Combining Imaging and Genomic Data in a Single Deep Learning Model

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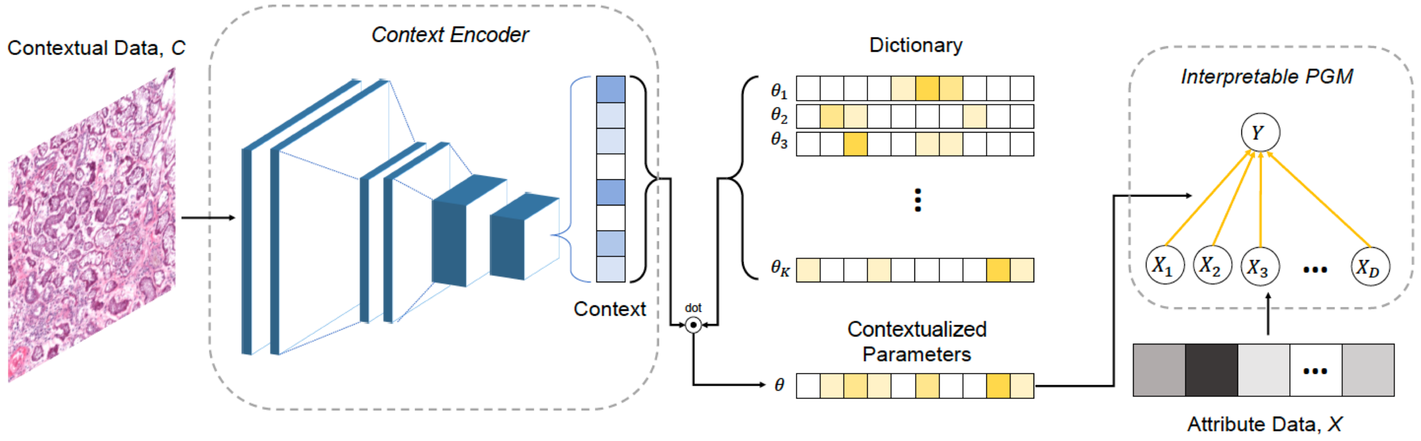
Motivation

- We'd like to use both imaging and genomic data to understand patients
- What model to use?
  - Images → convolutional neural networks (CNNs)
  - Genomic data → interpretable graphical models
- Can we combine these frameworks to make an interpretable deep model?[2]

Our Approach



A contextual explanation network (CEN)[1] combines "contextual" data (C) with an interpretable probabilistic graphical model (PGM) via a context encoder which selects sample-specific parameters ("explanations") as the linear combination of the values stored in a dictionary. The PGM then uses these sample-specific parameters to operate on the sample's attribute data (X) and calculate the final target Y.

Data

- Kidney Renal Clear Cell Carcinoma from The Cancer Genome Atlas
- RNA-seq and whole-slide histology images for 537 patients
- After pre-processing, we have 26525 train, 6293 valid, and 7585 test image patches (90.16%, 90.74%, 90.64% split of case/control data).

Improved Predictive Performance

- Task: predict case/control status of patient.

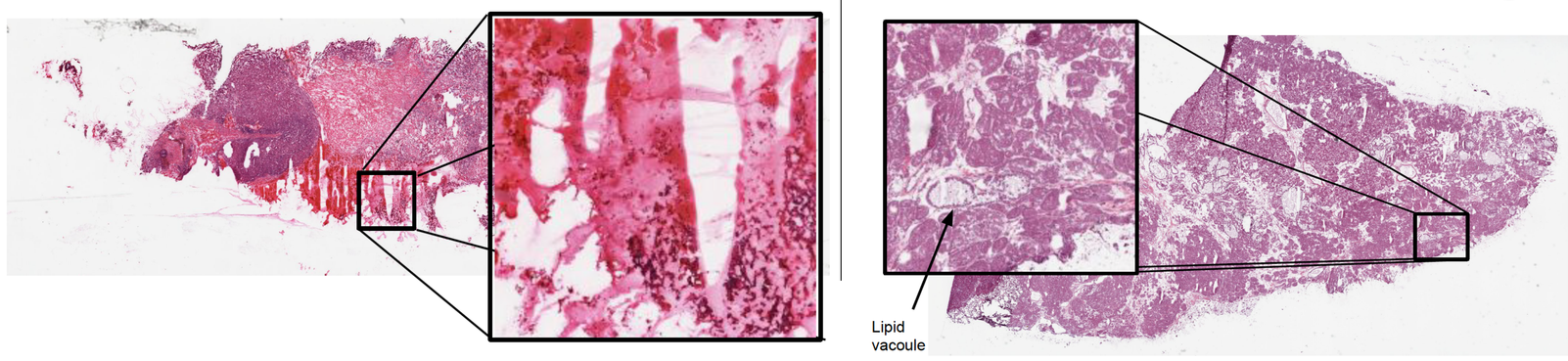
Model	Accuracy (%)		
	Train	Valid	Test
Log. Reg.	90.16	90.74	90.64
VGG	96.55	95.79	95.24
Resnet	98.38	96.74	96.08
MoE	98.50	92.05	97.32
CEN	**100.00**	**100.00**	**99.97**

