Assigned: *4-3-2024*
Due Date: ***5-1-2024 by Noon***

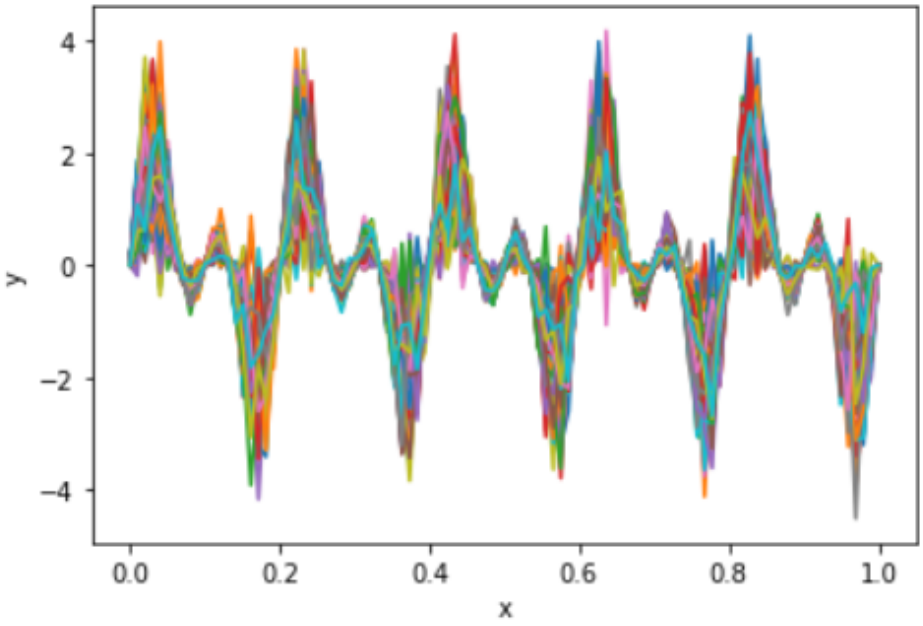
CS 6635/5635 Spring Semester 2024

*Assignment 6 (**Uncertainty Visualization and Perception/Color**)*

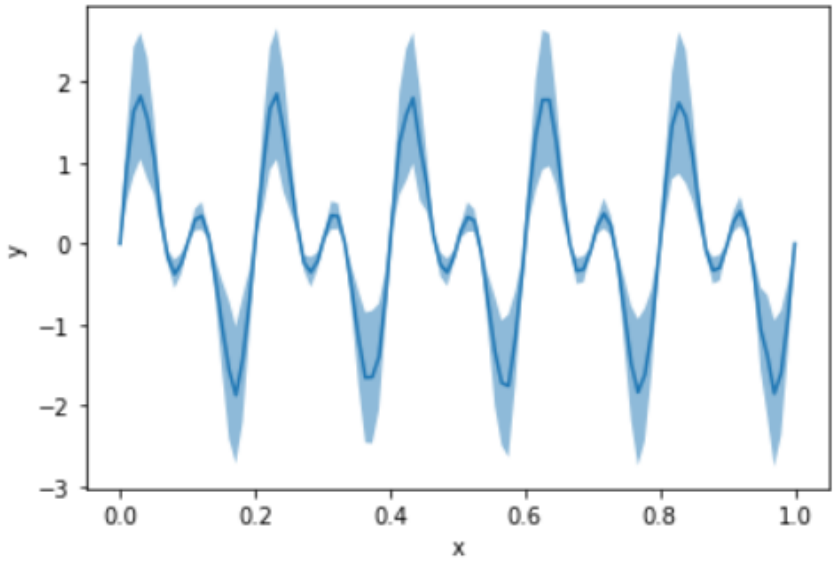
You can download data used in this assignment here:
https://my.eng.utah.edu/~cs6635/Assignment6-Data.zip

Part 1: Uncertainty Visualization of Isocontours [40 pts + 10 pts Extra Credit]

1) **[8 pts]** Uncertainty in data (adding and removing noise) with step-by-step visualization.
First, let's generate some noisy data and visualize the uncertainty. Create a uniform array from 0 to 1 in x with 100 points. Now, let $y = \sin(10\pi x) + \sin(20\pi x)$. Add Gaussian noise with mean of 0 and standard deviation of $\frac{\text{abs(y)}}{2}$ to each y-value. Do this for 100 instances of y(x). You should get a 100x100 array that looks like this when plotted individually as lines.



