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Exercise 1 (2 points). One of the problems that the paper "Visibility Equalizer" faces consists in rendering a large set of molecules in realtime. Explain why this is difficult to achieve at a high framerate, and how it is addressed.

It is difficult to achieve a high framerate due to the sheer amount of molecules that have to be rendered. The way it is addressed is to clip and discard the molecules that are occluded, and after the user has "equalized" the molecules through a set of coloured sliders, there are two ways to improve visualization through this clipping+discard method:

- In object space, object-space probabilistic clipping is used, each instance is given a probability *p* in [0..1]; if *p*=0 the instance is clipped (and thus discarded), and if *p*=1 it's not; but if *p* in (0..1), then there's a *1-p* probability that the instance will be clipped. The user can also fine-tune with, for example, a slider, the maximum distance at which probability starts decreasing.
- In view space, occluder removal is done through occlusion queries in order to get the elements in which the user wants to focus on. There are two passes: in the first one, offscreen, the focused objects are rendered to the stencil and depth buffers. The second one will draw all objects if they do not pass the depth-stencil test calculated before.

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Exercise 2 (2 points). We found a dead elephant and want to analyze if its death was due to hunting, or natural. We have scanned the body, which yielded a dataset of 20000x6000x4000 voxels. Since we are looking for important damages, we are mostly interested in analyzing the bones, and thus, we have defined a transfer function that renders the bones opaque, the skin semi-transparent, and the rest is transparent. We are having issues to render the model in realtime, due to the high cost of ray traversal. What acceleration technique could greatly help solving this problem? Justify the answer.

The main bottleneck, according to the statement, is the cost of ray traversal.

This can be mitigated by generating less rays: given that the only interesting areas are those that have skin and bones, those are the ones we are mostly interested in shooting rays. These areas can be identified by any sort of adaptive image sampling, such as tile-based sampling which evaluates the most important image blocks of each sample.

On top of that, we can use empty-space skipping to produce a tighter bounding box (which will not cast rays if they are not going to hit into it) and also skip any voxels that don't have neither skin nor bones inside it.

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Exercise 3 (2 points). What technique can be used to illustrate the changes in the white matter, and how is it calculated?

The technique that can be used is DTI, or Diffused Tensor Imaging. The calculation is done by calculating the diffusion of water molecules in at least 6 different directions (for instance, for each axis a displacement on both a postive and negative factor) with respect to the original signal or image, along with a weighted diffusion coefficient, which models the molecule displacement as a 3x3 covariance matrix.

This information can be used to obtain a decreased signal by using a Stejskal-Tanner solver of the form $S_{new} = S_{orig} \cdot e^{-wD}$**,** where the D is the diffusion coefficient, w its weight and S_{orig} the original signal/image. The result will cancel out the stationary molecules and intensify those molecules in movement. S_{new} is a 3x3 matrix that is composed of 3 orthogonal eigenvectors representing the tensor points in the X, Y, Z coordinates for each matrix column.

Exercise 4 (2 points). In this web: https://georgekatona.com/vivicitta/index.html, you can see a visualization of a marathon. From the point of view of perception, discuss the advantages and shortcomings of the selection of color for the runners.

The colour selection by itself is good, as it provides good contrast against the other elements of the chart; this is due to the fact that the river's light blue and the athlete's dark pink are complimentary colors. The homogenization also allows us to deduce clusters of athletes and how they evolve through time.

Although a separator or an intensity difference for the athletes in the loops (or crossing paths) could have improved visualization in order to not overlap athletes that are shown in the same "position" in the path, but some are coming into the loop while others are exiting it; by the looks of it, someone could interpret that the athletes are crashing or doing an effort avoiding each other!

That said, the colour selection homogenizes everyone and it doesn't provide enough information (or options) to classify or differentiate those runners: how do I know the genders of these runners, or how do I classify those runners between the casual runners and the elite ones, for instance?

The only way to compare is by individually filtering each runner, which can be done by writing the number of the athlete in the search box. But, when an athlete is selected*, the colour hue for the unselected athletes turns from the intense pink to a softer one, and the loss of contrast can make visualization a bit harder as the river has a similar intensity.

(* Although it's not a colour issue, there is an additional problem: the developer has not provided a list of numbers per athlete, making difficult to look up for a valid athlete – and it only displays *where* that athlete is, not any extra information regarding *who* he/she is.)

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Exercise 5 (2 points). We want to analyze the performance of the 50 students of a degree course for the last 10 years. We want to know how many of them are getting grades in the range A, B, C, D, and E. In order to do so, somebody has designed a set of 10 pie charts that encode the number of students in each grade for each course. As a student of SV, evaluate the selection of the visualization technique, justify your answer.

This visualization would be a compact one for each pie. Moreover, we would know for certain that the sum of all values in all ranges is 50.

However, comparisons between distinct years would be complicated, especially if the grade's origin point is distinct on each chart (B, C, D being the most affected grades), as anyone reading this chart has to mentally add an "offset" so that both items to compare start on the same level (and make comparisons easier). This becomes worse if the number of students per grade is not written or labeled. This reason also makes comparisons in the same pie between the number of students per grade difficult

I believe that the pie chart was not the appropiate type of chart to use. Instead, a bar plot per year would mitigate most of the issues that the pie chart has while keeping an appropiate representation, at the exchange of some compactness.