Ear to the ground

Telecom networks could monitor the Earth's crust to warn of earthquakes

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The revolution in communications in recent decades has created a worldwide network of underground and undersea optical fibre cables. Optical fibre has many times the voice and data capability of traditional copper wire and hence, copper wire networks have all but disappeared.

Philippe Jousset, Thomas Reinsch, Trond Ryberg, Hanna Blanck, Andy Clarke, Rufat Aghayev, Gylfi P Hersir, Jan Henninges, Michael Weber and Charlotte M Krawczyk, from Geoscience Institutes in Potsdam, Berlin and Reykjavik, Iceland and a UK-based industry body, describe in the journal, *Nature Communications*, an application of optical fibre networks in earthquake detection or prediction. It would be a great saving in the costs of installing dedicated sensors in earthquake-prone regions.

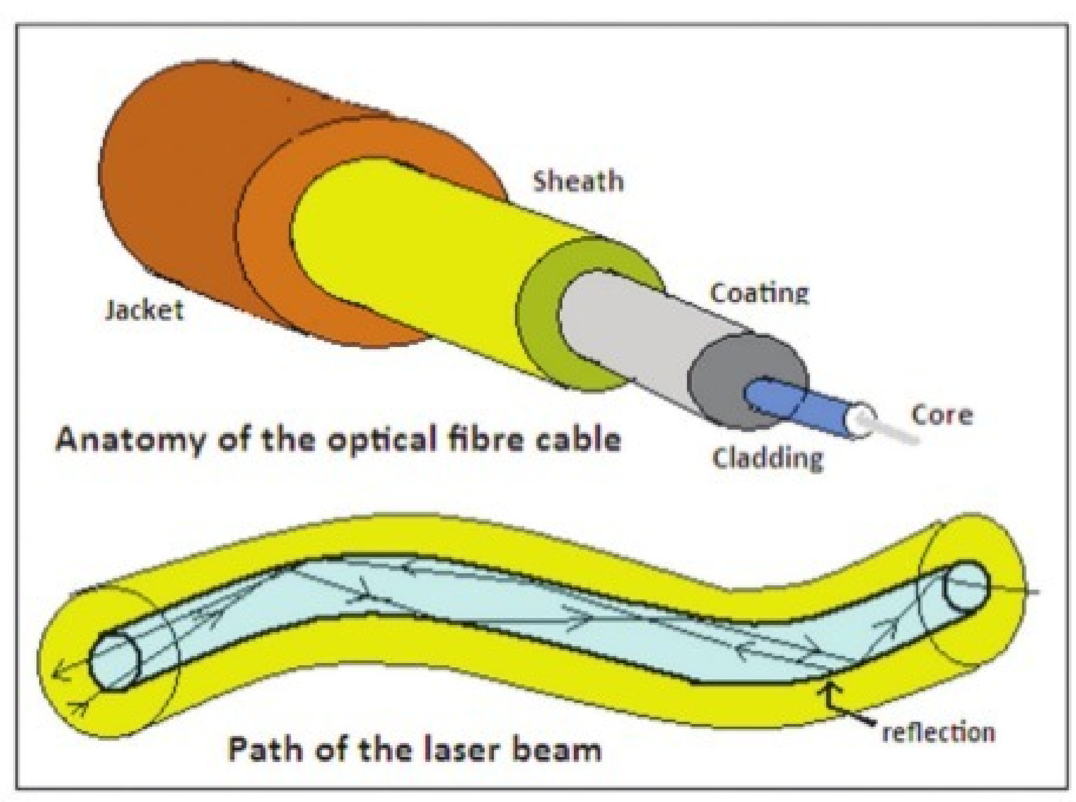
The Earth's crust and its rocky plates are understood to have condensed out of the melt that is still there deep within the core. While the continents can be considered to have finally formed, the process is not completely over, and some slow movement and shifting of position of landmasses continue. The motion is sometimes in spurts and starts, which are sensed as tremors and earthquakes. There are, in fact, thousands of small tremors, and it is estimated that major events occur, somewhere in the world, about once a month. These major events are usually in remote regions, but when they occur in populated areas, there is great damage and loss of life.

