Realistic Micro-Doppler Database Generation Through Neural Style Transfer Framework

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Abstract

Real-time monitoring of humans can assist professionals in providing healthy living enabling technologies to ensure the health, safety, and well-being of people of all age groups. To enhance the human activity recognition performance, we propose a style-transfer neural framework to generate realistic synthetic micro-Doppler signature dataset. The proposed network extracts environmental effects such as noise, multipath, and occlusions effects directly from the measurement data and transfers these features to the clean simulated signatures generated through our simulator called SimHumaLator. This results in more realistic-looking signatures qualitatively and quantitatively. We use these enhanced signatures to augment our measurement data and observe an improvement in the classification performance by 5% compared to no augmentation case.

Index Terms

WiFi based Sensing, PWR, micro-Dopplers, human activity recognition, style transfer neural network, simulator, data augmentation

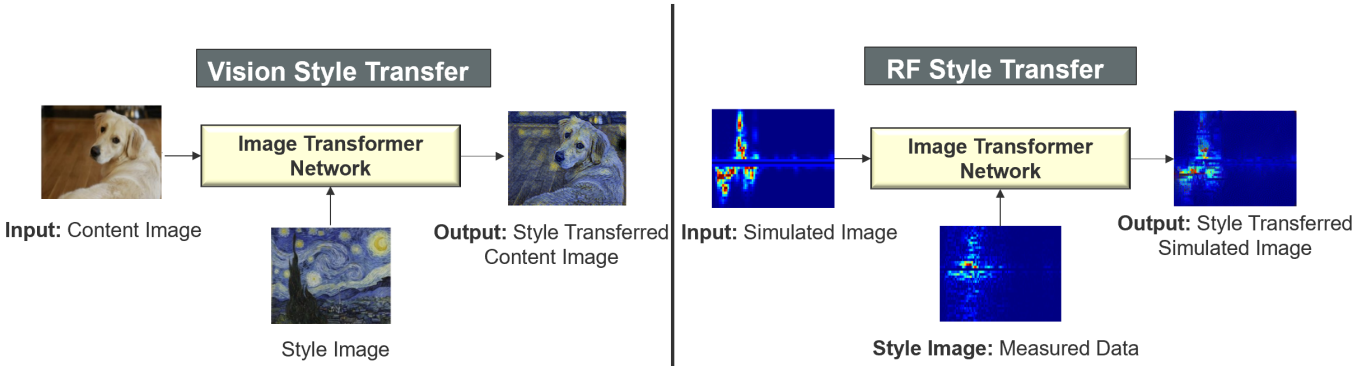

Fig. 1: Neural style transfer: an image transformer framework

I. Summary

This paper presents an effective style transfer framework to synthesize more realistic micro-Doppler signatures that possess excellent motion characteristics and environmental factors such as noise, multipath, clutter, and target-dependent nuances such as multipath and occlusion effects learned directly from the measurement data. The proposed network extracts global motion content from the clean simulated signatures and background texture information from the measured signatures to form a third image called style transferred image possessing the two qualities. To further demonstrate the quality of synthesized signatures, we did a detailed qualitative and quantitative analysis through spectrogram's visual inspection and its latent feature space visualization relative to the original measurement dataset. We also benchmark it with three other synthesized datasets: clean simulation data with no noise, AWGN noise added dataset and GAN noise dataset. The results highlight the superior quality of the style transferred signatures. Additionally, we propose a novel data augmentation scheme, which is a potential application of these signatures. We test the classification performance under the following augmentation scenarios- measurement data augmented with- simulation data with no noise, simulation data with added AWGN, simulation data with GAN noise, and style transferred data. The results show that the data generated through the style transfer framework outperformed all other cases by 3-5% on an average. The performance is more pronounced ($\geq 8\%$), especially when the replacement percentage is more than 80%.

Overall, the paper demonstrates the feasibility of generating realistic simulated micro-Doppler spectrograms using a style transfer framework. Since these signatures can effectively mimic realistic signatures, they can be used to augment the training dataset and effectively enhance the sensing performance of existing PWR system for real-world applications such as e-healthcare and ambient assisted living. Interested readers can download the simulator and read the detailed working methodology from https://uwsl.co.uk/.