An Application of Wireless Sensor Networks in Health Care Setting, Part II

Zhibin Gui, Yongxiang Fan

***Abstract*— This paper and the following papers present an application of wireless sensor networks (WSNs)in health care setting. The application involves building a reliable transmission system to transmit physiological data from ICU gateway to central server wirelessly in hospitals. Due to the length of this project, this paper will include several parts, which are published separately. This part mainly focuses on implementation issues.**

***Index Terms*—Wireless sensor networks, health care, implementation.**

I. INTRODUCTION

Wireless sensor networks play important role and have been studied extensively [1]-[42]. Following Part I, this part of the whole paper mainly focuses on implementation. Details of the experiment setups and implement steps are presented in this part.

II. IMPLEMENTATION

2.1 Experiment Procedures

1). Nodes should be programmed as Base station and Mote, respectively.

2). In order to avoid any unexpected influence, all the experiment including free space and on-body test is done in the chamber where can provide almost perfect environment and lowest impacts.

3). The base station is connected to the work station through the programming board. It will receive packet and read the information attached.

4). Check the port number of Mib520 board from 'Device Manager' in 'My Computer' shown as below. Need to check every time when connect it to the computer.

5). Open the RSSI vs PDR folder and compile the Base station source code from Cygwin interface by keying in 'make micaz' (compile the program and check the errors). Then, the system will process in Figure 4.1.2.

6). Then the node_id should be assigned to 1 each time while installing the code by using the following command. (Note: ttyS'x', where x=COM-2)

7). Change the transmission power in 'ApplicationDefinitions.h' in mote folder. Then repeat step 2 to step 5 with other motes, make sure the sending mote is assigned with specific node_id except 1 (1 is only for base station).

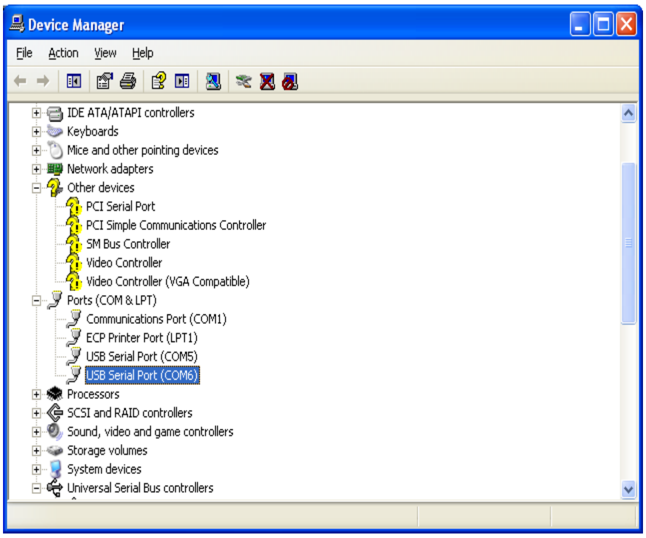

Figure 1 Check USB Serial Port Number

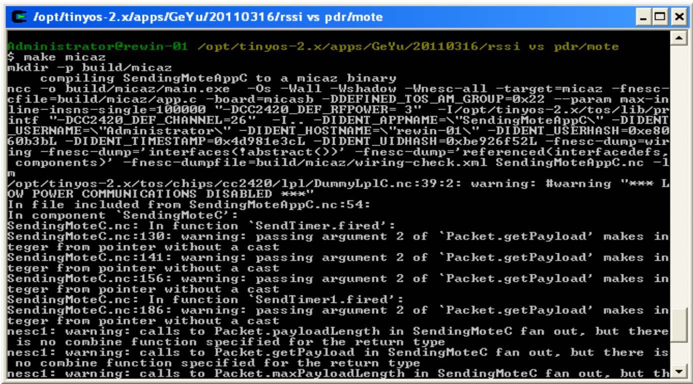

Figure 2 Check USB Serial Port Number

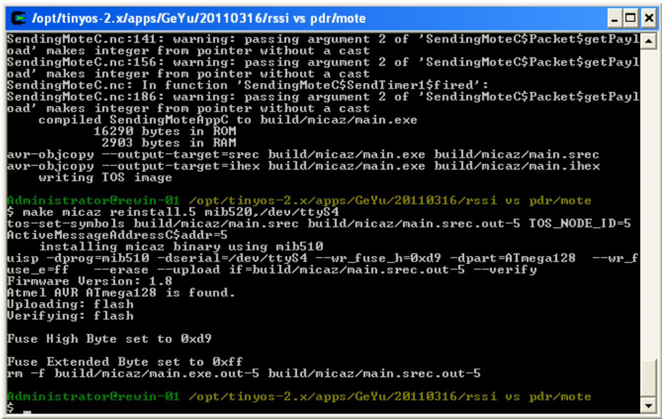

Figure 3 Load the Code to Base Station

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8). Then, place them on 2 tripods separately.

