Institute for Health & Equity

Bayesian learning algorithms for identifying and classifying heterogeneity of cell types in variety of solid tumors

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Bayesian, Hierarchical, Heterogeneity

- Bayesian modeling: Priors, Hyper-priors, Model Averaging
- Hierarchical: Many layers
- Heterogeneity: Non Stationarity at different levels
Aim 1

• To test the hypothesis that robust and flexible statistical learning algorithms can incorporate spatial information for creating predictive maps of cellular features in malignant solid tumors.

• 1a) To build novel convolution based covariance functions that capture patient specific variation, tissue specific variation and local histologic spatial features.

• 1b) To build multilevel ensemble models integrating hierarchical dependence structures for studying association of histology with disease, macroscopic image features and to predict cytology for new patients.

• 1c) To determine resilience of ensemble models against protocol deviations such as minor misalignments in in-vivo image and ex-vivo histology co-registration.
Covariance functions

- Mathematically,

\[
\text{Cov}(f(x), f(y)) = \psi_1 I(x, y \text{ in same individual}) \rho_{\text{ind}} ||x - y|| + \psi_2 I(x, y \text{ in same tissue structure}) \rho_{\text{tissue}} ||x - y|| + \psi_3 I(x, y \text{ in same cytologic region}) \rho_{\text{region}} ||x - y||.
\]
Covariance functions

Example:
Covariance functions
Mapping in vivo MRI to ex vivo cytology
Recent Success

• A Restricted Space-Filling Algorithm for Bayesian Learning with a Nearest Neighbor Gaussian Process (BLING)

Banerjee et al.

In BNP @ NeurIPS [Dec 2018].
Aim 2

- **Aim 2.** To test the hypothesis that fast and scalable algorithms using real-time feature estimation for MR image guided individualized adaptive radiation therapy are feasible and deployable in clinical settings.

- **2a)** Use non-linear feature estimation for studying association of MR-Linac images versus disease characteristics.

- **2b)** To develop computational tools for running the estimation process on parallelized architecture such as multicore graphics processing units (GPUs) for rapid real-time execution, necessary for clinical deployment.
Models and Pareidolia
In summary

• Lots to investigate ...

• My favorite quote, by Bill Watterson, C&H, “It’s a magical world, lets go exploring ...”

• Questions?