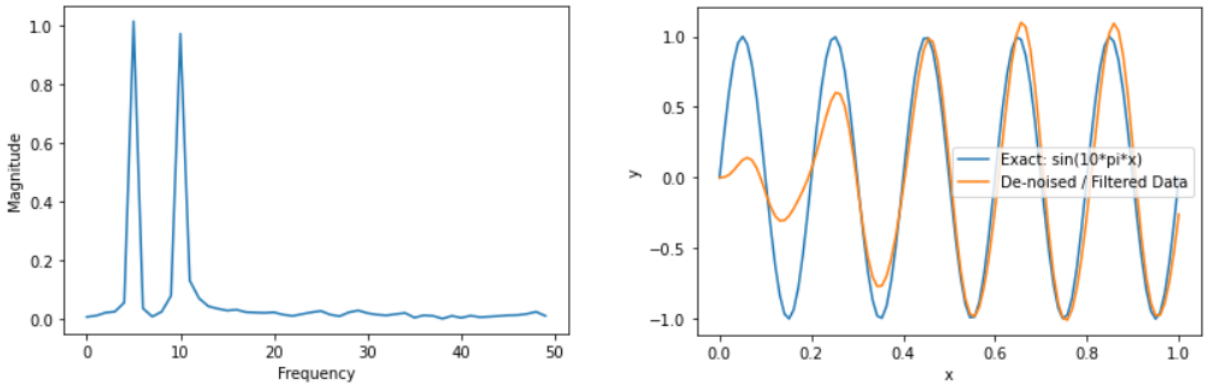
Now, plot the mean and one standard deviation over the set of noisy data, it should look like this.



Include an image of the plots in your report. Describe how your plot represents the uncertainty in the data based on the form of our Gaussian noise.

Now let's remove the noise **[Extra Credit: 10 pts]: Use Scipy or another package**

First, use a Fast Fourier transform (fft) to identify the frequencies. Then apply an appropriate bandpass Butterworth filter to remove signals other than $\sin(10\pi x)$. You should get the plots below:



Hint: use scipy.ftt and scipy.signal.butter. Use the bandpass range [4-6] and set the order of the filter to 2.

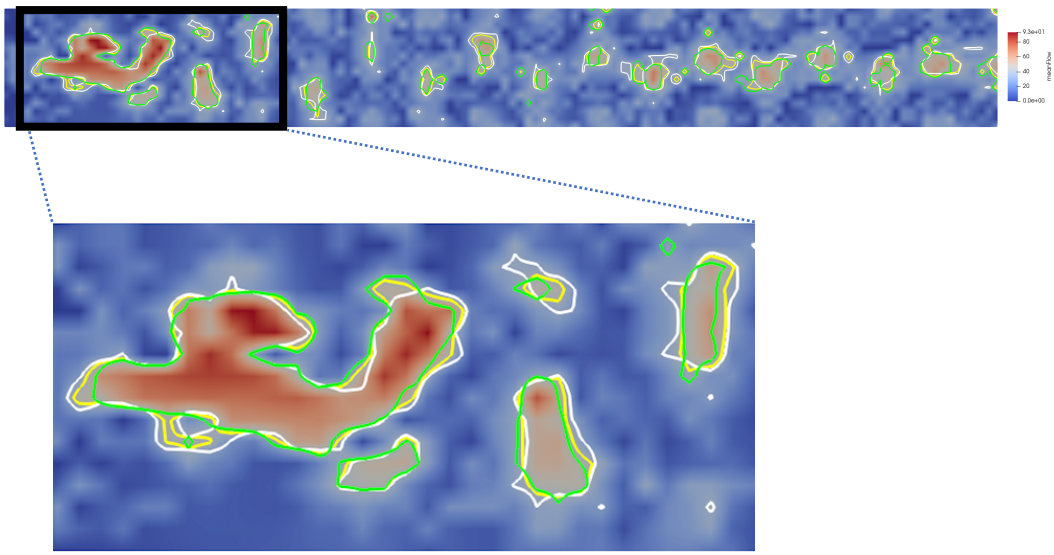
Include an image of the plots in your report. Describe what you learned from removing the noise. Why is the de-noised data different at lower x values?

2) **[16 pts]** Generate a *spaghetti plot* (uncertainty visualization technique) of isocontours for flow simulation data in ParaView:

(a) Download the flow simulations flow1.vtk, flow2.vtk, and meanFlow.vtk located in data/ flowData directory. The flow1.vtk and flow2.vtk represent the same flow captured with two different fluid viscosity values. The meanFlow.vtk represents the mean of the two flow

simulations (datasets courtesy of the Gerris Flow Solver project: http://gerris.dalembert.upmc.fr/gerris/examples/examples/index.html).