References

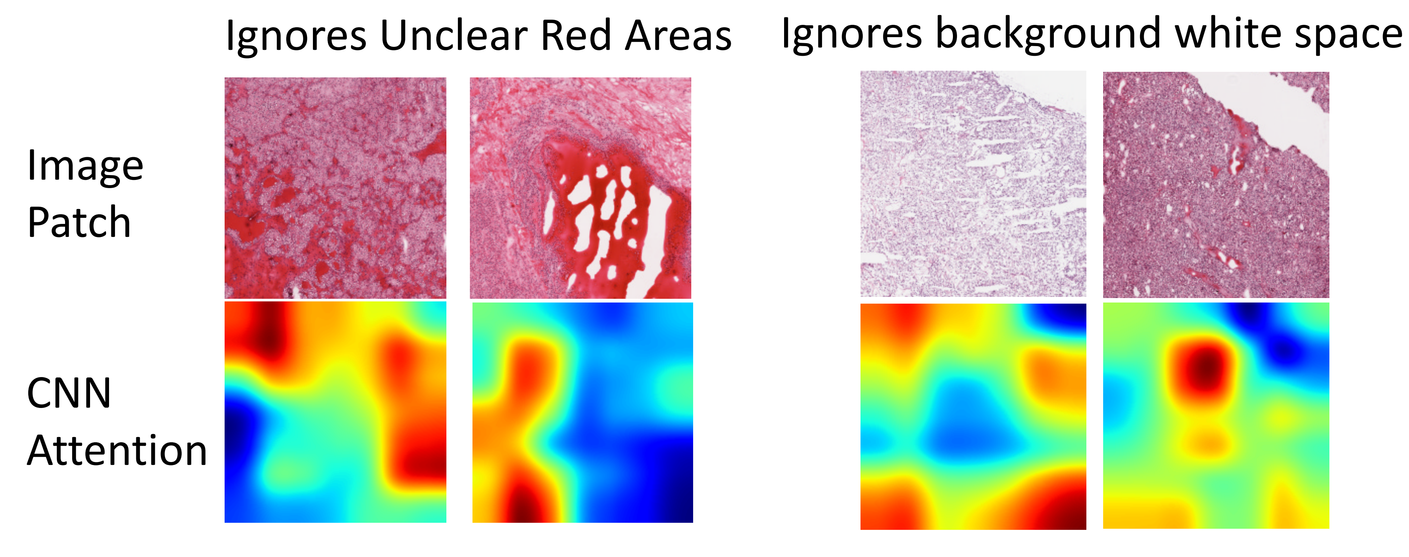
1. Al-Shedivat, Maruan, Dubey, Avinava, and Xing, Eric P. Contextual explanation networks. arXiv preprint arXiv:1705.10301 , 2017.
2. Ching, Travers, Himmelstein, Daniel S, Beaulieu-Jones, Brett K, Kalinin, Alexandr A, Do, Brian T, Way, Gregory P, Ferrero, Enrico, Agapow, Paul-Michael, Zietz, Michael, Hoffman, Michael M, et al. Opportunities and obstacles for deep learning in biology and medicine. bioRxiv , pp. 142760, 2018.

Explanations Tie Genomic Signatures to Phenotypic Patterns

	Explanation 1		Explanation 2		
	Enriched Term	FDR	Enriched Term	FDR	
Intercellular	Plasma Membrane Part	2.23e-6	Ribosome	2.67e-3	Intracellular
	Intrinsic Component of Plasma Membrane	4.57e-4	Translation Initiation Factor Activity	2.26e-2	
	Ion Transmembrane Transporter Activity	1.31e-2	Lipid Transport	2.99e-2	



Deep Learning Focuses on Important Tissue Areas



Conclusions

- Combining imaging and genomic data in a single model:
  - Improves predictive performance
  - Ties genomic signatures to phenotypic patterns
- Ongoing work for pancancer analysis – suggestions welcome!