HOW WERE INNS AND IJCNN FOUNDED?

How were INNS and IJCNN founded? To understand this, one needs to go back in history to learn more about INNS founder and IJCNN'07 plenary speaker, Stephen (Steve) Grossberg, and the forces that led him to establish INNS in 1987 with important help from several close colleagues.

Grossberg's story is a remarkable one by any standard. This is because he laid key conceptual and mathematical foundations of our field in 1957, 30 years before INNS was founded, while he was a 17 year-old Freshman in college. He did this without any intellectual guidance from his professors, and against the intellectual trends of the time. The year 2007 marks not only the 20th anniversary of IJCNN. It is also the 50th anniversary of this scientific revolution.

Grossberg's work began innocuously enough when he took the introductory psychology course as a Freshman at Dartmouth College in 1957. Thousands of us take Psych 1 without it triggering a scientific revolution. However, in Grossberg's case, when he learned about classical human and animal data about learning, his mind was seized with a passion to understand the philosophical paradoxes that he saw in the data. He became Dartmouth's first joint major in mathematics and psychology in order to pursue this lifelong passion.

Grossberg was particularly excited then, and remains so to this day, about the philosophically and scientifically challenging question: How can an individual learn autonomously in real-time in response to a changing world? With only elementary calculus and probability training as a mathematical aid, he struggled to represent such a process in a way that would explain paradoxical properties of data about human verbal learning and animal reinforcement learning. By the end of his Freshman year, after an intense intellectual struggle, he introduced the paradigm of real-time nonlinear neural networks with which to link mind to brain. In particular, he derived the Additive and Shunting Models, with their now well-known short-term memory traces (activations) and long-term memory traces (adaptive weights). These models lie at the core of essentially all connectionist models of mind and brain. The Additive Model is sometimes called the Hopfield model based on Hopfield's popular 1984 article on this topic. When Grossberg introduced the model in 1957, it was a seminal breakthrough, because it initated a revolutionary paradigm shift.

Indeed, even Artificial Intelligence was just being introduced when Grossberg began this pioneering work. It is an interesting historical coincidence that the first organized study of AI occurred in 1956 during the Dartmouth Summer Research Project on Artificial Intelligence, a year before Grossberg came to Dartmouth as a Freshman.

Grossberg knew no neuroscience when he derived the Additive and Shunting models from a real-time analysis of behavioral learning data. This derivation led to a neural network model with cell bodies, axons, and synapses in which behaviorally meaningful short-term and long-term memory traces had a natural interpretation in terms of neural potentials, signals, and the regulation of chemical transmitters. He hereby showed how brain mechanisms could be derived by analyzing how behavior adapts autonomously and in real time to a changing world. This thrilling discovery led Grossberg to study both psychology and neuroscience intensely from that time on.

To naturally express his new intuitions about autonomous real-time learning, Grossberg also introduced, again in 1957, the paradigm of nonlinear systems of differential equations into cognitive science, and was the first scientist to propose, and to quantitatively study, effects of nonlinear feedback, including top-down influences, on intelligent behavior and their underlying brain dynamics. Because even simple psychological hypothesis invariably led to nonlinear feedback dynamics when they were expressed in terms of real-time events, Grossberg realized that he had to learn a lot more mathematics, which is why his titles now includes a professorship in mathematics, as well as professorships in psychology, engineering, and cognitive and neural systems.

For example, Grossberg introduced Adaptive Resonance Theory (ART) to propose a solution of the fundamental "stability-plasticity dilemma." This is the problem of how humans, animals, and intelligent machines can continue to learn quickly throughout life about important events in a changing world, without undergoing catastrophic forgetting of previously learned but still important memories. Nonlinear feedback, notably top-down expectations and attention, play a central role in ART. As of this writing, all of the main predictions of ART have received support from both behavioral and neurobiological data.

A productive collaboration with Gail Carpenter over the past few decades has also led to the development of a widely used class of ART algorithms in technology, as well as new insights into ART as a cognitive and neural theory. In fact, Grossberg's collaboration with Carpenter was also crucial, as we shall see, in the story of INNS, IJCNN, and other neural network institutions.

It is important for students of neural networks to understand this history, if only because knowing a field's past can help us to more clearly understand its present and to predict its future. More of this history can be found in Grossberg's short article "Birth of a learning Law" that was published in the INNS/ENNS/JNNS Newsletter (1998, 21, 1-4) and is on his web page http://www.cns.bu.edu/Profiles/Grossberg along with more than 200 of his research articles and a statement called "My Interests and Theoretical Method." Interviews with Carpenter and Grossberg, as well as other neural network pioneers, can also be found in the 1998 MIT Press book "Talking Nets: An Oral History of Neural Networks", that was edited by James Anderson and Edward Rosenfeld.

