Ulrich Eberl, Joerg Puma

# Innovative Minds

## A Look Inside Siemens' Idea Machine

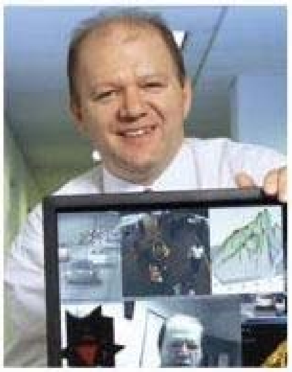
SIEMENS

# Visionary Personalities

Pioneers and Unconventional Thinkers, Breakthrough Innovations

# Merging Data Streams

A road runs right through the middle of Dorin Comaniciu's office. At first you don't see it. But when Comaniciu walks in, gently shuts the door behind him and begins outlining his work, the road starts to take shape. It's a road where ideas run on parallel paths like lanes, but where all the lanes travel together toward a common destination.



**Dorin Comaniciu, PhD**, is head of the Integrated Data Systems Department at Siemens Corporate Research in Princeton, New Jersey, and is responsible for coordinating Siemens' activities in biomedical informatics. Ultimately, his work boils down to teaching machines to see and interpret accurately – for a variety of applications.

The commonality of the ideas is not immediately obvious, though. The ideas run the gamut of applications, from new ways of interpreting the contours of a beating heart or fetal head to technologies for automatically keeping cars at a safe distance from one another, or giving tomorrow's doctors a way of visualizing genetic data in the context of structural molecular information.

As Comaniciu explains, his job is not only to keep the ideas humming along in their respective lanes – with new ones from himself and the 30-plus people in his department merging into the stream at regular intervals – but to ensure that no one loses sight of where they are going. "I encourage people to think," he says. "They have to keep the core question in mind – not just the immediate problems."

## Data Democracy

And the "core question" is a very big one, because it ultimately concerns the use of machines to interpret and understand the real world. The road to that goal begins with what is arguably Comaniciu's most far-reaching patent – a mathematical invention called Robust Information Fusion, which boils down to a novel way of detecting and weeding out questionable information from any given data source. The result is a kind of data democracy in which bits and bytes from different sources can be merged seamlessly into a single stream of information. What's more, since Robust Information Fusion is generic, it applies with equal effectiveness to improving the quality of data delivered by, say, an automotive radar-based distance control system, a smart surveillance camera or an ultrasound transducer.

Robust Information Fusion is based on the principle that each measurement that a sensor produces comes with a level of uncertainty. Engineers and mathematicians had been wrestling with the question of how to statistically weigh uncertain information. But no one could come up with a system that could robustly deal with both the variability of data interactions – essentially how multiple sensors affect each other's output – and the thorny question of how to weigh "inliers" and "outliers" – bits of data that are statistically outside the normal parameters of a data set – until Comaniciu came up with his data fusion method. "What we have done," explains Comaniciu, "is to develop a statistical method that weighs the combination of different pieces of data to obtain an optimum result. This is the core of our discovery. Essentially, the output of each sensor can be characterized statistically."

## Experts in the Algorithms

Comaniciu is using Robust Information Fusion to pave the way to the next logical step toward machine-based interpretation. "Once you have reliable data that can be fused, you can develop expert systems to evaluate it and draw conclusions from it," he says. The idea is called "database guidance," which, quite simply, boils down to translating the knowledge of experts into algorithms that can support human decision-making in areas as different from one another as medical diagnostics and driving a car. "A very realistic picture of the future," says Comaniciu, who earned a PhD in data compression in Romania before moving to the U.S. in 1996, "is that in a few years you'll be able to go to a general practitioner, have a body scan, and a full-color, anatomically clear image will come up on the screen, complete with values for each part of your anatomy and highlights on anything that may be of concern."

