CENTER FOR INFRASTRUCTURE ENGINEERING STUDIES

MISSOURI S&T

UTC
R180

Application of Sensor Networks to Intelligent Transportation Systems

by

Sahra Sedigh Sarvestani, Ph.D.
Electrical & Computing Engineering Department

**A University Transportation Center Program
at Missouri University of Science and Technology**

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16. Abstract

The objective of the research performed is the application of wireless sensor networks to intelligent transportation infrastructures, with the aim of increasing their dependability and improving the efficacy of data collection and utilization. Examples include health monitoring of bridges, flood level detection, and other applications of real-time data collection and analysis. This project will enable modeling, prediction, and improvement of trustworthiness for a variety of transportation infrastructures. In collaboration with the Center for Infrastructure Engineering Studies (CIES), a prototype of a base station with data acquisition and long range communication capabilities has been developed. The current application is the measurement of water levels for low-water bridges, and the prototype will be deployed by MoDOT in the immediate future. The research is directly tied to embedded computing (which is the subject of a course previously taught by the principal investigator) and to digital network communications (a new course developed and recently taught by the principal investigator). Three graduate students, one of whom is funded by the UTC, and two undergraduates are involved in the research. Planned future activities include collaboration with service learning activities at Missouri S&T, as well as the National Engineering Projects in Community Service (EPICS) program.

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ABSTRACT

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(1) Teaching – new courses developed; existing courses modified; lecture materials added or updated; labs added or updated and how the additions, modifications, updated, etc related to transportation issues

1. I developed a new course on Network Performance Analysis and Modeling (CpE/CS 401), which I am teaching for the first time in Fall 2009. A number of the examples and case studies presented relate to analysis of transportation networks.

2. I have taught Digital Network Design (CpE 319, distance course) in FS06, SP07, SP08, FS08, and SP09. Examples presented in class include the design of short- and long-range communication infrastructure for structural health monitoring.

3. I have taught Digital Systems Design (CpE 213) in S04, FS05, and FS08. Examples presented in class and homework assigned includes the design of an embedded system for structural health monitoring.

4. I taught Introduction to Computer Engineering (CpE 111) in FS07. Examples and assignments included logic design for flood detection systems and traffic signals.

(2) Research – proposals submitted / awarded / pending, including agency and 2-3 line synopsis of work proposed / performed and how it relates to transportation issues; journal articles published / accepted / submitted based on your work under these awards related to transportation issues; conference proceedings published / papers presented and seminars given based on your work as related to transportation issues

Grants awarded:

1. Evaluating and improving the utility of software in the analysis of electromagnetic immunity problems, $120,000, Samsung, 10/2009-9/2010. (Application of research results from the development of an embedded system for structural health monitoring)

2. Common Correctness for Protecting Confidentiality of Critical Infrastructure Systems, $34,343, National Security Agency, 8/2009-7/2010. (Transportation infrastructures are one domain analyzed)

3. Common Correctness for Protecting Confidentiality of Critical Infrastructure Systems, $32,999, National Security Agency, 1/2008-1/2009. (See above)

4. Refinement of Sensor Fusion of LIBS and Raman Emission Spectra in Trace Detection of Chemical and Biological Agents, $25,000, Leonard Wood Institute, 7/2008-9/2008. (Application of techniques developed for a wireless sensor network for structural health monitoring)

5. Sensor Fusion of LIBS and Raman Emission Spectra in Trace Detection of Chemical and Biological Agents, $140,000, Leonard Wood Institute, 11/2007-9/2008. (See above)

6. Design, Construction, Laboratory, and Field Testing of the Bridge on the Arnault Branch, Washington County, Missouri, $114,400, US Department of Transportation, 12/2006-12/2009.

7. Design, Construction, Laboratory, and Field Testing of the Bridge on the Arnault Branch, Washington County, Missouri, $302,500, Washington County, MO, 12/2006-8/2007.

8. Dependable Wireless Sensor Networks for Intelligent Infrastructures," $29,465, US Department of Transportation, 1/2005-12/2006.

