

From Galileo to Radiohead and Beyond...



Galileo's sketches of the moon from *Sidereus Nuncius*, published in March 1610.

BY MICHAEL HAUCK

Who could have imagined?

Every now and then, how we look at the world changes.

When Galileo fixed his eye to the lens of a telescope, he focused light to reveal details of our world never before seen by humankind. He then shared what he saw by carefully drawing the images he observed. He published his observations in a book called *Sidereus Nuncius* (*The Starry Messenger*). Galileo was, arguably, the world's first photogrammetrist (liberal use of term). The year was 1610.

Like Galileo, when rock-guitar band Radiohead scanned a concert with LIDAR, the band changed the world of human experience. They focused light to reveal musical creation in a way never before seen by humankind. They shared their art of image and sound using an open-source "music video without video" project and distributed the images in a free YouTube video. The year was 2008.

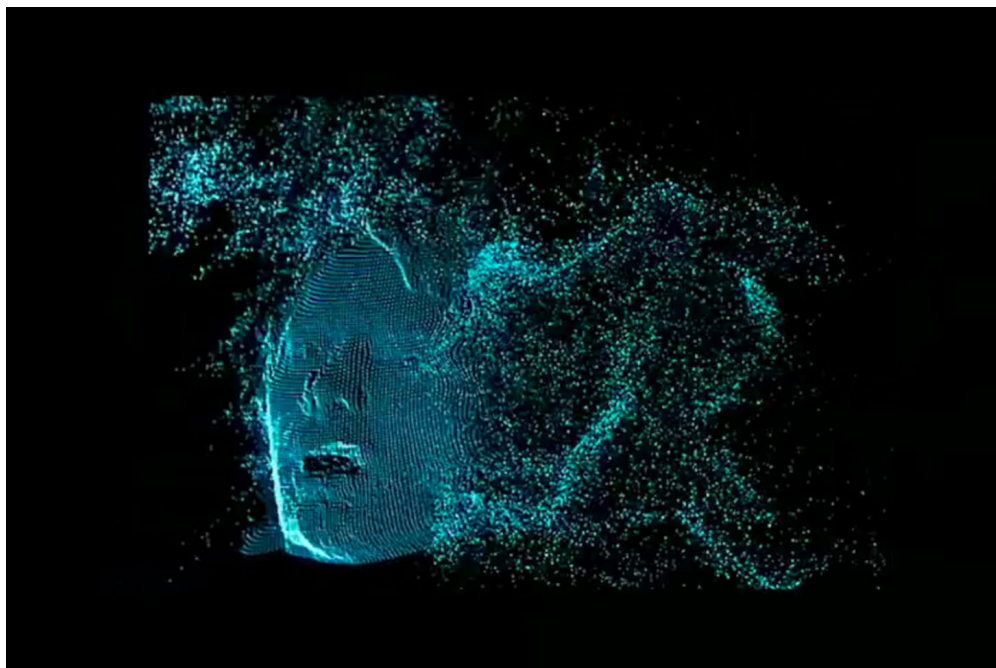
Much has happened in human history in the roughly 400 years between these two publications—one on paper, and the other on the internet. Humans understand our planet in fundamentally different ways then and now. And yet, human nature has not changed very much, if at all. What has changed is humankind's ability to manipulate the forces of nature with ever more

sophisticated technology, allowing us to view our world in ways that we could only imagine—or that we could not even imagine. This last 400 years holds clues to what will come in the next 400, so it is fitting to look back in time and ask ourselves what could be anticipated, and what could not.

At the time of Galileo, people already knew of lenses. Lenses were used to make eyeglasses to correct vision. The lens, of course, had already been around for at least two thousand years. The novel thing that surprisingly seems to have taken two millennia to accomplish was to put lenses together in a tube to focus light in order to bring a distant object into close focus.

Galileo was not the inventor of the telescope, but he was certainly a bleeding-edge first adopter. A German-Dutchman named Johann Lippershey filed the patent for the refracting telescope on September 25, 1608. Lippershey was a spectacle-maker, and so he was already changing the way people saw the world. Interestingly, it was called the “Dutch perspective glass.” One story about its invention states that children were playing with two spectacle lenses in Lippershey’s shop and noticed that lenses could be aligned to produce a larger image.

Galileo was not even the first to point a telescope at the heavens. Instead, Englishman Thomas Harriot drew Earth’s moon in July, 1609. Nonetheless, Galileo wasted no time in improving this concept with the design for a much more powerful refracting telescope which he illustrated in *The Starry Messenger*. He also illustrated what it could do—not just reveal details of the Moon, but also the moons of Jupiter, sunspots on the sun, and phases of Venus.



LIDAR image from open-source project House of Cards “music video without video” by rock band Radiohead (2008)

It turns out that Galileo’s father, Vincenzo Galilei was a fascinating fellow himself—an accomplished musician, composer, and music theorist. He played the lute, an ancient ancestor to the electric guitar. In music theory, one of his important contributions was to embrace dissonance if the voices flowed smoothly, and on-the-beat dissonance like suspensions, which he termed essential dissonance. These concepts were incorporated into Baroque music, and are elements to be found in the work of Radiohead four centuries later.

