Hypergraph p-Laplacian Regularization for Remotely Sensed Image Recognition

By: Ma, XQ; [Ma, Xianqiu[1]; Liu, WF; [Liu, Weifeng[1]; Li, SY; Li, Shuying[2]; Tao, DP; [Tao, Dapeng[3]; Zhou, YC; Zhou, Yichang[4]]

IEEE TRANSACTIONS ON GEOSCIENCE AND REMOTE SENSING
Volume: 57 Issue: 3 Pages: 1585-1595
DOI: 10.1109/TGRS.2018.2867570
Published: MAR 2019
Document Type: Article
View Journal Impact

Abstract

Graph-based and manifold-regularization (MR)-based semisupervised learning, including Laplacian regularization (LapR) and hypergraph LapR (HpLapR), have achieved prominent performance in preserving locality and similarity information. However, it still a great challenge to exactly explore and exploit the local structure of the data distribution. In this paper, we present an efficient and effective approximation algorithm of hypergraph p-Laplacian and then propose hypergraph p-Laplacian (HpLapR) to preserve the geometry of the probability distribution. In particular, hypergraph is a generalization of a standard graph while hypergraph p-Laplacian is a nonlinear generalization of the standard graph Laplacian. The proposed HpLapR shows great potential to exploit the local structures. We integrate HpLapR with logistic regression for remote-sensing image recognition. Experiments on UC-Merced data set demonstrate that the proposed HpLapR has superior performance compared with several popular MR methods including LapR and HpLapR.

Keywords

Author Keywords: Hypergraph; manifold learning; remote sensing; semisupervised learning (SSL); p-Laplacian

Author Information

Reprint Address: Liu, WF (reprint author)
China Univ Petr, Coll Inform & Control Eng, Qingdao 266580, Peoples R China.
Reprint Address: Zhou, YC (reprint author)
Univ Macau, Fac Sci & Technol, Macau 999078, Peoples R China.

Addresses:
[1] China Univ Petr, Coll Inform & Control Eng, Qingdao 266580, Peoples R China
[2] Xian Univ Posts & Telecommun, Sch Automat, Xian 710121, Shaanxi, Peoples R China
[3] Yunnan Univ, Sch Informat Sci & Engn, Kunming 650091, Yunnan, Peoples R China
[4] Univ Macau, Fac Sci & Technol, Macau 999078, Peoples R China

E-mail Addresses: liuwf@upc.edu.cn; angle_listy@163.com; dapeng.tao@gmail.com; yichangzhou@umac.mo

Funding

<table>
<thead>
<tr>
<th>Funding Agency</th>
<th>Grant Number</th>
</tr>
</thead>
<tbody>
<tr>
<td>National Natural Science Foundation of China</td>
<td>61671480, 61772655, U1732213, 61703347</td>
</tr>
<tr>
<td>Foundation of Shandong province</td>
<td>ZR2018MF017</td>
</tr>
<tr>
<td>Fundamental Research Funds for the Central Universities</td>
<td></td>
</tr>
<tr>
<td>China University of Petroleum (East China)</td>
<td>18CX07011A, YCX2017059</td>
</tr>
<tr>
<td>Yunnan Natural Science Funds</td>
<td>2016FB105</td>
</tr>
<tr>
<td>Program for Excellent Young Talents of Yunnan University</td>
<td>WX069051</td>
</tr>
<tr>
<td>Macau Science and Technology Development Fund</td>
<td>FDC1/189/2017/A3</td>
</tr>
<tr>
<td>Research Committee at University of Macau</td>
<td>MYRG216-00113-FST, MYRG218-00136-FST</td>
</tr>
</tbody>
</table>

View funding text
1. **Beyond pairwise clustering**  
   By: Agarwal, S; Lim, J; Zelnik-Manor, L; et al.  

