

## New Generation of Radar Systems Enabled with Cognition Professor Simon Haykin

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### *Abstract*

The analogy between the visual brain and radar has fueled Professor Simon Haykin's interest in studying the human brain for the past 25 years. He will address the formulation of the perception-action cycle that embodies five basic properties: Perception, Memory, Attention, Intelligence, and Language.

Realizing that the language in radar information processing is different from that in the brain, it is natural to demand the first four properties of human cognition for a radar system to be cognitive.

To satisfy this requirement, a hierarchical cognitive radar will be described that exploits local and global feedback loops around the receiver and transmitter, which are supplied with three distinct memory units: perceptual memory, executive memory, and action-perception matching memory.

In so doing, the whole system is coordinated with its environment in a powerful way. Through the use of clever learning procedures, a hierarchical perception-action cycle is built. The stage is now set to present experimental results, which demonstrate how the tracking resolution capability of a radar system is progressively improved as the memory units in the system are added, one by one. Future research challenges include:

- Improvements to the cubature Kalman filter in the receiver for perception of the environment.
- Approximate dynamic programming in the transmitter for action to control the environment.
- Bayesian target detection.
- Multiple target surveillance.
- Cognitive phased array radar, providing the ultimate in performance.

**Professor Simon Haykin** is Distinguished Professor in the Faculty of Engineering, McMaster University. He received his B.Sc. (1st class honors), Ph.D., and D.Sc., all in electrical engineering from the University of Birmingham, England. He is a Fellow of the IEEE, Fellow of the Royal Society of Canada, recipient of the Hooker Gold Medal from URSI for his contributions to radar and wireless communications, the recipient of Honorary Doctor of Technical Sciences, ETH, Zurich, Switzerland, and many other medals and prizes. Professor Haykin's current research passion is Cognitive Dynamic Systems, with application to radar and radio, and starting to extend this passion to energy systems.

Simon is a pioneer in adaptive signal-processing with emphasis on applications in radar and communications, an area of research which has occupied much of his professional life. In the mid 1980s, he shifted the thrust of his research effort in the direction of Neural Computation, which was re-emerging at that time. All along, he had the vision of revisiting the fields of radar and communications from a brand new perspective. That vision became a reality in the early years of this century with the publication of two seminal journal papers:

- "Cognitive Radio: Brain-empowered Wireless communications", which appeared in IEEE J. Selected Areas in Communications, Feb. 2005.
- "Cognitive Radar: A Way of the Future", which appeared in the IEEE J. Signal Processing, Feb. 2006.

