Drone Signal TDOA Estimation Algorithm Based on an Improved Wavelet Threshold Denoising Technique

Zhixuan FENG*, Peng GONG*, Yuhan LIU*, Piao HE*, Bin TANG*, Guangwei ZHANG*

* National Key Laboratory of Mechatronic Engineering and Control, School of Mechatronical Engineering, Beijing Institute of Technology, Beijing, China

3120220183@bit.edu.com , penggong@bit.edu.cn, rainyhelen@163.com, 3220230127@bit.edu.cn , 3120230249@bit.edu.cn, 6120240118@bit.edu.cn

Abstract—In the passive detection and positioning technology of UAV based on the principle of time difference of arrival (TDOA), the existing time-difference estimation method which relies on signal cross-correlation puts forward high requirements for waveform correlation of received signals. Noise interference in the received signal will lead to a large error in time delay estimation, which will seriously affect the positioning accuracy. To solve this problem, an improved wavelet threshold estimation method for UAV signal arrival time difference is proposed in this paper. In order to solve the problem of signal correlation and noise in traditional TDOA estimation method, wavelet denoising technology is used to pre-process the received signal and improve the accuracy of TDOA estimation. In addition, a new soft threshold function is introduced, which is improved on the traditional threshold function, reduces the oscillation of the hard threshold function and the constant error of the soft threshold function, while maintaining the local characteristics of the signal. The effectiveness of the proposed method is verified by simulation and measured data. The results show that the improved wavelet threshold denoising method has better denoising performance and significantly improves the stability and accuracy of TDOA estimation.

Keyword—Wavelet threshold denoising;Arrival time difference TDOA estimate;Threshold optimization;Signal processing.

Zhixuan Feng obtained the BS degree in Mechatronical Engineering from Beijing Institute of Technology in 2022 and is currently a Master's student in the School of Mechanical and Electrical Engineering at Beijing Institute of Technology. Her main research interests are signal processing, wireless network simulation, communication algorithms, etc.

Peng Gong received the BS degree in Mechatronical Engineering from Beijing Institute of Technology, Beijing, China, in 2004, and the MS and Ph.D. degrees from the Inha University, Korea, in 2006 and 2010, respectively. In July 2010, he joined the School of Mechatronical Engineering, Beijing Institute of Technology, China. His research interests include link/system level performance evaluation and radio resource management in wireless systems, information security, and the next generation wireless systems such as 3GPP LTE, UWB, MIMO, Cognitive radio and so on.

Yuhan Liu received the BS degree in North China Institute of Science and Technology in 2020, and followed by the MS degree in Beijing Institute of Technology in 2024, respectively. Now she is a Ph.D. candidate in School of Mechantronical Engineering, Beijing Institute of Technology. Her research interests include communication network simulation, radio fuse effectiveness evaluation and so on

Piao He obtained the BS degree in Aerospace Engineering from Beijing Institute of Technology in 2023 and is currently a Master's student in the School of Mechanical and Electrical Engineering at Beijing Institute of Technology. Her research interests include wireless network simulation and emulation, control science and engineering, communication algorithms, wireless communication, etc.

Bin Tang obtained the BS degree in Electronic Science and Technology from Beijing Institute of Technology in 2023 and is currently a Master's student in the School of Mechanical and Electrical Engineering at Beijing Institute of Technology. His research interests include wireless network simulation and emulation, control science and engineering, communication algorithms, wireless communication, etc.

Guangwei Zhang received Ph.D. degree in school of Mechatronical Engineering from Beijing Institut in 2021. He is currently pursuing the postdoctor in Beijing Institute of Technology, Beijing, China. He is working radar signal processing and intelligent detection，network simulation and emulation and so on.