Written Exam „Data Visualization“, February 11, 2019

Last Name: ..... First Name: .....

Mat.-No.: ..... Program: .....

Scores

Introduction 8 Pts	**Perception** 5 Pts	**Variables** 8 Pts	**Multivariate** 10 Pts	**Relations** 9 Pts	**Time** 5 Pts

Interaction 8 Pts	**Intro SciVis** 8 Pts	**Preparation** 8 Pts	**Volume Vis** 8 Pts	**Flow Vis** 8 Pts	**Total 85 Pts**

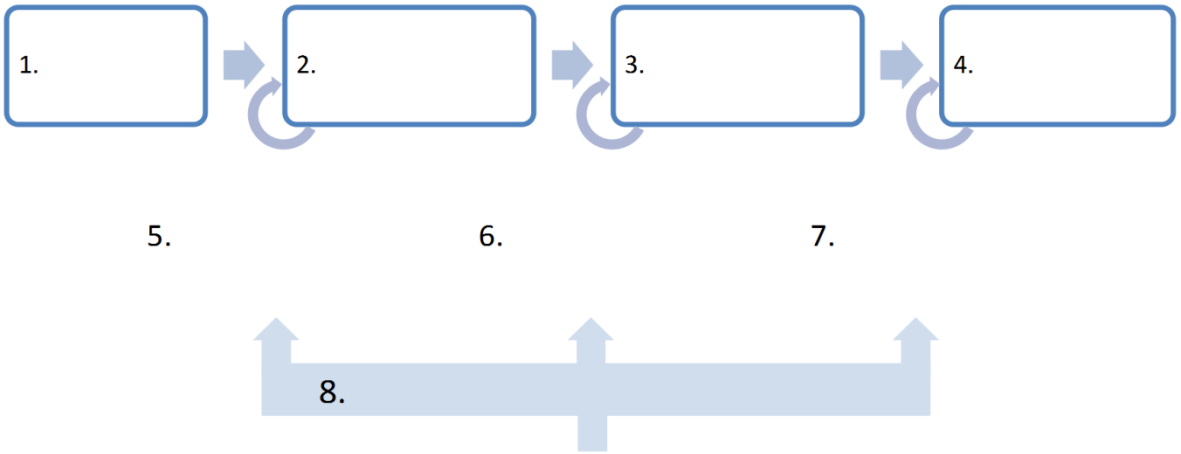
Instructions and Advices

- **All mobile phones and electronic devices must be switched off!**
- No other aids other than writing instruments (blue or black pen) and these prescribed test sheets are permitted!
- **Any attempt to cheat will result in the exam not being passed**.
- Please have your student and identity card ready.
- Please leave the exam sheets stapled together and do not remove any sheets.
- Own sheets are not permitted! At the end you will find an additional page if there is not enough space for the answers. Make it clear which notes, sketches, etc. are not to be evaluated or do not belong to the solutions.
- Please write in a concise form and clearly legible, as **unreadable answers will not be evaluated.**
- In total, a maximum of 85 points can be achieved, behind each task you will find the assigned points, e.g. [6 Pts].
- Duration of the exam: **90 minutes.**

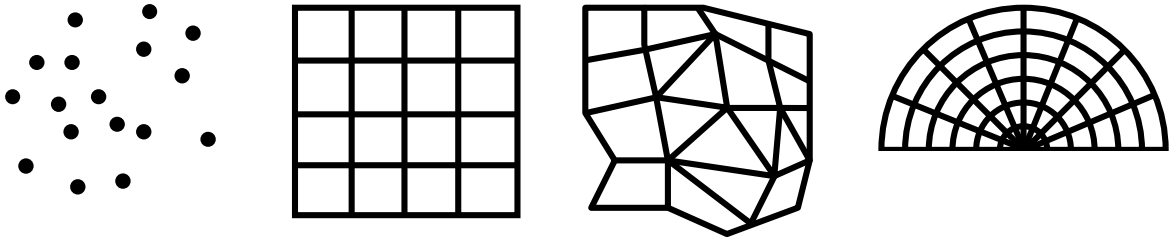
We wish you a successful examination!

