KTH Stockholm
CSC :: CST
Visualization, Autumn 2018
DD2257
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Test Exam

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General Instructions: Please read the following carefully before proceeding to solve the tasks!

- You have 2h time to finish the exam.
- You are allowed to use 4 pages (2 double-sided sheets, or 4 one-sided sheets) of hand-written notes.
- You are allowed to use a non-programmable calculator.
- Please answer the questions in English.
- All tasks specify how detailed the answer should be (written in italics).
- Do **not** write on the question sheets.
- **Return** the question sheets together with your answers.
- The exam consists of 7 tasks.
- You can obtain 100 points. If you obtain at least 50 points you will pass the exam.

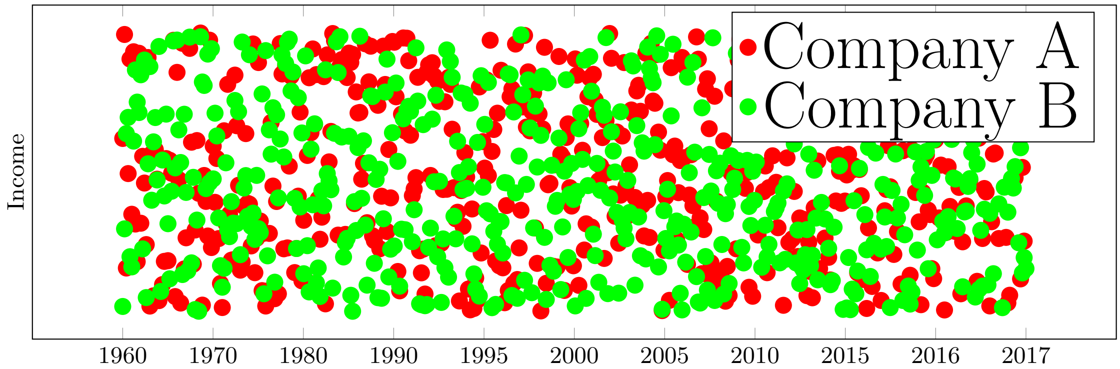
All the best!

Note: This is a text exam!

- The questions are from previous exams.
- The amount of expected work will be similar in the real exam.
- There are too many topics in this course to cover all of them in one exam. Therefore, any exam covers a selection of topics. The selection shown in this test exam may not coincide with the real exam.

Task 1: Critique of a Visualization **9 Points**

The following scatter plot shows the income of the employees of two companies. Criticize this visualization! List three issues where this visualization violates good practices. *(3 short sentences.)*



Task 2: Cell Lookup in a Uniform Grid **4+4+4+4 Points**

Consider the following uniform grid:

$$\mathbf{b}_{\min} = \begin{pmatrix} -3 \\ 6 \\ 0 \end{pmatrix} \qquad \mathbf{b}_{\max} = \begin{pmatrix} 24 \\ 24 \\ 9 \end{pmatrix} \qquad\qquad n_x = 10,\ n_y = 10,\ n_z = 10$$

where the points $\mathbf{b}_{\min}$ and $\mathbf{b}_{\max}$ span the bounding box and n_x, n_y, n_z are the number of grid vertices in each dimension. As usual, the grid vertices are denoted using an index triplet (i, j, k) with $0 \leq i < n_x$, $0 \leq j < n_y$, $0 \leq k < n_z$.

Determine the grid vertices required for trilinear interpolation at the following coordinates!
(It suffices to write down the index triplets.)

(a) $\mathbf{p}_a = \begin{pmatrix} -1 \\ 11 \\ 4.5 \end{pmatrix}$

(b) $\mathbf{p}_b = \begin{pmatrix} 11 \\ 9 \\ 9 \end{pmatrix}$

(c) $\mathbf{p}_c = \begin{pmatrix} 6 \\ 8 \\ 6 \end{pmatrix}$

(d) $\mathbf{p}_d = \begin{pmatrix} -1 \\ 7 \\ 10 \end{pmatrix}$

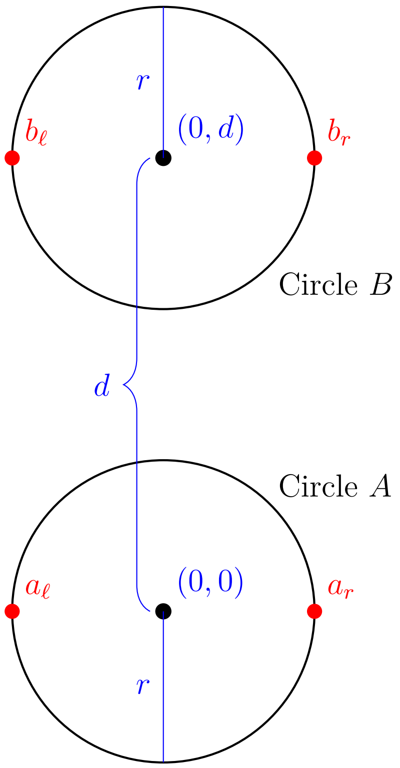
Task 3: Curvilinear Grid between two Circles **16 Points**

Consider two circles A and B in 2D with a radius of r and a distance between their centers of d. Assume that the circle A is centered at the origin and that circle B is centered at $(0, d)$. Let us denote the left-most and right-most points of the circles with a_ℓ, a_r and b_ℓ, b_r. See Figure 1 for the setup.