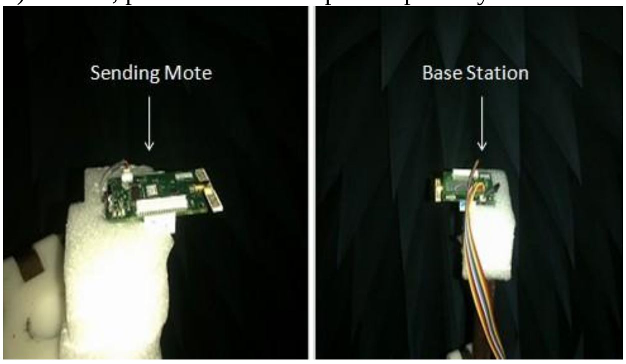

Figure 4 Base Station & Sending Mote

Then, turn on the base-station and sending mote, use the command of 'java net.tinyos.tools.PrintfClient -comm serial@COM5:micaz > tx3_50cm_1.txt' in Cygwin user interface, the RSSI value per packet and total number of packet received will be recorded and saved in .txt file. The base station is fixed at one side of the chamber, for each transmission power it starts with the farthest distance. The sending mote is placed 250cm away from the base station. Once powered on, the mote will send 1000 RSSI packets to the base station.

9). The above experiment is conducted repeatedly with different distance.

10. The main purpose is to determine the RSSI threshold value for the power control strategy which will helps to save the power supply and extend the battery usage.

2.2 RSSI vs PDR Chamber Free-Space Result Analysis

1). Link performance with different distance @ transmission power 3

Sending mote transmission power is pre-set to 3 and the distance between two tripods is fixed at 100cm. The result is attached at below.

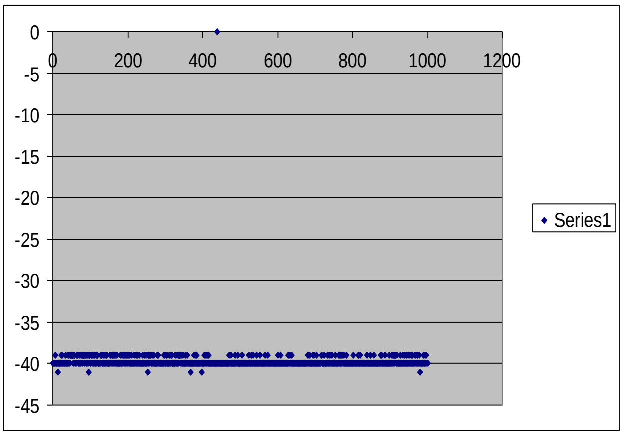

Figure 5 RSSI vs Time @Power 3, 100cm

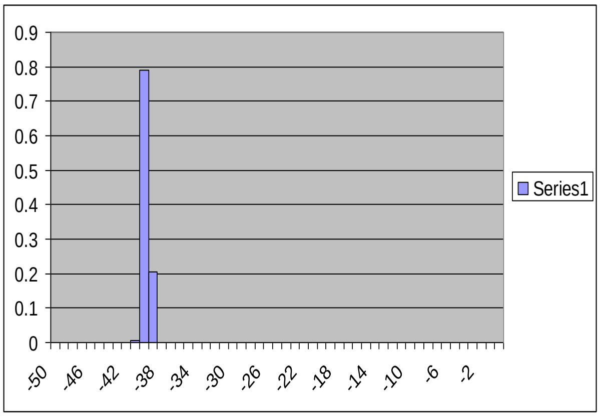

Figure 6 RSSI Probability Distribution @Power 3, 150cm

The packet delivery ration is 100 percentages. The link performance is good, it can be seen that RSSI value is changing between '-40' and '-39' and majority of the RSSI values are distributed at '-40'.

