Physicists create Star Trek-style holograms

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Star Trek's famous holodeck is a virtual reality stage that simulates any object in 3-D as if they were real. However, 3-D holographic projection has never been realized. A team of scientists from Bilkent University, Turkey, has now demonstrated the first realistic 3-D holograms that can be viewed from any angle.

Now, a team at Bilkent University, Turkey, has devised a way to project holograms depicting complex 3-D images. Their method is highlighted in *Nature Photonics*. "We achieved this feat by going to the fundamentals of holography, creating hundreds of image slices, which can later be used to re-synthesize the original complex scene," says Dr. Ghaith Makey, the first author of the paper.

"So far, it has not been possible to simultaneously project a fully 3-D object, with its back, middle and front parts. Our approach solves this issue with a conceptual change in the way we prepare the holograms. We exploit a simple connection between the equations that define light propagation, the same equations that were invented by Jean-Baptiste Joseph Fourier and Augustin-Jean Fresnel in the early days of the field," says Prof. Onur Tokel, one of the lead authors of the paper.

However, in order to reach their goal, the researchers had to introduce another critical ingredient. The 3-D projection would suffer from interference between the constituent layers, which had to be efficiently suppressed. "A technological breakthrough can rarely be traced to a fundamental mathematical result," says Prof. Fatih Ömer Ilday, the other lead author of the paper. "Realistic 3-D projections could not be formed before, mainly because it requires back-to-back projection of a very large number of 2-D images to look realistic, with potential crosstalk between images. We use a corollary of the celebrated central limit theorem and the law of large numbers to successfully eliminate this fundamental limitation."

Prof. Tokel says, "Our holograms already surpass all previous digitally synthesized 3-D holograms in every quality metric. Our method is universally applicable to all types of holographic media. The immediate applications may be in 3-D displays, medical visualization, air traffic control, but also in laser-material interactions and microscopy" says Prof. Serim Ilday of the Bilkent team. "The most important concept associated with holography has always been the third dimension. We believe future challenges will be exciting, considering the vision set by the holodeck, or the holovision of Isaac Asimov in the *Foundation* novels. Even Jules Verne touched upon this idea in *Carpathian Castle*, published in 1892. Clearly, the ensuing decades left us craving for more. We are closer to the goal of realistic 3-D holograms."

More information: Ghaith Makey et al, Breaking crosstalk limits to dynamic holography using orthogonality of high-dimensional random vectors, *Nature Photonics* (2019). DOI: 10.1038/s41566-019-0393-7

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