1. Introduction [8 Pts]

1. Complete the visualization pipeline by adding the names of individual representation forms (1.-4.), the transformation steps (5.-7.), and the users' influence (8) in the graphic below. [4 pts]



2. Name the following grid types (a) – (d): [2 Pts]



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

3. Give 2 examples of data sources for each of the following value ranges: [2 Pts]

Value range type	Data sources
nominal	
ordinal	
metric	

2. Perception [5 Pts]

2.1 What is preattentive perception? Explain the term, state the time in which it typically takes place, and briefly describe the influence of the number of distracting objects. [2 Pts]

2.2 Name (and, if necessary, sketch) four examples of preattentively perceptible visual variables. Give an example of how the combination of two features can no longer be perceived preattentively. [3 Pts]

3. Visual Variables [8 Pts]

3.1 Out of all the following variables, find the (one) visual variable that is the most effective for each of the data types below. [3 Pts]

angle, area, color hue, color saturation, connection, density, length, shape, texture, volume

Most effective for the data type…

… quantitative: _____

… ordinal: _____

… nominal: _____

3.2 Attention is needed when using color! Describe 2 problems regarding human perception that can occur with *color* as the visual variable. [2 Pts]

3.3 a) Regarding color palette design for nominal data, which color space is usually used to maximize *linear separation*? [1 Pt]

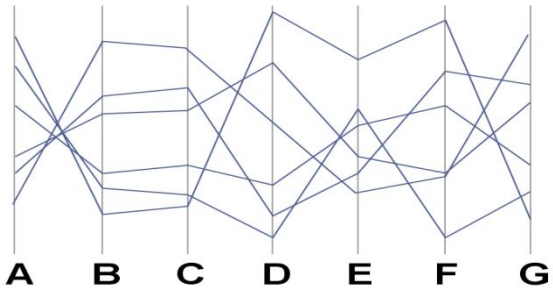
b) Describe a method for color palette generation utilizing *maximized linear separation* in the last-mentioned color space. [2 Pts]

4. Multivariate Data Visualization [10 Pts]

4.1 For the visualization of trivariate data, the Scatterplot Matrix was developed. Draw a basic visualization example for the comparison of apartments with the parameters *rent*, *number of rooms* and *square meters* in a Scatterplot Matrix. Simply select fictitious data from 4 apartments (please pay attention to the correct axis assignments). [3 Pts]

4.2 The Scatterplot Matrix is one technique to extend a Scatterplot to visualize three or more variables. Name two other approaches how Scatterplots can be extended for visualizing trivariate data. [1 Pt]

4.3 a) What is the name of the following visualization technique? State what the axes (A-G) and the diagram lines represent. Explain the advantages and disadvantages (at least 2 in total) of this technique. [3 Pts]



Name:

Axes represent…

Lines represent…

Advantages:

Disadvantages:

b) The axes can also be arranged differently. Name and sketch the resulting visualization technique. [1 Pts]

4.4 When visualizing multivariate data, a distinction can be made between techniques primarily providing object visibility and those that support attribute visibility. Explain these two terms. [2 Pts]

Object visibility:

Attribute visibility:

5. Visualizing Relations [9 Pts]

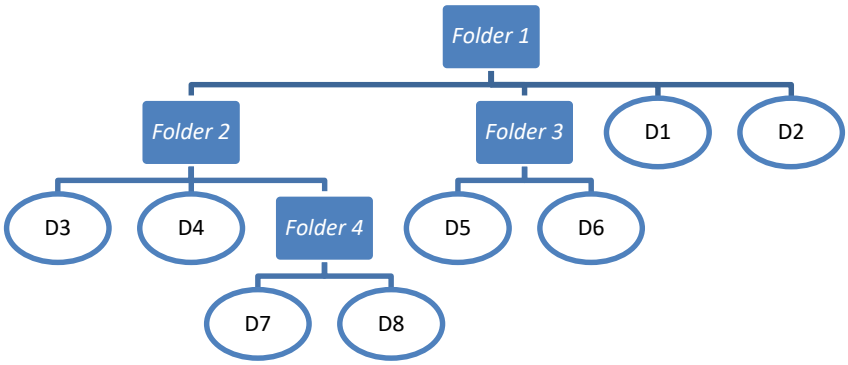
5.1 Tree visualizations can be divided into three main groups*: node-link diagrams*, *space filling approaches*, and *layered approaches*. For each group, explain the advantages and disadvantages, and give a sample technique of your choice (with sketch and short description). [6 Pts]