Proposals pending:

CAREER: Building a qualitative and quantitative understanding of dependability in cyber-physical systems, $447,205 over 5 years, submitted July 2009, NSF. (Transportation infrastructures are one domain being analyzed)

Proposals not awarded:

1. Enhancing problem solving ability using computers for STEM disciplines, $199,375 over 3 years, submitted May 2009, NSF. (Transportation is one of the domains used as an example for problem-solving)

2. Information and system assurance of critical infrastructures, $1,775,447 over 4 years, submitted Dec. 2008, NSF.

3. Interdisciplinary Fellowship Program in Doctoral Education in Large-Scale Pervasive Systems, $846,559 over 3 years, submitted May 2009, Department of Education.

4. IGERT-Collaborative Pre-Proposal: A Doctoral Program in Pervasive Computing and Security for Critical Infrastructure Monitoring, O($1M) over 5 years, submitted Apr. 2008, NSF. (Transportation infrastructure is one domain analyzed)

5. Real-Time Remote Monitoring of Bridge Scouring with Distributed Thermal Sensors, $375,198 over 3 years, submitted Oct. 2007, NSF.

6. EFRI Pre-proposal: ARACHNID Initiative for Enhanced Resilience and Sustainability of Weakly-coupled Communication and Transportation Infrastructures, $1,990,743 over 4 years, submitted Oct. 2007, NSF.

7. CI-TEAM Implementation Project: Information and System Assurance of Critical Infrastructures, $956,105 over 4 years, submitted August 2007, NSF.

8. Instrumentation for Remote Structural Monitoring of Bridges, $29,601 over 1 year, Missouri Research Board, submitted March 2007.

9. Real-Time Monitoring of Bridge Scouring with Distributed Thermal Sensors , $324,379 over 3 years, submitted Feb. 2007, NSF.

10. Wireless Sensor Systems for Monitoring and Detection, $40,273 over 1 year, submitted Oct. 2006, Missouri Research Board.

Journal articles:

1. P. Shah, T. Harms, F. Bastianini, and S. Sedigh. A wireless sensor network for structural health monitoring of bridges. IEEE Transactions on Intelligent Transportation Systems, to be submitted in Dec. 2009.

2. Faza, S. Sedigh, and B. McMillin. Incorporating the effects of software failure in quantitative reliability analysis for the electric power grid. International Journal of Critical Infrastructure Protection, submitted in Oct. 2009.

Peer-reviewed conference papers:

1. B. Banks, D. Lecko, Z. Bourque, S. Sedigh, and F. Bastianini. The smartbrick wireless sensor node for high-resolution structural health monitoring. In Proceedings of the 17th International SPIE Symposium on Smart Structures and Materials and Nondestructive Evaluation and Health Monitoring, San Diego, USA, Mar. 2010, to appear.

2. W. K. Al-Assadi, S. Gandla, and S. Sedigh. Design of a flood prediction system. In Proceedings of the 12th International IEEE Conference on Intelligent Transportation Systems (ITSC '09), St. Louis, USA, Oct. 2009.

3. F. Bastianini, T. Harms, and S. Sedigh. Autonomous structural health monitoring with the SmartBrick platform. In Proceedings of the 12th International IEEE Conference on Intelligent Transportation Systems (ITSC '09), St. Louis, MO, Oct. 2009.

4. T. Harms, P. Shah, S. Sedigh, Z. Bourque, and F. Bastianini. Zigbee-enabled structural health monitoring with the SmartBrick network. In Proceedings of the 7th International Workshop on Structural Health Monitoring (IWSHM '09), Stanford, USA, Sept. 2009.

5. A. Faza, S. Sedigh, and B. McMillin. Reliability analysis for the advanced electric power grid: from cyber control and communication to physical manifestations of failure. In Proceedings of the 28th International Conference on Computer Safety, Reliability and Security (SAFECOMP '09), Hamburg, Germany, Sept. 2009, recipient of best paper award.

6. P. Shah, A. Singh, S. Agarwal, and S. Sedigh. Sensor data fusion for spectroscopy based detection of explosives. In Proceedings of the SPIE Symposium on Defense, Security + Sensing, Orlando, FL, Apr. 2009.

