# Perceptually Driven Point Sample Rendering

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The field of image science and image processing have long sought to exploit certain characteristics of the *human visual system* (HVS) in the image representation schemes that they employ. The researchers in these fields have realised that there are limits of the human visual system in the intensity, spatial and temporal domain. This allowed them, among other things, to minimize the effect of the noise in the picture while decreasing the amount of memory necessary to store the picture to minimum.

For a long time, the field of computer graphics, namely the image synthesis (also called rendering), had not exploited the limitations of the HVS. In the meantime, the image compression and transmission techniques created by image scientists had routinely been applied to computer graphics pictures. This results in wasted effort as superfluous pictorial information is first synthesized, and then eliminated once the picture had been compressed.

Recently, the limitations of the HVS have been successfully exploited in the field of image synthesis, mainly in the context of global illumination computations [1]. *Global illumination* is a physically accurate calculation of lighting in an environment. It is computationally expensive for static environments and even more for dynamic environments. Very often, the global illumination algorithm is an iterative process, which converges to the correct solution. For a long time, the stopping condition for this process had been expressed in terms of variance of physical measures, although in most of the applications, it is a visual sensation of the resulting image, which is important. It is well known that the visual sensation quality does not correlate with the physical measures. The perceptually driven global illumination algorithms make use of the *computational models of the HVS* [3, 4], which can assess visual difference between two pictures in terms of probability of difference discrimination.

The *point sample modelling and rendering* [5, 6] is a new field in the computer graphics. It builds on the assumptions that a geometric object is modelled by a huge number of points samples of its surface (which is true for laser scanned 3D models) and that each single point is quite unimportant. The point sample representation is well suited for dynamic level of detail (LOD) control, which means that the multiresolution representation of the object is stored with the model and the particular LOD is extracted during the rendering process. The criterions of the LOD selection are various: the prescribed frame rate (number of displayed frames per second), maximal image deviation expressed in pixels, etc. If the LOD selection algorithm is not perceptually guided, then the perceived quality of the final image will vary over the image plane, and the image parts of lower quality will attract the observer's attention.

This research focuses on the *perceptually guided LOD selection in the context of point based rendering system*. The main problem that arises in this context is that the point sample rendering is intended for real time applications, while the computational models of the HVS are quite far from being evaluated in real time. Thus a precomputation of perceptual contents must be carried out and the results of this operation must be encoded with the model. A suitable compression scheme for the perceptual information has to be found, because this information is very view dependent. Also, a special care must be taken to prevent the precomputation process from being unbearably long: either a simplified, *incremental HVS computational model* can be used [7] or/and a modern *graphics hardware* can be used to accelerate the evaluation of the HVS model. Another problem is that the perception of the surface changes very rapidly as the position of the light source is altered. An examination of this dependence can result in general rules expressed as an algorithm, which can then be used by the LOD selection process.

All the HVS models are based on the fact that the HVS's sensitivity differ depending on spatial frequencies of the image. The higher the frequencies of the image are, the less sensitive the HVS is. Another feature of the HVS, *masking*, can be even more important in our application. Because of masking, the HVS is less sensitive to a noise in the parts of the image where the noise frequency and the image frequency is very near to each other. For example, it means that it is hard to distinguish a high-frequency noise in the picture of a treetop, while it is very easy in the picture of a wall. The masking model can be used to predict, whether an error introduced by using a coarser LOD will be perceptible or not. The answer to this question will surely depend on the frequency content of the surface being displayed.

By now, only rendered images are used to assess their quality. As mentioned above, the computational model of the HVS takes two pictures as an input and outputs the probability of difference discrimination. If one of them is a highest quality rendering and the second one is the approximation created by using a coarser LOD, then the model can be used to decide, whether the approximation is good enough. The problem is, that we do not have the high quality rendering. In our application, we would like to have a quality metric that would work *before* rendering an image. Thus, the ultimate goal of the research is to find a general relation between a frequency content of a surface and a LOD needed to represent the surface without introducing the disturbing artefacts. This relation must be able to take into account arbitrary viewing parameters (camera position, orientation, viewing angle) and arbitrary light source position and it must also be fast to evaluate.

**References:**


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