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Transformation of Spatial Structure of Ion Trajectories into Iconic Representation

J. M. Sharif[1,*], Ahmad Basri Zainal[2]

[1]Department of Computing
Universiti Teknologi Malaysia, Johor Bahru, 81310, MALAYSIA.
[2]British Malaysian Institute,
Universiti Kuala Lumpur (UniKL)

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Abstract: This paper discusses a technique designed to represent the spatial structure of ion trajectories by transforming the vector series from two-dimensional to three-dimensional space. There are four techniques available to represent spatial structures, such as orientation, direction and velocity. These techniques are iconic representation, the navigation function, the halo function and the transparency scheme. Iconic representation is a technique used to transform data sets into three-dimensional iconic shapes where each data set is transformed into cylindrical and conical shapes; these shapes are then used to represent ion trajectories. Additionally, to improve representation the navigation function, halo function and transparency scheme have been proposed. The navigation function is a technique for navigating in three-dimensional space around the iconic representation. The halo function is a technique used to enhance the representation of iconic shapes by adding a subtle halo around an icon and the transparency scheme is a technique used to represent a zoom-in effect during navigation around an iconic representation in order to visualize the cone located inside the cylinder. The result shows an iconic representation technique have been developed to transform a vector series from two-dimensional line graph in order to visualize the orientation, direction and magnitude of ion trajectories in three-dimensional space.

Keywords: Iconic Representation, Ion Dynamics, Color Scale, Coding Theory, Visualization,

1. Introduction

A spatio-temporal data set is a collection of data values vary in both space and time. It is common to visualize spatio-temporal data sets of lower dimensions by using line graphs, bar charts, or other pictorial representations of a similar nature. This poses a challenge to the visualization techniques used to devise the representation techniques of spatio-temporal data sets.

Ion trajectories in glass structure have been used to represent spatio-temporal data sets because ion trajectories consist of space and time values. For this basic research approach, it is important to understand the mechanism of complicated heterogeneous trajectories of ions in glass structures. However, the detailed descriptions of ion trajectories do not include the experimental measurement such as velocity and orientation [1]. This study conducts an effective transformation of spatial structure of ion trajectories from a series of vectors into an iconic representation to visualize their orientation, direction and magnitude in three-dimensional space.

This paper presents in eight sections and elaborates the representation technique for spatial structure of ion trajectories. The following section is iconic representation to visualize the orientation of ion trajectories.

2. Iconic Representation

Given an ion trajectory as a series of $n + 1$ points, $a_0, a_1, \dots, a_n$, then n is consecutive vector segments, $\overline{a}_1, \overline{a}_2, \dots, \overline{a}_n$, where $\overline{a}_i = (a_i - a_{i-1})$. Fig. 1 shows some test trajectories constructed using a cylinder as the icon. Basically, the top trajectory represents an object, or ions, travelling from left to right at a constant speed. The middle trajectory represents an object travelling in a circular motion in counter-clockwise direction at a constant speed and the bottom trajectory represents the ions travelling from right to left at increasing speed. Determining shapes becomes the main issue when representing spatial structure. Some test trajectories are used to explain the principal concept of the proposed techniques.

*Corresponding author: johan@utm.edu.my

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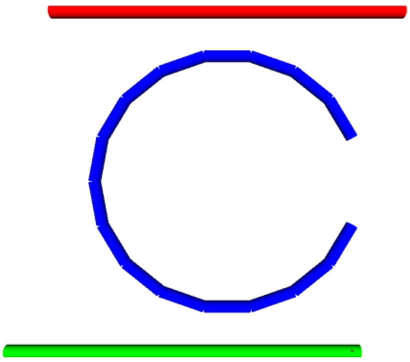


Fig. 1 Some Test Trajectories with Tube or Cylinder Shape.