2. **Polynomial Correlation Filters for Human Face Recognition**  
   By: Alkanhal, Mohamed; Muhammad, Ghulam  
   2012 11TH INTERNATIONAL CONFERENCE ON MACHINE LEARNING AND APPLICATIONS (ICMLA 2012), VOL 1 Pages: 646-650 Published: 2012

3. **Bounds for the largest p-Laplacian eigenvalue for graphs**  
   By: Amghibech, S.  
   DISCRETE MATHEMATICS Volume: 306 Issue: 2-1 Pages: 2762-2771 Published: NOV 2006

4. **Regularization and semi-supervised learning on large graphs**  
   By: Belkin, M; Matveeva, I; Niyogi, P  
   LEARNING THEORY, PROCEEDINGS Book Series: Lecture Notes in Computer Science Volume: 3120 Pages: 624-638 Published: 2004

5. **Manifold regularization: A geometric framework for learning from labeled and unlabeled examples**  
   By: Belkin, Mikhail; M; Niyogi, Partha; Sindhwani, Vikas  
   JOURNAL OF MACHINE LEARNING RESEARCH Volume: 7 Pages: 2339-2434 Published: NOV 2006

6. **SPECTRA, EUCLIDEAN REPRESENTATIONS AND CLUSTERING OF HYPERGRAPHS**  
   By: BOLLA, M  
   DISCRETE MATHEMATICS Volume: 117 Issue: 1-3 Pages: 19-39 Published: JUL 1 1993

7. **Spectral clustering based on the graph p-Laplacian**  
   By: Buhler, T; Hein, M.  
   P 26ANN INT C MACH Pages: 81-88 Other: 2-11-07149083083 Published: 2009

8. **Multilabel Remote Sensing Image Retrieval Using a Semi-supervised Graph-Theoretic Method**  
   By: Chaudhari, Bindita; Demir, Begüm; Chaudhuri, Subhasis; et al.  
   IEEE TRANSACTIONS ON GEOSCIENCE AND REMOTE SENSING Volume: 56 Issue: 2 Pages: 1144-1158 Published: FEB 2018

9. **Effective and Efficient Midlevel Visual Elements-Oriented Land-Use Classification Using VHR Remote Sensing Images**  
   By: Cheng, Gong; Han, Jianwei; Guo, Lei; et al.  
   IEEE TRANSACTIONS ON GEOSCIENCE AND REMOTE SENSING Volume: 53 Issue: 8 Pages: 4238-4249 Published: AUG 2015

10. **The Pascal Visual Object Classes (VOC) Challenge**  
    By: Everingham, Mark; Van Gool, Luc; Williams, Christopher K. I.; et al.  
    INTERNATIONAL JOURNAL OF COMPUTER VISION Volume: 88 Issue: 2 Special Issue: SI Pages: 303-338 Published: JUN 10 2010

11. **Multiview Cauchy Estimator Feature Embedding for Depth and Inertial Sensor-Based Human Action Recognition**  
    By: Guo, Yinan; Yao, Dapeng; Liu, Wenchang; et al.  
    IEEE TRANSACTIONS ON SYSTEMS MAN CYBERNETICS-SYSTEMS Volume: 47 Issue: 4 Special Issue: SI Pages: 617-627 Published: APR 2017