This history reveals at least one salient factor that is relevant to the founding of INNS: The new field of neural networks, at least in the way that Grossberg and his colleagues practiced it, is highly interdisciplinary, and brings together knowledge from psychology, neuroscience, mathematics, computer science, engineering, and physics. It was therefore, at least at first, difficult for people trained in just one traditional discipline to fully understand Grossberg's discoveries about how the brain works. He knew that all of his major discoveries were derived from simple, albeit novel, ideas. Moreover, these ideas were expressed naturally in an appropriate, but also new, mathematical framework which helped to predict surprising new emergent properties about how the brain works. One interesting theme for the historian of science is that scores of the predictions that Grossberg derived from this methodology have been supported by experiments that were done from 5 to 30 years after their publication.

Grossberg was eager for many others to be able to see the underlying simplicity and inevitability of these contributions. He also realized that this interdisciplinary literacy problem was a serious

one for the field as a whole. He therefore began to spend a significant amount of his time introducing infrastructure that could facilitate the training of young scientists and the broad dissemination of neural network ideas. INNS and IJCNN were a culmination of a decade of such infrastructure development.

For example, in 1980, with the sponsorship of the American Mathematical Society and the Society for Industrial and Applied Mathematics, Grossberg organized a conference on Mathematical Psychology and Psychophysiology that brought together a number of leading modelers at a conference in Philadelphia called Mathematical Psychology and Psychophysiology. The conference proceedings were published as an AMS/SIAM book.

Grossberg established the Center for Adaptive Systems (CAS) at Boston University in 1982, with a permanent charter from the BU Trustees, in order to train postdoctoral fellows in the neural networks field. Gail Carpenter was Co-Director of CAS with Grossberg. CAS played a major role in the founding of INNS and IJCNN, as we will soon see.

An important Tutorial Conference on Neural Modeling was organized in 1983 by Robert Hecht-Nielsen, David Hestenes, and Peter Killeen in Scottsdale, Arizona, with support by AFOSR, ONR, and Arizona State University. All three conference organizers were introduced to neural network research through Grossberg's work, and wanted to hold a meeting that would highlight his contributions, as well as the state of behavioral and neural modeling at that time. At this conference, Grossberg lectured all morning for a week on his research and was asked to unify all of the topics that other leading modelers would talk about in the afternoons. Around 50 modelers came to the meeting, which was considered a large meeting at that time!

The founding of CAS enabled additional conferences and educational infrastructure to get planned more efficiently. CAS Assistant Director, Cindy Bradford, provided flawless help with scientific administration and conference planning, and is well known today to participants in the Center of Excellence for Learning in Education, Science, and Technology (CELEST: http://cns.bu.edu/celest) and the annual International Conference on Cognitive and Neural Systems (ICCNS: http://www.cns.bu.edu/events/events.html). After CAS got established, things started to really heat up in 1985 – 1986:

Starting in 1985, Grossberg began a year-long lecture series at the MIT Lincoln Laboratory about many aspects of the models that he and his colleagues had been developing at CAS. This invitation arose when several Lincoln Lab group leaders heard Grossberg speak about his new models of how the brain sees at the annual meeting of the Optical Society of America. They thought that these ideas might solve some of the problems that they were having in processing data from artificial sensors, such as laser radar, synthetic aperture radar, infrared, and the like. This has turned out to be correct. These lectures inspired Lincoln Laboratory to initiate the DARPA National Study on Neural Networks from 1987 - 1989, which had a large impact on organizing research and funding in the field of neural networks.

Also in 1985, Grossberg and Ennio Mingolla organized a Workshop on Human and Machine Vision at Boston University, just prior to the annual meeting of the Psychonomic Society.

Another Boston University meeting was organized in 1986 by Gail Carpenter and Grossberg on Pattern Recognition in Natural and Artificial Neural Systems. This meeting was co-sponsored by CAS and the Society for Mathematical Biology. Organizing this meeting taught Carpenter and Grossberg to be very particular about meeting organizational details, when they realized, just in the nick of time, after twice reconfirming the refreshments for the meeting, that the people who supplied the refreshments did not also supply the tables on which the refreshments would be put!

Again in 1986, Daniel Bullock and Grossberg organized an AFOSR-sponsored workshop on Neural Models of Sensory-Motor Control at the annual conference of the Society for Mathematical Psychology, which was held that year at Harvard University.

Yet another workshop was organized by Carpenter and Grossberg in 1986, this one an NSF-sponsored two-day workshop in Boston on the topic Neural Networks and Neuromorphic Systems.

Thus, by 1986, CAS was devoted to training postdoctoral fellows in interdisciplinary neural network research, and facilitated the planning of multiple interdisciplinary meetings aimed at solving the problems of interdisciplinary training and communication on a larger scale. These experiences set the stage for the next wave of infrastructure development and conference planning that led to the establishment of both INNS and the IJCNN conferences.