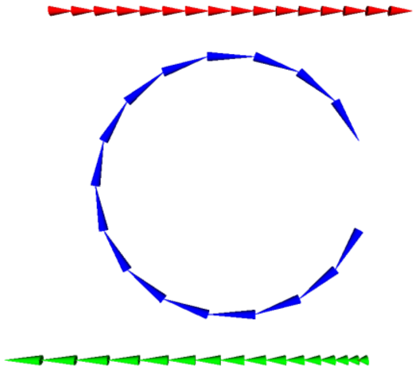


Fig. 2 Some Test Trajectories with Conical Shape Vector Segment

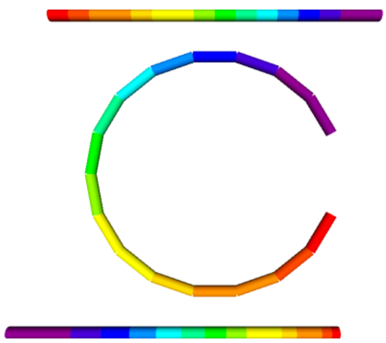
A cylinder [9], or a variety of cylindrical shapes, such as streamtubes [2], stream polygons [3], streamballs [4] and streamribbons [5], can represent the orientation and direction of ion trajectories in three-dimensional space; however, it is hard to represent their velocity. The trajectories of ions have been built from the transformation of three-dimensional data sets into vector segments. Special shapes have been built by Kehrer, J. and Lodha *et al.* [7,6] in order to represent the velocity for each of the vector segments. Pagot, C. et. al. also used the cylinder to represent the movement or orientation of ion trajectories, but to distinguish each of vector segments, including the velocity, is nearly impossible [3]. With a cylinder, it is impossible to tell the difference between the top and bottom trajectories or the beginning and the end of ion trajectories because of the challenge of representing motion in opposite directions and at different velocities.

Fig. 2 shows a conical shape being used as a vector glyph to represent some of the constructed test trajectories. As a result, the cone depicts the velocity at a given time interval by the length and orientation of motion by its conical shape. Cylinders and cones have been used to represent orientation, direction and velocity, but with the existing techniques, none of these can effectively represent orientation, direction and velocity as well as a timeline series. Instead of using cylinders and cones as representations of ion trajectories, the cylinder has been used to represent the global timeline with a global color scale and the cone has been used to represent the local timeline with a local color scale. These representation techniques showing timeline events of ion trajectories will discuss in future experiments.

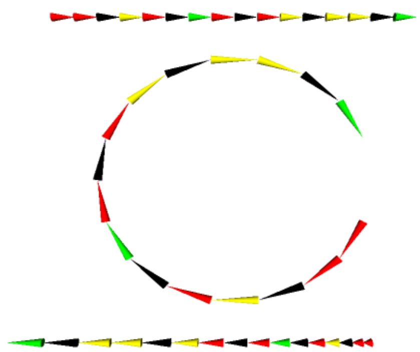
3. Composite Rendering

Two representation techniques of timeline events are shown in Fig. 3. Fig. 3(a) shows the cylinder has been used to represent the global time scale using a global color scale. Although the global color scale can differentiate between the top or bottom trajectories and represent motion in opposite directions with different velocities, the global color scale is for global scale viewing purposes only. Rainbow colors, which consist of seven key colors, have been used to represent the timeline of the global scale for ion trajectories between $0 \ll t \ll 1000$.

Fig. 3(b) shows the same trajectories using a conical shape, where each cone is represented by the local color scale. Given a small set of key colors (red, yellow and green) and a distinctive interval color (black), the colors generate a group code of consecutive m vectors, terminated by an interval color, as shown in Fig. 3(b) (details of the development of the local color scale, including group code, can be found in future works). The results of combining the techniques in Fig. 3(a) and Fig. 3(b) have been used on one thousand ion trajectory, as can be seen in Fig. 4. The purpose of combining the two techniques is to represent both the global and local time



(a)



(b)

Fig. 3 Color Scales

4. Navigation Function

The navigation function is another technique using one an algorithm that shows a zoom-in effect and navigation for ion trajectories. Fig. 4 shows the zoom-in and navigation effects on a portion of the one thousand ion trajectory. Indeed, zoom-in and navigation techniques can also help visualize global and local color scales during analysis. The following paragraph discusses depth-cueing, which is used to represent a depth impression in iconic representation techniques.

