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# ЭФФЕКТ «ЗЛОВЕЩЕЙ ДОЛИНЫ» ПРИ ПЕРЕДАЧЕ ГОЛОГРАФИЧЕСКИХ ИЗОБРАЖЕНИЙ

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Качество компьютерно-синтезированных изображений непрерывно улучшается, что приводит к увеличению объема файлов, содержащих эти изображения. Однако восприятие изображений человеком проходит несколько этапов. Если первоначально усложнение изображения и приближение его к реальному облику человека производят благоприятное впечатление, то потом наступает момент испуга и отторжения. Масахиро Мори назвал это эффектом «зловещей долины». С целью избежать этого эффекта все новые технологии представления внешнего вида человека подвергаются тестированию. Следует уделять особое внимание эффекту «зловещей долины» при сжатии и последующем восстановлении сложных изображений. В настоящей работе показано положение относительно «зловещей долины» 3D-изображений, восстановленных голограммой, синтезированной и переданной со сжатием по радиоканалу в соответствии с патентом RU2707582C1.

***Ключевые слова:*** голография; голографическая информация; 3D-объект; эффект «зловещей долины»; передача информации; 3D дополненная реальность; качество 3D-изображений.

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# «UNCANNY VALLEY» EFFECT IN HOLOGRAPHIC IMAGE TRANSMISSION

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The quality of computer-synthesised images is continuously improving, increasing in the volume of files representing them. It is noticed that passing from simple schematic images to increasingly complex ones, their perception goes through different stages. If initially the complication of the image and its approximation to the real image of a person makes a favourable impression, then there comes a moment of fright and rejection. Masahiro Mori called it the «uncanny valley» effect. Since then, all new technologies for presenting human images have been tested in order to avoid this effect. This effect should be treated especially carefully when compressing and then restoring complex images. This paper shows the position relative to the «uncanny valley» of the reconstructed 3D images, reconstructed by a hologram synthesised and transmitted with compression over the communication channel in accordance with patent RU2707582C1.

***Keywords:*** holography; holographic information; 3D object; «uncanny valley» effect; information transfer; 3D augmented reality; 3D image quality.

As it was shown in [1–4], in order to transmit 3D holographic video content via conventional communication channels, it is necessary to organise a significant compression of holographic information. However, as it was shown in [5], based on the analysis of the current state of work, traditional methods of entropy coding today are far from being able to implement the 106 times compression of holographic information required for such transmission. Therefore, a method was proposed for transmitting 3D holographic information in the form of two main 3D image modalities – 2D texture of the surface of the holographic object and its 2D topographic depth map [6], which allow transmitting 3D holographic information with significant compression, similar to the transmission of a radio signal by SSB method.

In [5–8], the results of the synthesis of such a computer hologram were shown and an experimental test of the possibility of transmitting 3D holographic information in this way with a television frame scan frequency, according to which a computer hologram was synthesised at the receiving end of the communication channel, restoring a three-dimensional image of the holographic object with quasi-continuous parallax and high quality of the restored image, not worse than the Full HD standard.

The quality of the 3D image restored by such a hologram is significantly closer than all previously known methods to the real perception of a human image. Dynamic virtual holographic image is even closer to reality.

And here there is a danger – the so-called «uncanny valley» effect [9], when the degree of similarity of the robot image, or 3D model, approaching the image of the living original does not yet reach one hundred percent coincidence, but it is already close enough. It is difficult to quantify this «close», but before reaching this limit, the 3D model emotionally suddenly begins to be perceived by a person as a danger, as a being of another, incomprehensible and even afterlife (fig. 1).

There are a number of studies of such an emotional reaction of people to the appearance of robots. At first, the results were predictable: the more the robot looks like a human, the cuter it seems, but only up to a certain limit. The most humanoid robots unexpectedly turned out to be unpleasant to people because of minor inconsistencies in reality, causing a feeling of discomfort and fear (fig. 1).

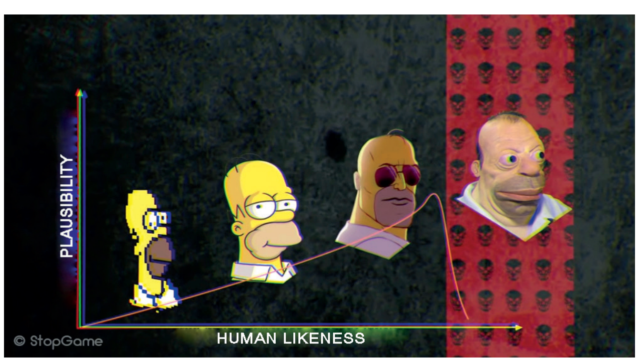
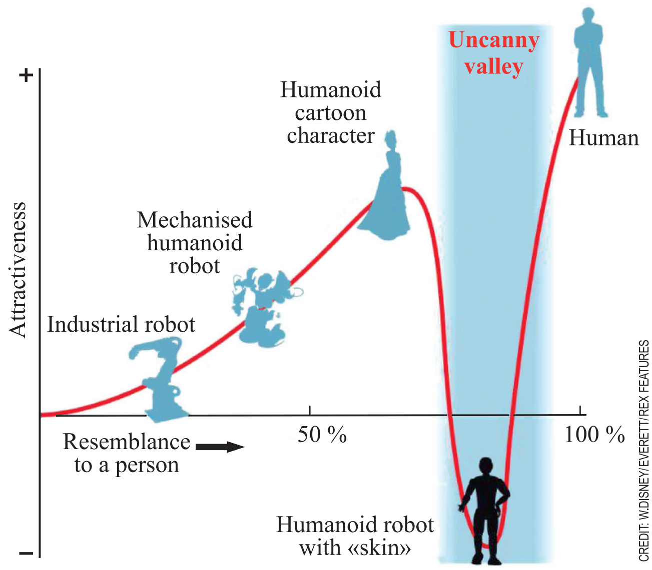



