Manton M. Matthews

1 Research Statement

My current research interests include wireless security, ontologies, natural language processing, intelligent user modelling, and graph theory. My research was originally in graph theory and in particular K1,3-free (clawfree) graphs. Then as a young Assistant Professor in Computer Science I made a conscious effort to redirect my research from graph theory to more main stream computer science topics. The first new areas explored were topics from parallel algorithms and functional programming. The functional programming through some joint conferences led to artificial intelligence and in particular intelligent user interfaces and natural language processing. The interest in knowledge representation for natural language processing led to the research in ontologies. Finally, working with a new assistant professor, Dr. Chin-Tser Huang, and our research group has led to several publications in protocols for wireless security.

I have served the Department since I was promoted to Associate Professor in 1987 as Director of Graduate Studies and as Assistant Chair since shortly thereafter. Twice I have served as Acting Chair, for the Department of Computer Science in 1990-1991 and for the Department of Computer Science and Engineering in 2005-2006. There is no doubt that this has hampered my research productivity. But when I started one of the major needs of the Computer Science Department was in directing masters theses, we didn't get the PhD degree until 1987. Over the years I have directed 105 masters students. Since the merger of Computer Science and Computer Engineering in 2000 the Computer Science and Engineering Department has had a non-thesis option for masters students and thus I have been able to devote more time in directing doctoral students. I have only had four doctoral students finish, but all have finished since the merger and I have two more in the pipeline that should finish soon, (Dec. 2008 and Aug. 2009).

For professional service I have served as a Commisioner of the Computing Accreditation Commission of ABET (2003-present) and have twice served as the Program Chair for the International Conference on Industrial and Engineering Applications of Artificial Intelligence and Expert Systems. (IEA/AIE-90, IEA/AIE-97 co-chair)

1.1 Graph Theory

My research interests have evolved over career. I suspect that this occurs to most everyone, but in my case it feels as if this has led to greater diversity in my case. Starting out my research was in graph theory and in particular $K_{1,3}$-free (clawfree) graphs. The major questions explored were/are:

1. the connection between the connectivity and hamiltonian cycles for clawfree graphs, and
2. extremal properties of clawfree graphs such as longest cycles and the maximum number of edges for a given number of points.

The paper "Hamiltonian Results in $K_{1,3}$-free Graphs," which appeared in the *Journal of Graph Theory* in 1984 has received considerable attention with around twenty papers publishing extensions and refinements of my work. This paper included what has become to be known as the Matthews-Sumner conjecture. This conjecture is that every clawfree 4-connected graph is hamiltonian. It was originally published in 1980 and although there has been considerable effort on the conjecture, it still remains an open question. There have been four international workshops on the Matthews-Sumner Conjecture. A reference to the 3rd workshop is "http://www.combinatorics.net/conf/conf.aspx?range=2002". Adrian Bondy classified it as simple, surprising, very old, and prolific in "http://www.ecp6.jussieu.fr/pageperso/bondy/proble *Beautiful Conjectures in Graph Theory,* page 35. In Bondy's classification scheme the term simple means simple to state.

1.2 Functional Programming / Parallel Processing

Coming from Mathematics I had a natural affinity for and interest in functional programming languages and parallel computation. This led me to attend a couple of the computer architecture conferences and in particular a workshop on Functional Programming, where I met John Backus and discussed the work he and Arvind were doing in data flow architectures at MIT. Several of the earliest of the theses that I directed were on topics related to data-flow architectures that arose from these conversations. The work in functional programming culminated in the

development of the FP-shell by Yogeesh Kamath, one of my master's students. Yogeesh won a best paper award for this work and later we published "Implementation of an FP-Shell," in the IEEE Transactions on Software Engineering, May, 1987. With Richard Reid we explored parallel parsing of natural language on a 128 node hypercube that the university had purchased. This implementation was derived from YACC, and handled ambiguity by pursuing different alternative parses on different subcubes of the hypercube. When the division of the subcube reached its limit the processing of alternatives had to rely on stacking the alternatives, but until that point the system achieved a very high level of parallelism with very little interprocess communication. Each node using its address in the hypercube always knew which parse to pursue. This work appeared in "Parallel Parsing of Ambiguous Languages," in *Lecture Notes in Computer Science,* vol. 604, Springer-Verlag 1992.

1.3 Intelligent User Interfaces

The second Functional Programming Conference that I attended was held consecutively with AAAI in 1984 and this is where I became introduced to artificial intelligence and in particular intelligent user interfaces. This lead to a number of papers and systems dealing with intelligent active user interfaces that model the knowledge of the user and make suggestions for improved performance. The underlying idea behind most of the work on intelligent user interfaces was to build systems that built models of users. These models captured what the user knows and does not know about using the system. The system then can become "active" and make suggestions either directly or through email on how to be more efficient and effective in using the system. The first paper on such "active assistance systems" was "Levi: A Prototype Active Assistance Interface," which was presented at the 1985 USENIX Association Meeting, Portland, Oregon, June 11-14 1985. Later this system was expanded to the Unix Shell in "USCSH: An Active Intelligent Assistance System," *Artificial Intelligence Review,* vol 14, April 2000.

1.4 Wireless Network Security

In Summer of 2004 with Dr. Chin-Tser Huang we formed a research group on network security. This group included doctoral students Chen, Zheng, Xu, Santhapuri and a master's student. Originally this group focussed on the problem of dual authentication between a base station and a mobile station in wireless LANs. "A Dual Authentication Protocol for IEEE 802.11 Wireless LANs," Xinliang Zheng, Chuming Chen, Chin-Tser Huang, Manton M. Matthews and Naveen Santhapuri, 2nd International Symposium on Wireless Communication Systems 2005 (ISWCS2005) September 5-7, 2005 Siena, Italy. Since that time we have had over 8 papers, two of the doctoral students have completed their PhDs and the other two should finish this year. The major issue addressed by the most recent work is protocol modifications adding to the security in multicasts under IEEE 802.16.

1.5 Natural Language / Ontologies

In May of 2004 one of my doctoral students, Chuming Chen, who had been working on security decided to take a full time job supporting bioinformatics research at the Medical University of South Carolina. Normally this would have been a great disappointment, however in this case we both felt this was an excellent opportunity for Mr. Chen to explore modeling of medical/bioinformatics knowledge to support the integration and interpretation of large experimental bioinformatics data sets. The work at the medical university centered around the use of shared XML Schemas to integrate data generated by different proteomics instruments, then the down-stream data analysis pipelines could then be developed based on the data encoded using the common XML schema, instead of developing different tools for different data sets. But what we realized was that OWL and its underlying description logic foundation provided better modeling capabilities. The rigid structure and less expressive of XML makes it hard to adapt to the rapid changing biomedical research. So we have been studying medical/bioinformatics ontologies and looking particularly at the problem of how they evolve. In particular we are studying how the changes that the experts make impact the overall structure (classification hierarchy) of the ontology.