6 The Console Tab:

The Console tab is the real heart of the JPEG Manipulator. From the Console tab, the user can load images and projects, manipulate the data of images, create new images and save project data. The Console tab provides two smaller picture boxes for viewing the original and manipulated images, which can also be stretched by adjusting the settings on the View menu. The Console tab also has a series of sub-tabs that contain a number of text fields that store all of the image and project data. An example of the Console tab is shown in the figure 2.6.1 (note that the small original and manipulated pictures are in stretch view mode).
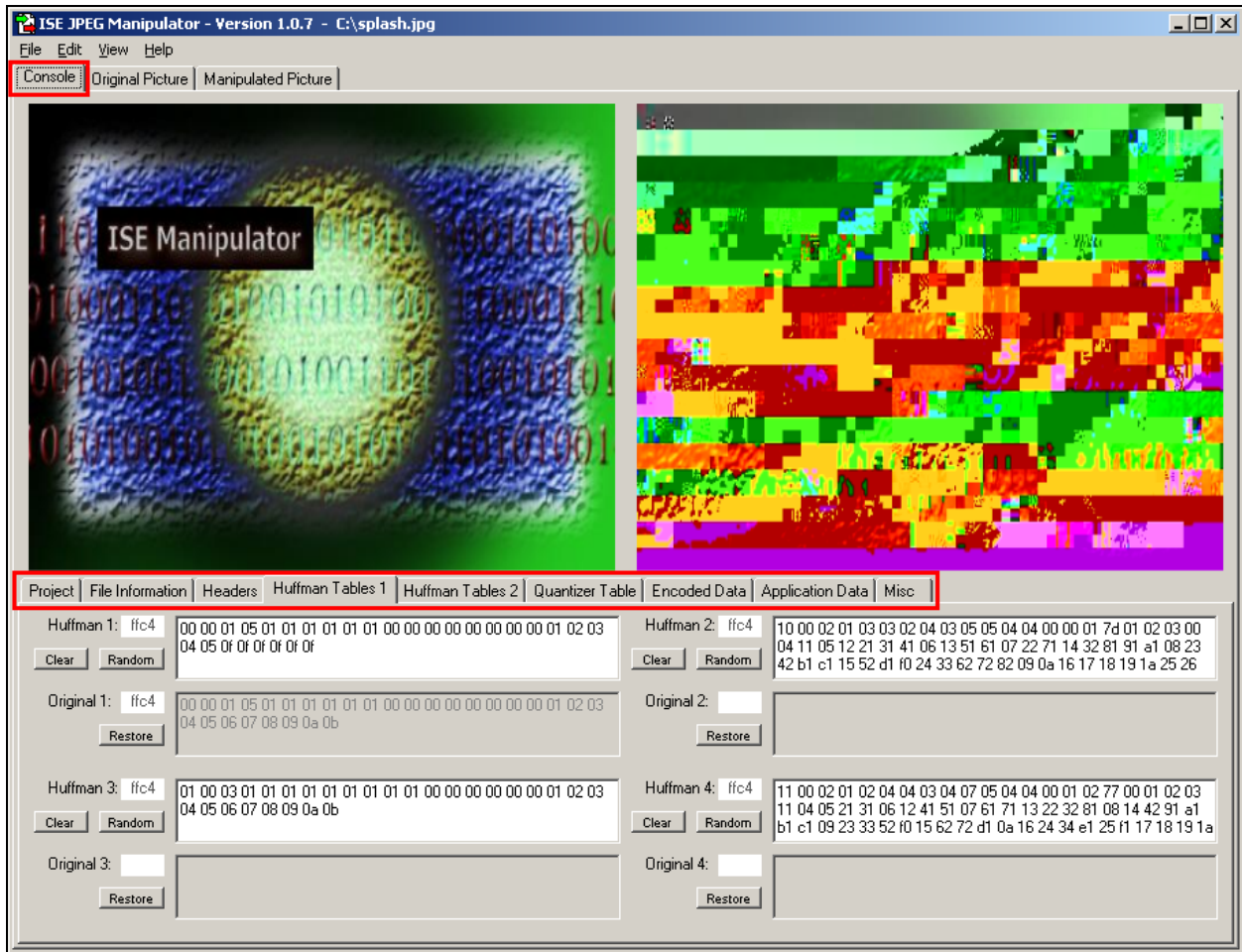
Figure 2.6.1 – The Console Tab

2.7 The Console Tab JPEG Data Sub-Tabs:
As shown in the picture above, the Console tab has a number of sub-tabs that contain all of the data loaded from the JPEG image and any project information. From these data sub-tabs, it is possible to change any of the data within the JPEG image. Each of these tabs are described in detail in this section of the manual. As stated in section 2.1, the data is represented a few different ways, depending on the type of image data that it happens to be. The following subsections will specify how the data for each of the data fields in the Manipulator is handled the data and how it will be treated when a manipulated image is encoded.