*Fig. 1.* An increase in the degree of human likeness leads, at a certain level, to a failure of plausibility

The unexpected decline in the «sympathy» graph (fig. 2) was called the «uncanny valley», moreover, it was found that animation enhances both positive and negative perceptions manifested near the «uncanny valley». Negative emotions first tell us that such details cannot exist in a living object, it is something inanimate, then, when approaching the image of a living person, negative emotions go through the roof.

*a*




*b*

*Fig. 2.* Emotional assessment of a person:
*a* – with an increase in the degree of human likeness of the image or the observed object has a sharp decline near full similarity;
*b* – a humanoid with «skin»

And only then, with a further increase in the degree of similarity, emotions rise quite sharply, reaching the level of a full-fledged benevolent perception.

Of course, in our research we could not but touch on this problem, although throughout our work in the last 10 years nothing like this has ever been found regarding the 3D images we have studied. This is probably due to the high level of image resolution taken from the very beginning, comparable or even exceeding the standards of today's high-definition television, such as Full HD and 4K. The resulting texture of real 3D images processed in this paper has long been known to us from modern photo and video materials. Figure 3 shows the assembly of images of a colour frame which has been transmitted in a series of frames as a short TV plot. You can also see the image of a living person; you can see both vertical and horizontal parallax.

There is also clearly no «uncanny valley» effect. There is no feeling of discomfort and fear when perceiving these images either in static or in dynamics. This means that the virtual 3D image transmitted and restored in this way is located significantly to the right of the so-called «uncanny valley».

It should also be noted that the depth map of the holographic object obtained in this work and the texture of its surface (fig. 4) are also not perceived as images of hostile humanoid creatures.

*Fig. 3.* Storyboard of the video image
which has been transmitted over the radio channel

