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Title(English)	Research on Reliable and Energy-Efficient Communications in Wireless Body Area Network Using Human Motion Classification-based Transmission Power Control
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Thesis Outline

This research develops a transmission power control method using human motion classification. The aim of this research is to provide low-energy and reliable communication for wireless body area network (WBAN). This doctoral thesis consists of six chapters.

Chapter 1 Introduction: this chapter firstly provides the overview of WBAN, which describes the promising applications in WBAN, technical challenges, and WBAN communication architecture. Next, developed and currently developing applications in WBAN are reviewed. After that, challenges and requirements of WBAN development are discussed, and then the solution proposed by this research is introduced. After that, related studies—human motion classification using radio signal strength and transmission power control for WBAN—are reviewed. Lastly, the contributions and outline of this thesis are given.

Chapter 2 Relevant techniques and tools for communication design in WBAN system: this chapter describes the machine learning techniques including back propagation neural network, k-nearest neighbor, support vector machine, and decision tree. These machine learning techniques are used to develop radio frequency-based human motion classification, which is a tool used to classify the human motion from the radio signal strength. Next, WBAN measurement and channel modeling methods are explained in order to understand the evaluation method used to assess the performance of the new communication design in WBAN. Lastly, the concept of Castalia network simulator, which is a tool used to evaluate the developed transmission power control method, is provided.

Chapter 3 Development of RF-based human motion classification: this chapter aims to develop the human motion classification using only the radio signal strength. In this chapter, firstly, RF signal processing is studied. The RF signal processing study includes time-domain computation to obtain features, which are derived values from observations, for the classification. Then, a feature selection method is performed to remove unnecessary features. After that, the structure of classification system is developed. Then, the parameter-oriented evaluation is conducted to identify the dominant parameters that affect the classification performance. It was found that the number of RF signal samples and the receiver location had the significant impact on the classification performance. For the number of RF signal samples, using a large number of RF signal samples resulted in higher accuracy rate than using a small number of RF signal samples. For the receiver location, the receiver at thigh and upper arm showed higher accuracy rate than the receiver at wrist and ankle.

Chapter 4 Development of temporal correlation model-based transmission power control: this chapter aims to reduce the energy consumption as mush as possible while maintaining high communication reliability. The transmission power control using temporal correlation model is developed to achieve this goal. In the proposed power control method, the temporal correlation model is used to estimate WBAN channel. The WBAN channel is estimated in terms of conditional distribution of channel gains. Then, the transmit power that satisfies the expected outage probability parameter, which is a user-defined parameter, is selected. This algorithm can trade-off between the energy consumption and reliability by adjusting the expected outage probability parameter. A guideline to tune the expected outage probability parameter is given. After that, the performance of the proposed power control method was evaluated to show that the proposed power control can effectively reduce the energy

consumption and achieve low packet loss rate. Lastly, the proposed power control is compared to other existing power control methods. The comparison shows that the proposed power control method has relatively low packet loss rate, and it consumes the lowest energy among all power control methods.

Chapter 5 WBAN communication system design using motion-aware transmission power control: this chapter develops the motion-aware transmission power control by combining the human motion classification and temporal correlation model-based transmission power control. In this chapter, the human motion classification is implemented by a neural network. The detail of neural network implementation is thoroughly described. After that, the performance of the motion-aware transmission power control was evaluated in four motion scenarios: ascending/descending stair, walking, sitting and standing scenarios. In ascending/descending stair, walking and standing scenarios, the motion-aware transmission power control generally had low packet loss rate and consumed low energy. However, in the sitting scenario, some links experienced very high packet loss rate, thus requiring another method such as the cooperative relay to improve the reliability. Additionally, the robustness of the motion-aware transmission power control was evaluated in an unexpected motion scenario. The evaluation results demonstrated that the proposed motion-aware power control method was acceptably robust against the unexpected motion scenario.

Chapter 6 Conclusion: this chapter provides the conclusion of this research. The motion-aware transmission power control developed in this research can effectively reduce the energy consumption while maintaining reasonably high reliability. Therefore, this motion-aware power control can be integrated to the communication stacks of WBAN system. In addition, the benefits and directions for future research are given.