2.7.1 The Project Sub-Tab:
The Project sub-tab allows the user to view the path and file name of the current project loaded (if any) and any project notes. Notice that the Project file name and the Project notes each have their own text fields. In addition, you can see six buttons here, which perform some of the functionality that can be found on the main menu (as described in section 2.3). Figure 2.7.1 is an example of what Project sub-tab looks like:
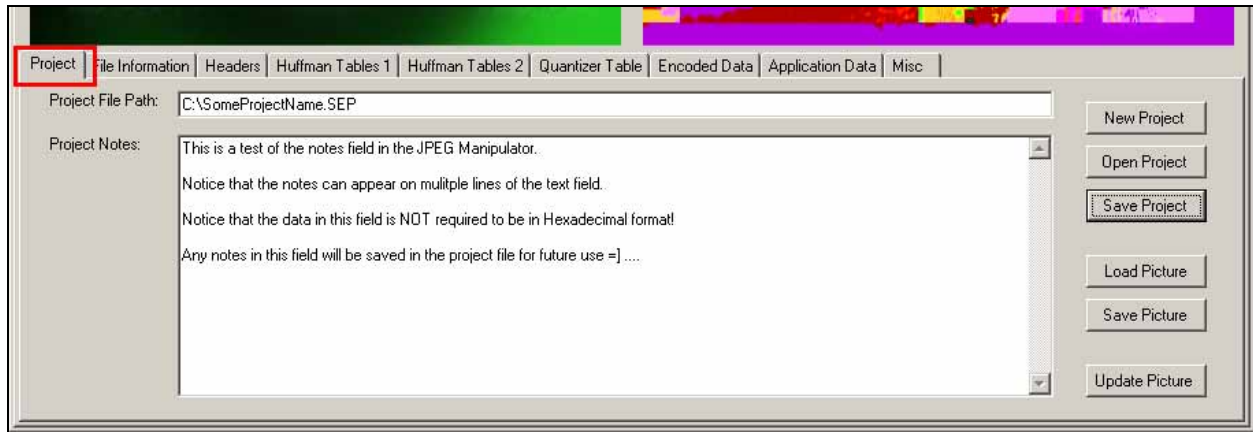
Figure 2.7.1 – The Project Sub-Tab

Notice that data stored in both of these fields can have any ASCII value and are not required to be entered as the hexadecimal characters as explained in section 3.1 of this document. Each of the six buttons found on this sub-tab performs the each of the respective functions:

1. **New Project** - Clears out the current project data and picture data in the Manipulator.
2. **Open Project** - Allows the user to open an existing project. If a project is already open, then the user will be warned before the Open Project action is taken.
3. **Save Project** - Allows the user to save all of the data currently loaded in the Manipulator in an SEP project file for future use.
4. **Load Picture** - Allows the user to Load a new JPEG image into the manipulator as an original image for editing. If there is an existing image previously open, the user will be warned before the Load Picture action is taken.
5. **Save Picture** - Allows the user to save the currently manipulated picture for future use.
6. **Update Picture** - Allows the user to create a new manipulated picture, based upon the current data in the manipulator data fields.

2.7.2 The File Information Sub-Tab:
The File Information sub-tab contains the file names of both the original image and the manipulated image, the size of the original file and the file comments in the original file. The data contained in these fields can be any ASCII character and is not limited to Hexadecimal format, as outlined in section 3.1 of this document. Also, any changed made to the data in the file comments will not be applied when the Manipulated image is generated. Figure 2.7.2 is an example of the File Information sub-tab:

Figure 2.7.2 – The File Information Sub-Tab

2.7.3 The Header Data Sub-Tab:

If the current image loaded is indeed a Baseline standard compression format, then the compression table header data will be broken up and loaded into the fields on the Header sub-tab. The information displayed here will be the SOF0 frame data (which should always be the ffc0 marker), the size of the data contained in the frame, the precision data, height and width data, the number of components and finally the component definitions. If the image loaded is not the Baseline standard compression format, then the Headers tab shouldn't contain any of the JPEG image data.