(b) Load the meanFlow.vtk, flow1.vtk, and flow2.vtk, and visualize their isocontours with different colors for the isovalue = 40 to generate a visualization similar to the following (please include the image in your report):

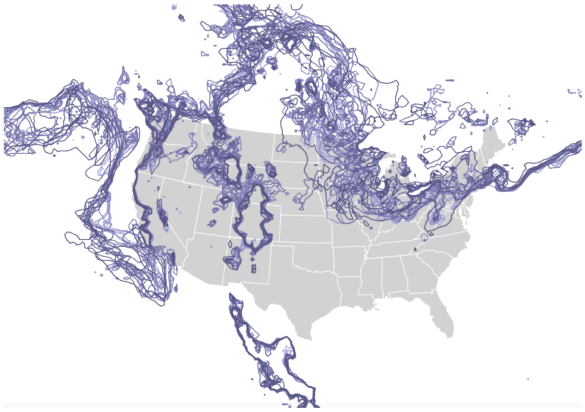


(c) Do all isocontours coincide? Describe why they do or do not coincide. Overlay the image from part (b) with three or four boxes showing regions of high/low positional variability in your spaghetti visualization of isocontours. Please include the image in your report.

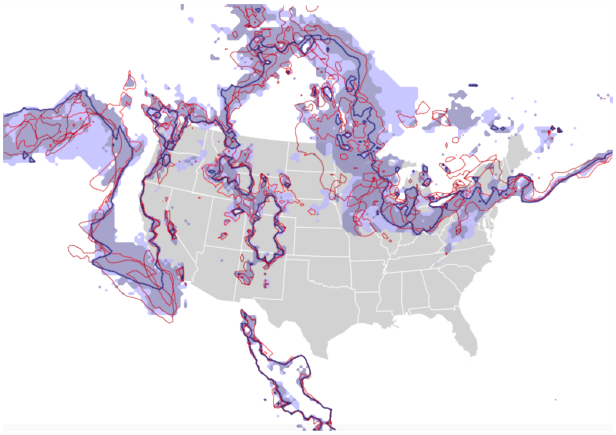
3) **[8 pts]** In your own words, briefly describe contour boxplots, and describe the conceptual similarities and differences between contour box plots and 1D boxplots, e.g., the ones generated in question 1. Refer to the Contour Box plots paper: *Whitaker, Ross T.; Mash Mirzargar; Robert M. Kirby (2013). "Contour Box plots: A Method for Characterizing Uncertainty in Feature Sets from Simulation Ensembles". IEEE Transactions on Visualization and Computer Graphics*. (https://www.cs.utah.edu/~kirby/Publications/Kirby-82.pdf)

When summarizing, please do it in your own words. Do not write the same thing as in the source material but with only slight changes in phrasing. Do not simply rewrite the same sentences as in the source material. If you are paraphrasing, it cannot be too similar to the source material. You should be able to write your answer without simultaneously looking at the original text. E.g. see this guide on appropriate paraphrasing/summarizing: https://owl.purdue.edu/owl/research_and_citation/using_research/quoting_paraphrasing_and_summarizing/paraphrasing.html

4) **[8 pts]** The images below depict the spaghetti and contour box plots for an uncertain temperature field. In your own words, discuss the advantages/disadvantages of contour box plots over spaghetti plots for isocontour uncertainty visualization.