Earthquakes, when they occur, create compression waves within the Earth's crust. A part of the waves moves over the surface of the Earth and a large part moves downwards. The part that moves downwards reflects off discontinuities in the rocky material within the Earth and rises to the surface. Devices placed by seismologists sense both sets of waves, or tremors, and this helps ascertain the location and severity of earthquakes. Discontinuities or faults in the rocky structure also get located and mapped. As faults like this are usually the sources of earthquakes, monitoring the activity at such locations that are prone to earthquakes can provide advance warning.

A meaningful monitoring arrangement, however, is difficult to install. The electronic sensors are required to be manufactured just for this application and they are expensive. They also need to be securely housed underground and provided with power supply. And then, they need to be connected by a communication line to a central control station, so that their data can be collected and processed. Providing such facilities in sufficient numbers to obtain useful information is expensive and time-consuming.

It is in this context that the team writing in *Nature Communications* reports a trial where an existing optical fibre network was used to collect seismic data in south-west Iceland — a region with known seismic and volcanic activity. The trial was able to collect data at a very fine, four metre spacing and continuously monitor structural features with very high resolution.

The optical fibre used for communications is a thin glass capillary, which guides laser beams along its length. The laser beams traverse the fibre by reflecting off its sides at a glancing angle. Rapid, electronic off-and-on switching of the beam allows digital data to be transmitted with great speed and accuracy. By using different glancing angles, many beams of light can be sent at the same time and a cable with a bundle of fibres can carry huge data.



As no electric current is involved, the information in the cable is not affected by external fields, like power lines, and this is an added advantage. The bundles of fibres are packed into tubes of made of plastic and steel mesh, for strength. The cables are then laid in channels buried in the ground, to carry digital data for hundreds of kilometres.

Another advantage of optical fibres is that there is negligible loss of signal strength. There is, however, some loss, and this occurs because there is a small back-reflection when the laser beam bounces off the sides of the fibres. This loss is made good by inserting repeaters, which pick up weakened signals and pump them back in with full strength.

While back-reflection needs to be compensated, the same feature is useful in detecting seismic disturbances along the route where the optical cable is laid. Instrumentation at the transmitting end of the cable can detect this back-reflected signal and from the timing of detection, the spot of reflection can be located. In fact, the location can be extremely exact, as close as correct to one to 10 metres.

Now, when a seismic wave passes, the earth that the wave passes through is compressed and stretched for an instant. As the optical fibre cable that is laid in the Earth is also stretched or compressed, this affects the back reflection of the laser beam that is passing through the cable. The movement is exceedingly slight but the wavelength of the laser beam in the cable is so small that change is easily detected. Monitoring the back-signal is thus a way of continuously watching for seismic disturbances. As optical fibres are now extensively laid, back reflection monitoring can be a sensitive medium for detecting and measuring seismic activity over wide areas.

The authors of the paper report that they tried the method over a 15 km optical fibre cable length. The data from back-scattering records enables segregation of the low frequency waves and the high frequency waves. Man-made disturbances, like traffic rumble or impacts due to power stations, pipelines and so on, give rise to high frequency seismic waves, while waves arising from earthquakes are low frequency. This is also the case because waves from earthquakes come from long distances. High frequency components are thus lost to scattering and only the low frequency part remains.

The data picked up by the 15 km piece of cable was able to make out the different source of seismic signals, including local earthquakes, quakes at intermediate distances and signals from very large distances. The team then verified the detections against the signals picked up by conventional sensors in the same area. The signals in the conventional sensors were also used to validate and calibrate the signals detected by the cable.

The trials carried out "point to the extraordinary potential of this technology for new applications in earth hazard assessment and exploration all over the world," the team says in the paper.

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PLUS POINTS

'Touch' and go

Nasa is preparing to launch a spacecraft at the Sun. The Parker Solar Probe will get closer to the star than any mission before, enduring searing heat to try and understand the mysteries of the Sun. It will become the first ever mission to "touch" the Sun.

It will launch on its unprecedented mission on 4 August, Nasa announced. That comes after a number of delays to ensure that the craft is ready. The spacecraft will launch on a United Launch Alliance Delta IV Heavy rocket, from Space Launch Complex 37 at Cape Canaveral Air Force Station in Florida, Nasa said.