1. *Node-link diagram:*

2. *Space filling approaches (enclosure):*

3. *Layered approaches:*

5.2 Given is the following hierarchy of folders and files (D1-D8). All files have the same size.



Draw a corresponding Treemap for this hierarchy. [3 Pts]

6. Visualizing Time-Varying Data [5 Pts]

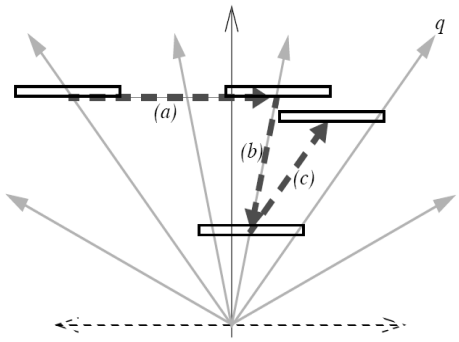
6.1 What are the three fundamental approaches for mapping time-oriented data? Name advantages and disadvantages for each approach. [3 Pts]

6.2 Characterize radial time visualizations and state their advantages. Give two examples. [2 Pts]

7. Presentation and Interaction [8 Pts]

7.1 State and briefly describe Shneiderman's Mantra. [2 Pt]

7.2 Define the term Space-Scale-Diagramm (SSD)! Which operations are characterized through the trajectories a, b, and c? [2 Pts]



Definition:

