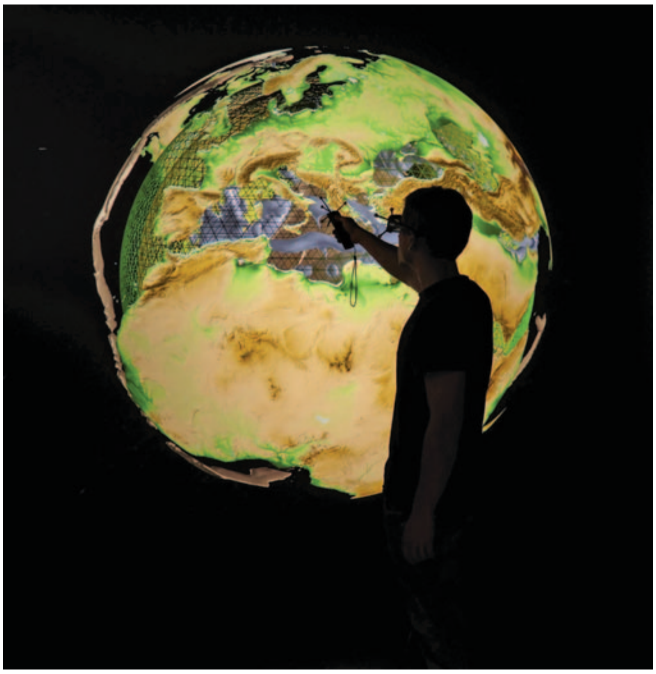
Excitement continues to surround the potential of virtual reality (VR) as researchers explore new applications. Here, a perspective is shared from the Leibniz Supercomputing Centre

From Cardboard to CAVE

The promise of being easily and seamlessly transported into a virtual world and interacting with its imaginary objects or other users has been tantalisingly close to fulfilment for decades. The quest towards this vision has generated a large amount of research as well as some tangible (literally, in the case of haptic interfaces) VR applications during the last four to five decades. However, about 15 years ago the hype seemed to have turned into disillusionment: news releases were sparse, academic activities didn't always make the headlines and VR seemed to disappear from the most used internet searches. To a casual observer it seemed that VR was "not worth the headache", especially as early VR solutions could cause actual headaches (or worse) due to tracking latency, flickering and the low-resolution of the displays.

Against this backdrop, calling the recently renewed interest the 'Renaissance of VR' seems quite justified. The product announcements and launches are numerous: from down-to-earth 'pseudo-VR' gadgets (such as Google Cardboard that turns your mobile phone into a 3D display) to those resembling devices in The Matrix (such as Avegant Glyph that plans to project the video directly into the user's retina). Internet and media giants seem to be betting on VR, either by their own products (the abovementioned Cardboard, HTC Vive and so on), strategic investments (NextVR, backed by Time Warner and Comcast Ventures) or outright acquisitions (e.g. Facebook's acquisition of VR startup Oculus for $2bn (~€1.8bn)). Novel uses of VR are being piloted and tested, ranging from advertisement to training of artisanal skills or public speaking. The general public seems to have a renewed interest in VR, too; after all, anticipated prices of mid-range solutions are expected to drop to "hobbyist" level.