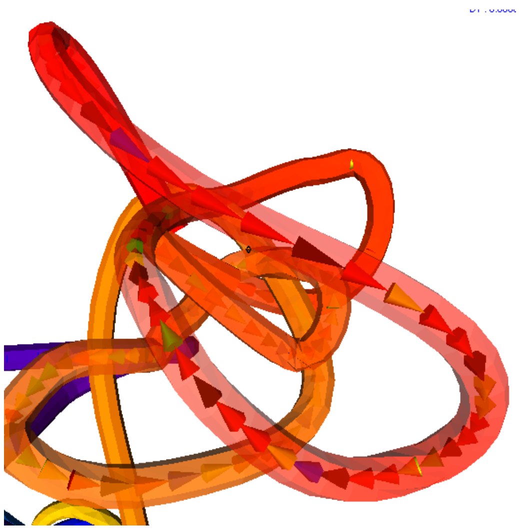


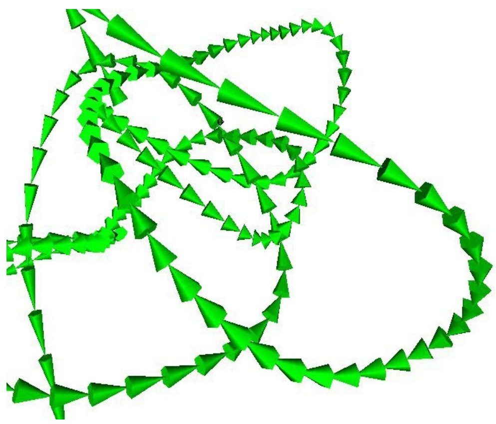
Fig. 4 Effect of Zoom-In

Depth-cueing is a technique used to improve depth impression in images [8]. The zoom-in and navigation functions alone do not help much in representing the cueing of ion trajectories. In order to achieve depth impression in ion trajectories, objects are sorted from farthest to nearest before the rendering process occurs. Thus, the image incrementally obtains contributions from all the overlapping objects, including the transparent layer in the scene or image.

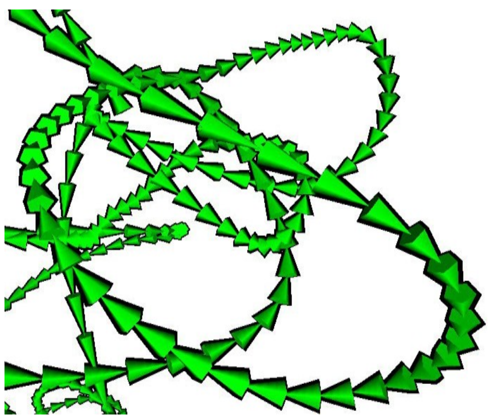
During navigation and zoom-in, depth-cueing needs to be updated. Depth- cueing is used together with the navigation and zoom-in functions in order to improve depth impression in ion trajectories. In order to visualize the cone inside the cylinder, it is also necessary to improve the representation technique by using the halo function.

5. Halo Function

Halos are used to illuminate the cones and the halo function has been implemented to illuminate the trajectories of the cones. See Fig. 5 for the differences between the before and after representations using halos. In Fig. 5(b), the cones are more defined when compared to the cones in Fig. 5(a). The use of the halo function can also help distinguish between each of the vector segments used for visualizing a temporal issue. The following section discusses the transparency scheme used to represent the zoom-in effect on cylinders and cones.



(a) Without halos function



(b) With halos function

Fig. 5 Cones and the Halos Function

6. Transparency Scheme

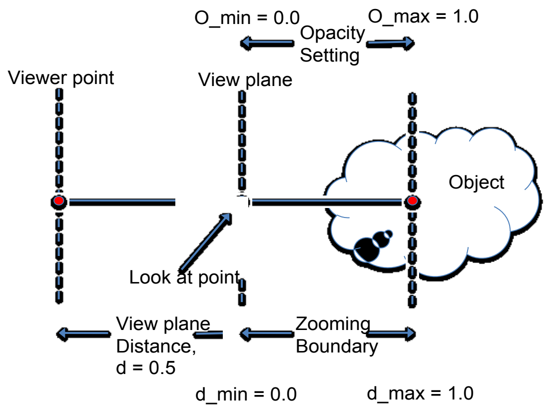


Fig. 6 Transparency Scheme

The transparency scheme is a technique used to represent the effect of zooming in on cylinders and cones. In order to visualize the cone inside the tube, the opacity of the cylinder needs to be controlled with a basic transparency scheme, as shown in Fig. 6. First, the boundary of the zoom-in effect is set up at d_{min} and d_{max} . When d_{max} starts to touch or hit an object, then the calculation of the cylinder opacity begins using Eq. 1. d_{max} will start to touch or hit an object when the camera moves close to an object. The camera represents the view-plane of the navigation function

$$f_{depth_i} = \frac{d_{max} - d_i}{d_{max} - d_{min}} \qquad (1)$$

where d_i is the distance of the cylinder between d_{min} and d_{max} and where d_{min} and d_{max} are computed as the distance from the cylinder to the look-at-point. Thus, the nearest cylinder is displayed using the highest value of transparency and the cylinder at the farthest point, or maximum depth, is displayed using the highest value of opacity f_{depth_i}.