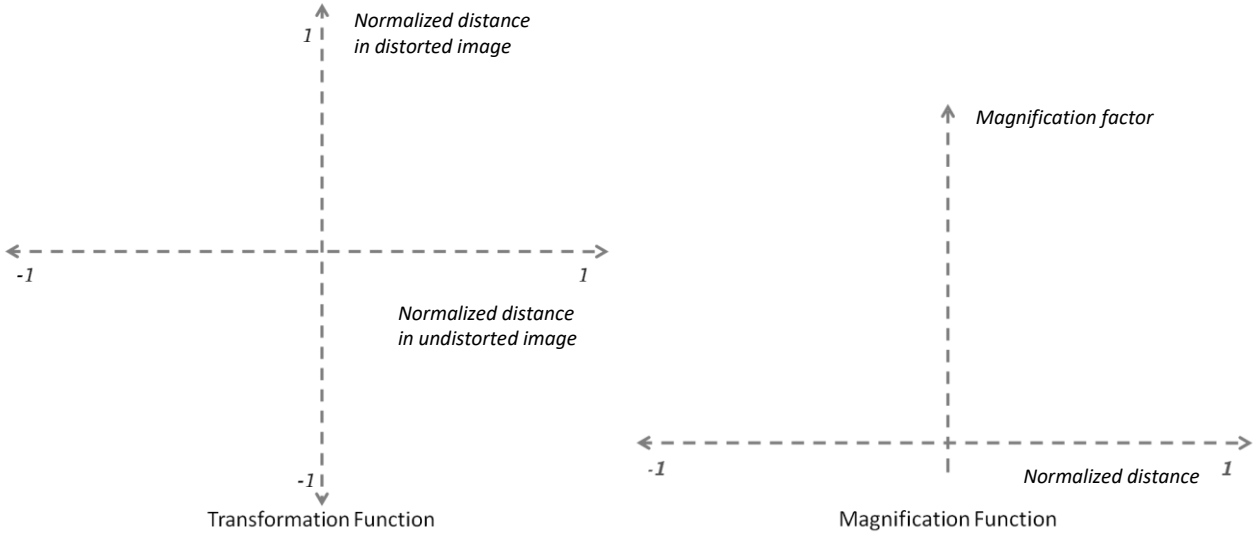
(a) …

(b) …

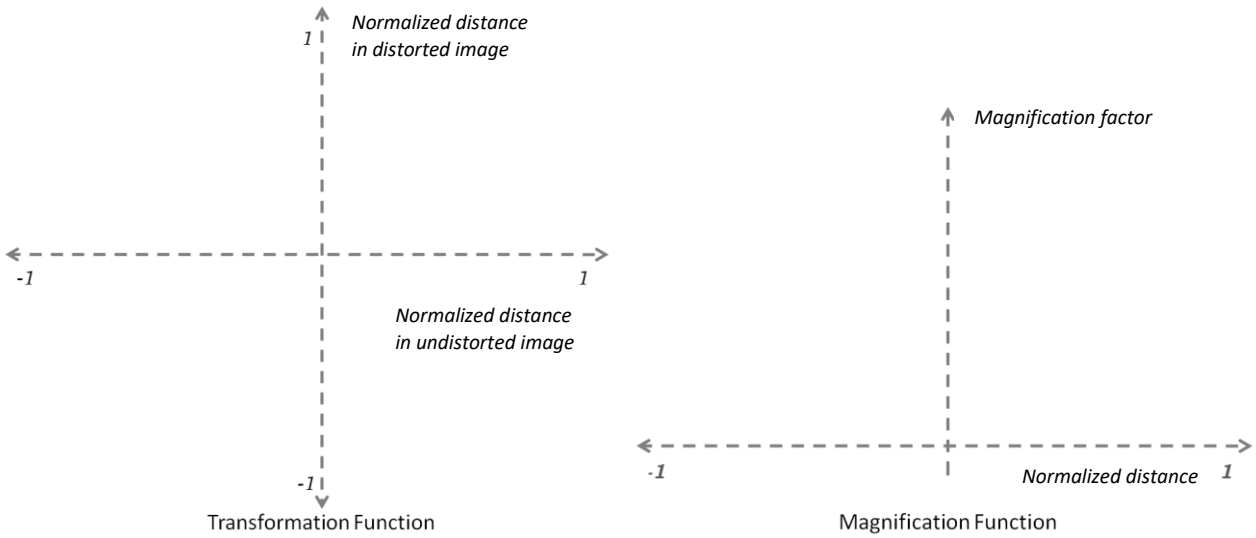
(c) …

7.3 Select two of the techniques *Bifocal Display*, *Polyfocal Display*, *Graphical Fisheye View* and *Perspective Wall* and draw the corresponding transformation and magnification functions in the following diagrams. [4 Pts]

Technique 1: _____



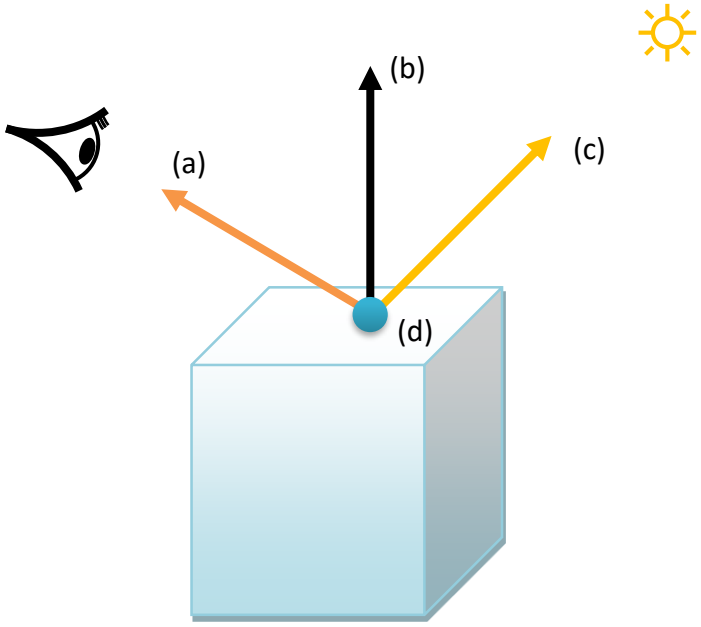
Technique 2: _____



8. Introduction to Scientific Visualization [8 Pts]

8.1 How can you compute the surface normals of an iso-surface? [1 Pt]

8.2 Name the vectors (a)-(c) and the surface parameter (d) that are required for basic lighting calculations (e.g. in Blinn-Phong). [2 Pts]



(a) ...

(b) ...

(c) ...

(d) ...