7. T. Harms, B. Banks, S. Sedigh, and F. Bastianini. Design and testing of a low-power wireless sensor network for structural health monitoring of bridges. In Proceedings of the 16th International SPIE Symposium on Smart Structures and Materials and Non-destructive Evaluation and Health Monitoring, San Diego, USA, Mar. 2009.

8. B. Banks, T. Harms, F. Bastianini, and S. Sedigh. A low-cost wireless system for autonomous generation of road safety alerts. In Proceedings of the 16th

International SPIE Symposium on Smart Structures and Materials and Nondestructive Evaluation and Health Monitoring, San Diego, USA, Mar. 2009.

9. A. Faza, S. Sedigh, and B. McMillin. The advanced electric power grid: Reliability modeling and complexity reduction techniques. In Proceedings of the 27th International Conference on Computer Safety, Reliability and Security (SAFECOMP '08), Newcastle-upon-Tyne, UK, Sept. 2008.

10. T. Harms, B. Banks, F. Bastianini, and S. Sedigh. Enhancement of autonomous real-time SHM with short-range wireless communication. In Proceedings of the 4th European Workshop on Structural Health Monitoring (EWSHM 2008), Cracow, Poland, July 2008.

11. S Gosavi, S. Sedigh, and W. Al-Assadi. Design and FPGA prototyping of a flood prediction system. In Proceedings of the 2008 IEEE Region 5 Conference, Kansas City, USA, Apr. 2008.

12. T. Harms, F. Bastianini, and S. Sedigh. An embedded wireless system for remote monitoring of bridges. In Proceedings of the 15th International SPIE Symposium on Smart Structures and Materials and Nondestructive Evaluation and Health Monitoring, San Diego, USA, Mar. 2008.

13. V. Plessi, F. Bastianini, S. Sedigh, N. Galati, and A. Nanni. An autonomous networked wireless device for structural health monitoring. In Proceedings of the 3rd International Conference on Structural Health Monitoring of Intelligent Infrastructure (SHMII-3), Vancouver, Canada, Nov. 2007.

14. T. Freiberger, S. Sedigh, and E. Atekwana. Hydrological monitoring with hybrid sensor networks. In Proceedings of the International Conference on Sensor Technologies and Applications (SENSORCOMM 2007), Valencia, Spain, Oct. 2007.

15. A. Faza, S. Sedigh, and B. McMillin. Reliability modeling for the advanced electric power grid. In Proceedings of the 26th International Conference on Computer Safety, Reliability and Security (SAFECOMP '07), pages 370{383, Nuremberg, Germany, Sept. 2007.

16. F. Bastianini, V. Plessi, S. Sedigh, N. Galati, and A. Nanni. A low-cost wireless system for real-time structural health monitoring. In Proceedings of the 6th International Workshop on Structural Health Monitoring (IWSHM '07), Stanford, USA, Sept. 2007.

17. V. Plessi, F. Bastianini, and S. Sedigh. A wireless embedded system for real-time environmental and structural monitoring. In Proceedings of the 5th IFIP Workshop on Software Technologies for Future Embedded & Ubiquitous Systems (SEUS '07), Santorini Island, Greece, May 2007.

18. A. Z. Faza and S. Sedigh. A general purpose framework for wireless sensor network applications. In Proceedings of the 30th Annual International Computer Software and Applications Conference (COMPSAC '06), pages 356{358, Chicago, USA, Sept. 2006, recipient of student paper award.

(3) Service – professional and campus committee memberships, tech transfer activities, etc that are related to transportations issues

1. Publications Chair of the 12th IEEE International Conference on Intelligent Transportation Systems (ITSC), 2009, 2010.

2. Organizer and Chair of Special Session on Intelligent Structural Health and Safety Monitoring at the 12th IEEE ITSC, 2009.

3. Embedded Systems Track Chair of the 32nd IEEE International Computer Software and Applications Conference (COMPSAC), 2008.

4. Peer reviewer for Journal of Intelligent Material Systems and Structures.