

Performance Analysis of Hybrid Deep Learning Model for Indoor localization

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Abstract

Localization using Wi-Fi received signal strength (RSSI) signals gives accurate results for indoor localization. However, the signal interference, multipath effects and non-line of sight conditions (NLOS) from the indoor experiment area degrade the localization performance. To compensate for these localization challenges that exist in Wi-Fi RSSI based localization systems, we propose a hybrid deep learning model (HDLM) based localization system which uses RSSI heat maps instead of raw RSSI signals. The HDLM in the proposed system utilizes the combined form of convolutional neural network and long short-term memory network (CNN-LSTM) architecture and improves the system's localization performance. The experiment results and analysis show that the proposed HDLM based localization system reduces the localization error with the help of RSSI heat maps and gives better localization performance than CNN and LSTM models. The proposed architecture archives 88% model accuracy for localization than other deep learning models.

I. Introduction

Localization using Wi-Fi received signal strength (RSSI) [1] is an effective localization approach when the inertial measurement unit (IMU) sensor based [2] or camera-based [3] localization systems show high margins of localization errors. In Wi-Fi RSSI based localization approach, the system utilizes access points (APs) in the experiment area and estimates the user distance from APs. The localization accuracy of the Wi-Fi RSSI based localization systems depends on the accurate user distance estimation from APs. To estimate the distance from APs, a free space path loss model (FSPLM) [4] is used which utilize the RSSI values from APs. The RSSI signal values from APs are easily fluctuate with indoor channel conditions such as multipath effects, non-line of sight (NLOS) conditions and signal interferences. To stabilize the RSSI data from APs and enhance the indoor localization performance, we propose a localization system which uses the RSSI heat maps instead of raw RSSI values and estimates the user position. The proposed system feed the heat maps into a hybrid deep learning model (HDLM) and predicts the user x and y position values. The HDLM is a combined form of convolutional neural network and long short-term memory network (CNN-LSTM) [5] and estimate the user position accurately.

In this paper, we analyze the performance of the proposed HDLM for indoor localization. The proposed HDLM gives accurate localization results for RSSI heat maps and improves the localization performance. To validate our proposed system performance, we compare the proposed HDLM performance with CNN and LSTM models and analyses the model accuracy

for indoor localization. Through extensive experiments and result analysis, we demonstrate the superior performance of the proposed HDLM with CNN and LSTM models. The rest of the paper is organized as follows; Section II presents the proposed indoor localization system using Wi-Fi RSSI heat maps. In Section III, we discussed the experiment results and analysis of the proposed localization system and Section IV concludes the paper.

II. Proposed Indoor Localization System Using Wi-Fi RSSI Heat Maps

The proposed indoor localization system effectively utilizes the advantage of RSSI heat maps and reduced the localization error. The RSSI heat map-based localization approach reduced the localization challenges faced by Wi-Fi RSSI signals and gives better localization performances. Fig. 1 shows the proposed indoor localization system using Wi-Fi RSSI heat maps [6].

In Fig. 1, the proposed system collects the RSSI data from APs and generate RSSI heat maps for each location. The unique characteristics of the each RSSI heat map are a useful information for the localization and each heat map pattern represents the x and y location values of a particular location from the experiment area. The generated heat maps are used as input for the HDLM and the model predicts the user x and y positions. The HDLM in the proposed system uses a CNN-LSTM architecture and train the CNN-LSTM with heat maps. The model after training is ready for location prediction and gives the user's x

and y positions for test data. As compared to CNN and LSTM models, the proposed HDLM uses the combined features of CNN and LSTM models and gives the best results for indoor localization. The CNN model in the HDLM gives the classification results with spatial features. The output of the CNN model is given to the input of the LSTM model and which predicts the location results with sequential data. The HDLM model uses the image as the input and gives user's location information.

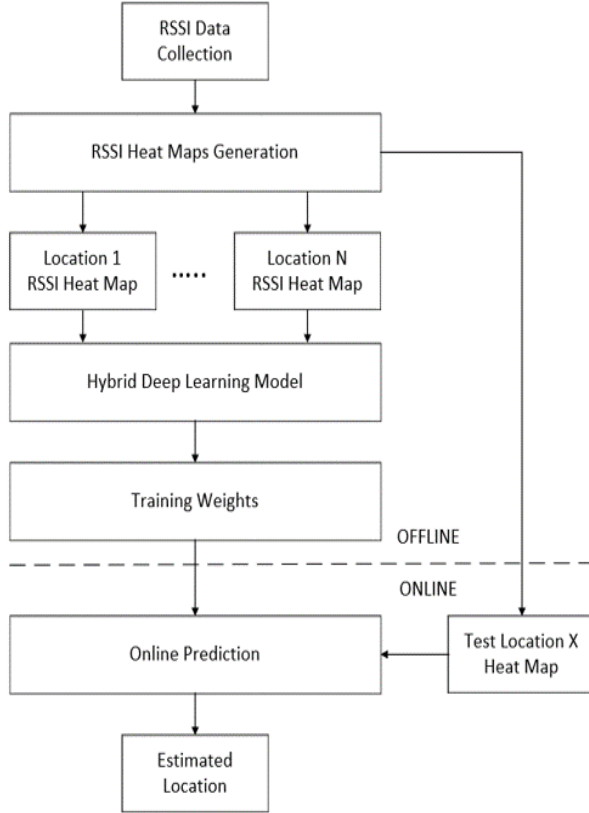


Fig. 1 Proposed indoor localization system using Wi-Fi RSSI heat maps.

