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Horizontal dilution of precision-based ultra-wideband positioning technique for indoor environments

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Abstract: Ultra-wideband (UWB) technology provides considerable performance in many indoor localization problems thanks to its very wide spectrum and high-resolution characteristics. In this paper, we propose using the horizontal dilution of precision (HDOP) to decrease the localization error in indoor environments for UWB localization systems. To achieve this aim, first we determine the positioning accuracy of a commercially available UWB positioning system using laboratory experiments. Next, the results of the position estimations obtained by the HDOP are compared with the experimental results acquired by the UWB positioning system. Finally, we investigate a detailed comparison with the least squares (LS), nonlinear regression (NLR), and iterative nonlinear regression (INR) techniques. In terms of the mean position estimation error, the proposed HDOP technique increases the performance of the UWB positioning system and the LS algorithm by approximately 10% and 3%, respectively. In addition, while the proposed HDOP technique provides localization for all of the test points, both the NLR and INR algorithms perform below the expected levels at the same points.

Key words: Wireless networks, ultra-wideband, localization, dilution of precision, least squares techniques, linear regression

1. Introduction

Wireless communication systems acquire practical solutions to today's communication problems with many successful applications [1–3]. In addition, they seem to be the systems that follow the technological improvement closely [2]. With the help of the advantageous and practical solutions to problems that they provide, wireless communication systems draw the attention of researchers and lead them to contribute to the solutions of localization and real-time tracking. In the literature, there are different studies for various environments to estimate a user's position and follow the user when it is needed [3]. While the Global Positioning System (GPS) [4] is accepted as the most important and accurate solution among the presented solutions for outdoor environments, there is no commonly accepted method for indoor environments. Studies have been focused on ultra-wideband (UWB) technology, which has better signal resolution compared to traditional radio technology [5]. High-bandwidth UWB radio transceivers transmit data faster and with a small error probability by minimizing the effects of multipath interferences. This yields a faster and more reliable wireless communication environment between wireless equipment in indoor environments [6].

UWB systems transmit at prespecified power levels [7] in order to not be affected by the interferences caused by systems using the same frequency spectrum. Thus, UWB signals, which are at prespecified power

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