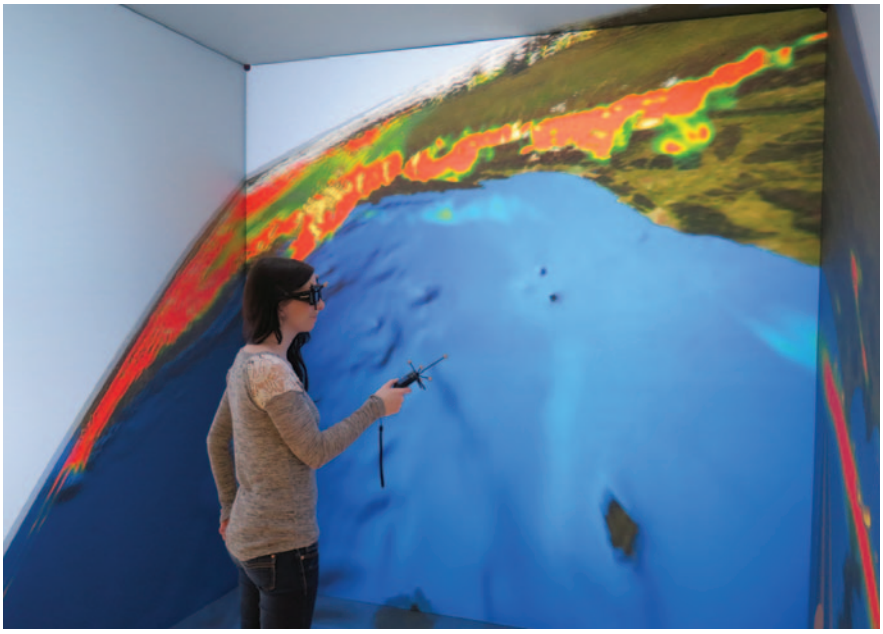


Visualisation of complex data is a progressive VR application

Underlying realities of virtual reality

The rapid improvement of display technologies, especially those intended for the smartphone market, is one of the enabling factors of the VR renaissance. Today a high quality five-inch full HD display is a commodity that can be bought for a few tens of dollars and weighs less than 100 grams. Ten years ago a standard mobile display had 1/50th of today's pixel count – a full HD resolution was desktop only, at over $1,000 (and 10kg). Similar developments in other basic components mean that – unlike ten years ago – it is possible to develop usable VR displays using commodity components. On the input side the VR-related developments have been even more radical: many of the technologies to track users' movements and gestures on the market today were either not invented in 2005 or too expensive for the market.

As with most digital technologies, these underlying improvements were and are largely driven by entertainment. Gaming and other interactive, immersive diversions are probably the most obvious and immediate areas of growth for VR. However, there are clear research/business cases that may also start to have a significant impact on the market. For example, more or less any 'Big Science' challenge requires solving several 'Big Visualisation' problems. And this is one of the areas where the limitations of the commodity solutions start to become apparent. These restrictions are only partly due to the limited (albeit greatly improved) visual resolution and field of view of the current head-mounted displays. In addition, when visualising and analysing data as a team, it can be very useful to be able to see other VR users in the same virtual space. The best and most efficient way to overcome the limitations is to use so-called 'CAVE environments', where images are projected onto the walls of a room. The user stands inside the room (wearing 3D glasses) surrounded by the displays and interacts with the VR simulation in a more intuitive way. It is possible to create a virtual world that not only fills the whole field of view of the user, but also allows walking around (and through) the objects being visualised, or picking items up and even 'feeling' them. However, in addition to requiring large rooms with multidisplay systems embedded in the walls, implementing CAVE applications is far from trivial. For example, synchronising the multiple graphics processors (responsible for the different parts of the display) with the computing and input processing requires both extensive expertise with the specific CAVE installation and deep understanding of the problem the application tries to solve.



Virtual clouds, rainfall and flooding allow for rapid situation assessment, with the geometry of the 3D projection displayed on the CAVE walls

VR@LRZ

The most interesting question is, of course, whether the current renaissance of VR can finally meet the expectations. Thus, the Leibniz Supercomputing Centre (LRZ) in Garching bei München maintains a broad range of basic and applied VR research activities. One of the indications of the important role these activities have played in the global VR research is the choice of LRZ as the venue of the 2016 'ACM Virtual Reality Software and Technology' conference. The advanced infrastructure at LRZ also allows complementing conference papers with live demonstrations at LRZ's Virtual Reality and Visualisation Centre (V2C). The approaches that allow the presentation of different VR applications in quick succession have been honed in frequent demonstrations at V2C, such as the annual 'V2C Open Lab Days' that showcase different aspects of VR to the general public.

Some of the LRZ projects are linked to environmental computing. Seismology applications or high-resolution visualisation of the inner structure of the Earth (as seen on the first image), for example, are introduced to the CAVE. Another example is hydrometeorology, where the ability to visualise development of meteorological phenomena and their impact on the ground (e.g. flash floods or landslides) has considerable promise in improving the speed and efficiency of operational responses in crisis situations. The same visualisation framework can also be useful in longer term planning, e.g. as a way to improve risk awareness in zoning processes and public consultations. Other research addresses the development of VR applications *per se,* both to ease the development for users of today and to make future applications usable through a wider range of interfaces and devices. While it is expected that a full scale CAVE installation will retain many of its advantages for the foreseen future, being able to leverage emerging commodity solutions is an important part of LRZ's vision of bringing 'VR for All'.

VR at the workplace - "Now where did I put the Post-It with the password...?"

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