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Dissertation Defense

Doctor of Philosophy in Intelligent Systems

HARMONIZATION OF MULTI-SCANNER MAGNETIC RESONANCE IMAGING DATA

by **Mahbaneh Eshaghzadeh Torbati**

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Room 536A/DBMI, 5607 Baum Blvd, Pittsburgh, PA 15206

Committee:

- Dana Tudorascu, Associate professor, Psychiatry and Biostatistics, University of Pittsburgh
- Ahmad Tafti, Assistant professor, Health Information Management, University of Pittsburgh
- Shyam Visweswaran, Professor, Department of Biomedical Informatics, University of Pittsburgh
- Davneet Minhas, Research Instructor, Department of Radiology, University of Pittsburgh
- Seong Jae Hwang, Assistant Professor, Department of Artificial Intelligence, Yonsei University

Abstract:
The integration of datasets from multiple sites or scanners in neuroimaging studies has become increasingly prevalent. However, the presence of substantial technical variability associated with scanners poses a challenge that can introduce unintended biases in downstream analyses. Moreover, this scanner-related variability, known as scanner effects, can manifest in longitudinal neuroimaging data due to potential scanner upgrades or replacements at sites. Harmonization methods have emerged as techniques to address scanner effects on multi-scanner neuroimaging data, encompassing both brain images and image-derived summary measures. Harmonization can be accomplished through various approaches, including the estimation and removal of scanner effects, as well as adapting the multi-scanner data to a scanner-middle-ground space or a target scanner domain. In these approaches, matched data can serve as additional labeled dataset to uncover scanner effects in the multi-scanner data. Harmonization methods that utilize matched data are referred to as supervised harmonization methods, leading many sites to collect additional matched data to facilitate harmonization. However, the current availability of neuroimaging data often lacks such matched data. Consequently, a thorough understanding of scanner effects and the development of both supervised and unsupervised harmonization methods are imperative.

This dissertation contributes to the field of harmonization of T1-weighted MRIs in several ways. Firstly, scanner effects and two harmonization methods for mitigating scanner effects in both images and image-derived measures are investigated. Secondly, MISPEL, a novel supervised image harmonization method is developed. MISPEL leverages matched data to learn a mapping to a scanner-middle-ground space. Third, a novel unsupervised image harmonization method, ESPA, is proposed. ESPA simulates

scanner effects as augmentations on images and learns to harmonize images by adapting them to a scanner-middle-ground space. These contributions aim to enhance the understanding and effectiveness of harmonization techniques, addressing the challenges posed by scanner effects in neuroimaging studies.