Concealed Threats in Liquids

Ground-breaking MagViz device aids faster, accurate airport screening

Quick Read
MagViz distinguishes potential-threat liquids from harmless shampoos and sodas screened at airport baggage checkpoints.

Airports are stressful places—long lines, frequent delays and a frantic pace. MagViz, a scanning machine that differentiates dangerous substances from benign liquids and gels such as shampoo and beverages, could be the answer to safer, less stressful travel.

Los Alamos National Laboratory (LANL) scientists developed the technology, adapted from Magnetic Resonance Imaging (MRI) techniques but with far more capabilities.
MagViz is revolutionary not only because it helps travelers get to their destination on-time but because it identifies concealed threats that look harmless, such as bottled water or a tube of toothpaste. In fact, unlike MRIs, MagViz can even locate threats hidden inside the metal foil of a child's juice box. MRI machines are stumped by metal, so common baggage such as suitcases or laptop computers could not be screened.

The sealed bottles above all look the same. Without time-consuming or potentially dangerous chemical tests, MagViz can tell the harmless from the harmful. In the left image, a bin loaded with various commodities has a possible threat substance partially layered beneath a foil package. MagViz identifies the possible threat in the center container. The right image displays how MagViz can identify a possible hazard from otherwise normal and similar looking liquid containers. In both images, the potential hazard is circled in red on the MagViz display. From brains to baggage: a new take on MRI

When a threat chemical is identified, the machine marks the technician's image of the screened container with a red dot; harmless substances get green dots; a yellow dot indicates further inspection is required. Currently, MagViz identifies 50 liquids, with more threat-reduction capabilities coming soon.
"That's one of the beauties if this technology," LANL project leader Michelle Espy said. "We can add different threats as we become aware of them."
How it Works
Ultra-low-field nuclear MRI-based identification senses atomic frequencies—chemical fingerprints—that create images for technicians to quickly find threats.
In an MRI machine, magnetic fields cause hydrogen atoms to line up and spin in a substance. The atoms begin to wobble, falling out of rhythm. This wobbling of hydrogen atoms occurs in unique patterns for different chemicals, captured by sensors in an easy-to-read image.

To increase accuracy, the Los Alamos team incorporated a prepolarization field 100 times stronger than the magnet used to measure the spin. The technology relies on sophisticated detectors called superconducting quantum interference devices, or SQUIDs. Whereas a hospital MRI detects spin with a sensor akin to a radio antenna tuned to a specific set of frequencies, SQUIDs can pick up the oscillation of hydrogen or other atoms at any frequency.

Although the MagViz system is capable of producing complex three-dimensional images, baggage-screening agents quickly receive a simple but precise color-coded readout.

In an impressive example of the Lab's unparalleled in-house collaborative capabilities, members from many diverse fields (such as physics, engineering, computing, instrumentation and space systems) helped develop MagViz. The widespread collaboration led to innovative ideas that allow units to be extremely small, portable and inexpensive so they can be used by medics for quick battlefield diagnosis or developing-world hospitals that lack the funds or large facilities required for conventional MRI machines.

A prototype was unveiled at the Albuquerque International airport in December, where it will be tested prior to proposed launch at many airports in 2012. MagViz currently screens and analyzes contents in one minute. The goal is for MagViz to work in conjunction with X-ray machines and speed up transportation without risking reducing security. Airline passengers will soon be able to relax and worry less about on-board terrorism—and they can conveniently travel with liquids.

MagViz Technology Utilizes Ultra-low-field Magnet

Los Alamos National Laboratory scientists and engineers are renowned for their innovative and interdisciplinary discoveries. While developing a magnetic resonance imaging brain scanner, former project leader Bob Kraus and his team imagined applications beyond the hospital: if the system could differentiate separate aspects of the brain, how about different liquids such as those found on airport baggage-screening conveyors? Could it determine whether a bottle contains innocuous apple juice or explosive liquids? The answer was, "yes", and it was created in a system called MagViz.

MagViz is an ultra-low-field MRI system that detects different atomic frequencies created by different chemicals. In the machine, magnetic fields cause hydrogen atoms in a substance to line up and spin. The movement creates an image translated by MagViz to alert technicians about the contents of a liquid or gel.

The airport-bound MagViz machine should have a footprint about the size of x-ray screeners currently in use. Screening agents operating MagViz will see a colorcoded image with numbers to differentiate distinct containers. Green dots are benign substances. Red dots indicate threat substances, and if the machine cannot identify a particular liquid, the image will bear a yellow dot.

Traditional MRI machines use massive superconducting magnets that draw strong signals from scanned objects and provide clear images. However, due to these strong magnets, any metal distorts the image, so common airport baggage such as suitcases, cellular phones and laptops could not be successfully screened. This is what makes MagViz unique: its ability to decipher chemicals within metal containers.

The MagViz team engineered new ways to filter background noise and create an accurate image. The team also is working to recycle the extremely expensive helium used to cool the superconductors (superconducting quantum interference devices, or SQUIDs) used in the sophisticated detectors.

The SQUID relies on the same physics behind the traditional hospital MRI with one big exception: instead of big magnetic fields, the fields are no stronger than the magnetic field of the Earth. The method retains the primary strength of traditional MRI: the ability to probe chemical environments as well as provide images. The same physics that gives rise to tissue contrast in an anatomical MRI of the body allows MagViz to determine differences in the chemical composition of liquids. While X-ray methods commonly used in airports sample density and nuclear properties, MagViz (which will be used in conjuction with X-rays) has the ability to directly probe chemical environments, providing complementary information.

To learn more about MagViz and SQUID, contact LANL's Michelle Espy at 505-665-6218 or email espy@lanl.gov.

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