World Academy of Science, Engineering and Technology
International Journal of Computer and Information Engineering
Vol:18, No:08, 2024

Improving Fingerprinting-Based Localization System Using Generative AI

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Abstract : With the rapid advancement of artificial intelligence, low-power built-in sensors on Internet of Things devices, and communication technologies, location-aware services have become increasingly popular and have permeated every aspect of people's lives. Global navigation satellite systems (GNSSs) are the default method of providing continuous positioning services for ground and aerial vehicles, as well as consumer devices (smartphones, watches, notepads, etc.). However, the environment affects satellite positioning systems, particularly indoors, in dense urban and suburban cities enclosed by skyscrapers, or when deep shadows obscure satellite signals. This is because (1) indoor environments are more complicated due to the presence of many objects surrounding them; (2) reflection within the building is highly dependent on the surrounding environment, including the positions of objects and human activity; and (3) satellite signals cannot be reached in an indoor environment, and GNSS doesn't have enough power to penetrate building walls. GPS is also highly power-hungry, which poses a severe challenge for battery-powered IoT devices. Due to these challenges, IoT applications are limited. Consequently, precise, seamless, and ubiquitous Positioning, Navigation and Timing (PNT) systems are crucial for many artificial intelligence Internet of Things (AI-IoT) applications in the era of smart cities. Their applications include traffic monitoring, emergency alarms, environmental monitoring, location-based advertising, intelligent transportation, and smart health care. This paper proposes a generative AI-based positioning scheme for large-scale wireless settings using fingerprinting techniques. In this article, we presented a semi-supervised deep convolutional generative adversarial network (S-DCGAN)-based radio map construction method for real-time device localization. We also employed a reliable signal fingerprint feature extraction method with t-distributed stochastic neighbor embedding (t-SNE), which extracts dominant features while eliminating noise from hybrid WLAN and long-term evolution (LTE) fingerprints. The proposed scheme reduced the workload of site surveying required to build the fingerprint database by up to 78.5% and significantly improved positioning accuracy. The results show that the average positioning error of GAILoc is less than 0.39 m, and more than 90% of the errors are less than 0.82 m. According to numerical results, SRCLoc improves positioning performance and reduces radio map construction costs significantly compared to traditional methods.

Keywords : location-aware services, feature extraction technique, generative adversarial network, long short-term memory, support vector machine
Conference Title : ICDAAIE 2024 : International Conference on Data and Artifical Intelligence Engineering
Conference Location : New York, United States
Conference Dates : August 08-09, 2024