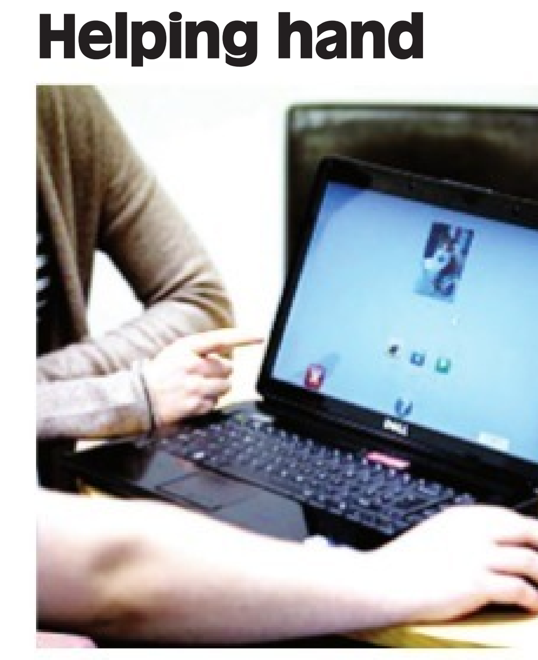
The small craft — only the size of a car — will come just 3.8 million miles from the surface of the Sun. Temperatures there will reach nearly 1,400 degrees Celsius and the probe will be protected from them by a 11.43 cm carbon-composite shield.

While there, the craft "will trace how energy and heat move through the Sun's atmosphere and explore what accelerates the solar wind and solar energetic particles", Nasa said. Those processes have vast affects down on Earth, but still remain largely mysterious.

Scientists have sought the answers that the Parker Solar Probe should give for 60 years and the origins of the mission began in the 1990s. But it has now been enabled by the breakthroughs in thermal engineering that will allow the small probe to survive despite the blazing heat it will be subject to as it flies close to the Sun.

The Independent

Helping hand



Computer therapy can help people with aphasia learn new words even years after a stroke, a new study conducted by the University of Sheffield has revealed.

Researchers from the University's School of Health and Related Research found there are a number of significant benefits to using computer therapy for people affected by aphasia, in comparison to usual speech and language therapy alone. The language disorder, which is caused by an injury to the brain, can make it difficult for people to talk, understand, read and write. One in three people are affected by aphasia after a stroke.

Results of the five-year study showed computer therapy enabled patients to increase their speech and language practice — 28 hours on average compared with 3.8 hours of usual speech and language therapy over a six month period. Participants also significantly improved their ability to say the words they chose to practise. This showed that people with aphasia can learn new words even after a long time post-stroke with computer therapy. They could still say the words six months after the computer therapy had finished.

Sue Hutchings had a stroke four years ago, she said, "I find it very frustrating. You just can't get it out and in the end I give up." Her husband, Richard noticed a big difference in Sue since taking part in the computer therapy. "Just recently she has felt comfortable, or it has been natural even for her to have a polite conversation with people and that is really good to see. I believe it all started with the programme," said Richard. The approach tested is most likely to be a good value for money option for people with mild and moderate word-finding difficulties.

Rebecca Palmer, from the University of Sheffield and chief investigator of the study said, "Although people were able to say more words they didn't always automatically use these words in conversation. This would suggest we need to do something to help people practise more in everyday communication situations."

Ray of hope

Northern white rhinos could be brought back from the brink of extinction within three years using lab-grown embryos

JOSH GABBATISS

IVF-ready embryos have been created using sperm from northern white rhinos in an unprecedented development that paves the way for the resurrection of the species. The sperm was used to fertilise eggs from the closely related southern variety, and the resulting hybrid embryos have been frozen for implantation into surrogate mothers.

Northern white rhinos were left functionally extinct after the last male, Sudan, passed away in March, but their tragic demise has stimulated efforts to develop technologies that can bring them back from the dead. Using IVF, the researchers hope to see the first northern white calf born in decades within the next three years.

The downward spiral of the rhinos caused by poaching in central Africa has been watched helplessly by scientists and conservationists for years. As numbers dwindled and the remaining rhinos struggled to reproduce, Thomas Hildebrandt and his team at the Leibniz Institute for Zoo and Wildlife Research in Berlin, Germany, collected semen from the last surviving males in the hope it could one day revive the northern whites. "We came to the point around 2008 that there was no chance to save this subspecies with the techniques we had available at that time," he said.

