Evenly Spaced Streamline Placement

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# 1 Introduction

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he problem of visualizing vector fields has been widely addressed in the past years because it has numerous applications. The main issue is to visualize properly the direction and magnitude of the flow. Spatial resolution techniques such as arrow plots, streamlines or particles traces suffer from their spatial resolution that limits drastically their usefulness, in the presence of a turbulent flow.

A solution was offered by Dr. Wilfrid Lefer and Prof. Bruno Jobard of University of Pau and Pays de l'Adour, France, which provided a new algorithm to visualize 2D steady vector fields. This method can compute veriety of flow fields from texture like styles to hand writing like styles. The proposed method is upto the mark in terms of quality and is computationally less expensive than other methods.

This report aims to explain our project, in which, we have implemented the said algorithm in C/C++. We have developed a program which generates evenly spaced streamlines for any given steady vector field.

# 2 Related Work

To properly render fine grain details of a vector field, high spatial resolution techniques are required which makes field presentatio dense. But there are several situations where sparse field presentation is also required. Methods that visualize a flow field typically fall into two categories: Dense field representaions and hand-drawing style.

First method, spot noise texture synthesis, a dense field representaion, has been proposed by Prof. Jarke J. van Wijk of Eindhoven University of Technology. This method creates a directional texture by superimpsing many flow oriented ellipses. Each ellipse is generated by projecting a spherical spot onto a surface and by advecting the spot with the direction and magnitude of the vector field at the projection point. This amounts to the flow field-controlled generation of a band-limited noise. Initially straight, the spots are now bent along short streamlines to follow the curvature of the vector field. An important feature of this method is the local control on the generated image. more spots provide more accuracy. Generation time is dependant on total number of spots used while generating the texture. Therefore, we can get a trade off between Image Quality and Rendering Time.

Another interesting method is the Line Integral Convolution or LIC which was proposed by Dr. Leith Leedom and Dr. Brian Cabral. A LIC texture is generated by convoluting an input texture with a streamline-oriented one-dimensional filter kernel. The images obtained with this technique are very effective, showing more details than the previous one. But it also requires a lot of computational power.

Prof. Greg Turk from University of Norht Carolina at Chapel Hill and Prof David Banks from Mississippi state Univerity proposed a image guided streamline placement method. It uses a stochastic mechanism to refine the placement of streamlines iteratively.

First, some streamlines are randomely generated. Then at every step of refinement process, a small change is randomly performed. the change can be any combination of three valid operations: (1) changing the position and/or length of a streamline, (2) joining streamlines that are very close to each other, and (3) creating a new streamline to fill a gap. AN energy function is used to measure variation of energy in current and updated images. Modification is only accepted if energy variation is negative.

This method creates very high-quality flow fields but its convergence is very slow as it sometimes takes several minutes to compute field for a single image. This method will also not work with dense field images becuase number of possible modifications increases exponentially.

# 3 Methodology

In order to implement evenly spaced streamlines, we have selected 4 random points on the field from which we generated initial streamlines. Then we are finding two seedpoints at distance d\_sep for every point in the streamline. Then we are generating streamlines from the seed-points. If at any point, a streamline comes closer than distance d\_test, then the streamline is terminated immedietly. This procedure is repeated for every streamline, which finally gives us a field in which all streamlines are evenly spaced from each other.

Algorithm which we are using is as follows:

*Compute an initial streamline and put it into the queue*

*Let this initial streamline be the current streamline*

*Finished := False*

***Repeat***

***Repeat***

*Select a candidate seedpoint at d = d\_sep apart from the current streamline*

***Until*** *the candidate is valid or there is no more available candidate*

***If*** *a valid candidate has been selected* ***Then***

*Compute a new streamline and put it into the queue*

***Else***

***If*** *there is no more available streamline in the queue* ***Then***

*Finished := True*

***Else***

*Let the next streamline in the queue be the current streamline*

***EndIf***

***EndIf***

***Until*** *Finished=True*

# 4 Implementation

We have Implemented this project in C/C++. We have used .ply files to load the vector field data. For the GUI and Visualization, we are using OpenGL libraries like GLUI and GLUT.

In order to store seedpoints, we are using a struct which contains several float variables like x, y, vx, and vy. We are storing a single streamline in a vector of seedpoints. And those streamlines are again stored in a vector. In essence, we are using 2D or nested vectors to store the streamlines and seedpoints data.

We are changing the y co-ordinate of current streamline by d\_sep distance in order to get new seedpoints.

To get the streamlines, we are using euler’s integration method. i.e. going forward one unit at a time in the direction of vector of current pixel. We are retreiving the vector value of a certain pixel, then converting the vector to a unit vector by finding its magnitude and dividing the vector by its magnitude. We then move forward to next pixel by adding the vector value to the current co-ordinates(x = x+ vx and y = y + vy). For every point of the streamline traversed, it is checked against the termination condition in order to decide if the point should be displayed or not.

For our termination condition, we have created a grid with size of resolution of the image (i.e. 512). For every point of a streamline displayed, we are setting a flag in the grid indicating that pixel is used in a streamline. When checking for new point, we traverse though every point which is in d\_test (d\_test = d\_sep/2) radius of the current point to check if it is used in any other streamlines or not. If yes then we terminate the current streamline. Otherwise, we continure to create a streamline unitil (1) its magnitude is lower than a certain threshold (sink point) or (2) streamline crosses the image boundries.

# 5 Results and Discussions

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Fig. 1. Magnetization as a function of applied field. Note that “Fig.” is abbreviated. There is a period after the figure number, followed by one space. It is good practice to briefly explain the significance of the figure in the caption.

Figure axis labels are often a source of confusion. Use words rather than symbols. As an example, write the quantity “Magnetization,” or “Magnetization *M*,” not just “*M*.” Put units in parentheses. Do not label axes only with units. As in Fig. 1, for example, write “Magnetization (A/m)” or “Magnetization (Am−1),” not just “A/m.” Do not label axes with a ratio of quantities and units. For example, write “Temperature (K),” not “Temperature/K.” Table 1 shows some examples of units of measure.

Multipliers can be especially confusing. Write “Magnetization (kA/m)” or “Magnetization (103 A/m).” Do not write “Magnetization (A/m) × 1,000” because the reader would not know whether the top axis label in Fig. 1 meant 16,000 A/m or 0.016 A/m. Figure labels should be legible, approximately 8 to 12 point type. When creating your graphics, especially in complex graphs and charts, please ensure that line weights are thick enough that when reproduced at print size, they will still be legible. We suggest at least 1 point.

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TABLE 1  
Units for Magnetic Properties



Statements that serve as captions for the entire table do not need footnote letters.

aGaussian units are the same as cgs emu for magnetostatics; Mx = maxwell, G = gauss, Oe = oersted; Wb = weber, V = volt, s = second, T = tesla, m = meter, A = ampere, J = joule, kg = kilogram, H = henry.

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Theorems and related structures, such as axioms corollaries, and lemmas, are formatted using a hanging indent paragraph. They begin with a title and are followed by the text, in italics.

**Theorem 1.** *Theorems, corollaries, lemmas, and related structures follow this format. They do not need to be numbered, but are generally numbered sequentially.*

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**Acknowledgment**

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