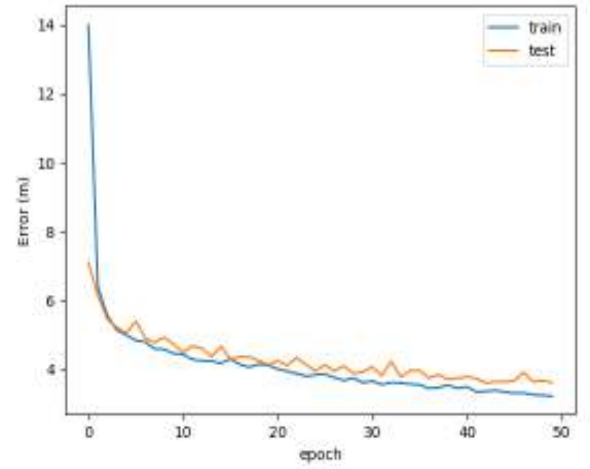
III. Experiment and Result Analysis

To evaluate the localization performance of the proposed HDML based indoor localization system, we did an experiment with an Android smartphone. The user holds the smartphone in his hand and walked in the experiment area. The Wi-Fi RSSI receiver module in the smartphone collects the RSSI values from APs through an Android application. The collected RSSI data used for heat map generation and generated 3000 heat maps for model training and 1500 heat maps for testing. Fig. 2 shows the localization performance of the different models.

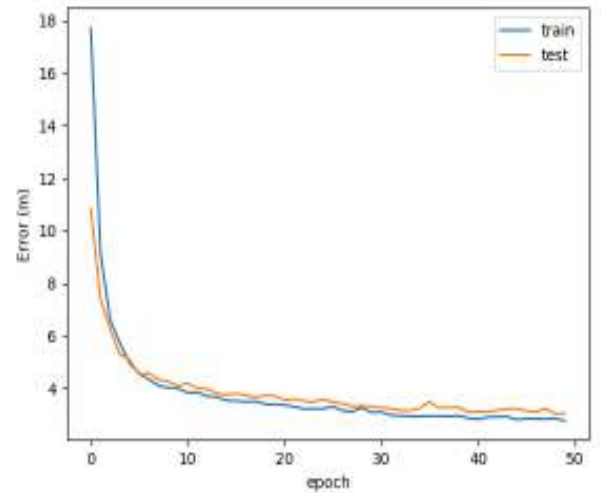
From Fig. 2, the proposed HDLM model achieves a minimum localization error than other models and converges the localization error quickly. As compared to other models, the HDLM gives accurate localization results with RSSI heat maps. The model accuracy from each model is summarized in table 1.

From Table 1, the proposed HDLM gives the best model accuracy than other models and reduces the localization error for Wi-Fi RSSI based localization

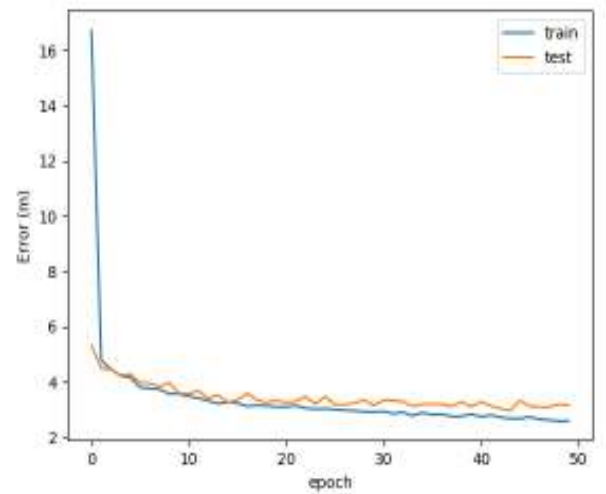
systems. From the experiments and result analysis, the proposed HDLM outperforms existing approaches and gives accurate user position results for indoor localization.



(a) CNN



(b) LSTM



(c) Proposed HDLM

Fig. 2 Localization performance of the different models.

Table 1: Accuracy comparison of models.

Model	Accuracy (%)
CNN	82.30 %
LSTM	85 %
Proposed HDLM	88 %

IV. Conclusion

In this paper, we analyze the performance of the HDLM based indoor localization system using Wi-Fi RSSI heat maps. The experiment and result analysis show that the proposed HDLM based indoor localization system provides accurate localization results for Wi-Fi RSSI based localization systems. The Wi-Fi RSSI heat map-based localization system is an alternative solution for Wi-Fi RSSI signal interferences. The heat map-based localization system is also reducing the multipath effects for indoor environments and gives better results for indoor localization. In the future work, we intend to add the advanced deep learning architectures such as generative adversarial networks for Wi-Fi RSSI heat maps-based localization systems.

Acknowledgment

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