The parameter f_{depth_i} is assigned a value between 0.0 and 1.0 to specify the distance of the cylinder from the view-plane. The opacity of the cylinder varies between the maximum value at $O_{max} = 1$ and the minimum value at $O_{min} = 0$ using the depth coefficient f_{depth_i}, which is computed using the linear interpolation function as stated as in Eq. 2 :

$$O_{\overline{a}_i} = (1 - f_{depth_i})O_{max} + f_{depth_i}O_{min} \qquad (2)$$

Three different transparency schemes have been developed to visualize cones inside cylinders during zoom-in activities. These schemes are the standard scheme, opacity scheme and depth scheme

6.1 Standard Scheme

This is the standard transparency scheme without modifications of any parameter as shown in Fig. 6. The camera only moves toward the object where the O_{min}, O_{max}, d_{min} and d_{max} are given fixed values. By modifying the parameter values of opacity, such as O_{min} and O_{max}, an opacity scheme is introduced in the following section

6.2 Opacity Scheme

An opacity scheme has been introduced in order to obtain various values of O_{min} and O_{max} where d_{min} and d_{min} have been fixed at one value only, such as $d_{min} = 0.0$ and $d_{max} = 1.0$. This scheme can be illustrated in Fig. 6 where the values of O_{min} and O_{max} are varied while the value of d_{min} and d_{max} are fixed. This technique is useful to highlight the corresponding area or point of interest by adjusting the value of the opacity scheme, for example between O_{min} and O_{max}. The following section introduces a depth scheme with a variety of values for d_{min} and d_{max}.

6.3 Depth Scheme

The depth scheme considers the various values of d_{min} and d_{max}, with a fixed value of opacity, as shown in Fig. 6. The benefit of this scheme is to highlight the corresponding area or point of interest in ion trajectories by adjusting the value of d_{min} and d_{max}. Other benefits of this scheme can be found in future works

The above-mentioned techniques have been developed to represent the spatial structure of ion trajectories.

7. Discussion

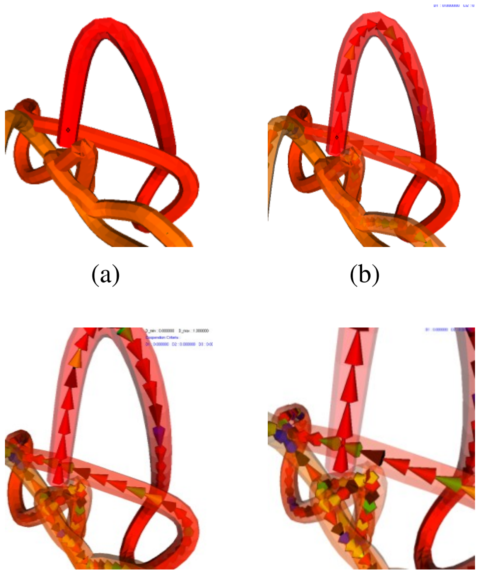
The spatial structure of ion trajectories has been represented with appropriate iconic representation techniques. For related work on ion dynamics in glass, Habasaki and Ngai [8] have used graphs and simulation tools to represent ion trajectories. A graph is a 2D image representation whereas the techniques developed in this paper are 3D image representations using combinations of cones and cylinders. The icons can represent the direction, position and velocity of each of the vector segments in 3D space, compared to 2D graphs that can only represent the path of ions without direction and velocity. Cylinders have been used to represent the flow of data, or streamline, in 3D space. In this study, however, cylinders are used to represent orientation as well as the global time scales in ion trajectories. Cones have previously only been used to represent the direction and the magnitude of streamlines, however in this study, cones are used to represent direction and magnitude, including the local time scale, of ion trajectories. The combination of cylinders and cones has been used to represent spatial structure.

Simulation only generates animation of ion dynamics without represents the entire range of the trajectories from start to the end of the simulation results. The techniques developed in this study represent the spatial structure for each vector segment, including direction, position and velocity. The improvements in the representation techniques were further enhanced with several additional techniques. These techniques include composite rendering, the zoom-in effect, the halo function and depth-cueing and transparency schemes. The proposed techniques have contributed to improve the representation techniques of the spatial structure of ion trajectories by transforming two-dimensional line graph into three-dimensional iconic representation to visualize direction, magnitude and velocity of the vector series. The three transparency schemes for representing the opacity values of cylinders during zoom-in activities standard, opacity and depth schemes each has its own advantages and rely on suitability during representation of the spatial structure.

