University of Victoria | Graduate Studies

PROGRAMME

The Final Oral Examination
for the Degree of

DOCTOR OF PHILOSOPHY
(Department of Electrical and Computer Engineering)

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2011 Amirkabir University of Technology MASc

"Blind Received Signal Strength Difference Based Source Localization with System Parameter Error and Sensor Position Uncertainty"

Monday, August, 25, 2014
10:30 A.M.
Engineering Office Wing, room 430

Supervisory Committee:
Dr. T. Aaron Gulliver, Department of Electrical and Computer Engineering, UVic
(Supervisor)

Dr. Fayez Gebali, Department of Electrical and Computer Engineering, UVic
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Dr. George Tzanetakis, Department of Computer Science, UVic
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Dr. Payman Arabshahi, Faculty of Electrical Engineering, University of Washington

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Dr. Faoruk Nathoo, Department of Mathematics and Statistics, UVic

Abstract

Passive source localization in wireless sensor network (WSN) is an important field of research with numerous applications in signal processing and wireless communications. One purpose of a WSN is to determine the position of a signal emitted from a source. This position is then estimated based on received noisy measurements from sensors (anchor nodes) that are distributed over a geographical area. In most cases, the sensor positions are assumed to be known exactly, which is not always reasonable. Even if the sensor positions are measured initially, they can change over time.

Due to the sensitivity of source location estimation accuracy with respect to the a priori sensor position information, the source location estimates obtained can vary significantly regardless of the localization method used. Therefore, the sensor position uncertainty should be considered to obtain accurate estimates. Among the many localization approaches, signal strength based methods have the advantages of low cost and simple implementation. The received signal energy mainly depends on the transmitted power and path loss exponent which are often unknown in practical scenarios. In this dissertation, three received signal strength difference (RSSD) based methods are presented to localize a source with unknown transmit power. A nonlinear RSSD-based model is formulated for systems perturbed by noise.

First, an effective low complexity constrained weighted least squares (CWLS) technique in the presence of sensor uncertainty is derived to obtain a least squares initial estimate (LSIE) of the source location. Then, this estimate is improved using a computationally efficient Newton method.
The Cramer-Rao lower bound (CRLB) is derived to determine the effect of sensor location uncertainties on the source location estimate. Results are presented which show that the proposed method achieves the CRLB when the SNR is sufficiently high. Least squares (LS) based methods are typically used to obtain the location estimate that minimizes the data vector error instead of directly minimizing the unknown parameter estimation error. This can result in poor performance, particularly in noisy environments, due to bias and variance in the location estimate. Thus, an efficient two stage estimator is proposed here.

First, a minimax optimization problem is developed to minimize the mean square error (MSE) of the proposed RSSD based model. Then semidefinite relaxation is employed to transform this nonconvex and nonlinear problem into a convex optimization problem. This can be solved efficiently to obtain the optimal solution of the corresponding semidefinite programming (SDP) problem. Performance results are presented which confirm the efficiency of the proposed method which achieves the CRLB.

Finally, an extended total least squares (ETLS) method is developed for blind localization which considers perturbations in the system parameters as well as the constraints imposed by the relation between the observation matrix and data vector. The corresponding nonlinear and nonconvex RSSD-based localization problem is then transformed to an ETLS problem with fewer constraints. This is transformed to a convex semidefinite programming (SDP) problem using relaxation. The proposed ETLS-SDP method is extended to the case with an unknown path loss exponent. The mean squared error and corresponding CRLB are derived as a performance benchmark. Performance results are presented which show that the RSSD-based ETLS-SDP method attains the CRLB for a sufficiently large signal to noise ratio (SNR).

Awards, Scholarships, Fellowships

2014 – Teaching Excellence Award, University of Victoria

2014 – Paper Award IEEE Ocean Conf., Newfoundland

2013 – Outstanding Graduate Award, University of Victoria

2013 – IEEE Ocean Engineering Scholarship

2013 – Teaching Excellence Award, University of Victoria

2012 – EEE OCEAN Engineering Scholarship

2014 – Graduate fellowships, University of Victoria

Presentations

1. Lohrasbipeydeh, H.; Gulliver, T.A; Amindavar, H. and Dakin T. *"Unknown transmit power energy based source localization in wireless sensor networks."* IEEE VTC Conference, Vancouver, B.C., Canada, Sept. 2014. (oral)

2. Lohrasbipeydeh, H.; Gulliver, T.A; Amindavar, H. and Dakin T. "*Efficient RSSD-based source positioning with system parameter uncertainties."* IEEE VTC Conference, Vancouver, B.C., Canada, Sept. 2014. (oral)

3. Lohrasbipeydeh, H.; Dakin, T; Gulliver, T.A; Grasse, C.D. *"Passive acoustic energy based diver detection and depth estimation."* IEEE Ocean Conference, Newfoundland, Canada, Sept. 2014. (poster)

4. Lohrasbipeydeh, H.; Dakin, T.; Gulliver, T.A; Zielinski, A. *"Single hydrophone passive source range and depth estimation in shallow water."* IEEE Ocean Conference, Bergen, Norway, June 2013. (oral)