(a)Spaghetti plots



(b) Contour box plots

Fig: Uncertainty visualization of isocontours

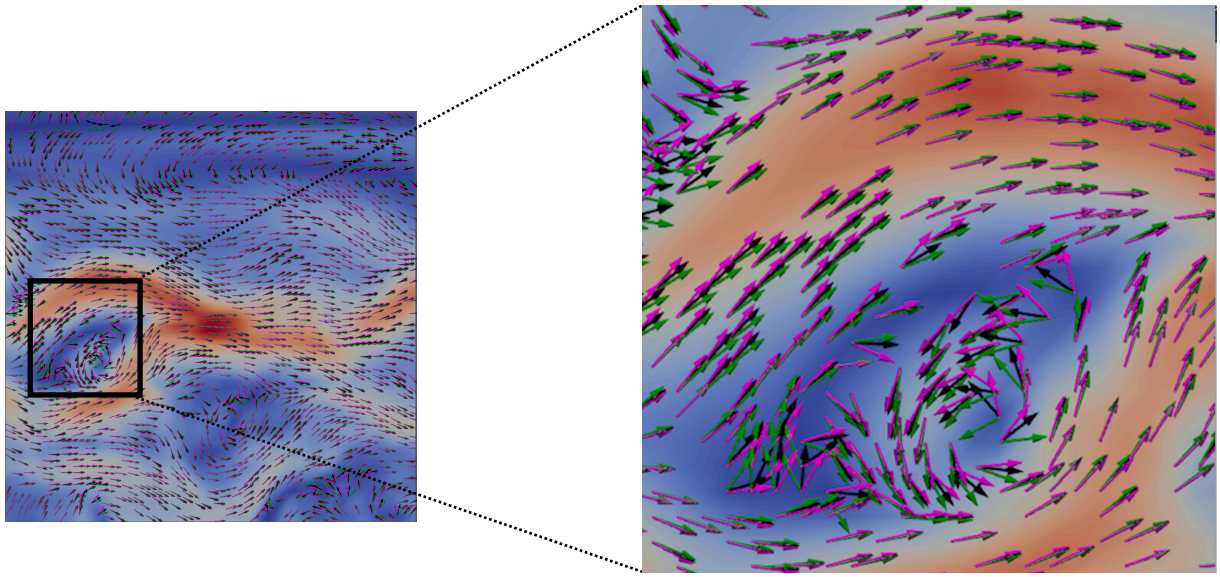
Median Isocontour

Outlier Isocontour

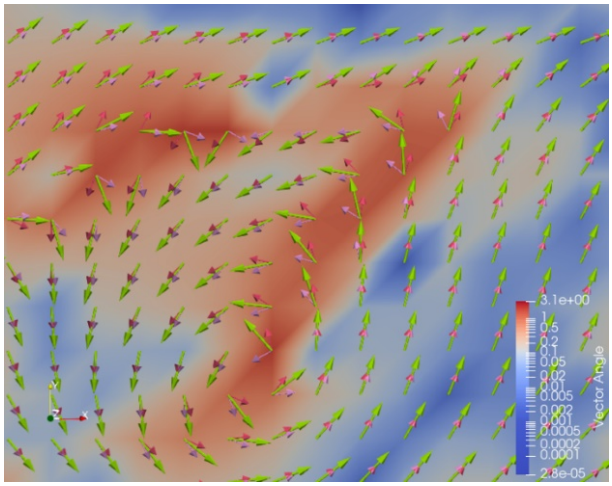
Part 2: Uncertainty Visualization of a Vector Field [25 pts]

Download the uncertain wind field data wind1.vtk and wind2.vtk located in data/windData. The mean vector field is represented by meanWind.vtk.

1) **[10 pts]** Visualize each vector field using Arrow Glyphs with different colors using the Solid Colors option to generate three images and put them in your report. Now overlay these three images with a color mapped surface to visualize the uncertainty in vector directions as depicted below. Put the resulting image/images in your report.



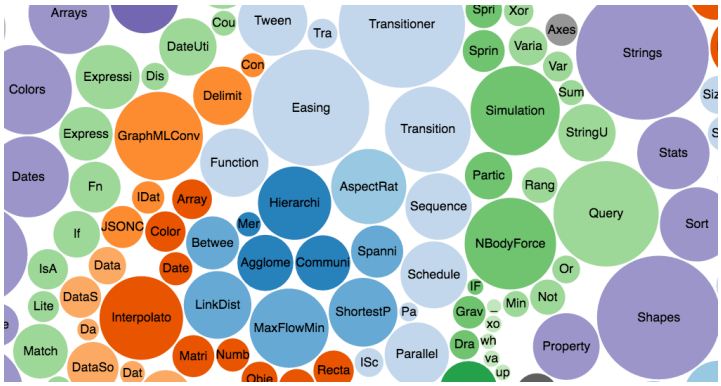
2) **[10 pts]** Now change the color map of the surface to visualize the angle between wind1 and wind2 vector fields. You will need the Append Attributes filter to combine the fields and the Calculator filter to compute the angle. Note that the Calculator's "mag" function computes the vector's length, which is commonly called the vector norm, and the "norm" function normalizes the vector. Then, enable log scale for color maps and use the color map's control points(located below the color map's opacity line editor) to enhance contrast. Then, make the wind1 and wind2 glyphs smaller than the meanWind to make it easier to discern. Show an image of the whole field and one of a turbulent region and put them in your report.

