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Graph Convolutional Gaussian Processes

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Background

- Why Graphs?
  - Non-Euclidean domains are everywhere!
  - Useful information in the structure of an observation.
- Geometric Deep Learning provides many insights.
  - Large number of parameters, small number of observations.
- Bayesian methods and Gaussian processes.
  - Typically perform poorly with large input dimensions.
- Convolutional Gaussian Processes (van der Wilk, et al 2017)
  - Provide an efficient algorithm for estimating GPs that decompose into functions on subsets of inputs.

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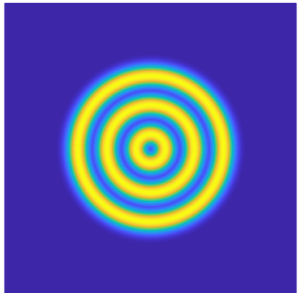
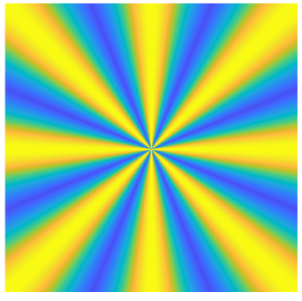
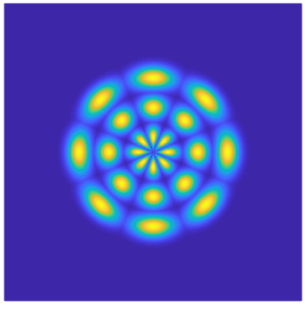
Graph Convolutional Gaussian Processes







$$
\begin{aligned}
f(\psi) &= \sum_{i \in \mathcal{V}} g(\mathbf{z}^{[i]}) \\
g &\sim \mathcal{GP}\left(\mathbf{0}, k_g\left(\mathbf{t}, \mathbf{t}'\right)\right) \\
\Rightarrow f &\sim \mathcal{GP}\left(\mathbf{0}, \sum_{i=1}^{|\mathcal{V}|} \sum_{j=1}^{|\mathcal{V}'|} k_g\left(\mathbf{z}^{[i]}, \mathbf{z}'^{[j]}\right)\right)
\end{aligned}
\tag{1}
$$

$$
\begin{aligned}
z_k^{[v]} &= D_k(v)\psi \\
&= \sum_{\mathcal{V}} \psi(v') u_k(v, v') \\
&\forall v \in \mathcal{V}, \quad k = 1 \ldots K
\end{aligned}
\tag{2}
$$

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Related Work and Contributions

Graph GPs (Ng et al., 2018) rely on the graph Laplacian, which limits their applicability to the same domain:

Same number of vertices and edge structure.

GCGPs can be applied across domains with different edge structure.

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MNIST Results

Table 1: Error rates on MNIST classification

Method	Error rate
MNIST	
Conv. GP (25-dim) †	2.1%
RBF GP (784-dim) †	1.9%
GCGP (24-dim)	**1.7%**

† van der Wilk, et al (2017)

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Superpixel MNIST Results

Table 2: Error rates on Superpixel MNIST classification

Method	Error rate
MNIST Superpixel 75	
ChebNet (Defferrard, et al 2016)	24.4%
MoNet (Monti, et al 2017)	8.9%
GCGP	**4.2%**

Table 3: Ablation study on Superpixel 75 error rates

Examples per class	100	500	1000
Error rate	13.7%	8.3%	6.3%

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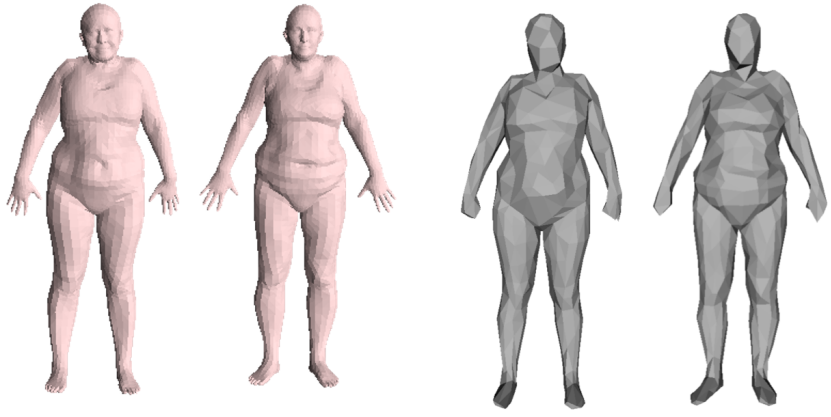
3D Mesh Results

Table 4: Error rates on MPI Faust mesh classification

Number of vertices	500	1000	2500
MoNet	40.00%	33.33%	33.33%
GCGP	**23.33%**	**10.00%**	**3.33%**



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Acknowledgements

Thank You!

Poster tonight at 6:30 PM in Pacific Ballroom 212