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The Enhanced Producibility Basic Skills Trainer displays a terrain scene to the gunner in either visible or infrared spectrum, to simulate the operation of the weapon system. One task in the construction of these terrains is the stitching together of a series of infrared images, so that the resulting larger infrared image covers and lines up with a corresponding visible spectrum photograph. A software program called Overlay has been developed to help perform this task, and is the focus of this report.

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EPBST Imagery Generation Software

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Final Report

F/DOD/ARMY/AMCOM/EPBST Imagery Generation Software
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1. Introduction

A Javelin trainer called the EPBST (Enhanced Producibility Basic Skills Trainer) displays a terrain scene to the gunner in either visible or infrared spectrum, to simulate the operation of the Javelin weapon system. One task in the construction of these terrains is the stitching together of a series of infrared images, so that the resulting larger infrared image covers and lines up with a corresponding visible spectrum photograph. A software program called **Overlay** has been developed to help perform this task, and is the focus of this report.

2. Input Data and Layer Structure

The input data to Overlay is a single visible spectrum image together with a series of up to 255 infrared images. The visible spectrum image is stored as an RGB, 24-bits-per-pixel image in one of three standard image formats: JPG, PNG, or BMP. The infrared images are gray-scale images which can be stored either as (1) 8-bits-per-pixel in one of three standard formats, or (2) 12-bits-per-pixel in the original FLR format that is produced by sampling data from the ITAS sensor. Thus when using IR data captured from the ITAS sensor, the images may first be reduced to 8-bits-per-pixel and stored in a standard image format, or they may be input directly into Overlay, in which case they will be reduced to 8-bits within Overlay as each is opened.

The input images are called **layers**, and are numbered in the order in which they were opened. The visible spectrum image is always opened first, becoming layer 0, and the IR layers are numbered 1, 2, ..., N. Typically the IR images are captured in an up-and-down or back-and-forth fashion, and follow a corresponding filename convention. Thus if they are opened in alphabetical filename order, the resulting layers should progress across the visible spectrum image, for example with the first few IR layers covering the left edge of the visible spectrum image, then the next few covering a column of imagery just to the right, and so on. It is not necessary to open and establish the complete set of IR layers at the beginnning of the workflow. Instead, the first few IR layers may be

opened and manipulated until they are reasonably well lined up with layer 0 and each other; then some additional IR layers may be opened and manipulated, and so on.

