Statistica Sinica **35** (2025), 1-25
doi:https://doi.org/10.5705/ss.202022.0314

NAPA: NEIGHBORHOOD-ASSISTED AND POSTERIOR-ADJUSTED TWO-SAMPLE INFERENCE

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Abstract: Two-sample multiple testing problems of sparse spatial data are frequently arising in a variety of scientific applications. In this article, we develop a novel neighborhood-assisted and posterior-adjusted (NAPA) approach to incorporate both the spatial smoothness and sparsity type side information to improve the power of the test while controlling the false discovery of multiple testing. We translate the side information into a set of weights to adjust the p-values, where the spatial pattern is encoded by the ordering of the locations, and the sparsity structure is encoded by a set of auxiliary covariates. We establish the theoretical properties of the proposed test, including the guaranteed power improvement over some state-of-the-art alternative tests, and the asymptotic false discovery control. We demonstrate the efficacy of the test through intensive simulations and two neuroimaging applications.

Key words and phrases: False discovery rate, multiple testing, side information, sparsity, spatial smoothness, weighted p-values.

1. Introduction

Two-sample hypothesis testing of sparse spatial data is a fundamental problem in a wide variety of scientific applications. It manifests in numerous forms. One example is to compare the cerebral white matter tracts between multiple sclerosis (MS) patients and healthy controls (Goldsmith et al., 2011). The data records the fractional anisotropy measure along the right corticospinal tract, and takes the form of one-dimensional (1D) function. The scientific interest is to compare two sets of fractional anisotropy profiles and locate the tract regions that distinguish cases from controls. Another example is to compare the brain grey matter cortical thickness between subjects diagnosed with attention deficit hyperactivity disorder (ADHD) and typically developing controls (Bellec et al., 2017). The data records the volume of grey matter at different brain locations in a three-dimensional (3D) space. The scientific interest is to compare two sets of brain structural images and identify differentiating brain regions. In addition to these examples, similar problems arise in many other applications, for instance, astronomical surveys (Czakon et al., 2009), disease mapping (Sun et al., 2000), ecology (Bini et al., 2009), and genomics (Sun and Wei, 2011).

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