2) Now increase the distance between two tripods to 200cm. The environment in chamber is clean, there will be no multipath.

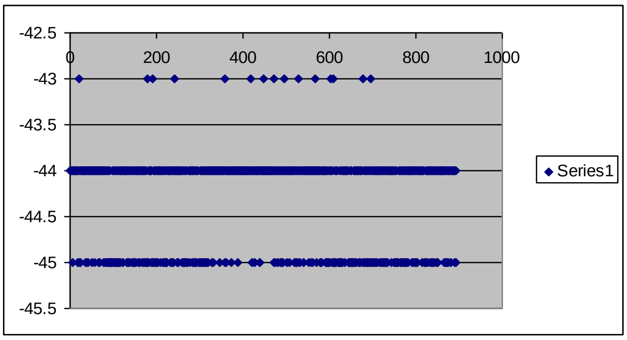

Figure 7 RSSI vs Time @Power 3, 200cm

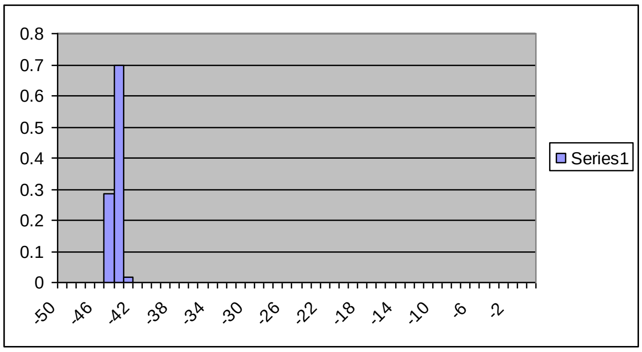

Figure 8 RSSI Probability Distribution @Power 3, 200cm

Note: Majority of the RSSI values are distributed between -44 and -45.

3) Decrease the distance between two tripods to 180cm and start transmitting again, now the PDR value achieves to 98.9 percentages which is slightly higher than before.

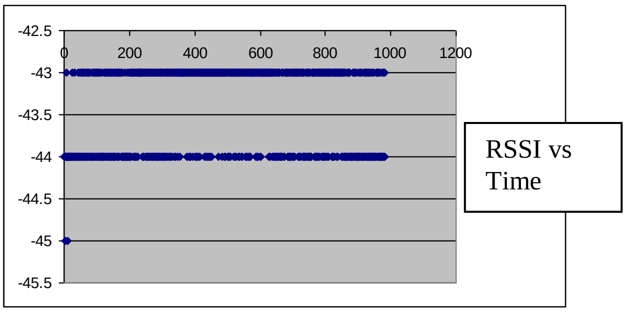

Figure 9 RSSI vs Time @Power 3, 180cm

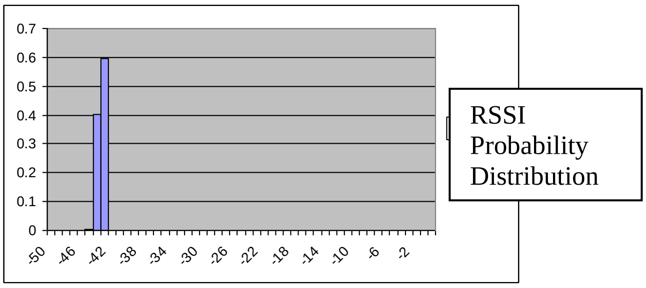

Figure 10 RSSI Probability Distribution @Power 3, 180cm
Note: Majority of the RSSI values are distributed between -43 and -44.

In conclusion, for transmission power 3, the PDR value can be higher than 95 percentages for RSSI value mainly distributed at '-43' and '-44'. As a result, the threshold RSSI value is determined at '-43' to keep the link transmission quality. It means that when the RSSI value of specific packet drop below '-43', the mote will increase its transmission power to a higher level which is pre-installed into the mote.

Link performance with different distance @ transmission power 7: Sending mote transmission power is changed and pre-set to 7, the distance between two tripods is fixed at 300cm. The result is attached at below.