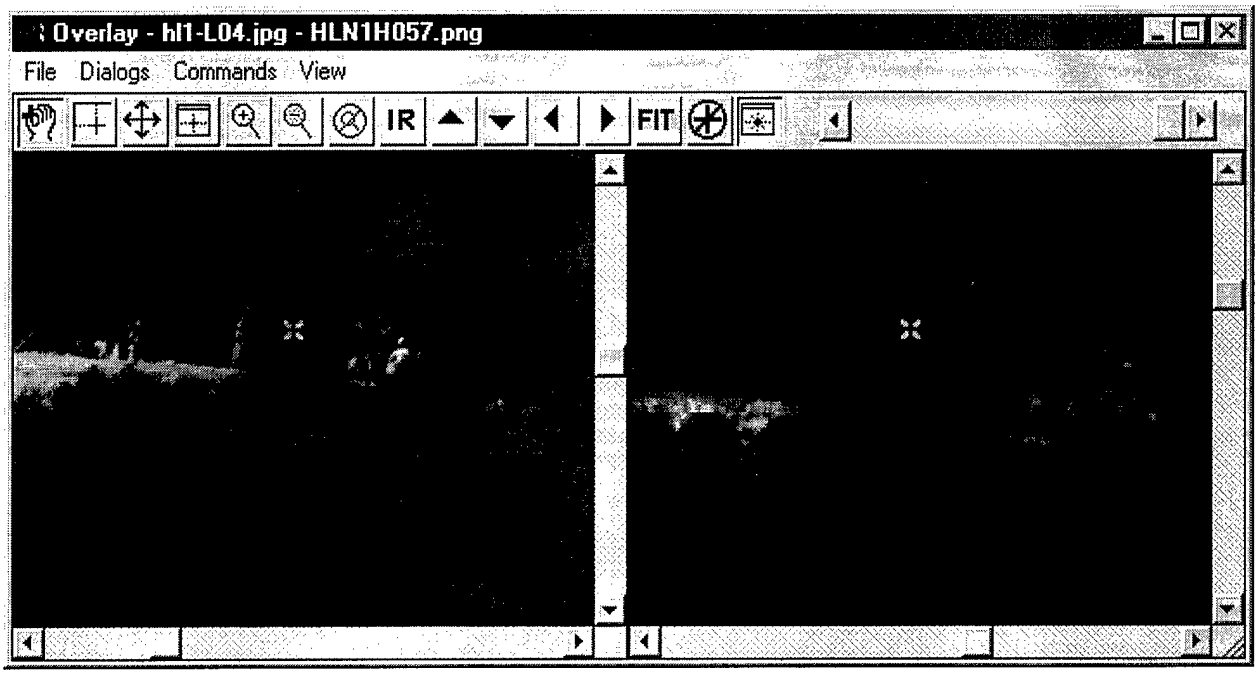

Figure 1: Overlay Main Window

The first step after starting up the Overlay program is to open the layer 0 image, either by using the Open Visible file menu command, or by selecting one of the recently opened images listed at the bottom of the File menu. Assume that we are starting a new project. After selecting an image using the Open Visible command, the image appears in the left pane of the Overlay main window, and the right pane is blank.

There are two File menu commands for opening IR layers, Open IR and Browse IR, each of which brings up a standard Windows file open dialog box:

(1) With the Open IR command, only one file may be selected, which is then opened as a new IR layer, using the next available layer number. The IR image is displayed in the right pane alongside the visible spectrum image in the left. (See Figure 1.) The new layer may be "placed" onto the stack of previously displayed images in the left pane, either by dragging and dropping it there, or by point measurement and fitting. The first method is activated by pressing down the third toolbar button from the left, the Move Image button. With that toolbar button activated, look for a feature visible on both the new layer (in the right pane) and the visible spectrum image or a previously placed IR layer in the left pane. When such a correspondence is spotted, press the left mouse button with the cursor over the feature in the right pane, and hold it down while dragging the cursor to the corresponding place in the left pane. The second method (point measurement and fitting) is discussed in section 3.

(2) With the Browse IR command, multiple files may be selected at one time, which are then displayed in the right hand pane of the main window, using a grid pattern of thumbnail (reduced size) images. These thumbnail

IR images are not yet regarded as layers by the software; they become layers only when dragged and dropped from the right hand pane onto the left. The drag/drop procedure is similar to that explained for the single image case above. The size and arrangement of the IR thumbnails may be customized on the Settings dialog box. The set of available IR images displayed as thumbnails may be altered by reselecting the Browse IR command. A Browse Mode menu item (under the View menu) allows the user to toggle on and off the display of the thumbnail IR images.

IR layers placed using the drag/drop procedure described above are scaled using the current value of an IR-to-visible scale parameter. If the IR layer is too small or large in relation to the visible spectrum image, use the Adjust Scale dialog to adjust the scale. It is not necessary or worthwhile to try to get the scale perfect, since the final positioning of the layers will be accomplished later using block adjustment.