These fears were confirmed when tests revealed the only surviving northern whites — a mother and daughter named Najin and Fatu — had serious reproductive problems. That should have been the end but rapid advances in reproductive and stem cell science have given Hildebrandt and his international team of experts hope. Using techniques normally reserved for the creation of champion racehorses, the scientists used some of the preserved sperm to fertilise an egg extracted from a southern white female. The trial served as a test before experimenting with precious eggs taken from northern whites. The next step is to gain permission from the authorities in Kenya — where Najin and Fatu currently reside — to perform the same procedure using those eggs. Having created the first ever test tube rhino embryos, the scientists now see a clear path ahead to creating a new generation of northern whites using surrogate mothers in Africa, Europe and the US.

"We are quite confident with the technology," said Hildebrandt, "We will start with a pure southern white rhino embryo in the next weeks and months to test the system, and after that is successful we will implant a northern white rhino into a surrogate mother. Our goal is that within three years we have the first northern white rhino calf born."

Though there are risks associated with the extraction of eggs from adult rhinos, not least anaesthetising a 1,700kg mammal, the scientists are sure northern white calves produced this way will be perfectly healthy. "We make foals from the best champions around the world and they still become champions, so the fact the embryo is made in the laboratory doesn't mean it's a fake embryo," said Cesare Galli, a veterinary medic who led the procedures at Avantea medical laboratory in Italy. These initial results were published in the journal *Nature Communications*.

In a separate venture, the scientists are aiming to produce new sperm and eggs from stem cells, which they hope to create using samples of skin and other tissues collected from 12 different northern whites. Though this approach will likely take up to a decade to yield results, the scientists consider it a crucial component in their long term strategy to create a healthy, genetically diverse rhino population.

The Independent

Mediated internalisation

Here's a look at how cells absorb molecules by using receptor proteins on the surface of membranes

TAPAN KUMAR MAITRA

Receptor-mediated endocytosis (also called clathrin-dependent endocytosis) is a pathway for concentrating and ingesting extra-cellular molecules by means of specific receptors on the outer surface of the plasma membrane. It is the primary mechanism for the specific internalisation of most macromolecules by eukaryotic cells. Depending on the cell type, mammalian cells can ingest hormones, growth factors, enzymes, serum proteins, antibodies, iron, and even some viruses and bacterial toxins by this mechanism.

An interest in familial hypercholesterolemia, a hereditary predisposition to high blood cholesterol levels and hence to atherosclerosis and heart disease, led Michael Brown and Joseph Goldstein to the discovery of receptor-mediated endocytosis, for which they shared a Nobel Prize in 1986.

The process begins with the binding of ligand molecules to their respective receptors on the outer surface of the plasma membrane. As the receptor-ligand complexes diffuse laterally in the membrane, they encounter specialised membrane regions — called coated pits — that serve as sites for the collection and internalisation of such complexes. In a typical mammalian cell, the coated pits occupy about 20 per cent of the total surface area of the plasma membrane.

Accumulation of receptor-ligand complexes within the coated pits triggers accumulation of additional proteins — including adaptor protein, clathrin and dynamin — that are required for promoting membrane curvature and invagination of the pit. These proteins are found on the inner cytosolic surface of the plasma membrane. Invagination continues until the pit pinches off from the plasma membrane, forming a coated vesicle. The clathrin coat is released, leaving an un-coated vesicle. The coat proteins and dynamin are then recycled to the plasma membrane, where they become available for forming new vesicles, while the endocytic vesicle is free to fuse with an early endosome.

The speed and scope of receptor-mediated endocytosis are impressive. A coated pit usually invaginates within a minute or so of being formed, and up to 2,500 such coated pits invaginate per minute in a cultured fibroblast cell.

There are actually several variations of receptor-mediated endocytosis. The receptors are concentrated in coated pits only after the formation of receptor-ligand complexes. In another variation of receptor-mediated endocytosis, receptors are constitutively concentrated in coated pits independent of formation of receptor-ligand complexes. Binding of ligands to receptors simply triggers internalisation.

In yet another variation, the receptors are not only constitutively concentrated, but they are also constitutively internalised regardless of whether ligands have bound to the receptors. Early endosomes are sites for the sorting and recycling of extracellular material brought into the cell by endocytosis. Protein molecules essential for new rounds of endocytosis are often — but not always — recycled after separation from the material fated for digestion. The early endosome continues to acquire lysosomal proteins and matures to form a late endosome, which then develops into a lysosome.

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