In addition, it is important to understand that the data on the Header sub-tab is represented as its Hexadecimal value. This type of representation is outlined in section 3.1 of this document and any changes made to these fields should be made in the same way, as the hexadecimal format of the values you wish to change the data to. For example, the Marker field here should say "ff c0" which means that the binary value of these two bytes in the file is: "1111 1111 0110 0000." Also, any changes in the size of the data in this frame does not need to be made by the user manually as the Manipulator will calculate the new size of the frame (and number of components) when generating the manipulated image. The picture below is an example of the Header data sub-tab:
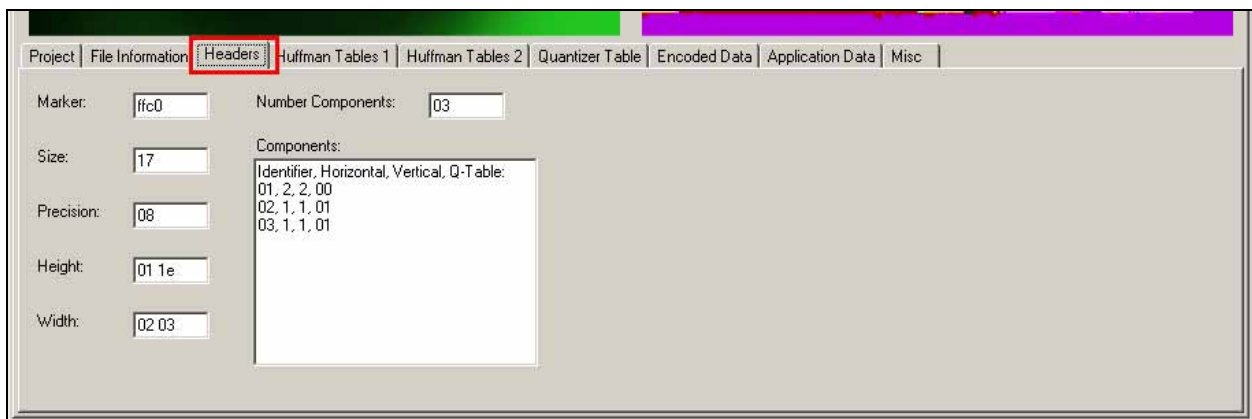

Figure 2.7.3 – The Headers Sub-Tab

2.7.4 The Huffman Table Sub-Tabs:

As mentioned previously, the Manipulator was designed specifically for use with the Baseline standard JPEG compression format. This format uses the Huffman compression algorithm to create the entropy encoded data stream for the JPEG image. Thus, these compression tables can be found on the two Huffman Table sub-tabs. However, even if the image doesn't use the baseline compression, any compression data encountered in the JPEG file will be stored on this sub-tab.

The Huffman Table sub-tabs contain a number of text fields and buttons for the user to interact with the image data. Each tab contains data fields for four tables, original and manipulated compression table data, the compression table maker data, and a series of buttons for manipulating the tables. When a compression frame is loaded in the manipulator, the marker is loaded in the marker field, and then the rest of the frame's data, except for the size information, is loaded into the corresponding Huffman table field. The data is loaded in Hexadecimal format and any changes made to this data should be as hexadecimal ASCII characters that represent the values of each of the bytes of the data. Section 3.1 describes in-depth how this data is represented. Also, the size of the marker is purposefully removed from this table so that if the user changes the size of the table, then the new size data will be recalculated when the new image is generated. Notice that once the user tries to manipulate the values of one of the tables, the original data is stored in the corresponding, grayed out field just below it. There are three buttons corresponding to each of these tables:

1. **Clear** - this button clears out all of the data in the corresponding table field.
2. **Random** - this button adds a random byte of data onto the end of the field.
3. **Restore** - this button restores the original data from the image to the corresponding compression table.