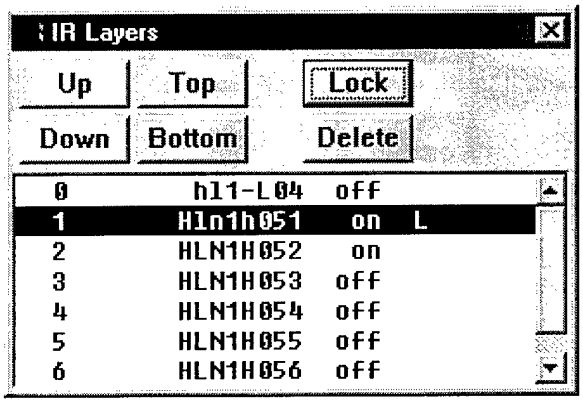

Figure 2: Layer List Dialog

The Layer List dialog box displays the layers in order by layer number. It displays each layer's filename (minus the extension), its on/off status, and lock status. The on/off status determines whether the layer is shown in the stacked display in the left pane. It may be toggled by double-clicking on a row in the dialog box; there are also menu commands for All IR layers ON and All IR layers OFF. The lock status determines whether a layer is allowed to be repositioned during block adjustment; layers marked with an 'L' are locked in place during that command. Clicking the Lock button toggles the lock status of the active layer.

The **active layer** is the layer currently highlighted in the layer list. It is also the layer displayed in the right pane when not in Browse Mode. In Browse Mode, the right pane indicates the active layer with a small square blue marker. (Other images which have been loaded are indicated by red markers.) When the Show Layer Outline menu item is checked (under the View menu), a blue outline indicating the placement of the active layer is drawn in the left pane. A layer can be made active by clicking on its row in the layer list, by clicking on its thumbnail in the Browse display, or by right-clicking on a location in the left pane where it is displayed.

The active layer may be deleted using the Delete button on the Layer List dialog box. This command does not delete any files; it just closes the image and removes it from the list of layers.

The Layer List dialog also has four buttons for controlling the stack ordering of the layers. As new layers are opened they are initially placed on top of the stack; i.e. when displayed in the left pane the new layer initially

appears on top of all other images. The visible spectrum image (layer 0) always remains at the bottom of the stack, but the IR layers may be shifted up and down. Two of the buttons shift the active layer up or down one level in the stack; the other two move it directly to the top or bottom (not counting layer 0).

Another control affecting display of the layers is the transparency scrollbar to the right of the toolbar in the Overlay main window (see Figure 1). When the scrollbar control is in its default position to the far right of the scrollbar as in Figure 1, the IR layers are displayed fully opaque over the visible spectrum image in the left pane. Moving the control to the left makes the IR layers transparent, the visible spectrum showing through more and more the further the control is moved to the left.

3. Point Measurement and the Fit Command

IR layers can be roughly placed onto the visible spectrum image using the drag/drop procedure discussed in section 2, but precise positioning requires the measurement of points and use of the commands (Fit, Adjust Block) which make use of point measurements. Here "measuring" a point refers to clicking the mouse with the cursor over some noticeable feature in the image. The idea is to measure the same feature in more than image, providing the software with information about how the images line up with one another. For the most part, the user needs only measure points linking layer 0 with the IR layers; measurements linking pairs of IR layers are generated automatically during block adjustment.

To measure a point, make sure Browse Mode is turned off, and press the Measure Point button (the second button from the left on the main window toolbar). The Point List dialog is displayed if it was not already; it lists the points which have been measured on the active layer. Two sets of coordinates for the point may be present: (x, y) pixel coordinates on layer 0 and (x, y) pixel coordinates on the active layer. Prior to the point having been measured the coordinates are blank. Thus in the example shown in Figure 3, one point (with point id 0) has been measured on both layer 0 and the active layer, and the software is ready for the user to measure a second point (with point id 1). If the user now clicks the left mouse button in either of the image display panes, that click will be

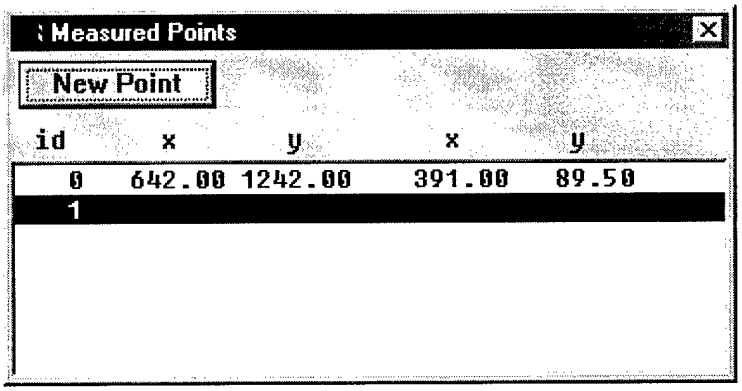

Figure 3: Point List Dialog

interpreted as a measurement of point 1, on layer 0 if clicked in the left pane, or the active layer if clicked in the right pane. Note that a mouse click in the left plane is treated as a measurement on layer 0 even if other layers are displayed on top of layer 0 at the location of the mouse click.

