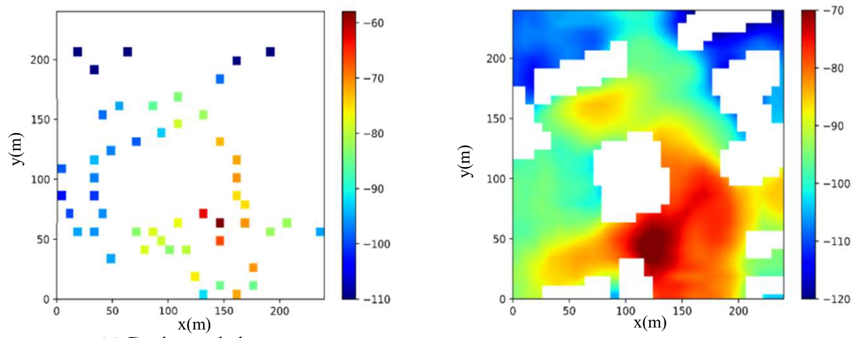
3rd URSI AT-AP-RASC, Gran Canaria, 29 May – 3 June 2022

Radio Environment Map Construction Based on Autoencoders

Chuan Hao Yu[1], Jing Jing Yang[1]*, Ming Huang[1]*, Zhi Gang Chen[2], and Ji Da Wu[2]
(1) School of Information Science and Engineering of Yunnan University Kunming, 650091, PR China
(2) Radio Monitoring Center of Yunnan Province, Kunming 650228, China
* yangjingjing@ynu.edu.cn; huangming@ynu.edu.cn

The construction of radio environment maps is the basis of cognitive radio application and radio regulation, and the accurate construction of radio environment map is of great engineering significance. The radio environment map construction usually employs spatial interpolation-based and parameter-based conformation methods, which fail to fit deep environment features. Deep learning based methods have powerful data learning capability, and convolutional autoencoder has excellent performance in data reconstruction. In this paper, a deep convolutional autoencoder based method is adopted to solve the problem of reconstructing the radio environment map for 4G base station coverage in urban environment.

To extract higher-order features, a 26-layer deep convolutional autoencoder[1] network architecture is designed in this paper. This architecture includes an encoder and a decoder, with the encoder consisting of convolutional layers and average pooling layers, and the decoder consisting of convolutional transposition layerss and upsampling layer. The experiments were conducted at the Donglu Campus of Yunnan University in Kunming, China. 4G base station data is collected using FEKO software processed with extended dimensionality, mask identification, sampling to feed the training model. In the building-free area of the map, the root mean square error (RMSE) for the convolutional autoencoder, Kriging, Inverse distance weighting(IDW) and nearest neighbour(NN)[2] are about **3.92, 5.42, 5.9 and 8.23 dB,** respectively. In the building area, we use the minimum receiving sensitivity of the mobile phone (τ=-130dBm) to replace the value of the building area and RMSEs are **13.29, 25.84, 27.18 and 27.63dB** for convolutional autoencoder, Kriging, IDW and NN, respectively. Results show that convolutional autoencoder has not only learned the building characteristics of the radio environment but also has minimal reconstruction errors. The reconstruction RMSEs of square maps with side lengths of 200m, 300m, 400m and 500m are **2.65, 4.75, 5.45 and 5.91dB** respectively, which shows that the larger the range of reconstructed map, the greater the mean square error. Finally a map of the radio environment within the target range was constructed using the real data as shown in Figure 1. (a) shows the distribution of real sampling values, while (b) represents the reconstructed map. Taking the actual 65 measured values of reference signal received power (when under the range of a base station but not monitored, the threshold value is set to be -110dBm), of which 50 are taking for the input and the remaining 15 values for calculation, a RMSE of **4.68dB** is obtained. Therefore, the research method implemented in this paper has practical application for the construction of radio environment maps. This work was funded by the National Natural Science Foundation of China (Grant Nos. 61863035, 61963037), and Ten Thousand Young Top-notch Talents Program of Yunnan Province (Grant No. YNWR-QNBJ-2018-310).



(a) Real sampled map

(b) Reconstructed map

Figure 1. Real map reconstruction

1. Y. Teganya and D. Romero, "Deep Completion Autoencoders for Radio Map Estimation," in IEEE Transactions on Wireless Communications, doi: 10.1109/TWC.2021.3106154.

2. M. Suchanski, P. Kaniewski, J. Romanik, E. Golan and K. Zubel, "Radio Environment Maps for Military Cognitive Networks: Deployment of Sensors vs. Map Quality," 2019 International Conference on Military Communications and Information Systems (ICMCIS), 2019, pp. 1-6, doi: 10.1109/ICMCIS.2019.8842720.