5. Lohrasbipeydeh, H.; Zielinski, A.; Gulliver, T. A. "*Dynamic behavior of sound generated by gas bubbles injected underwater."* IEEE Ocean Conference, Bergen, Norway, June 2013. (oral)

6. Lohrasbipeydeh, H.; Dakin, Gulliver, T.A.; Zielinski, A. *"Characterisation of Sperm Whale vocalization based on Echolocation signals."* IEEE Ocean Conference, Bergen, Norway, Sept. 2013. (oral)

Publications

1. Lohrasbipeydeh, H.; Gulliver, T.A.; Amindavar, H.; "Kernel recursive regularized total least square estimator." *IEEE Transaction on Signal Processing,* **2014**. (submitted).

2. Lohrasbipeydeh, H.; Gulliver, T.A.; Amindavar, H.; "Blind received signal strength difference based source localization with system parameter errors", *IEEE Transaction on Signal Processing*, **Jun 2014**. (accepted).

3. Lohrasbipeydeh, H.; Gulliver, T. A.; Amindavar, H.; “A minimax SDP method for energy based source localization with unknown transmit power.” *IEEE Wireless Communication Letter*, **May 2014**. (accepted).

4. Lohrasbipeydeh, H.; Gulliver, T. A.; Amindavar, H.; “Received signal strength difference based source localization with unknown transmit power and sensor position uncertainty,” *IEEE Transaction on Wireless Communication,* **2013,** (under revision)**.**

5. Lohrasbipeydeh, H.; Dakin, T.; Gulliver, T. A.; Zielinski, A.; “Passive acoustic sperm whale echolocation click and creak detection.” *IEEE Transaction of Ocean Engineering,* **May 2014.** (under revision).

6. Lohrasbipeydeh, H.; Zielinski, A.; Gulliver, T. A.; “On the Characteristics of sound generated by bubbles injected underwater.” *Journal of Hydroacoustics*, **2012,** 15, 1642-1817, 111-122.

7. Mosayyebpour, S.; Lohrasbipeydeh, H.; Gulliver, T. A.; “Two-Channel robust time delay estimation in noisy reverberant and time-varying room environment”, Submitted to IEEE Transaction on Speech and Audio Processing, (under revision) Nov. **2013.**

8. Lohrasbipeydeh, H.; Amindavar, H.; "Diver Range Estimation Based on Shallow Water Cavitations," *IEEE International Conference on Acoustics, Speech and Signal Processing,* **2012**, March, (ICASSP) 1673-1676.

9. Lohrasbipeydeh, H.; Zielinski, A.; Gulliver, T. A.; “A new acoustic passive sperm whales depth tracking method.” *IEEE TENCON*, Cebu, Philippines, Nov. 19-22, **2012.**

10. Lohrasbipeydeh, H.; Mosayyebpour, S.; Gulliver, T. A.; “Single hydrophone passive acoustic sperm whale range and depth estimation.” I*EEE International Conference on Acoustics, Speech and Signal Processing*, **2013,** May, (ICASSP) 754-757.

11. Mosayyebpour, S.; Lohrasbipeydeh, H.; Gulliver, T. A.; “Time delay estimation via minimum-phase and all-pass component processing.” *IEEE International Conference on Acoustics, Speech and Signal Processing,* **2013,** May (ICASSP), 4285-4289.

12. Lohrasbipeydeh, H.; Dakin, T.; Gulliver, T. A.; Zielinski, A.; “Single hydrophone passive source range and depth estimation in shallow water.” *Proceedings of IEEE Ocean Conf.,* Bergen, Norway, **June 2013**, 1-4.

13. Lohrasbipeydeh, H.; Zielinski, A.; Gulliver, T. A.; “Dynamic behavior of sound generated by gas bubbles injected underwater”, *IEEE Ocean Conf.*, Bergen, Norway, **Jun. 2013**, 1-4.

14. Lohrasbipeydeh, H.; Dakin, T.; Gulliver, T. A.; Zielinski, “Characterisation of Sperm Whale vocalization based on Echolocation signals,” *IEEE Ocean Conf.,* San Diego, USA, **Sep. 2013,** 1-5.

15. Lohrasbipeydeh, H.; Gulliver, T. A.; Amindavar, H.; Dakin, T.; “Unknown transmit power energy based source localization in wireless sensor networks,” *Proceedings of IEEE VTC Conf,* Vancouver, Canada, **March 2014**.

16. Lohrasbipeydeh, H.; Gulliver, T. A.; Amindavar. H.; Dakin, T.; “Efficient RSSD-based source positioning with system parameter uncertainties.” *Proceedings of IEEE VTC Conf, Vancouver, Canada*, **March 2014**.

17. Lohrasbipeydeh, H.; Dakin, T.; Gulliver, T. A.; Grasse, C. D.; “Passive acoustic energy based diver detection and depth estimation.” *Proceedings of IEEE Ocean Conf., Newfoundland, Canada,* **Sept. 2014**.