Next-generation radar

More complexity, more information

Dan Fuhrmann is working to develop signal design and signal processing methods for next-generation radar systems. “Radar systems are a technology for seeing things at a distance using electromagnetic waves. That is the basic principle,” he says. “What people are trying to do now is take advantage of the flexibility that new technology gives us.”

“We are basically shining a very intelligent flashlight, that sends energy where you want it to go, and not where you don’t,” Fuhrmann explains. “With new radar systems, multiple transmitters and receivers work together, cooperating, synchronized, each seeing reflections from the others. It gives a tremendous amount of flexibility in how you illuminate an area you are trying to search,” he says.

There are several key differences. Unlike a flashlight, radar systems operate at different frequencies (i.e. microwave). Radar can look over very long (or short) distances of 10s or 100s of kilometers. “But from my point of view, the most interesting thing about radar systems is that the illumination is very structured. There is a time structure to the transmitted signals.”

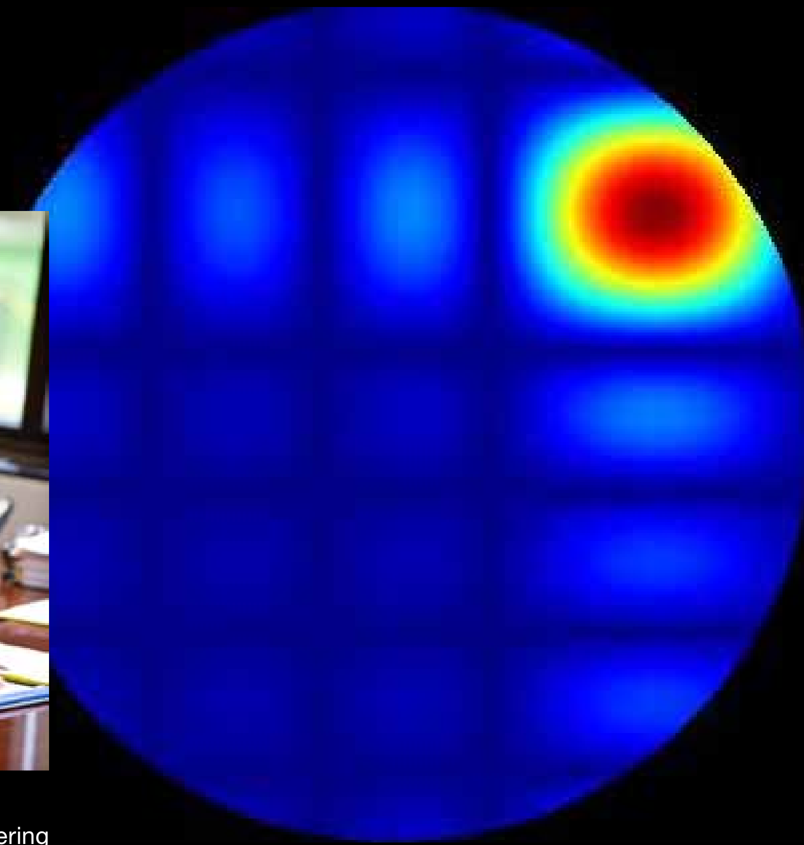
Just as in TV, radio or cellular telephone signals, radar signals carry information. “One feature of radar is that allows the user to gather a lot more information in return from the signals that come back,” he notes. “But here’s what’s new—we are adding more and more levels of complexity to transmitted signal in order to get more and more information in return.”

With traditional radar signals, everyone sees the same signal. With the new systems, different signals are sent in different directions. “It’s an interesting characteristic, in that someone at one location can’t tell exactly what a transmitter at another location is doing. They don’t necessarily have all the information,” adds Fuhrmann. “There is also flexibility in how you illuminate any small target that you are trying to track. We can direct illumination on a particular object, with either a narrow beam or a broad spotlight, depending on how it is moving.”

A radar beam can be as narrow as a pencil or even a laser pointer, though in that case, “We need to know what we’re looking at.”

Modern radar systems include high-speed digital-to-analog, or D/A, converters. “We might be able to compute a signal that you want to transmit to the tracked object, and then D/A conversion will translate the computed waveform into a transmitted signal.” New radars may compute signals “on the fly” as well. The advantage? Being able to select the transmitted signal adaptably to achieve a particular surveillance objective. “A tracking radar operates just like a spotlight following an actor on a stage,” Fuhrmann points out. “The more control one has over the spotlight, the better.”

Signals can be adapted to the environment to minimize the amount of clutter (reflections from the ground); to keep energy on the target; and finally, to illuminate only the target object and nothing else. “We want the data coming back to be informative. You can learn a lot about what you’re trying to see by using the appropriate signal.”



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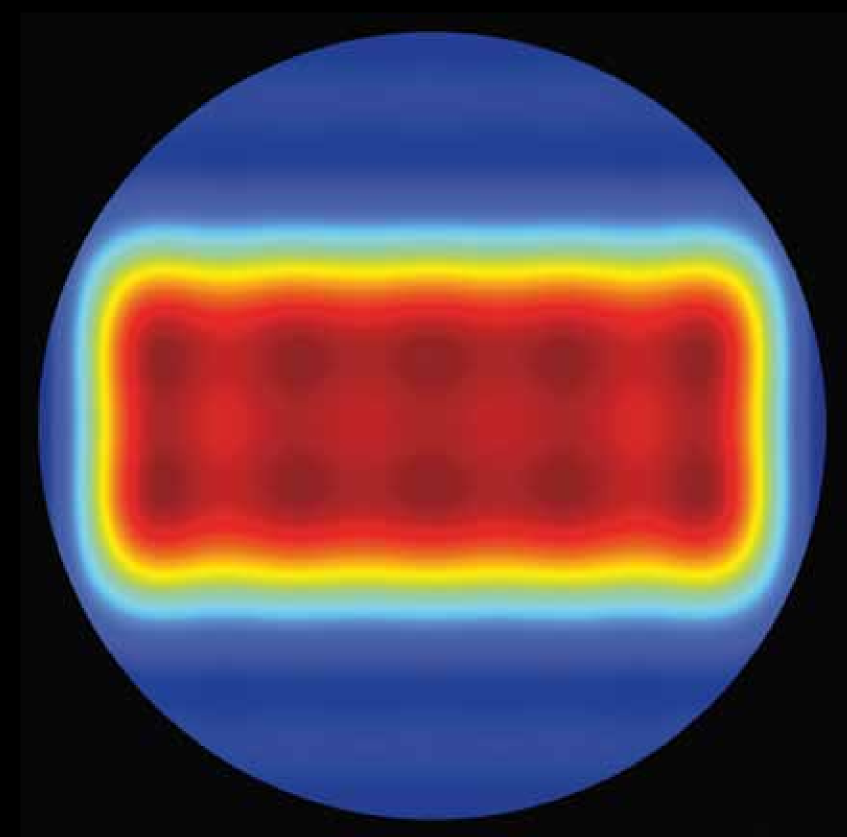

Next-generation radar system beampatterns, depicted using visualization tools written in the programming language MATLAB. The upper panel shows the beampattern for one transmitter, and the lower panel shows the composite beampattern created by multiple transmitters working together.