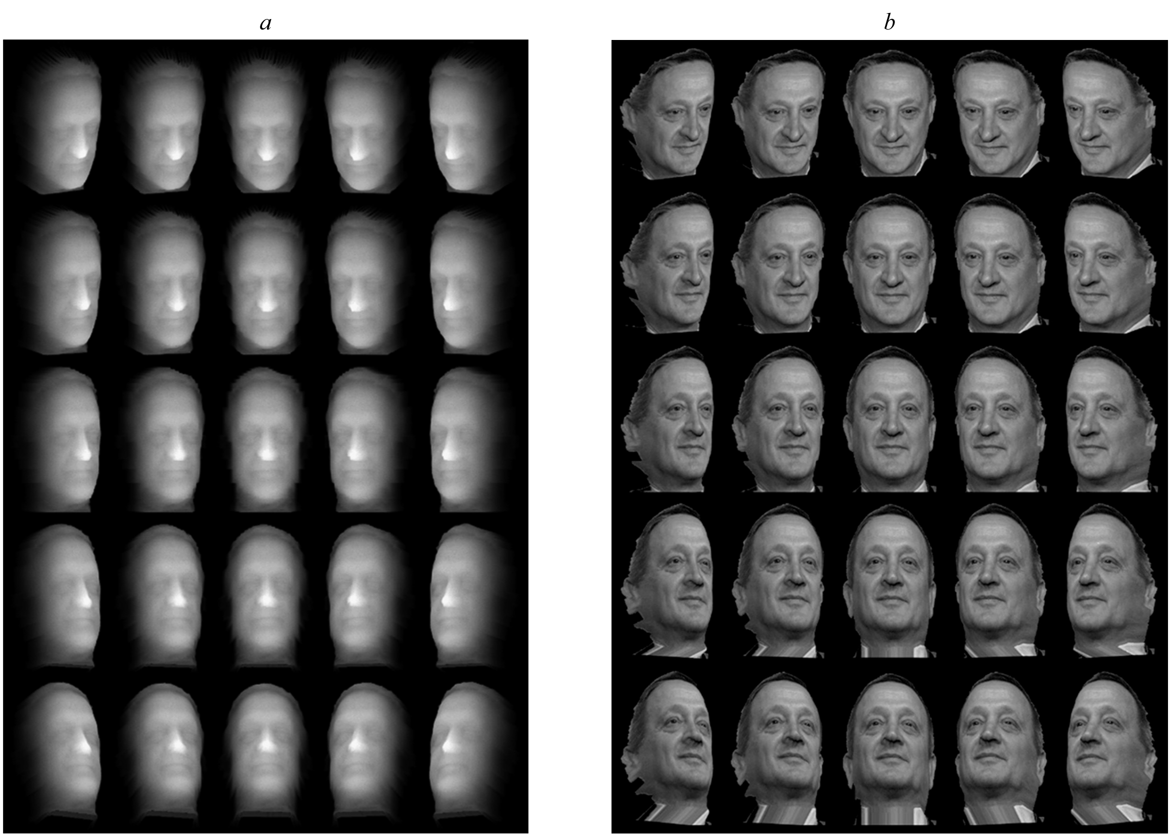


*Fig. 4.* Storyboard of the video image transmitted over the radio channel:
depth maps (*a*); textures (*b*)

Moreover, the assembly in fig. 4, *a*, which shows the parallax of only the depth map of a 3D object (mask), is really perceived as a mask similar to the death mask that we know, for example, from the famous mask of A. S. Pushkin, and therefore somewhat alarming, although it does not cause significant negative emotions. This can be explained by the same «uncanny valley» effect, since the image is already close to the real one, but still different, resembling the smooth surfaces of polygonal technology. But the assembly of texture images in fig. 4, *b*, which have undergone affine transformations corresponding to the isometric projections of the previous two image assemblies, does not cause negative emotions at all.

Comparing the above images with the images in fig. 2, *b*, it can be seen that the 3D polygonal representation, despite the fact that it creates a significantly greater computational load than 3D images under the patent of the Russian Federation No. 2707582C1, that significantly inferior to the latter, which have a smaller amount of information transmitted over the communication channel. Taking as a basis the chart developed in [9], we can add our place on this graph.

The marks I and II shown on the curve (fig. 5) correspond to the emotional assessment of the image (see fig. 4, *b*, and fig. 3). Interestingly, both colour (see fig. 3) and black-and-white frames (see fig. 4, *b*) caused approximately the same sense of perception among the respondents. Marks I and II on the emotional perception curve of a complete 3D colour image (see fig. 3) represent the range of variance of the assessments of a group of 64 surveyed students of different courses. Mark I corresponds to the worst emotional perception of the image restored by the hologram at the receiving end of the communication channel (see fig. 3 and fig. 4, *b*), and mark II corresponds to the best in both fig. 4, *b*, and fig. 3. The range of the spread of the estimated marks I and II on the graph (see fig. 5) did not exceed 5.7 %.

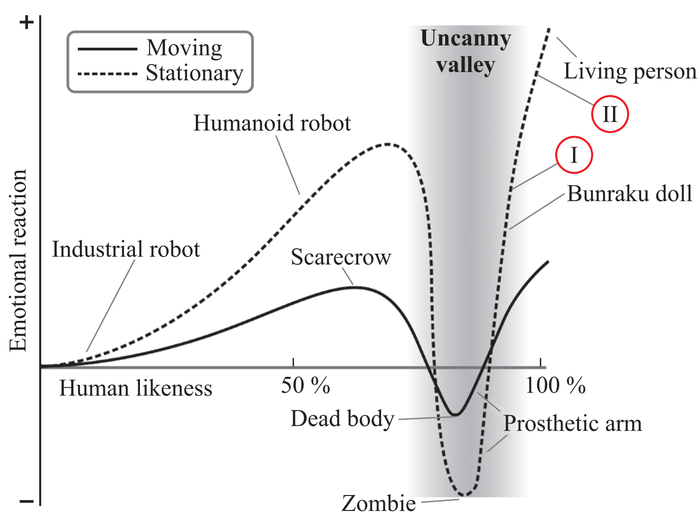



*Fig. 5.* The emotional reaction of a person with an increase in the degree of human likeness of the image of the observed object has a sharp decline near full similarity. Marks I and II correspond to the range of perception of images from fig. 3 and fig. 4, *b*

According to the survey results, it can be concluded that the presented images of 3D portrait projections of a person are perceived as an image of a real, living object, emotionally closer to a living person than to a humanoid bunraku doll, which itself is already evaluated without a sense of fear and is on the graph in the field of positive emotions.

Apparently, such a good result of the evaluation of the presented images is associated with the high resolution of the standard of the photo image used, which transmits even small wrinkles on a person's face, bringing his perception closer to the real one. Together with the image of a 3D mask, this allows you to create quite adequate TV content, closer to 3D augmented reality than 3D content with polygonal graphics, not to mention voxel graphics.

This confirms the viability of the method used in this work for representing a 3D dynamic stream of a holographic image in the form of two streams of 2D dynamic, mutually consistent content, in which each 3D holographic frame is digitally synthesised by two corresponding frames, one of which represents a map of the surface of the object, and the other – the texture of its surface.

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