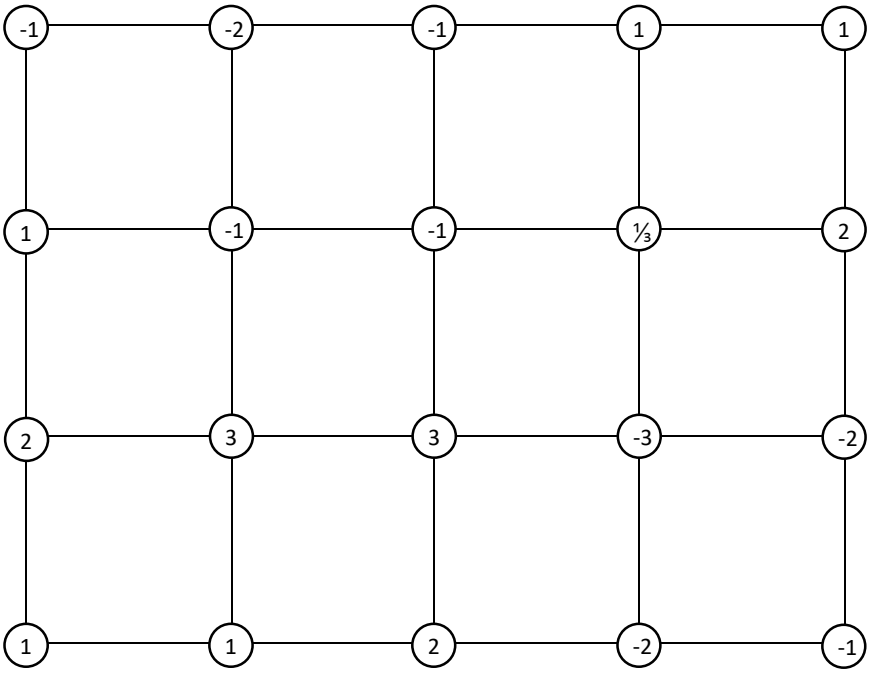
8.3 Given the following regular grid with a function value sampled at each grid point (written in the circle). Draw the iso-line(s) for the function value $v = 0$ that would be produced by the Marching Squares algorithm.

a) For each edge of the grid cells, mark the intersection points and draw as exact as you can. [2 Pts]

b) Mark/hatch all the cells where ambiguous cases occur. [0.5 Pts]

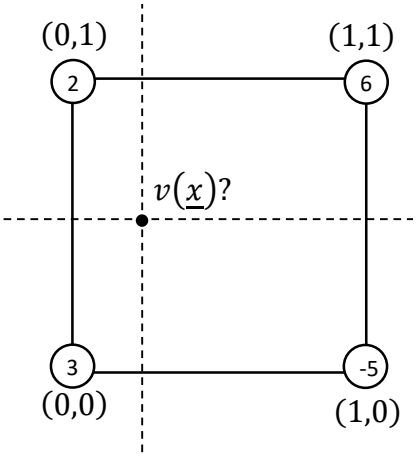
c) Resolve ambiguous cases by explicitly calculating the function values in the centers of the affected cells and decide by value threshold. [1.5 Pts]

d) Draw all the iso-line(s) into the sketch. [1 Pt]

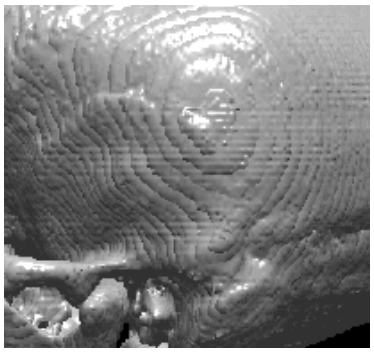


9. Data Preparation [8 Pts]

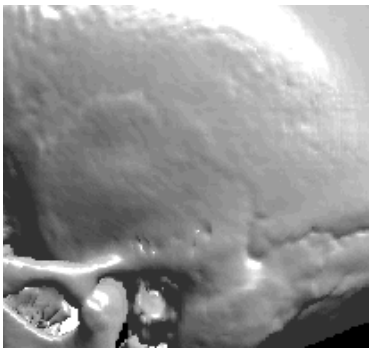
9.1 Given is one cell of a regular grid with function values $v_{i,j}$ (written in the circles) on every grid point. Determine the value $v(\underline{x})$of the query point $\underline{x} = \begin{pmatrix} 1/4 \\ 1/2 \end{pmatrix}$ via bilinear interpolation. [3 Pts]



