A 3D Location Estimation Method using the Levenberg-Marquardt Method for Real-Time Location System

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1. Abstract

Real-time location systems (RTLS) are systems for detecting the location information of tags attached to a person or object in real time. Recently, RTLS are popular as a car navigation system and for mobile phone map applications. Uses in factories and distribution centers include inventory management and safety support. Location detection devices currently in use include those based on GPS, Wi-Fi, and ultra-wideband (UWB). UWB is a radio technique using ultra-wide bandwidth (defined as greater than 450 MHz in Japan), which is used for high-speed data transmission and obstacle detection by radar, in addition to location detection. We selected a UWB device in consideration of the following two points because UWB devices offer a better balance of accuracy and cost than other devices in use at factories and distribution centers.

(a) To detect pallets, cases, workers, and so on, a location accuracy of 20 to 30 cm is needed.

(b) The number of sensors per unit area needs to be kept to a minimum to control cost.

Handling 3D location estimation problems involves solving non-linear least-squares problems to minimize the error sum of squares of distance as measured by sensors and the probable distance as calculated by the algorithm. One general method for solving this problem is the steepest descent method (SDM). However, this method does not converge quickly, and it is necessary in the RTLS to estimate the location of moving objects such as forklifts and workers, in addition to stationary bodies. To estimate the location of moving objects, a highly accurate and fast algorithm is required. Therefore, in this study, we applied the Levenberg-Marquardt method (LMM), which is popular as a quickly converging algorithm, to 3D location estimation problems and carried out several experiments. We compared the results of estimating the 3D location by LMM and SDM at multiple points and found no significant difference in terms of location accuracy. For the computation time, LMM is several hundred times faster than SDM, being able to consistently compute a location in 0.03 ms or less.