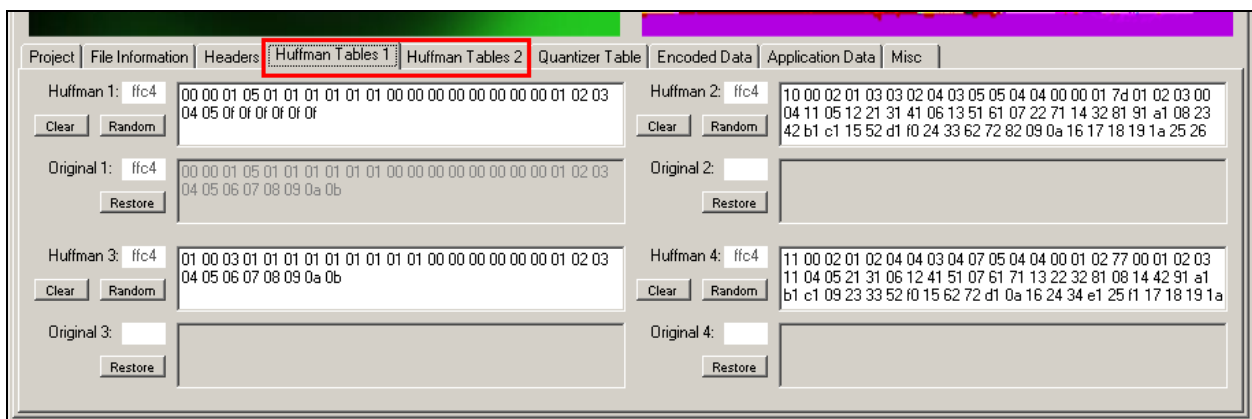Figure 2.7.4 is an example of the Huffman Table 1 data sub-tab:

Figure 2.7.4 – The Huffman Tables Sub-Tabs

2.7.5 The Quantizer Table Sub-Tab:

The Quantizer table sub-tab contains all of the data for the DQT frames (i.e. the Quantizer tables) contained in the JPEG image. As defined by the JPEG standard, each of these tables should be exactly 64 bytes long for all Baseline compression images. Each of the Quantizer's marker data, table data and table number is displayed here. In addition, there are several buttons to interact with the data.

When the Quantizer frame is loaded in the manipulator, the marker is loaded in the marker field, and then the rest of the frame's data, except for the size information and the table information (i.e. all of the DTC coefficients) are loaded into the corresponding Quantizer table field. The data is loaded in Hexadecimal format and any changes made to this data should be as hexadecimal ASCII characters that represent the values of each of the bytes of the data. Section 3.1 describes in-depth how this data is represented. Also, the size of the frame is purposefully removed from this table so that if the user changes the size of the table (even though the Baseline standard dictates that these tables have exactly 64 coefficients), then the new size data will be recalculated when the new image is generated. Notice that once the user tries to manipulate the values of one of the tables, the original data is stored in the corresponding, grayed out field just below it. The three buttons corresponding to each of these tables has the following function:

1. **Clear** - this button clears out all of the data in the corresponding table field.
2. **Random** - this button adds a random byte of data onto the end of the field.
3. **Restore** - this button restores the original data from the image to the corresponding Quantizer table.

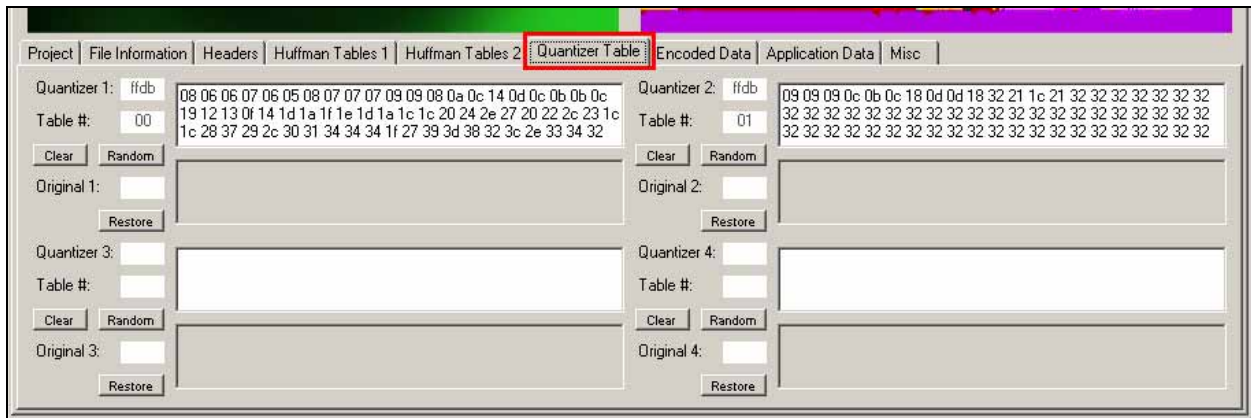The picture below is an example of the Quantizer Table sub-tab:

Figure 2.7.5 – The Quantizer Table Sub-Tab

2.7.6 The Encoded Data Sub-Tab:

The Encoded Data sub-tab contains all of the SOS frame data (i.e. Scan Header data), as well as up to the first 20 KB of the entropy encoded data stream. Although there are fields for the original data, any changes made to the data on this sub-tab will not be applied to the Manipulated picture as this functionality will have to be left for a future

software enhancements.   Therefore, any changes made on the text fields will not be accounted for.