12. **Transferring Deep Convolutional Neural Networks for the Scene Classification of High-Resolution Remote Sensing Imagery**  
    By: Ha, Fan; Xia, Gui-Song; Hu, Jingwen; et al.  
    IEEE TRANSACTIONS ON GEOSCIENCE AND REMOTE SENSING Volume: 56 Issue: 8 Pages: 4210-4220 Published: AUG 2018
<table>
<thead>
<tr>
<th>#</th>
<th>Title</th>
<th>By:</th>
<th>Times Cited</th>
</tr>
</thead>
<tbody>
<tr>
<td>13</td>
<td>Image Retrieval via Probabilistic Hypergraph Ranking</td>
<td>Haung, Yuch; Liu, Qinghlan, Zhang, Shao; et al.</td>
<td>114</td>
</tr>
<tr>
<td>14</td>
<td>Video Object Segmentation by Hypergraph Cut</td>
<td>Haung, Yuch; Liu, Qinghlan, Metaxas, Dimitra</td>
<td>60</td>
</tr>
<tr>
<td>15</td>
<td>Spectral-Spatial Constraint Hyperspectral Image Classification</td>
<td>Jia, Rongrong; Gao, Yang; Gong, Richang; et al.</td>
<td>136</td>
</tr>
<tr>
<td>16</td>
<td>CDMA: Coupled discriminant multi-manifold analysis for matching low-resolution face images</td>
<td>Jiang, Junyan; Hu, Rumin; Wang, Zhongyan; et al.</td>
<td>25</td>
</tr>
<tr>
<td>17</td>
<td>Beyond bags of features: spatial pyramid matching for recognizing natural scene categories</td>
<td>Lazebnik, S.; Schmid, C.; Ponce, J.</td>
<td>1,926</td>
</tr>
<tr>
<td>18</td>
<td>A New Accuracy Assessment Method for One-Class Remote Sensing Classification</td>
<td>Li, Wenkai; Guo, Qinghua</td>
<td>18</td>
</tr>
<tr>
<td>19</td>
<td>p-Laplacian Regularization for Scene Recognition</td>
<td>Liu, Weifeng; Ma, Xuey; Zhou, Yicong; et al.</td>
<td>11</td>
</tr>
<tr>
<td>20</td>
<td>Multiview Hessian Regularization for Image Annotation</td>
<td>Liu, Weifeng; Tao, Dacheng</td>
<td>184</td>
</tr>
<tr>
<td>21</td>
<td>p-Laplacian Regularized Sparse Coding for Human Activity Recognition</td>
<td>Liu, Weifeng; Zha, Zhongjun; Wang, Yanjiang; et al.</td>
<td>65</td>
</tr>
<tr>
<td>22</td>
<td>Semi-Supervised Multitask Learning for Scene Recognition</td>
<td>Lu, Xiaojian; Li, Xuelong; Mou, Lichao</td>
<td>79</td>
</tr>
<tr>
<td>23</td>
<td>Remote Sensing Scene Classification by Unsupervised Representation Learning</td>
<td>Lu, Xiaojian; Zheng, Xiangtao; Yuan, Yuan</td>
<td>60</td>
</tr>
<tr>
<td>24</td>
<td>Graph-Regularized Low-Rank Representation for Destriping of Hyperspectral Images</td>
<td>Lu, Xiaojian; Wang, Yulong; Yuan, Yuan</td>
<td>143</td>
</tr>
<tr>
<td>25</td>
<td>Manifold Regularized Sparse NMF for Hyperspectral Unmixing</td>
<td>Lu, Xiaojian; Wu, Hao; Yuan, Yuan; et al.</td>
<td>155</td>
</tr>
<tr>
<td>26</td>
<td>On the eigenvectors of p-Laplacian</td>
<td>Luo, Dijun; Huang, Heng; Ding, Chris; et al.</td>
<td>13</td>
</tr>
<tr>
<td>27</td>
<td>Manifold Regularized Multitask Learning for Semi-Supervised Multilabel Image Classification</td>
<td>Luo, Yong; Tao, Dacheng; Geng, Bo; et al.</td>
<td>121</td>
</tr>
<tr>
<td>28</td>
<td>Multiple Kernel Learning for Remote Sensing Image Classification</td>
<td>Naazmand, Saeid; Demiri, Begum; Bruzzone, Lorenzo; et al.</td>
<td>4</td>
</tr>
</tbody>
</table>
Flexible Manifold Embedding: A Framework for Semi-Supervised and Unsupervised Dimension Reduction
By: Nie, Feiping; Xu, Dong; Tsang, Ivor Wai Hung; et al.
IEEE TRANSACTIONS ON GEOSCIENCE AND REMOTE SENSING Volume: 56 Issue: 3 Pages: 1425-1443 Published: MAR 2018

Times Cited: 220

Joint Sparse Representation and Embedding Propagation Learning: A Framework for Graph-Based Semi-Supervised Learning
By: Pei, Xiaobing; Chen, Chuanbo; Guan, Yue
IEEE TRANSACTIONS ON IMAGE PROCESSING Volume: 19 Issue: 7 Pages: 1921-1932 Published: JUL 2010

Times Cited: 2

Showing 30 of 50  View All in Cited References page