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VIRTUAL RADAR VOLUMES: CREATION, ALGORITHM ACCESS, AND VISUALIZATION

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1. INTRODUCTION

The concept of a volume scan of radar data represented as a collection of increasing elevation scans has existed since the advent of radar technology. The classic notion of a volume scan beginning at the lowest elevation scan, and ending at the highest elevation scan is simple and logical. However, this definition is overly confining concerning four-dimensional navigation through the data, and its ingestion into rapid update versions of volumetric feature detection algorithms. Within the Warning Decision Support System - Integrated Information architecture (WDSS-II), a "virtual volume" product has been developed to contain the most recent data at all elevation angles within the radar volume. This product has several advantages over other volumetric products in the field, as will be discussed in this paper.

2. VIRTUAL VOLUME CREATION

Current methods of radar volume construction aggregate recent radar elevation scans, iteratively proceeding from lower to higher elevation angles, all of which are confined to the same volume scan. In a time-centric system, such as WDSS-II, the restraint of constructing volumetric products within the same volume scan is eliminated, allowing the aggregation of the most recent products at all levels. This "virtual volume" consists of the latest data available at all elevation angles.

The virtual volume concept is equally logical as that of the classical volume scan because the choice of the volume's beginning and ending elevation angles is arbitrary, so long as the ending elevation angle is circularly one level below the beginning elevation angle (I.e. 19.5° is circularly one level below 0.5°; 0.5° is circularly one level below 1.5°, etc.).

The following situation illustrates the virtual volume concept:

Current volume scan: 88
Current elevation scan tilt number: 4
Total tilts in current Volume Coverage Pattern: 8

Current volume scan structure:	88 tilt 4
	88 tilt 3
	88 tilt 2
	88 tilt 1
Current virtual volume structure:	**87 tilt 8**
	87 tilt 7
	87 tilt 6
	87 tilt 5
	88 tilt 4
	88 tilt 3
	88 tilt 2
	88 tilt 1

The virtual volume is updated with the arrival of each new elevation scan. Using the above example, when tilt 5 from volume scan 88 arrives, the tilt 5 from volume scan 87 is replaced in the virtual volume.

3. ALGORITHM ACCESS

Algorithms implemented within the WDSS-II architecture have access to virtual volume products for volumetric processing. Currently, the Vertically Integrated Liquid (VIL), Composite Reflectivity, and Bounded Weak Echo Region (BWER; Lakshmanan and Witt 1997) algorithms operate on virtual volumes.

Algorithms are notified of an available product via the arrival of that product's record from an index. The index serves as a database of available product records; the record houses information about where the actual data resides, and how the system can create the virtual volume product from the data.

Current algorithms perform the bulk of their processing on the two dimensional elevation scans. Thus, the virtual volume merely serves as a sequencing data structure for these algorithms, providing them with the most recent version of the entire volume that is ready for processing. The use of virtual volumes is made efficient by caching previously processed elevation scans, eliminating redundant retrievals.

Because the virtual volume is updated with each successive elevation scan, the algorithm is notified of a newly available virtual volume after each elevation scan. This notification allows any algorithm that processes volumetric data to be considered a "rapid update"

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algorithm, since its results will be updated after each elevation scan, rather than only once at the end of the volume scan. Algorithms such as the NSSL Mesocyclone Detection Algorithm (MDA; Stumpf, et al. 1998) and the NSSL Tornado Detection Algorithm (TDA; Mitchell, et al. 1998) will be used to test this concept further.

In addition to processing virtual volumes, algorithms may also create virtual volumes as output. The Velocity Dealiasing and Linear Least Squares Derivative (LLSD; Elmore, et al. 1993) algorithms produce a result for each elevation scan, which is aggregated into a virtual volume.

4. VISUALIZATION

Because a virtual volume consists of the latest data available at all elevation angles, four dimensional navigation through the data is significantly simplified during storm interrogation. Ultimately, humans interpret images as two dimensional projections, thus, virtual volumes are visualized by navigating vertically through the elevation scans that comprise the volume. The navigation interface is a grid of buttons, and resides in the product management tab page, at the bottom of the viewing window, as shown in Figure 1.

The buttons allow both forward and backward temporal navigation (Left- and Right- Arrow) and vertical navigation. The buttons are color coded based on the recency of the product they will navigate to. The Left Arrow is always red, because it will always navigate towards an old product. The Right Arrow is color coded as follows:

-gray- if the most recent product is already being viewed

-green- if it will navigate towards the most recent product

-red- if it will navigate towards a product that is not the most recent

Vertical navigation is controlled by the center column of the button grid. The top and bottom buttons are labeled with the resulting elevation angle. The center button is labeled with the current elevation angle. These buttons are also color coded, according to the following rules:

-gray- the referenced elevation angle is circularly around the volume (I.e. currently viewing 0.5°,going down would take you circularly to 19.5°)

-green- the referenced elevation angle IS the most recent version of that product AND part of the current volume scan, using the traditional definition

-red- the referenced elevation angle IS NOT the most recent version of that product AND IS NOT part of the current volume scan, using the traditional definition

-coral- the referenced elevation angle IS the most recent version of that product BUT IS NOT part of the current volume scan, using the traditional definition

This color coding scheme acts to quickly inform the user of product recency and the current position of the radar in the volume coverage pattern.

Vertical cross sections of any orientation can be generated from virtual volume products, as shown in Figure 2. Because the cross section is directly related to the virtual volume, the cross section is updated with the volume.

5. CONCLUSIONS

Virtual volumes provide a number of advantages over traditional volumetric products created by other display systems, such as the “All Tilts” product in AWIPS.

1) virtual volumes are able to display the most recent data at all elevation angles

2) virtual volumes simplify navigation through the volumetric data during storm interrogation

3) virtual volumes support automatically updating vertical cross sections

4) volumetric feature detection algorithms can process virtual volumes and function as “rapid update” algorithms with minimal changes to the code base

Future versions of the virtual volume product will address the “vertical discontinuity” at the volume scan changeover by correcting for storm motion at each level.

6. ACKNOWLEDGEMENTS

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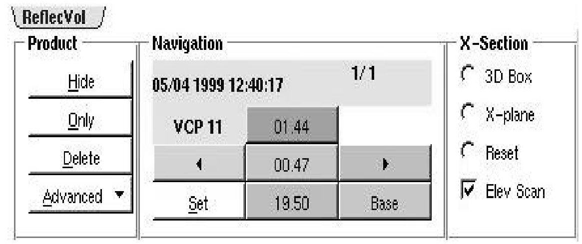

Figure 1. Image of the button grid used for virtual volume navigation.

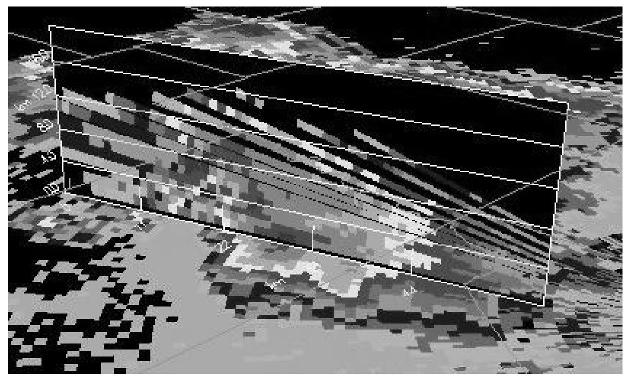

Figure 2. Vertical cross section through a reflectivity virtual volume.