Advanced Deep Learning Techniques For Fingerprint Preprocessing

The success of deep learning based models in image processing applications promotes their use in fingerprint preprocessing. However, poor generalization on unseen data and black box behaviour are the general limitations of deep models. Both these limitations of deep models are inherent to state-of-the-art fingerprint preprocessing models as well. Through this thesis, we exploit advanced deep learning techniques, namely adversarial learning, attention mechanism, and uncertainty estimation for fingerprint preprocessing. We demonstrate that adversarial learning and attention mechanism help fingerprint preprocessing models to generalize on unseen, disparate sensing and acquisition techniques. We also illustrate that uncertainty estimation introduces interpretability in fingerprint preprocessing models such that a human operator can understand when the model is likely to make a mistake. The first three contributions of this thesis propose deep learning techniques that ensure improved generalization ability of fingerprint preprocessing models. The first contribution proposes a generative adversarial network for fingerprint enhancement which significantly outperforms state-of-the-art and serves as an efficient backbone network for fingerprint enhancement. Subsequently, we propose to utilize channel-level attention to boost the generalization ability of state-of-the-art fingerprint enhancement models. Next, we observe the limitation of state-of-the-art ROI segmentation methods on new and unseen sensors. To address this, we propose a recurrent adversarial learning based model, which has improved generalization ability on new and unseen sensors without requiring human-annotated ROI for the unseen sensor. For the other two contributions, we work on introducing interpretability in deep learning based fingerprint preprocessing models. For this, we find Monte Carlo Dropout to be an effective method to quantify the model's confidence in prediction and improve the representation ability of the baseline model. Finally, we estimate data uncertainty in fingerprint preprocessing to quantify the noise present in fingerprint images and demonstrate its usefulness in promoting noise-aware fingerprint preprocessing.