別紙４（課程博士）

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Abstract

論文内容の要旨 (博士)

Title of Thesis 博士学位論文名	Design and Analysis of Wireless Positioning System in an Indoor Environment and Its Application to Mobile Robot （室内環境での無線測位システムの設計および解析と移動ロボットへの応用）

(Approx. 800 words)
(要旨 1,200 字程度)

The wireless positioning system (WPS) has gaining respectful attentions in the recent years. There are promising applications of WPS especially in today's modern world where everything requires wireless connectivity. The information received from the wireless transmitter is not only useful for communication and networking, but it can be also manipulated for computing the whereabouts of the receiver i.e. the position of the receiver. A mobile robot for example could employ the WPS system for its localization algorithm. Since such systems use the information received from the outside sensing element, then the use of on-board sensing elements such as the exorbitant laser range finder (LRF) can be reduce. Therefore, the WPS system is cost effective.

The round robot Terapio development has been phenomenal especially in the medical industries where Terapio could greatly assist medical practitioners in their daily works. The functionality of Terapio is indeed plentiful including the human tracking and following, simultaneous localization and mapping system, power assists system, medical record databases, dynamic eye systems, patients monitoring system, etc. In order to increase the functionality of Terapio, this dissertation proposed to employ the WPS system for Terapio wireless positioning which can reduce the development cost. In addition, the WPS system is also a convenient approach for Terapio mobility tracking.

This dissertation focuses on three parts for employing the WPS system. The 2.4GHz Wireless Fidelity (WiFi) signal were used in this work. WiFi signal is chosen due to the fact that the signal is ubiquitous i.e. available everywhere as well as cheap implementation. It is as a matter of fact suitable since its application could reduce the development cost of the mobile robot.

The first part considers the placement of the wireless transmitters where the optimal locations were selected that yielding the minimum positioning error in the mobile robot point of view. In order to achieve these objectives, an algorithm called the Grid Greedy Search Logic (GGLS) is proposed with the combination of Tree Hierarchy and the formulation of the cost function. The finding from this part of research suggests that the placement of the wireless transmitter is not necessarily in symmetrical form when the initial placement location is taken into consideration.

The second part of this work is redirected into the assessment of WiFi signal using the Design of Experiment (DoE) method. Two essential parameters of transmitting devices were studied i.e. the antenna heights of the transmitter and the separation distance between the transmitter and receiver (Tx-Rx). The hypothesis was made, and then the experiments were conducted in the manner of replicated randomization. The data were later analyzed using the statistical tools. The Analysis Of Variance (ANOVA) results suggested that the antenna heights of the transmitter are not significant when fingerprinting technique is used for position estimation. This finding then is later validated using the actual positioning system using fingerprinting technique where the spatial signal fingerprint database is made and positioned using the state-of-the-art WKNN positioning system.

The third part of this research is emphasizes on the WPS using the fingerprinting technique. Since the fingerprinting technique requires the signal fingerprint database which is rather costly to build, interpolation is proposed. Three interpolation methods are experimented, namely the Inverse Distance Weighting (IDW), the geo-spatial Kriging algorithm and the firstly ever used interpolation method for wireless signal the Modified Shepard's Method (MSM). The finding from this experiment suggested that the proposed method i.e. MSM scored the lowest positioning error despite the popularity of Kriging algorithm as the wireless interpolation method. Subsequently, a novel method of wireless signal interpolation to automatically construct the fingerprinting database is proposed, known as the Signal Propagated Modified Shepard's Method (SP-MSM). This new novel technique considers the wireless signal properties such as the close-in distance and the path loss exponent. The signal properties were firstly estimate using the Euclidean simplex method and later included in the MSM interpolation algorithm. The accuracy is later evaluated defining four distinctive stationary locations. Afterwards, signal filtering using three different methods i.e. the moving average digital filter, low pass filter and Kalman filter are used due to the fluctuative and unpredicted behavior of WiFi signal. The Kalman filter as expected performs prominently improving the positioning accuracy. In addition, the comparisons of the different positioning techniques such as the trilateration are also discussed in the effort of improving the accuracy of the WPS system.

Finally, this dissertation is concluded and some future works are delineated. The WPS systems in the sense of the two frameworks were proposed for Terapio. The first framework is finding the optimal location to place the WiFi transmitters, and the second framework is the interpolation of WiFi signal to construct the fingerprinting database. The use of appropriate filter could yield in reasonable accuracy for indoor positioning system for a mobile robot application. In addition, the WPS architecture can be easily adapted into various other systems such as the multi-agents systems, the Internet-of-Thing (IoT) as well as cloud computing systems.