The techniques in this paper are not only used to represent the spatial structure, they also help to visualize the global and local time scales by using cylinder and cone trajectories. Several analytical tests were conducted to observe the correlation between global and local color scales in composite rendering, as depicted in Fig. 7. To determine the correlation, find $t = 0$ ($t = 0$ is represented on the global color scale by a red color for cylinders) then look into the first two key colors at the global scale which lie between red and orange.

Next, there is the local color scale within the global color scale when the camera is moved close to the target area, such as $t = 0$. Once the camera moves, the transparency scheme takes over until the local color scale can be seen clearly. Fig. 7 shows the images of the local color scale are derived from the global color scale by using the standard transparency scheme. Fig. 7 (a) shows the top of the trajectory as cylinder shapes in red. When the camera moves forward to the look at point, or viewpoint, as shown in Fig. 7 (b), the opacity of the nearest cylinder to the viewpoint is gradually decreased. Decreased opacity of the cylinder can be seen in Fig. 7 (c) where the camera moves forward to the viewpoint. This causes the cylinder to become transparent and reveal the trajectory of the cones, which represents the local color time scale, as seen in Fig. 7 (d). Interpretation takes place on the consecutive vector segments to determine the local time scale. The interpretation process is elaborated on in detail in the future works.

The standard transparency scheme, where the values of opacity and depth could be varied, is not yet significant. The benefit of the opacity value will later be seen during collaboration events. The advantages of the standard scheme are the viewer does not have to worry about the optimum setting for depth and opacity values. The disadvantages of the standard scheme are the viewer can move the camera forward to the target area, $t = 0$, then the trajectory of two key colors are not included in the screen. Depth and opacity schemes were introduced in order to solve this problem; further discussion is undertaken in the future works.



(a) (b) (c) (d)

Fig. 7 Zoom-In Effects with Standard Scheme

8. Summary

This paper has described a technique to represent the spatial structure of ion trajectories, including some additional features such as *composite rendering*, zoom-in effect, depth-cueing and transparency schemes. These representation techniques help to extract the spatial structure information from ion trajectories. The representation of timeline events in ion trajectories is discussed in the future works.

References

[1] Habasaki, J. and Ngai, K. L. (2013). Molecular dynamics study of network statistics in lithium disilicate: Qn distribution and the pressure-volume diagram. The Journal of Chemical Physics. 139(064503).

[2] Walfisch, D., Ryan, J. K., Kirby, R. M. and Haimes, R. (2009). One-Sided Smoothness- Increasing Accuracy-Conserving Filtering for Enhanced Streamline Integration through Discontinuous Fields. In Journal of Scientific Computing, vol. 38. 164–184.

[3] Pagot, C. and Osmari, D. and Sadlo, F. and Weiskopf, D. and Ertl, T. and Comba, J. (2011). Efficient Parallel Vectors Feature Extraction from Higher-Order Data Computer Graphics Forum, vol. 30, no. 3, 751--760.

[4] Spies, T., Moorhead, R. and Brill, M. (2007). Remote Sensing Information Visualization Using Volume Based Objects in World Wind. In IEEE International Geoscience and Remote Sensing Symposium (IGARSS 2007). Jul. IEEE, 2213–2216.

[5] Huitema, H. and Liere, R. V. (2000). Interactive Visualization of Protein Dynamics. In Proceedings of Conference on Computer Graphics (VISUALIZATION 2000). Oct. IEEE, 465–468

[6] Kehrer, J. and Hauser, H. (2013). Visualization and Visual Analysis of Multifaceted Scientific Data: A Survey. IEEE Transactions on Visualization and Computer Graphics. 19(3), 495-513. ISSN 1077-2626.

[7] Lodha, S. K., Fitzpatrick, D. and Helmbold., D. P. (2007). Aerial lidar data classification using expectation-maximization. In In Proceedings of the SPIE Conference on Vision Geometry XIV, vol. 6499. Jan. L1–L11.

[8] Hearn, D. D., Baker, M. P. and Carithers, W. (2010). Computer Graphics with OpenGL.(4th ed.). Upper Saddle River: Pearson Prentice Hall

[9] Pobitzer, Armin and Peikert, Ronald and Fuchs, Raphael and Schindler, Benjamin and Kuhn, Alexander and Theisel, Holger and Matković, Krešimir and Hauser, Helwig (2011). The State of the Art in Topology-Based Visualization of Unsteady Flow Computer Graphics Forum. 30(6). 1789--1811.