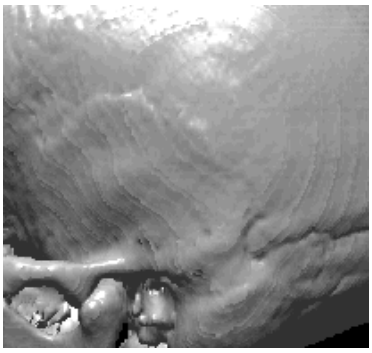
9.2 The pictures show the same volume data, but different approaches for the computation of the surface normals were used. Assign the right technique to the renderings (a) – (c): *Forward Differences, Central Differences, Sobel Operator* [1 Pt]



(a) _____



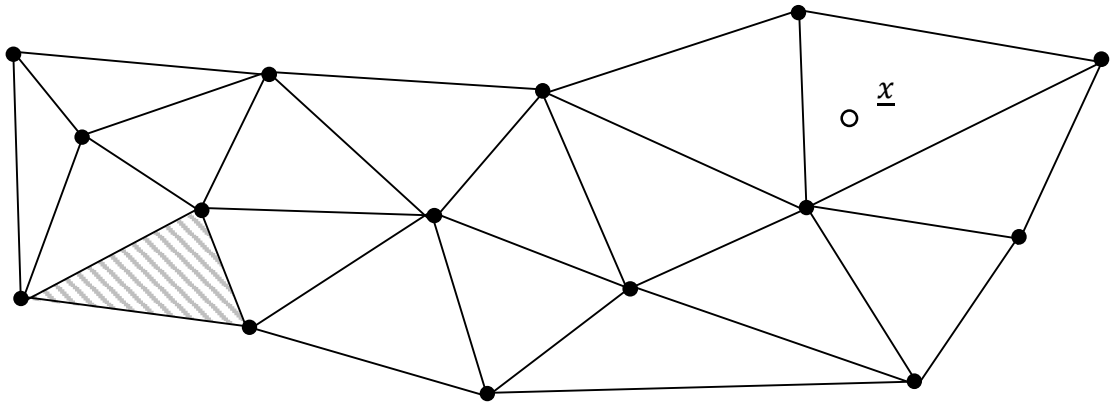
(b) _____



(c) _____

9.3 Describe a case where the results of the *central differences* deviate strongly from those of the *forward differences*. [1 Pt]

9.4 Given the following triangle mesh.



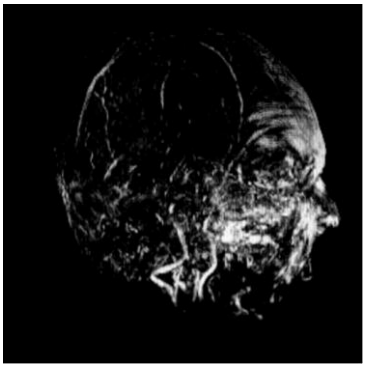
a. Describe an algorithm how to find the triangle that contains the given target point $\underline{x}$ starting with the marked/hatched triangle. [2 Pts]

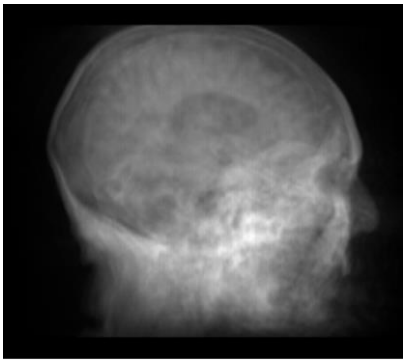
b. Label the triangles in the sketch that got visited by the algorithm in the correct order (e.g. use numbers). [1 Pt]

10. Volume Visualization [8 Pts]

10.1 Compare direct and indirect volume visualization. What are the basic approaches? What are the general differences? [2+2 Pts]

10.2 Assign the following compositing methods for direct volume rendering to the pictures (a) – (c): *max, average, first* [1 Pt]





(a) (b) (c)