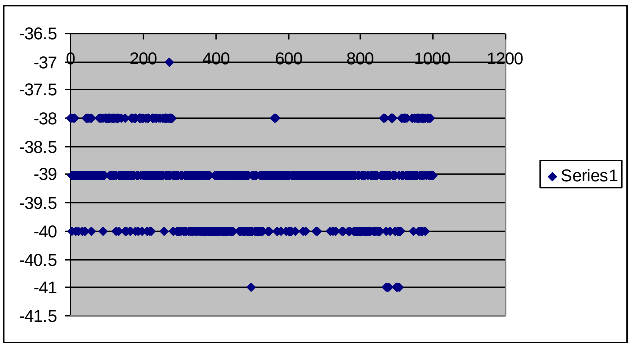

Figure 11 RSSI vs Time @Power 7, 300cm

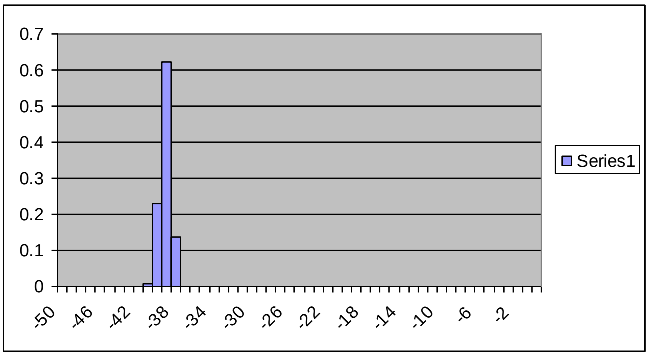

Figure 12 RSSI Probability Distribution @Power 7, 300cm

From the results, it is clearly show that even the distance is 300cm, the PDR can still achieve to 100 percentages with transmission power at 7. Hence, there is no need to test the distance smaller than 300cm, it will definitely give the same PDR. At TX7, the performance is good within a range of 3m. Benchmarking of RSSI value at TX7 is not possible due to the constraint of chamber space.

III. RSSI V.S. PDR ON-BODY RESULT ANALYSIS

The PDR on-body experiment result conducted in chamber will be used as reference and the standard threshold value will be determined based on the link performance. All the Micaz motes should be wear properly on each specific position on human body, basically there are 9 Micaz motes functioning as sending mote and 1 as sink which is placed at the right-hand side of waist. Each sending mote will be placed on arm, head and ankle separately.

The transmission power of base-station can be any value which will not affect the performance as receiver. It will receive packet from other sending mote. By using the 'printf' function, the parent_id, RSSI (radio signal strength indication) and PDR (packet delivery ratio) can be displayed from the cygwin interface. In terms of power saving purpose, the most suitable transmission power for each specific position can be chosen.

This part will present and evaluate the link performance for each node. For every specific power level, node with PDR higher than 95 percentages will be discussed. The main purpose is to find the minimum transmission power that needed for each specific position.

3.1. Performance of each link.

There are basically 10 links placed properly on human body with different location. The main purpose is to test and record the performance of each power level for all links by calculating the packet delivery ration every time. The modal should keeps standing at one corner in chamber. Due to the chamber environment, the result can be considered accurate and stable.

3.2 Node 5 to sink at transmission power 3.

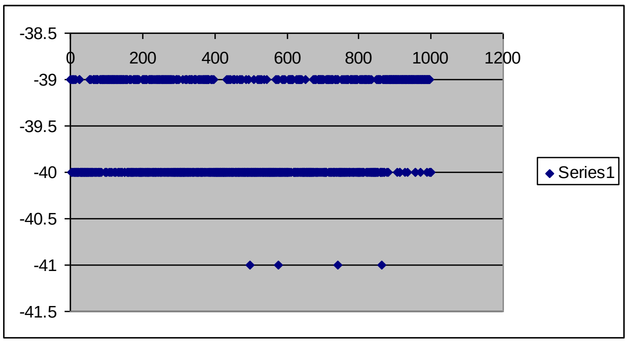

Figure 13. RSSI vs Time @Power 3

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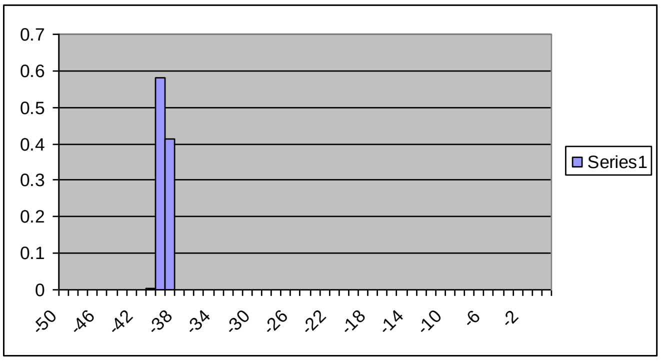