The highlighted point in the Point List dialog is called the active point. It is displayed over the images as a diagonal cross (×) as opposed to other points which appear as a plus sign (+). It is the active point that is measured when a mouse click occurs, whether or not it has been measured before. If previously measured, and the mouse click is far from the previous position, a warning message allows the user to cancel prior to moving the measurement to the new location.

The New Point button activates a new point; i.e. one which has not yet been measured on either image.

Measurements may be deleted using the Delete Point(s) command (under the Commands menu). Highlighting multiple points in the Point List enables this command to delete multiple points at one time.

The Grab Point command, activated using the leftmost toolbar button, enables the user to activate a point by a mouse click in the image display panes; the closest point which has been measured on the active layer becomes the active point.

The Window Center command, activated using the fourth toolbar button from the left, allows the user to center the left and right image display panes on features of interest using mouse clicks. A typical sequence in measuring a point is to activate the Window Center command and click on in the left and right panes on something that appears to be a common feature; having centered the feature, hit the Zoom In button one or more times to make the feature more visible; then hit the Measure Point button and measure the point if satisfied that a common feature is identifiable.

The Fit command may be used to update the placement of the active layer, based on that layer's point measurements. An earlier version of the Overlay program did not contain an Adjust Block command, and relied entirely on the Fit command. Because the Fit command adjusts only one layer, and adjusts that layer only with regard to layer 0 and not the other IR layers, it was difficult to get the various IR layers to line up with one another, and eliminate visible seams between the IR layers. The Adjust Block command, as explained in the next section, adjusts the placement of multiple IR layers at the same time. It eliminates the need to measure several points linking each IR layer to layer 0; it is often enough to measure just a few such points, possibly even skipping some of the interior IR layers entirely, and then allow the software to generate tie points between the IR layers to tie everything together.

4. Block Adjustment

The Adjust Block command involves a set of layers, called a **block**. The following rules determine which IR layers are included in the block; to be included a layer must

(1) have been "placed" onto the visible spectrum image (by the drag/drop procedure or the Fit command),

(2) be toggled "on" for display in the left pane, and

(3) overlap at least one other IR layer satisfying (1) and (2), and either the layer itself or one that it overlaps must be unlocked.

When the Adjust Block dialog is displayed (by selecting this item from the Dialogs menu), the rules above are applied and the layers found to be in the block are listed on the dialog box (see Figure 4). The Update button beneath the layer list is used to reapply the rules after making changes which would affect the block. For example, the user may decide to lock or unlock some layers after displaying the dialog; hitting the Update button will reapply the rules to create a new list of block layers.

