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Sparse Projections of Medical Images onto Manifolds

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(Submitted on 22 Mar 2013 (v1), last revised 28 Mar 2013 (this version, v2))

Manifold learning has been successfully applied to a variety of medical imaging problems. Its use in real-time applications requires fast projection onto the low-dimensional space. To this end, out-of-sample extensions are applied by constructing an interpolation function that maps from the input space to the low-dimensional manifold. Commonly used approaches such as the Nystr\"{o}m extension and kernel ridge regression require using all training points. We propose an interpolation function that only depends on a small subset of the input training data. Consequently, in the testing phase each new point only needs to be compared against a small number of input training data in order to project the point onto the low-dimensional space. We interpret our method as an out-of-sample extension that approximates kernel ridge regression. Our method involves solving a simple convex optimization problem and has the attractive property of guaranteeing an upper bound on the approximation error, which is crucial for medical applications. Tuning this error bound controls the sparsity of the resulting interpolation function. We illustrate our method in two clinical applications that require fast mapping of input images onto a low-dimensional space.

Comments:	International Conference on Information Processing in Medical Imaging (IPMI 2013)
Subjects:	**Computer Vision and Pattern Recognition (cs.CV)**; Learning (cs.LG); Machine Learning (stat.ML)
Cite as:	**arXiv:1303.5508 [cs.CV]**
	(or **arXiv:1303.5508v2 [cs.CV]** for this version)

Submission history

From: George Chen [view email]
[v1] Fri, 22 Mar 2013 03:24:10 GMT (1100kb,D)
[v2] Thu, 28 Mar 2013 19:21:33 GMT (1101kb,D)

Which authors of this paper are endorsers?