When the Scan Header frame and the Entropy Encoded data is loaded in the manipulator, everything except the frame marker is stored on Encoded Data sub-tab. The data is loaded in Hexadecimal format, although any changes made to this data will not be accounted for. Section 3.1 describes in-depth how this data is represented. Also, keep in mind that only the first 20 KB of the Encoded Data is shown in the encoded data field. Figure 2.7.6 is an example of Encoded Data sub-tab:
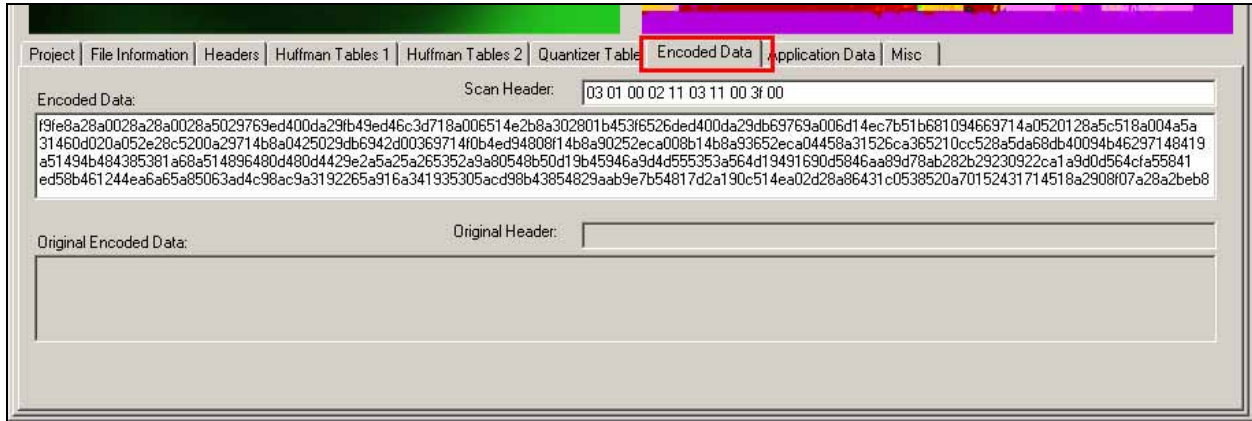

Figure 2.7.6 – The Encoded Data Sub-Tab

2.7.7 The Application Data Sub-Tab:
The Application Data sub-tab contains all of the data found in APP frames (i.e. Application Data frames) of the JPEG image. Although there are up to sixteen application frames allowed in the Baseline compression standard, there are only ten spaces available on the Application data tab. Since application data isn't critical to the representation of the particular image, the decision was made to only include up to ten frames in the Manipulator (in all the random samples collected during the development of the Manipulator, none contained more than ten, in fact all of the images contained much less).

When the Application Data frame is loaded in the manipulator, the marker is loaded in the Marker field, and then the rest of the frame's data, except for the size information is loaded into the corresponding text field. The data is loaded in Hexadecimal format and any changes made to this data should be as hexadecimal ASCII characters that represent each of the bytes of the data. Section 3.1 describes in-depth how this data is represented. The size of the frame is purposefully removed from this table so that if the user changes the size of the table, then the new size data will be recalculated automatically when the new image is generated. Figure 2.7.7 is an example of the Application Data sub-tab:
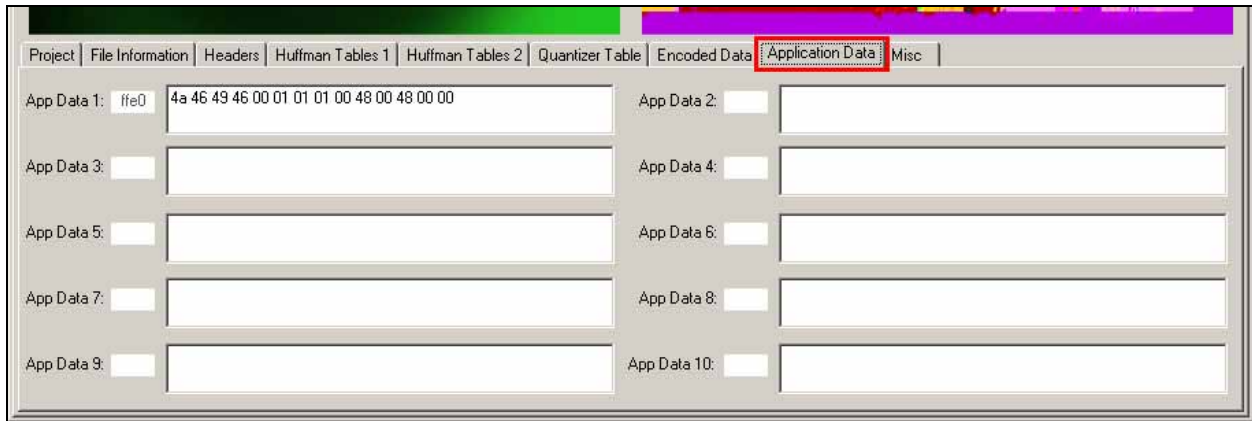
Figure 2.7.7 – The Application Data Sub-Tab