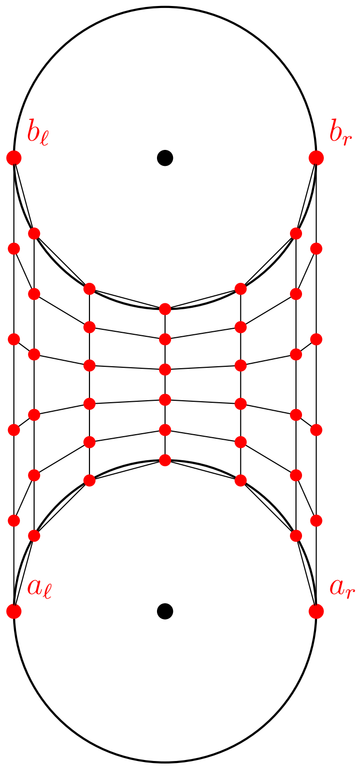
Create a curvilinear grid between these circles with a_ℓ, a_r and b_ℓ, b_r as the corner vertices! Describe the curvilinear grid using coordinate functions for the grid vertices such as $x(i, j)$ and $y(i, j)$, where i, j are the indices of the vertices! *(It suffices to just write down the formulas, but a derivation (Härledning) is appreciated.)*

(Hint: The coordinates of points p *on a circle with radius* r *can be described as*

$$\mathrm{p}(\alpha) = \begin{pmatrix} r\cos(\alpha) \\ r\sin(\alpha) \end{pmatrix}$$



(a) Overview of the setup.



(b) Final curvilinear grid. In this example, the grid has 7×6 vertices.

Figure 1: Two circles A and B with radius r and a distance between their centers of d. The points a_ℓ, a_r and b_ℓ, b_r are the corners of the curvilinear grid.

with $\alpha \in [0, 2\pi)$ ***being the angle on the circle.)***

Task 4: Bilinear Interpolation in the Unit Square **2+8+2 P**

Given is the bilinear function $f(x, y)$ with $f(0, 0) = 3$, $f(1, 0) = 2$, $f(0, 1) = 2$, $f(1, 1) = 3$ as shown in Figure 2.

(a) Compute $f(0.5, 0.5)$.

(b) Determine the formula for the gradient of the given f.

(c) Compute the gradient at $(0.5, 0.5)$.

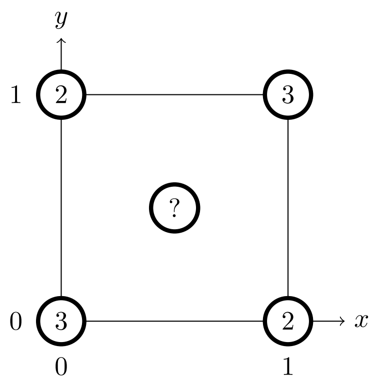


Figure 2: A bilinear cell of a 2D scalar field.

Task 5: Classic LIC versus FastLIC **8+8 Points**

Consider the 2D vector field $\mathbf{v}(x, y) = (1, 0)^T$ and a 2D texture with the dimensions 256×256. How many stream lines need to be computed to convolve the texture when using:

(a) the classic LIC algorithm. ***(one number)***

(b) the FastLIC algorithm. ***(one number)***

Task 6: Stream Lines and Path Lines **8+8 Points**

Consider the vector field

$$\mathbf{v}(x, y, t) = \begin{pmatrix} \cos(t) \\ \sin(t) \end{pmatrix}.$$

Sketch the stream lines and the path lines of $\mathbf{v}$. Indicate any assumptions that you make!
(A rough sketch in 2D suffices. Do not draw in 3D or space-time! If you choose a parameter, or fix some other value, make sure to indicate your choice.)

Task 7: Critical Points in Gradient Vector Fields **5+10 Points**

Consider the vector field $\mathbf{v}(x, y)$ which is the gradient of a scalar field, i.e., $\mathbf{v}(x, y) = \nabla s(x, y)$. It is known that not all types of critical points can appear in a gradient vector field.

(a) Which types of critical points can appear in a gradient vector field $\mathbf{v}(x, y)$? ***(List of critical point types.)***

(b) Proof your statement from (a)! ***(A proper proof or argumentation is required.)***