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Abstract of doctoral dissertation
"Normalizing flow models for modeling uncertainty in machine learning tasks"

In recent years, machine learning models have achieved remarkable results across a wide range of tasks, including classification, regression, and data generation, spanning various modalities such as tabular data, text, images, and point clouds. However, many of these applications have focused primarily on deterministic predictions, often overlooking the importance of modeling uncertainty in those predictions. This dissertation aims to address this limitation by utilizing Normalizing Flow models to effectively model uncertainty across a spectrum of machine learning tasks.

This thesis consists of seven papers and is divided into three parts. The first part, covered in Publications [I-III], focuses on applying normalizing flows to discriminative tasks. Publication [I] introduces TreeFlow, a novel approach that enhances tree-based parametric models with more expressive probability distributions for regression tasks. Publication [II] presents NodeFlow, an end-to-end probabilistic regression framework for tabular data that improves upon TreeFlow's two-stage learning process. Publication [III] demonstrates the versatility of these methods by adapting them to personalized natural language processing, yielding significant improvements in emotion recognition and hate speech detection.

The second part of the thesis, encompassing Publications [IV-VI], explores the application of normalizing flows to generative tasks. Publication [IV] introduces the Flow Plugin Network (FPN), an innovative architecture that integrates normalizing flows with pre-trained generative models. Publications [V, VI] present PluGeN, a sophisticated approach for multi-label conditional generation that leverages pre-trained models, demonstrating its potential in generating images and 3D point clouds with attribute combinations not seen during training.

The third part, covered in Publication [VII], investigates the intersection of discriminative and generative tasks within the domain of Explainable AI (XAI). It introduces a novel method for generating Probabilistically Plausible Counterfactual Explanations using Normalizing Flows (PPCEF), enhancing the plausibility and interpretability of AI explanations.

All the publications listed here were presented at top- and high-tier conferences or published in high-impact journals. The research demonstrates the versatility of normalizing flows across

various machine learning paradigms, contributing to the development of more accurate, controllable, and interpretable AI systems. This work opens up several promising avenues for future research, including scaling these methods to larger datasets, integrating them with other emerging paradigms, and extending their application to new domains.