Professional Engineering Seminar # 6: For Bio-Inspired Flight Project

Speaker: Dr. Kelly Cohen, Associate Professor, School of Aerospace Systems, College of Engineering and Applied Science, University of Cincinnati
Date: July 2, 2010
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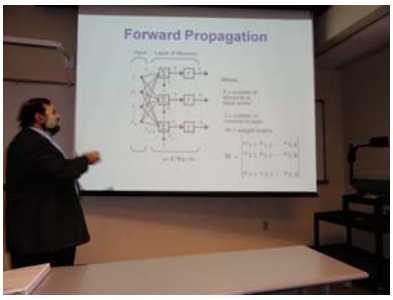
Dr. Cohen grew up in India, and at 18 immigrated to Israel to earn a B.S. in Aerospace Engineering. He worked as an aeronautical engineer for the Israeli military as a manager in the Unmanned Air Vehicles Division from 1985-2005. He earned an M.S. in 1991 and a Ph.D. in 1995. From 2001-2003 he worked as a Visiting Researcher at the U.S. Air Force Academy in Colorado Springs. In 2005 he retired from the military and became research contractor. He has been at the University of Cincinnati for the past three years.

Dr. Cohen has a very lively presentation style, and is very passionate about his research on artificial neural networks (ANN), linguistic reasoning, and fuzzy logic. His first topic was the explanation of forward propagating networks which mimic the biological characteristics of learning, demonstrating, adapting and growing. Biological organisms have the ability to adapt quickly to new situations and therefore have the potential for growth. This familiarity with the environment allows organisms to be efficient in the use of resources. His research focuses on the neural mechanisms used to accomplish this efficiency, and how technology can be programmed to use the same types of mechanisms. Artificial neural networks are inspired by how the brain works, and Dr. Cohen explained how learning is an adjustment to synaptic connections between neurons. The photographs below were taken when Dr. Cohen was explaining a diagram of ANN, specifically McCulloch-Pitts Neurons.



Dr. Cohen also explained how the key elements of ANN form a novel structure in the way information is processed. Input is received from several sources, which have an additive effect upon one another. If the signal is strong enough, the artificial neuron will fire, and the signal will be propagated forward in the network. If many of these networks are layered together, as in a brain, the

matrix will allow the regulation of learning and decision making. The larger the network, the more experiences can be processed.

The learning done by these networks, as well as by the brain of an organism, can be categorized into two main types, supervised and unsupervised. Dr. Cohen gave several amusing everyday examples to help the audience understand the difference between these. Unsupervised learning is common among children, such as learning that sand does not taste good as they play in a sandbox. Supervised learning is being told by adults "Don't touch that, it's hot and you'll get burned." His colorful examples helped make the concepts clear. In his research, Dr. Cohen looks for patterns to use as initial input to teach machines to problem solve with these matrices and increase efficiency.

The second main topic addressed was that of fuzzy logic. In contrast to Boolean logic, which is quite black and white, fuzzy logic occurs in degrees of gray. One can be a little hungry, but not a little dead. Fuzzy logic occurs in infinitesimally small increments, whereas Boolean logic is all or nothing. Fuzzy logic applies to the decision making in ANN in a particular way. It is very difficult to program a computer to understand the vagueness of the real world. Exactly what is meant by a 'little' hungry? Fuzzy logic allows programmers to model and control the nuances overlooked by the binary (Boolean) logic of computers. Dr. Cohen is the director of the Morphing and Optimal System Technology Lab, also known as MOSTECH. Computers must be programmed to deal with the fact that the truth of any statement is a matter of degree. There are many 'smart' machines already on the market today, an example where fuzzy logic is used in the washer. Its circuitry is built with sensors that detect parameters such as the murkiness of the water as the clothes tumble through, and then change the length of the wash cycle accordingly. The research of Dr. Cohen and his team focuses on this same approach to aircraft that sense their environment and change their function (flight path, wing shape, speed, etc.) accordingly without remote control input from humans.

The last part of the presentation was spent describing the various applications of morphing aircraft in commercial and military applications. He explained how a swarm of drones could potentially be programmed to react to one of their members being shot down by enemy fire, and the remaining drones could adapt to fill the void left by the missing plane in flight, without having a command center recalling them, thereby aborting the mission, or send new instructions by remote with limited firsthand knowledge of the exact situation. Commercial applications could also save time and money. If a jet could morph and hover like a helicopter, then morph again to land, it would save time and resources needed to use different aircraft for different needs, and thereby greatly increase flight efficiency.