After Grossberg founded CAS and spent a number of years training postdoctoral fellows there, it became clear that a new interdisciplinary curriculum was needed to more fully train scientists in the biology and technology of neural modeling, and to do so at an earlier stage of their careers. After several years of administrative negotiations and approvals, he founded the Graduate Program in Cognitive and Neural Systems (CNS) in 1988, which became the Department of Cognitive and Neural Systems in 1991. CNS did, as planned, develop a unique new interdisciplinary graduate curriculum for training BA, MA, and PhD students in modeling how brains give rise to minds, and in transferring these new design and mechanistic insights into neuromorphic technology. Many other interdisciplinary departments also began to get founded around this time, but most not with the primary focus that CNS placed on training students in advanced behavioral and neural modeling.

As Grossberg was founding CAS and CNS, he realized that it would be important to have a new interdisciplinary journal in which to publish the research that such interdisciplinary training institutions would produce with ever greater frequency. It is hard to realize now how resistant traditional journals were 25 years ago to publishing neural modeling articles. Grossberg was a pioneer in overcoming this resistance in a number of leading mind and brain journals. These experiences strengthened his belief that the field needed its own interdisciplinary journals that would focus exclusively on neural models in the broadest sense, ranging from psychological and biological models, through mathematical and computational analyses, to engineering applications. He therefore approached several leading publishers, and founded the journal Neural Networks in 1987 with Pergamon Press as its publisher. He invited Teuvo Kohonen and Shun-Ichi Amari to be the editors-in-chief for Europe and Asia, while he served as editor-in-chief for North and South America. He also coordinated all three editorial offices with the help

of Cindy Bradford as editorial assistant. The first issue of Neural Networks came out in 1988. Several other neural modeling journals were founded during the next ten years.

Robert Hecht-Nielsen and Bart Kosko, whose work in neural networks was also strongly influenced by Grossberg, realized that large, widely publicized conferences were needed to grow with the field. They therefore negotiated with IEEE to get permission to hold an International Conference on Neural Networks (ICNN) in San Diego in 1987. They invited Grossberg to be the General Chairman of the conference. Grossberg again worked closely with Gail Carpenter and their colleagues at CAS to organize the conference program and publicity. This led to yet another advanced lab experience in conference planning for Carpenter and Grossberg. The budget for ICNN'87 program development was basically nil, and various people at IEEE expressed their doubts that ICNN could be brought off. In order to get the word out, Carpenter and Grossberg put together the conference brochure and program, stuffed thousands of brochures into envelopes, and went to the Newton Highlands, MA, post office on Christmas eve of 1986 to have the post office put stamps on the envelopes. Their request was denied, so they spent Christmas eve licking stamps for "the cause." As it turned out, ICNN'87 was a brilliant success with almost 2000 people in attendance.

As ICNN was being planned, Grossberg came increasingly to feel that the neural networks field needed its own Society. He had quite a bit of experience by that time in organizing meetings with the cooperation of other societies. But these experiences only made it seem even clearer that a new society was needed as the home of the burgeoning new interdisciplinary community of neural networks practitioners. Such a society would be served by the new Neural Networks journal. Grossberg therefore founded the International Neural Network Society in 1987, became its first President, and invited leading neural networks researchers of multiple persuasions to form its Board of Governors. The initial INNS Board of Governors read like a Who's Who of leading neural network researchers. Harold Szu, a long-time friend from Grossberg's graduate days at The Rockefeller University, was a great help in planning the initial INNS infrastructure. Grossberg announced the formation of INNS at his plenary lecture at ICNN'87. INNS has since stimulated the formation of the European Neural Network Society (ENNS) and the Japanese Neural Network Society (JNNS). All three societies today share Neural Networks as their archival society journal.

The final step in forming INNS was to plan an annual INNS meeting that would serve as an international forum where people from multiple disciplines, ranging from the biological to the technological, could regularly come together to exchange ideas and results. He and Gail Carpenter cooperated again to plan the first annual INNS meeting, which was held in Boston in 1988, and drew a very large and enthusiastic audience. Carpenter was both the meeting's organization chairman and the first INNS Vice President. Fourteen other societies agreed to cooperate with INNS in this venture, thereby demonstrating by example the interdisciplinary community that INNS hoped to form.

Grossberg gave opening remarks at the first INNS meeting in which he noted that, during the 14 months since members began to join, 3071 joined at a steady rate of 200 members a month. At that time, there was no sign of saturation in the INNS growth rate. There were members from 38 countries around the world, and 49 states of the United States. At that time, 20% of the members

were in the life sciences, 19% from the computer and information sciences, 27% from the different branches of engineering sciences, 2% from business, and the remaining 7% from a variety of other fields.

IJCNN arose as a fusion of the ICNN and INNS annual meetings in 1989. IJCNN is currently the largest meeting in the world that is devoted to neural network research, in all of its manifold manifestations. We therefore have a lot to celebrate on this 20th anniversary of IJCNN, and 50th anniversary of the scientific revolution that IJCNN is dedicated to serve.