PhD THESIS ABSTRACT

"Development of non-invasive methods for identification and authentication in THz domain"

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In many imaging systems, different research directions can be pursued to improve overall system performance. In THz technology, we can identify several challenges associated with the initial stages of signal preprocessing, but the focus is on image display methods. In this thesis, significant attention is devoted to investigating techniques for estimating signal amplitude under ideal and noisy conditions. Given that in all imaging systems, regardless of their technology (radar, ultrasound, etc.), when the received signal estimation is poor, the resulting image has poor quality.

In this context, one of the objectives of the thesis is to introduce new image display methods that will increase the amplitude estimation capability at reception and thus improve the final quality of the reconstructed image. The new techniques proposed in this thesis are based on the representation of signals in phase space, a space that offers the possibility of identifying features difficult to observe in other representations. Based on this concept, MF (Match Filter) and DTW (Dynamic Time Warping) are generalized to work in the phase space representation domain, allowing the creation of 4 new image reconstruction techniques. Noting the advantages and disadvantages of these 4 techniques, the 5th technique exploiting phase space trajectory dynamics is introduced in the thesis and gives the highest quality results. These methods are validated using proprietary image databases created in a controlled way in the laboratory. At the same time, the performance of the newly introduced methods is quantified using image quality metrics and compared with those of methods currently used in real imaging systems.

The second part of the thesis focuses on the characterization and classification of images that exhibit perspective variation constraints, namely translations and rotations. The feature vector derived from an image subject to translation or rotation differs from that derived from the original image. The very likely consequence of this is a misclassification of the models. To this end, this thesis proposes the use of unique decompositions in the context of translation and rotation, TI-WPD (Translation Invariant Wavelet Packet Decomposition) and RI-WPD (Rotation Invariant WPD). Based on the invariant image representations, 4 new feature extraction techniques are introduced, such as vertical, horizontal, N-directional and N-zonal features. In addition, new feature structuring approaches are introduced that take into account frequency partitioning within the wavelet decomposition. These are adapted to train graph neural networks (GNNs) and classical ML classifiers such as k-NN, SVM, etc. All approaches presented in the second part of the thesis are validated on proprietary as well as public databases and compared with multiple classical image characterization and classification methods.

Finally, the efficient reconstruction and new image characterization methods we propose increase the accuracy of all classifiers used, proving their ability to be used in the THz domain, but also with the possibility of extension to other imaging domains.