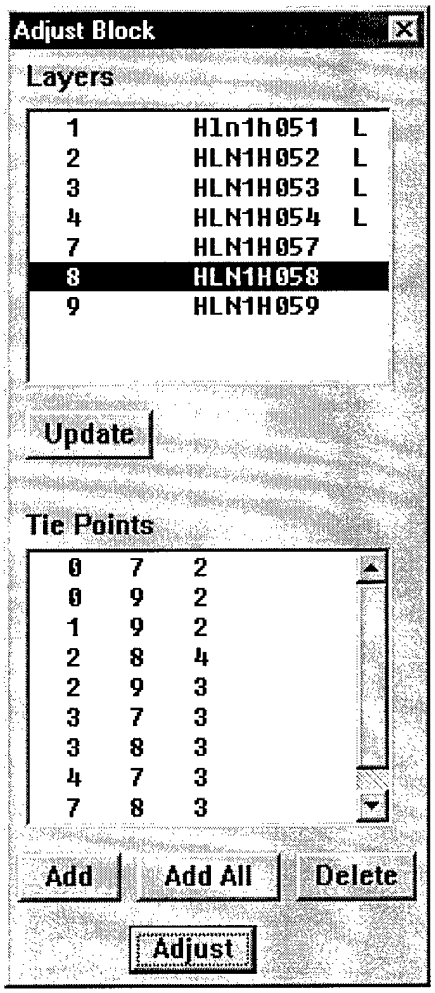

Figure 4: Adjust Block dialog

In the example shown in Figure 4, seven IR layers satisfied the rules and were included in the block, the first four locked and the last three unlocked. This situation might arise after an earlier block adjustment had produced a satisfactory placement of layers 1 through 4. The current block adjustment will leave those layers in their current positions, but use their positioning in adjusting the placement of the other three layers (7, 8, and 9).

The adjustment depends on tie points, which are point measurements like those discussed in section 3. Each tie point consists of the measurement of a point on two layers of the block; here we regard layer 0 as a block layer and treat it as being locked. The Tie Points list on the dialog displays pairs of layer numbers in the first two columns; the third number in a given row is the number of tie points measured on those two layers. The rules for which pairs of layers appear in this list are similar to those for listing the layers of the block; a pair of layers is listed only if they overlap based on their current placement, and only if at least one of them is unlocked. In the example shown, the first two rows indicate that two points have been measured on layer 0 and layer 7, and likewise two points on layer 0 and layer 9. These are the only four points measured on the visible spectrum image (layer 0) involved in the current block adjustment. (There may have been other measurements linking layers 1 through 4 with layer 0, but these are not included since both layers are "locked.") The other tie points, those linking two of the IR layers, are generally produced automatically using the Add or Add All buttons, although they can also be measured using the mouse as described in section 4. To view or measure tie points on two of the IR layers, highlight a row in the tie point list; the left and right panes will then display the corresponding IR images. To return to the standard display (IR images stacked on layer 0 in the left pane), highlight any layer in the layer list of the Adjust Block dialog, or highlight layer 0 in the Layer List dialog.

The Add button generates new tie points for the highlighted and displayed pair of IR layers, if the software is able to find corresponding features in the two images. The search is performed based on the current relative

placement of the two IR layers; when the software is unable to find matches it may help to adjust the layer placement using the Move Image or the Fit commands. A maximum of four tie points are added.

The Add All button is equivalent to applying the Add button for each pair of IR layers in the tie point list. The Delete button deletes tie points from the highlighted pair of IR layers. The typical procedure when working with new IR layers in a block adjustment is to start by hitting the Add All button; then proceed through the list highlighting each row to visually examine the tie points generated. Bad tie points may be deleted using the Delete Point(s) command. New points may be measured using the Measure Point command as in section 3 where needed to supplement the automatically generated tie points.

When ready to perform the adjustment it is a good idea to return to the normal stacked display in the left pane, so that the results of the adjustment can be viewed. Hit the Adjust button; if the computation is successful the unlocked images in the block will shift around in the left pane to their new positions.

5. Output Data

Two commands are used to save results in Overlay: Save Data and Save IR (both under the File menu). The Save Data command writes a data file with the same name as the visible spectrum input image, but having a ".ov" extension. For example the data file corresponding to image file cp3-L04.jpg is cp3-L04.ov. This data file is a plain text file viewable in any text editor. It stores information about the layers: their file names, placement relative to layer 0, stack order, point measurements, and brightness adjustments. When a file is opened with the Open Visible command or selection from the recent files list, Overlay reads the corresponding data file if it is present, and reconstructs the layers from the information in the data file.

The Save IR command is used to save the composite IR image constructed from all the IR layers as they are currently displayed in the left pane. Typically the user will want to use the All IR Layers ON command prior to the Save IR command, since only what is displayed is saved in the output image.