The first step down that road has already been taken. It's called "Auto EF" – a unique database-guided program based on a Comaniciu patent that can be used in the context of an ultrasound examination to automatically measure the heart's ejection fraction (EF) – the fraction of the total volume of blood in the heart chambers when the muscle is relaxed (diastole) that is pumped in a single beat. "Today," says Comaniciu, "this crucial measurement is either estimated or determined manually. An expert needs a couple of minutes to do it, but it takes the software two seconds to do the same thing."

Coming up with a breakthrough like Auto EF is no easy matter, though. "There were times when one or two months would go by without any progress," recalls Comaniciu. "But those are the times you keep your chin up and say, 'We are Siemens. We can do it!'" A big part of "doing it," he adds, is motivating his team: "You have to be innovative. You have to think out of the box. However, as a manager you have to learn to care for your people and to stimulate and enthuse them. To accomplish that, it's essential to be committed. Personally, I strongly believe that the technologies we've been developing can make a real difference in people's lives. This is not always obvious. But when you're in a children's hospital and you see those little kids, you become very motivated."

Perhaps the largest program Comaniciu is involved in is called Health-e-Child. As head of the science committee guiding this four-year effort, he envisions the development of a biomedical information platform that integrates data from genetic, clinical and epidemiological sources. The program focuses on pediatric heart diseases, inflammatory diseases and brain tumors. Following up on another one of his patents, Comaniciu's team is working on other programs that will accelerate key ultrasound tests in obstetrics in a similar fashion. They are also involved in longer-range projects to develop databases that will eventually support automated identification of colon cancer, prostate cancer and autism based on magnetic resonance scans.

## Transforming Information into Knowledge

"Robust Information Fusion holds the promise of turning database-guided systems into a major, mainstream service supporting virtually every field of activity," says Comaniciu. "For instance, in the autism project it will be used to combine and interpret molecular information and neuronal information taken from MR scans."

According to Comaniciu, who is married – his wife is a professor of wireless communications – and has a five-year-old daughter, the market for database-guided systems is large and increasing. "Automatic, accurate data analysis has ramifications in all domains – from the merging of data from magnetic resonance and ultrasound with general patient records to the identification of surface anomalies on turbine blades in the power generation field and the merging of data from cameras, radar and other sensors in the automotive area in order to improve automatic driver assistance systems," he says.

Naturally, these fields are not going to go from zero to sixty overnight. Developing the database that allows a system such as Auto EF, for instance, to recognize the perimeter of a beating heart in real time from fuzzy ultrasound images is a significant challenge. To do so, top cardiologists must invest hours viewing images and annotating them with information regarding how they interpret them. With this in mind, Comaniciu's team, in collaboration with Siemens Corporate Technology, plans to establish a center of competence in Bangalore, India, to focus on developing software tools designed to simplify annotation in the field of database-guided medical diagnostics.

## Formula for Ideas

Database diagnostics and breakthroughs in Robust Information Fusion are what Comaniciu refers to as "powerful science" – that is, science that can unleash new applications across the board. "Most of the time," he says, "innovation is defined as developing something new. But it is also possible to bring about fundamental scientific discoveries by combining existing solutions, and with enough of a push it is possible to bring them forward to the extent that they make a real difference across a spectrum of technologies." He adds, however, that one of the crucial elements in such success stories is communication. "First, you have to be able to convince management. Second, you have to be able to connect with your customers. Third, especially for a team like ours that has members in the U.S., Germany and India, you have to get the researchers to communicate with one another. They have to be able to do that in order to learn from the group experience and from mistakes."

How does powerful science get started? "Naturally, you first have to develop ideas to the point where they achieve critical mass, in order to get innovations moving," says Comaniciu. "In this case, some of the ideas came from my own background and some from our research. My own formula for developing ideas is quite simple. It involves understanding the current state-of-the-art and asking how we can go beyond it." He adds that his department has a core of very strong scientists "and we develop many ideas here that come from brainstorming and from a culture of innovation. We have several departments that have been developing complementary technologies and that interact synergistically. So we can combine the best from all the different areas."