10.3 What is the purpose of a histogram when designing a transfer function? [1 Pt]

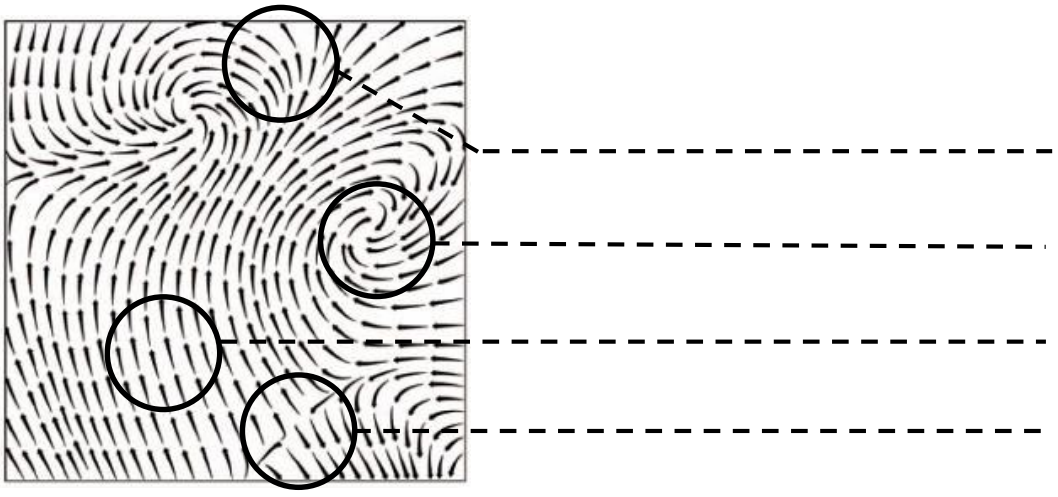
10.4 Assign the techniques to either direct or indirect volume rendering: [2 Pts]

Technique	Indirect	Direct
Shear Warp	☐	☐
Dual Contouring	☐	☐
Marching Cubes	☐	☐
Raycasting	☐	☐

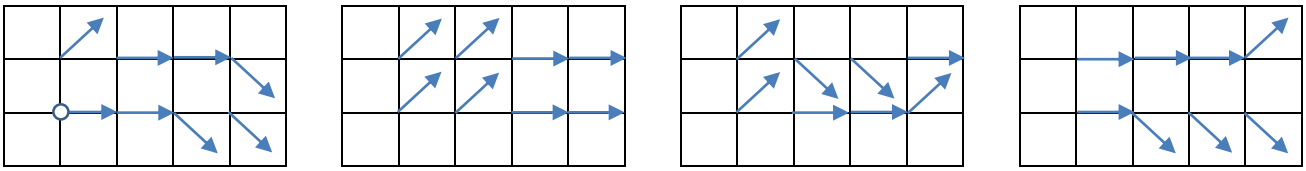
11. Flow Visualization [8 Pts]

11.1 Describe a common mathematical approach to analyze the local environment of critical points. [2 Pts]

11.2 Describe the properties of the regions marked in the picture with the following attributes: *divergent, convergent, saddle, left/right turning, spiral, harmonic* [3 Pts]

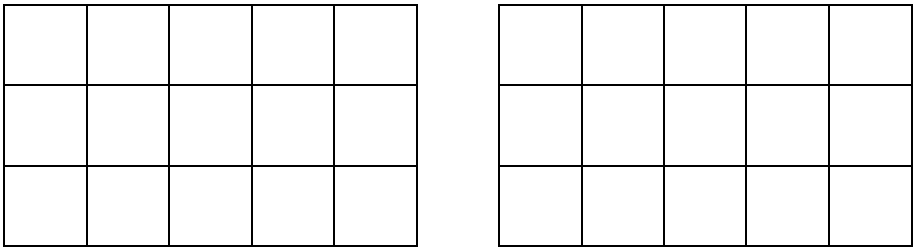


11.3 Given is a progressive flow field in successive time steps $t_0 .. t_3$



t_0 t_1 t_2 t_3

Draw the following characteristic lines in the sketches below starting with the marked grid point: *path line, stream line for* t_2 [2 Pts]



path line stream line

11.4 How can you extend *Integrate and Draw* methods to visualize the strength and orientation of the vector field at a given sample position? [1 Pt]