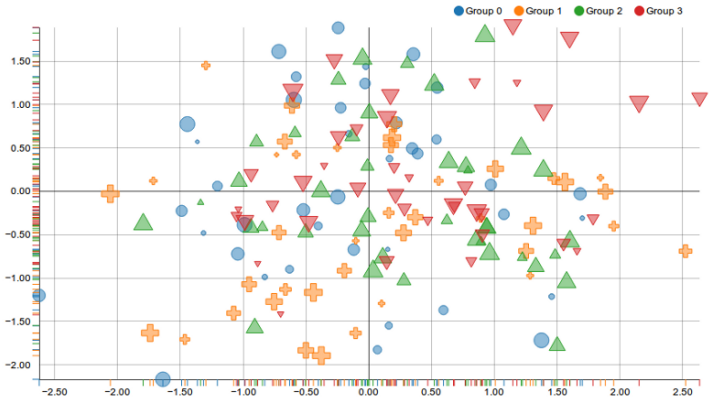


Part 3: Reading questions [20 pts]
These questions pertain to Chapter 39 of The Visualization Handbook: *Extending Visualization to Perceptualization*.

Q1: **[5 pts]** What is preattentive processing, and why is important? Please answer in your own words.

Q2: **[5 pts]** What types of preattentively processed features are used in the following two visualizations? Please answer separately each image. Try to identify as many relevant types/classes as possible.





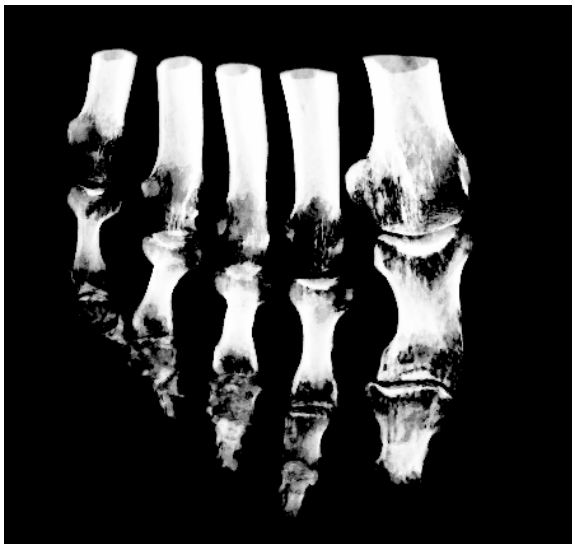
Q3: **[10 pts]** We have created many visualizations in previous assignments. Select one visualization that you have created from a previous assignment that may not be perceptually significant. State what you can do to improve the perceptualization and try to re-visualize it in ParaView. (Images of your previous visualization and the new design should be in your report.)

Part 4: Color Maps [20 pts]

Color maps are very important in conveying information in data visualization. Load the data under the part4/ directory in ParaView, visualize it using different colormaps provided in Paraview: “Cool to Warm” and “Rainbow Desaturated”.

Now make a custom colormap using the website https://sciviscolor.org/colormovesapp/. To use the tool, you will need to create a reference image of the dataset which you drag and drop into the ColorMoves window. To create the reference image, you will need to follow this guide: https://sciviscolor.org/colormoves/float-files/instructions/ The current link is broken, so this is a cached version.

The first one should be white and by also modifying the transfer function in ParaView and the background, you should be able to just show the bones similar to this.



Now, make a color map with two color maps within it, one colormap for the bone and another for the flesh. Here is an example:

More details can be found here if needed https://sciviscolor.org/colormoves/overview/. Save your colormaps as an XML file and import them to ParaView, there is an Import button under Choose Preset and it will come up at the bottom when searching for all.

Compare differences of visualization of all four colormaps. State pros and cons of these colormaps. Include images in your report to support your conclusions.

Conclusion: [5 pts]

As part of your report, compare and contrast results and note any interesting observations when exploring data from the assignment. You can also elaborate on challenges faced when implementing the project. In addition, tell us what you learned from this assignment and add appropriate references, if any.

What to turn in:

Write a **report documenting your results**, including any necessary plots/figures, and answering any questions asked above. Be sure to explain any figures you submit and to write a **conclusion** at the end of your report. Your homework is primarily graded upon your report. Please submit your report on Canvas in PDF format. Please also submit your code/.pvsm files as compressed zip files.

- Your report should be in PDF format and should stand on its own.
- It should describe the methods used.
- It should explain your results and contain figures.
- It should also answer any questions asked above.

- It should cite any sources used for information, including source code.

Note: Any figures/plots in the report should be captioned appropriately. Also be sure to include axis labels in all plots.

This homework assignment is due on **May 1, 2024 by 11:59 am**. If you don't understand these directions or have questions, please send questions to teach-cs6635@sci.utah.edu or come see one of the TAs or the instructor during office hours **well in advance of the due date.**