2.7.8 The Misc Data Sub-Tab:

The Misc sub-tab contains the data of the rest of the possible frames allowed within a JPEG image. Much of this data is not allowed for the Baseline compression standard, but to make sure that the Manipulator would be compliant for all standards currently defined, these data fields were included. The Misc sub-tab contain data fields for the marker data and frame data for the restart interval frame, marker data and frame data for the number of lines frame, marker data and frame data for the expand image frame, marker data and frame data for any hierarchical progression frame, data for the Restart Mod 8 frame and a field for any program errors generated by the Manipulator during execution.

When the frames on the Misc sub-tab are loaded in the Manipulator, the marker is loaded in the marker field (except for the Restart Mod 8 field), and then the rest of the frame's data, except for the size information is loaded into the corresponding text field. The data is loaded in Hexadecimal format and any changes made to this data should be as hexadecimal ASCII characters that represent the values of each of the bytes of the data. Section 3.1 describes in-depth how this data is represented. The size of the frame is purposefully removed from these tables so that if the user changes the size of the table, then the new size data will be recalculated automatically when the new image is generated. The picture below is an example of the Misc Data sub-tab:
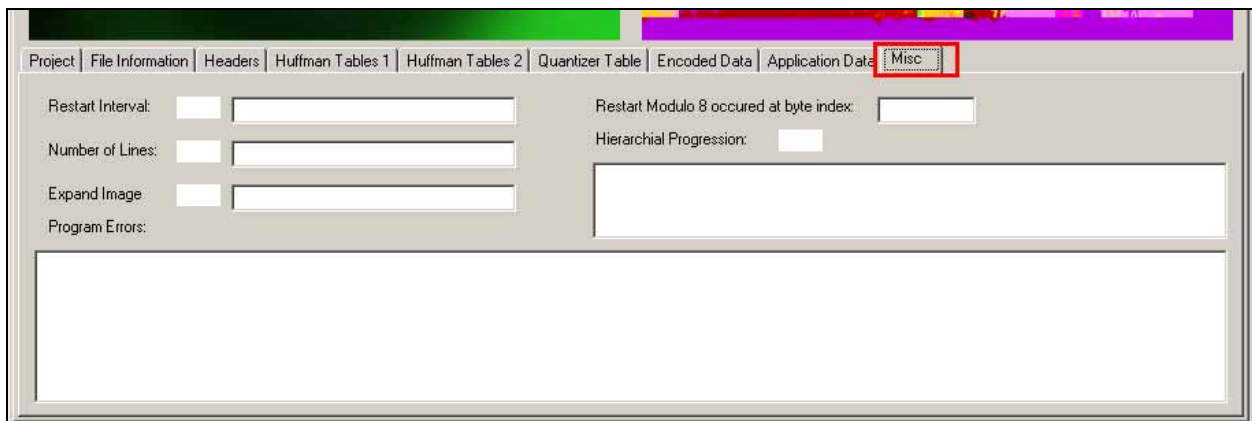

Figure 2.7.8 – The Misc Sub-Tab

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Chapter 3: References and Related Readings

There were a number of documents and research papers used by Team ISE in completing this piece of software and this entire project. This section of the document is devoted to giving credit to all of those extremely helpful references. Team ISE recommends looking over the following data if you are unfamiliar with the JPEG file formats or the concept of Selective Encryption.

Chang, H. and Li, X. On the Application of Image Decomposition to Image Compression and Encryption. Research Paper. 1996.

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