Figure 14. RSSI Probability Distribution @Power 3

Node 5 is placed at the right elbow where is quite close to sink. Both of the two antennas are almost parallel with each other, the packet delivery ratio can achieve 100 percentages easily even with the lowest transmission power. In conclusion, this position can choose power index ‘3’. From the figure above, the majority of the RSSI values are distributed between -39 and -40 which is relatively high enough to support good link performance. It can be assumed that all other larger transmission power level will all achieve 100 percentages PDR. Node 6 to sink at transmission power 3.

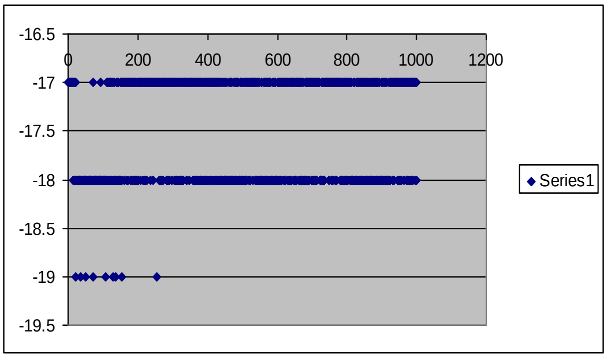

Figure 15. RSSI vs Time @Power 3

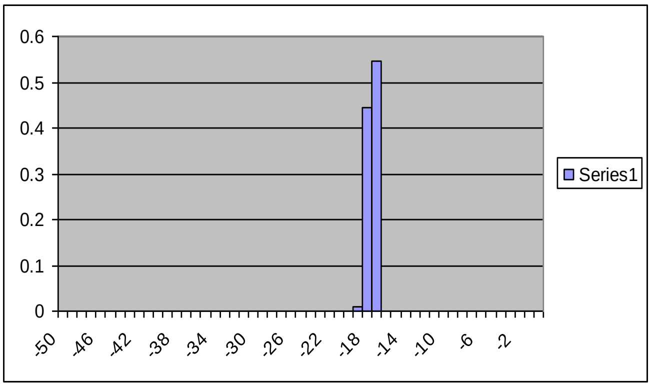

Figure 16 RSSI Probability Distribution @Power 3

Node 6 is placed at right wrist, the link performance is considered very good which result in a 100 percentages packet delivery ratio. The situation is almost the same as node 5, and packet RSSI value major distributed at -17 and -18 where indicates an excellent link quality. But only these two nodes can transmit to the sink successfully at power 3. It seems power 3 is too small to support the transmission task for the rest of the motes.

IV. CONCLUSION

This part of the paper mainly focuses on implementation issue. This part solved many unique problems. That is why this part is very important. More results will be provided in the following papers.

REFERENCES

[1] Z. X. Luo, “Anti-attack and channel aware target localization in wireless sensor networks deployed in hostile environments,” *International Journal of Engineering and Advanced Technology*, vol. 1, no. 6, Aug. 2012.

[2] C. Intanagonwiwat, R. Govindan, and D. Estrin,"Directed Di usion: A Scalable and Robust Communication Paradigm for Sensor Networks," in *Proc. ACM MOBICOM '00*, Boston, Massachusetts, August 2002.

[3] K. Sohrabi, B. Manriquez and G. Pottie,"Near-Ground Wideband Channel Measurements," in *Proc. IEEE VTC'99*, New York, 1999.

[4] Z. X. Luo, “Modeling sensor position uncertainty for robust target localization in wireless sensor networks,” in *Proc. of the 2012 IEEE Radio and Wireless Symposium*, Santa Clara, CA, Jan. 2012.

[5] R. Rajagopalan and P. K. Varshney, "Data-aggregation techniques in sensor networks: A survey," *IEEE Communications Surveys and Tutorials*, vol. 8, pp. 48-63, Fourth Quarter, 2006.