Jumping ahead almost two hundred years from Galileo’s time, Jules Verne imagined a trip to the moon in his 1865 science fiction novel *De la terre à la lune* (*From the Earth to the Moon*). Around the same time, possibly inspired by Galileo’s detailed drawings of the Moon, Dutch artists were imagining the lunar

landscape as if they had successfully taken Verne’s trip and landed on the Moon. They drew mountains, valleys, and volcanoes. Most remarkably, beyond the lunar landscape, they drew the Earth as they imagined it might be seen from the Moon.

Taking another two hundred year leap forward, humans gleaned their first real view of Earth from the perspective of the Moon, taken by NASA’s Lunar Orbiter I on August 23, 1966. According to an account by Dave Williams of NASA Goddard, photographing the Earth from the Moon was not part of the planned mission. Instead, the plan was to map the Moon in preparation for a lunar landing. This image was followed just two years later by the remarkable “Earthrise” color photograph of the Earth from the Moon, taken by the Apollo 8 mission. The Earthrise



"Earthrise" photograph of the Earth from the Moon by Apollo 8 crewmember Bill Anders, taken December 24, 1968.

photograph looks remarkably like the sketches of Dutch artists in the 1800's.

Back to the 1600's, Galileo realized that the telescope could do more than make distant things appear close—it could also make tiny things appear big. So, in 1625, he is credited with the invention of the compound microscope, which he called the "occholino" ("little eye"). Others who played with the telescope before him may have noticed the same phenomenon. It is not a big leap of imagination to look through the wrong end of a telescope!

The microscope also was a powerful instrument for scientific investigation. The world's second photogrammetrist (arguably, since his "photos" were hand-drawn facsimiles) may have been Robert Hook, who published *Micrographia*,

replete with impressive illustrations. He followed in the footsteps of Giambattista Odierna, who made the first detailed description of a tiny thing in *Locchio della mosca* (*The Fly's Eye*), which he published in 1644. It is important to note that both the microscope, like the telescope, is necessary to the making of a LIDAR system.

LIDAR systems were certainly NOT around in Galileo's time! The laser was not invented until the mid 1900's, and it was not until 1959 that Gordon Gould coined the term LASER. The very next year the first functioning laser was operated by Theodore Maimon. A short 11 years later, the Apollo 15 mission employed LIDAR to map the surface of the Moon.

LIDAR was invented as a scientific instrument, and its earliest application

was in mapping. But in short order it also became an instrument of art. James Frost and Aaron Koplin approached the rock band Radiohead with the notion of filming a music video without using a video camera. Instead, they proposed creating a music video in 3D using technologies such as LIDAR. The result was Radiohead's House of Cards video.

Note that the first artistic application of the telescope might be considered the invention of the kaleidoscope in 1815 by Englishman David Brewster. The kaleidoscope was first intended as a scientific tool to study the polarization of light, but it was immensely popular as a toy from the very beginning. Is the kaleidoscope a mere toy, or is it an artistic instrument? Is LIDAR a mere scientific instrument? For some who employ it professionally, LIDAR systems are indeed a lot of fun!

Looking back on the last four hundred years leading up to Radiohead's LIDAR images and the industry of LIDAR-based mobile mapping, what can be said about the past that might give insight to the future? For one thing, I think we can sometimes see explosive adoption of new technology, e.g. the proliferation of the telescope once invented (built around the globe within a couple of years, the rapid embrace of the kaleidoscope (200,000 units sold in the first three months), and the creation of the mobile mapping industry. On the other hand, why did it take thousands of years after the invention of the lens before someone lined up two lenses in a wood and leather tube to make a telescope? It is hard to imagine.

There is another and very powerful generalization that can be made. Consider the power of the human imagination. For example, Galileo

showed humankind the Moon as a real object circling the Earth, which was visited in art via the spaceship of Jules Verne. Humans saw the Earth from the Moon through the eyes of Dutch artists who imagined what the view would be like from the lunar landscape. Humans then travelled to the Moon in a real spaceship and took a real photograph of the Earth from the Moon. Humans often accomplish what we imagine, even if it takes hundreds of years, and humans seldom accomplish what we do not imagine.

How will we look at the world in the future? What awaits the LIDAR world in the next year, next four hundred years, or next millennia? All that will come has seeds in the present. But which seeds? Will it be new platforms, e.g. Unmanned Aerial Systems (UAS)? Will it be new imaging techniques, e.g. full-frame acquisition? Will it be increased bandwidth of interrogation, e.g. multispectral? Will it be new ways to extract additional information from light, e.g. waveform analysis? Will it be new ways of visualizing the data, e.g. machine vision? Almost certainly, it will be whatever we imagine.

I wonder, when Galileo pointed his telescope to the night sky and the Moon, did he ask himself if future generations would ever stand on the Moon and point a telescope back at the Earth? In his wildest dreams, could he even have imagined that a rock band would record a music video with lasers? ■

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