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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.

There are two major issues to face when rendering molecular models in realtime. First, the complexity of the models, second, its changing nature.

Molecular models are commonly represented with atomistic visualizations, that require rendering one sphere per atom. Rendering a sphere with high resolution implies a high number of triangles, and molecules have a lot of atoms. This results in very large numbers of triangles that can be difficult to render in realtime. The second issue is that, in molecular rendering in general, the atoms are moving (each one independently) continuously. This poses difficulties into adding pre-calculated structures that are able to cope with the limitations of the number of triangles. In this paper, they have a related complication, which is the fact that the elements may be occluded interactively. This is a problem equivalent to the moving of the atoms in molecular rendering, since it prevents the user to use precalculated structures.

The way the Visibility equalizer addresses these limitations is by making an intense use of instancing features of GPU rendering. By using instances, one can reduce the number of objects sent to the GPU since we are reusing the same geometry, only changing the transformations applied in a per-object basis.

Besides, they use other techniques to perform the clipping of objects in a fast way, such as occlusion queries, and compute shaders that accelerate the clipping calculations.

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.

Since we only render as opaque and semi-transparent the bones and the skin, there is a lot of volume that will be transparent. Therefore, there are two main techniques that can be used: isosurface rendering, and empty space skipping.

Empty space skipping seems the more sensitive technique to use, since we can guarantee not losing quality, as we would, if using other techniques like downsampling. Note that the model is huge, and the skin will likely be quite thin compared to the size of the model. Therefore, downsampling risks losing a lot of details in the skin and the bones. By creating a data structure that lets us skip empty regions, we can devote the GPU resources into ray marching for interesting regions.

The other technique, isosurface rendering, also makes sense here because we only want the skin to be semi-transparent, and the bones to be opaque. Therefore, we are not rendering much of the volumetric data. In this case, this would also make sense, extract the isosurface, and render it as a triangle mesh, or render the model using ray marching and isosurface detection.

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 to illustrate the changes in the white matter is by rendering the Fractional Anisotropy. Fractional anisotropy measures the fraction of the diffusion that is anisotropic, and it can be thought of as the difference of the tensor ellipsoid's shape from that of a perfect sphere. It is calculated as the normalized variance of the eigenvalues, and it is considered as a measure of the white matter integrity, although changes in FA could be caused by other factors too.

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 indicated webpage uses saturated, pink color to illustrate the runners. From the point of view of perception, this has a major effect, it attracts our attention. The same happens with the particles in movement, too.

However, given that all runners catch our attention due to the movement and the color, we are unable to naturally concentrate on the ones that are in the head. Therefore, all runners compete for our attention the same level, which is not completely desirable when the region they occupy starts to cover a big portion of the screen. It would be more interesting reserving the more saturated color to the first or a small group we want to highlight.

Besides, the way they are painted, individual runners cannot be distinguished. And, there are parts of the path where there are crossings, which makes it difficult to distinguish the relative position of the individual runners.

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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.

Using pie charts for this kind of comparison is clearly not adequate at all. There are several reasons for this: first, our perception of angles is worse than the perception of lengths or positions, second, being unable to estimate angles with high accuracy makes the comparison of the evolution even worse. Moreover, very important, since each pie chart will likely be slightly different, we have not reference angles to compare one year with the next one, since all portions (except for the first one) will start at different positions each year.

As a result, it would be much better using a line chart with five lines, which is low enough to encode them with a different color each. In this scenario, comparisons would be much easier, as well as estimation of values.