[6] Z. X. Luo, “Robust energy-based target localization in wireless sensor networks in the presence of byzantine attacks,” *International Journal of Innovative Technology and exploring Engineering*, vol. 1, no.3, Aug. 2012.

[7] C. Yao, P.-N. Chen, T.-Y. Wang, Y. S. Han, and P. K. Varshney, "Performance analysis and code design for minimum Hamming distance fusion in wireless sensor networks," *IEEE Trans. Inform. Theory*, vol. 53, pp. 1716-1734, May 2007.

[8] Z. X. Luo, “A new direct search method for distributed estimation in wireless sensor networks,” *International Journal of Innovative Technology and Exploring Engineering*, vol. 1, no. 4, Sept. 2012.

[9] A. Woo, D. E. Culler, “A Transmission Control Scheme for Media Access in Sensor Networks," in *Proc. ACM MOBICOM 2001*, pp.221-235, Rome, Italy 2001.

[10] W. Ye, J. Heidemann and D. Estrin, "An Energy-Efficient MAC Protocol for Wireless Sensor Networks," in *Proc. INFOCOM'02*, New York, USA,June, 2002.

[11] Akyildiz, I.F., W. Su, Y. Sankarasubramaniam, E. Cayirci, "A Survey on Sensor Networks", IEEE Communications Magazine, August,2002, pp.102-114.

[12] David Culler, Deborah Estrin, Mani Srivastava, “Overview of Sensor Networks,” *IEEE Computer, Special Issue in Sensor Networks*, Aug 2004.

[13] J. Z. Li, J. B. Li, and S. F. Shi, “Concepts, issues and advance of sensor networks and data management of sensor networks,” *Journal of Software*, 2003, vol. 14 no.10, pp.1717-1727.

[14] Z. X. Luo, and T. C. Jannett, “Energy-based target localization in multi-hop wireless sensor networks,” in *Proc. of the 2012 IEEE Radio and Wireless symposium*, Santa Clara, CA, Jan. 2012.

[15] K. Liu, J. Deng, P. K. Varshney, and K. Balakrishnan, "An acknowledgment-based approach for the detection of routing misbehavior in MANETs," *IEEE Trans. Mobile Comput*., vol. 6, pp. 536-550, May 2007.

[16] Q. Cheng, P. K. Varshney, J. H. Michels, and C. M. Belcastro, "Fault detection in dynamic systems via decision fusion," *IEEE Trans. Aerosp. Electron. Syst*., vol. 44, pp. 227-242, Jan. 2008.

[17] Z. X. Luo and T. C. Jannett, “Optimal threshold for locating targets within a surveillance region using a binary sensor network,” in *Proc. of the International Joint Conferences on Computer, Information, and Systems Sciences, and Engineering* (CISSE 09), Dec. 2009.

[18] R. Niu, P. K. Varshney, and Q. Cheng, "Distributed detection in a wireless sensor network with a large number of sensors," *Information Fusion*, vol. 7, pp. 380-394, Dec. 2006.

[19] Z. X. Luo and T. C. Jannett, “A multi-objective method to balance energy consumption and performance for energy-based target localization in wireless sensor networks,” in *Proc. of the 2012 IEEE SoutheastCon*, Orlando, FL, Mar. 2012.

[20] Engin Masazade, Ramesh Rajagopalan, Pramod K. Varshney, Chilukuri Mohan, Gullu Kiziltas Sendur, and Mehmet Keskinoz, "A Multi-objective Optimization Approach to Obtain Decision Thresholds for Distributed Detection in Wireless Sensor Networks," *IEEE Transactions on Systems, Man, and Cybernetics* - Part B, Vol. 40, No. 2, April 2010.

[21] Z. X. Luo and T. C. Jannett, "Performance comparison between maximum likelihood and heuristic weighted average estimation methods for energy-based target localization in wireless sensor networks," in *Proc. of the 2012 IEEE SoutheastCon*, Orlando, FL, Mar. 2012.

[22] F. Stann and J. Heidemann, "RMST: Reliable Data Transport in Sensor Networks," in *Proc. 1st IEEE Workshop on Sensor Network Protocols and Applications (SNPA),* 2003.

[23] B. Hull, K. Jamieson, and H. Balakrishnan, "Mitigating Congestion in Wireless Sensor Networks," in *Proc.2nd ACM Conference on Embedded Networked Sensor Systems (SenSys'04),* 2004.

