ViewPort: An Object-Oriented Approach to Integrate Workstation Software for Tile and Stack Mode Display

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Diagnostic workstation design has migrated towards display presentation in one of two modes: tiled images or stacked images. It is our impression that the workstation setup or configuration in each of these two modes is rather distinct. We sought to establish a commonality to simplify software design, and to enable a single descriptor method to facilitate folder manager development of "hanging" protocols. All current workstation designs use a combination of "off-screen" and "on-screen" memory whether or not they use a dedicated display subsystem, or merely a video board. Most diagnostic workstations also have two or more monitors. Our central concept is that of a "logical" viewport that can be smaller than, the same size as, or larger than a single monitor. Each port "views" an image data sequence loaded into offscreen memory. Each viewport can display one or more images in sequence in a one-on-one or traditionally tiled presentation. Viewports can be assigned to the available monitor "real estate" in any manner that fits. For example, a single sequence computed tomography (CT) study could be displayed across all monitors in a tiled appearance by assigning a single large viewport to the monitors. At the other extreme, a multisequence magnetic resonance (MR) study could be compared with a similar previous study by assigning four viewports to each monitor, single image display per viewport, and assigning four of the sequences of the current study to the left monitor viewports, and four of the earlier study to the right monitor viewports. Ergonomic controls activate scrolling through the off-screen image sequence data. Workstation folder manager hanging protocols could then specify viewports, number of images per viewport, and the automatic assignment of appropriately named sequences of current and previous studies to the viewports on a radiologist-specific basis. Furthermore, software development is simplified by common base objects and methods of the tile and stack modes. Prototype workstation display software and folder manager protocol implementation will be described and demonstrated.

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KEY WORDS: diagnostic workstation, folder manager, hanging protocols, tile mode, stack mode, display, workstation, object-oriented.

EFFECTIVE AND efficient soft-copy interpretation workstations that have been demonstrated commercially and in research environments^{1,2,3} tend to have two display modes: *tile*, which is an analogy of traditional multiformat film presentation; and *stack* or *cine*, which has no film

analogy and only can be implemented on a computer workstation. Stack mode, most experts agree, is a powerful and efficient way to present cross-sectional image series. In particular, for magnetic resonance (MR) examinations, where multiple series or sequences are produced, and often must be compared with a similar prior examination, stack mode with off-screen memory provides a very effective and efficient way to use limited physical display area.

Workstations today tend to implement tile and stack modes as two almost completely distinct modes of operation. What we have sought to do, and demonstrate, is a common base object concept, ViewPort, which merges these two modes of operation. With the implementation of appropriately designed methods, merely "maximizing" and "minimizing" the window display objects converts between stack and tile modes. This yields a powerful and simpler user interface, which provides the radiologist with a virtually instantaneous switch between these two modes, enhancing rather than causing conflict within the "hanging protocols" that are so important to the successful implementation of folder manager concepts at the diagnostic workstation.⁴

METHODS AND MATERIALS

The implementation is demonstrated on a prototype Windows95/Windows NT (Microsoft Corp. Redmond, WA) workstation based on a traditional inexpensive Pentium PC, with Microsoft Visual C++. The central concept is that of a "logical" ViewPort that can be smaller than or the same size as a single monitor. Similar to current workstation designs,^{5,6} our system also uses a combination of "off-screen" and "on-screen" memory. Each port "views" an image data series loaded into "off-screen" memory. The application uses the Multiple Document Interface (MDI)—a Microsoft Windows specification Application Programming Interface (API), which allows for maintaining multiple document or child windows within a single client area.⁷ A ViewPort is created as a child window; the use of

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MDI supports the coexistence of several ViewPorts and, therefore, the multiple stack display mode.

The user interface of the ViewPort application includes the following options that can be set by the user depending on the type of studies being viewed: (1) number of ViewPorts, (2) number of monitors, (3) magnification factor for image viewing, and (4) modes of setting images in focus. Currently 1×1 (1 ViewPort) and 2×2 (4 ViewPorts) ViewPort modes are supported. Future improvements will include support for a 3×3 (9 ViewPorts) mode. Currently, the application is being extended to two monitors. The magnification factor option includes the “stretched” bit modes ($2\times$, $\frac{1}{2}\times$, auto) and the “unstretched” bit model ($1\times$), which is also the default mode. The options for setting images in focus include movement by timer (cine/stack mode), slider (cine/stack mode), and mouse buttons. The movement modes controlled by the mouse buttons include stack scroll-view and view by page and row of images, also previous and next buttons. Currently, the application uses a basic 1:1 mapping of “off-screen” images to display port images, as demonstrated in Fig 1. Future improvements will implement sort algorithms for image sequencing based on anatomical references.

Table 1 elucidates folder manager implementation examples using the available ViewPort features.

Maximization of a particular study in a stack mode will bring to the front the “tile” mode, displaying images belonging to the study. This concept is illustrated in Fig 2. Minimization of the tile ViewPort will reset the first image in the tile in focus, returning to the stack mode. The option of “dragging” the window of a ViewPort (in stack mode) will be provided as a gradual way for converting from a stack to a tile mode. With the “dragging” action, images belonging to the study are incorporated into the ViewPort. The tiled images have a magnification factor of $1\times$. The number of images included in this tile are determined by three factors: (1) central processing unit (CPU) resource consumption for loading images from “off-screen” to “on-screen” memory, (2) image size, and (3) pixel resolution of the available ViewPort “real estate.”

CONCLUSIONS

This article demonstrates the power of the base object ViewPort to unify the software development

Table 1. Folder Manager Implementation Examples

Example 1: MR: Current and prior examinations	
Select number of ViewPorts and positions (default: two monitors; four on each);	
ViewPort Number:	Exam/Series Assignment:
1	Current T2 axial first echo
2	Current T2 axial second echo
3	Current T1 sagittal loc
4	Current axial post-gad
5	Prior T2 axial first echo
6	Prior T2 axial second echo
7	Prior T1 sagittal loc
8	Prior axial post-gad
Example 2: CT: Current and prior examinations, both with contrast	
Select number of ViewPorts and positions (default: two monitors; one on each)	
ViewPort Number:	Exam/Series Assignment:
1	Current CT series 1
2	Current CT series 1
Note: Do not routinely display scoutviews or scanograms	
Example 3: CT: Current examinations only; use both monitors	
Select number of ViewPorts and positions (default: two monitors; one on each)	
ViewPort Number:	Exam/Series Assignment:
1	Current CT series 1
2	Current CT series 1 (linked and synched with positive offset equal to number of images in ViewPort 1)

of stack and tile modes of image data presentation for a soft-copy diagnostic workstation. The methods described that support ViewPort—specifically, the ability of an image to display itself within a ViewPort at a location with a magnification factor, and the ability of the ViewPort to scan through the assigned image data series on user command—provide the radiologist with powerful controls to examine the study with ease and efficiency. The software object methods for stack and tile modes are essentially identical, and the workstation operates in a single, unified mode. Switching between

Fig 1. ViewPort mapping concept.

Fig 2. Maximized ViewPort converts stack to tile mode.

stack and tile modes occurs automatically based upon window size: minimize (to a single image) and maximize. Folder manager "hanging protocols" no longer need to distinguish between these

two modes. We anticipate that in the not-too-distant future this platform, using object-oriented tools as described here, will support a very cost-effective, ergonomic, and efficient diagnostic workstation.

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