# Preface

WSN (Wireless Sensors Networks) is intended to be deployed in environments where sensors can be exposed to circumstances that might interfere with measurements provided. Such circumstances include strong variations of pressure, temperature, radiation, and electromagnetic noise. Thus, measurements may be imprecise in such scenarios. Data fusion is used to overcome sensor failures, technological limitations, and spatial and temporal coverage problems.

Not many books addressed the real life problem in WSN applications. In this book, we are proposing real implementation of data fusion algorithms; taking into consideration the resource constrains of WSN. In addition, we are introducing some real applications, as case study, in the industry.

The data fusion can be implemented in both centralized and distributed systems. In the centralized fusion case, we propose four algorithms to be implemented in WSN. As a case study, we propose a remote monitoring framework for sand production in pipelines. Our goal is to introduce a reliable and accurate sand monitoring system. The framework combines two modules: a Wireless Sensor Data Acquisition (WSDA) module and a Central Data Fusion (CDF) module. The CDF module is implemented using four different proposed fusion methods; Fuzzy Art (FA), Maximum Likelihood Estimator (MLE), Moving Average Filter (MAF), and Kalman Filter (KF). All the fusion methods are evaluated throughout simulation and experimental results. The results show that FA, MLE and MAF methods are very optimistic, to be implemented in WSN, but Kalman filter algorithm does not lend itself for easy implementation; this is because it involves many matrix multiplications, divisions, and inversions. The computational complexity of the centralized KF is not scalable in terms of the network size. Thus, we propose to implement the Kalman filter in a distributed fashion. The proposed DKF is based on a fast polynomial filter to accelerate distributed average consensus. The idea is to apply a polynomial filter on the network matrix that will shape its spectrum in order to increase the convergence rate by minimizing its second largest eigenvalue. Fast convergence can contribute to significant energy savings. In order to implement the DKF in WSN, more power saving is needed. Since multiplication is the atomic operation of Kalman filter, saving power at the multiplication level can significantly impact the energy consumption of the DKF. This work also proposes a novel light-weight and low-power multiplication algorithm. Experimental results show that the TelosB mote can run DKF with up to seven neighbors.

This book is based on Abdelgawad PHD dissertation. The work presented was carried out through a large scale research project titled UCoMS (Ubiquitous Computing and Monitoring System) supported by DoE and State of Louisiana.

We appreciate the support, the project team, and the working environment of UCoMS. The VLSI group infrastructure, stimulating and challenging environment, and the weakly presentation and discussion have been an asset to the presented work.

Abdelgawad offers all praise to the almighty God, Allah, the Most Gracious, and the Most Merciful for his blessings bestowed upon him and for giving him the strength to achieve what he has accomplished in his life. Abdelgawad dedicates this book to his family which has played an important role in his life and study. Their support and encouragement has made this book a reality. He would like to thank his mother for her prayers, love, and faith in him. Ahmed's deepest appreciation goes to his lovely wife, Dalia Aboelfadl, his precious daughter, Salma, his handsome son, Mohamed, and his little son, Ali for their unlimited encouragement, sacrifices, and for being by his side.

Bayoumi would like to dedicate this book to his smart, energetic, and dedicated students.

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