[24] Z. X. Luo, "A censoring and quantization scheme for energy-based target localization in wireless sensor networks," *Journal of Engineering and Technology*, vol.2, no.2, Aug. 2012.

[25] H. Chen and P. K. Varshney, "Theory of the stochastic resonance effect in signal detection---Part II: Variable detectors," *IEEE Trans. Signal Process*., vol. 56, pp. 5031-5041, Oct. 2008.

[26] Z. X. Luo, "A coding and decoding scheme for energy-based target localization in wireless sensor networks," *International Journal of Soft Computing and Engineering*, vol.2, no. 4, Sept. 2012.

[27] C. Intanagonwiwat, R. Govindan, D. Estrin, J. Heidemann, and F. Silva, "Directed diffusion for wireless sensor networking," *ACM/IEEE Transactions on Networking*, vol. 11, no. 1, 2002.

[28] Z. X. Luo, "Distributed estimation in wireless sensor networks with heterogeneous sensors," *International Journal of Innovative Technology and Exploring Engineering*, vol. 1, no.4, Sept. 2012.

[29] M. Karpinski, A. Senart, and V. Cahill, "Sensor networks for smart roads," in *Proceedings of the Second IEEE International Workshop on Sensor Networks and Systems for Pervasive Computing (PerSeNS'06),* Pisa, Italy, pp. 13–17 March 2006.

[30] Z. X. Luo, "Overview of applications of wireless sensor networks," *International Journal of Innovative Technology and Exploring Engineering*, vol. 1, no. 4, Sept. 2012

[31] Y. Wang, G. Zhou, T. Li, "Design of a wireless sensor network for detecting occupancy of vehicle berth in car park," in *PDCAT'06: Proceedings of the Seventh International Conference on Parallel and Distributed Computing, Applications and Technologies*, IEEE Computer Society, Washington, DC, USA, 2006, pp. 115–118.

[32] S. C. Ergen and P. Varaiya, "Optimal placement of relay nodes for energy efficiency in sensor networks," in Proceedings of *IEEE International Conference on Communication*, Istanbul, Turkey, June 2006.

[33] Z. X. Luo, P. S. Min, and S. J. Liu, "Target localization in wireless sensor networks for industrial control with selected sensors," *International Journal of Distributed Sensor Networks*, 2013.

[34] W. Chen, L. Chen, Z. Chen, S. Tu, "A realtime dynamic traffic control system based on wireless sensor network," in *Proceedings of the 2005 International Conference on Parallel Processing—Workshops, IEEE,* Oslo, Norway 2005, pp. 258–264.

[35] M. Wiering, J. Vreeken, J. V. Veenen, and A. Koopman, "Simulation and optimization of traffic in a city," in *IEEE Intelligent Vehicles Symposium,* Parma, Italy, June 2004.

[36] Z. X. Luo, "Parameter estimation in wireless sensor networks with normally distributed sensor gains," *International Journal of Soft Computing and Engineering*, vol. 2, no. 6, Jan. 2013.

[37] Q. Cheng, B. Chen, and P. K. Varshney, "Detection performance limits for distributed sensor networks in the presence of nonideal channels," *IEEE Trans. Wireless Commun*., vol. 5, pp. 3034-3038, Nov. 2006.

[38] Z. X. Luo, "Parameter estimation in wireless sensor networks based on decisions transmitted over Rayleigh fading channels," *International Journal of Soft Computing and Engineering*, vol. 2, no. 6, Jan. 2013.

[39] R. Niu and P. K. Varshney, "Performance analysis of distributed detection in a random sensor field," *IEEE Trans. Signal Process*., vol. 56, pp. 339-349, Jan. 2008.

[40] Z. X. Luo, "Distributed estimation and detection in wireless sensor networks," *International Journal of Inventive Engineering and Sciences*, vol. 1, no. 3, Feb. 2013.

[41] D. Chen and P. K. Varshney, "On demand geographic forwarding for data delivery in wireless sensor networks," *Computer Communications*, vol. 30, pp. 2954-2967, Oct. 2007.

[42] S. Zhang, W. Xiao, J. Gong, and Y. Yin, "A novel human motion tracking based on wireless sensor network," *International Journal of Distributed Sensor Networks*, 2013.