Curriculum Vitae

Ziheng Sun, Ph.D.

Center for Spatial Information Science and Systems, George Mason University
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EDUCATION

- 2009-2015 ***Ph.D. Photogrammetry and Remote Sensing*** the State Key Lab for Information Engineering in Surveying, Mapping and Remote Sensing (LIESMARS), Wuhan University
  - *Dissertation: Study of Key Technologies of Task-Driven Intelligent Composition of Geospatial Processing Web Services*
- 2005-2009 ***B.Sc. Geographical Information System*** School of Resource and Environmental Science, Wuhan University

RESEARCH INTERESTS

- Geospatial cyberinfrastructure
- Geoprocessing workflow
- Big data
- High-performance computing
- Machine learning
- Remote sensing
- Agrogeinformatics
- Environmental Science

EXPERIENCES

- 2015-present
  Research Assistant Professor
  George Mason University

- 2013-2015
  Research Associate
  Geroge Mason University

- 2009-2013
  Research Assistant
  Wuhan University

MEMBERSHIP

- IEEE, member
- IEEE young professionals, member
- IEEE geoscience and remote sensing society, member
- AAG (American Association of Geographers), member
- AGU (American Geophysical Union), member
- ESIP (Earth Science Information Partners), member

- OGC (Open Geospatial Consortium), member

PUBLICATIONS

Journal Papers:

1. **Ziheng Sun**, Di, L. and Gaigalas, J. SUIS: simplify the use of geospatial web services in environmental modelling. Environmental Modelling & Software. 2019.
2. **Ziheng Sun**, Di L., Hao H., et al. CyberConnector: a service-oriented system for automatically tailoring multisource Earth observation data to feed Earth science models. Earth Science Informatics, 2018, 11(1), 1-17.
3. **Ziheng Sun**, Di L., Fang H. Using Long Short-Term Memory Recurrent Neural Network in Land Cover Classification on Landsat and Cropland Data Layer time series. International Journal of Remote Sensing, 2018. 1-22.
4. **Ziheng Sun**, Liping Di, Gil Heo, Chen Zhang, Hui Fang, Peng Yue, Lili Jiang, Xicheng Tan, Liying Guo, Li Lin, GeoFairy: Towards a one-stop and location based Service for Geospatial Information Retrieval. Computers, Environment and Urban Systems, 2017, Vol. 62, Pages 156-167.
5. **Ziheng Sun**, Hui Fang, Liping Di, Peng Yue, Realizing parameterless automatic classification of remote sensing imagery using ontology engineering and cyberinfrastructure techniques, Computers & Geosciences, Volume 94, September 2016, Pages 56-67.
6. **Ziheng Sun**, Fang, H., Di, L., Yue, P., Tan, X., & Bai, Y., Developing a web-based system for supervised classification of remote sensing images. GeoInformatica, 2016, 20 (4), 1573-7624.
7. **Ziheng Sun**, Hui Fang, Meixia Deng, Aijun Chen, Peng Yue, Liping Di. Regular Shape Similarity Index: A Novel Index for Accurate Extraction of Regular Objects from Remote Sensing Images. Geoscience and Remote Sensing, IEEE Transactions on, 2015, vol. 53, no. 7, pp. 3737-3748, DOI: 10.1109/TGRS.2014.2382566. (***nominated as TGRS Best Paper in 2015****)*
8. **Ziheng Sun**, Chunming Peng, Meixia Deng, Aijun Chen, Peng Yue, Hui Fang, Liping Di. Automation of Customized and Near-Real-Time Vegetation Condition Index Generation Through Cyberinfrastructure-Based Geoprocessing Workflows. Selected Topics in Applied Earth Observations and Remote Sensing, IEEE Journal of, 2015, vol. 7, no.11, pp. 4512-4522.
9. **Ziheng Sun**, Peng Yue, Lei Hu, Jianya Gong, Liangpei Zhang, Xianchang Lu. GeoPWProv: Interleaving Map and Faceted Metadata for Provenance Visualization and Navigation. Geoscience and Remote Sensing, IEEE Transactions on, 2013, vol. 51, no. 11, pp. 5131-5136. (***highlighted in the book Remotely Sensed Data Characterization, Classification, and Accuracies.)***
10. **Ziheng Sun**, Peng Yue, Liping Di. GeoPWTManager: a task-oriented Web geoprocessing system. Computers & Geoscience, 2012, vol. 47, pp. 34-45.
11. **Ziheng Sun**, Peng Yue, Xianchang Lu, Xi Zhai, Lei Hu. A task ontology driven approach for live geoprocessing in a service oriented environment. Transactions in GIS, 2012, vol. 16, no. 6, pp. 867-884.
12. Jiang, Lili, **Ziheng Sun**, Qingwen Qi, and An Zhang. "Spatial Correlation between Traffic and Air Pollution in Beijing." The Professional Geographer (2019): 1-14.
13. Zhong, Shaobo, Liping Di, **Ziheng Sun**, Zhanya Xu, and Liying Guo. "Investigating the Long-Term Spatial and Temporal Characteristics of Vegetative Drought in the Contiguous United

States." IEEE Journal of Selected Topics in Applied Earth Observations and Remote Sensing 12, no. 3 (2019): 836-848.
14. Zhang, Chen, Liping Di, **Ziheng Sun**, Li Lin, G. Yu Eugene, and Juozas Gaigalas. "Exploring cloud-based Web Processing Service: A case study on the implementation of CMAQ as a service." Environmental Modelling & Software 113 (2019): 29-41.
15. Peng Yue, Jianya Gong, Liping Di, Jie Yuan, Lizhi Sun, **Ziheng Sun**, Wang Qian. GeoPW: Laying Blocks for the Geospatial Processing Web. Transactions in GIS, 2010, vol. 14, no. 6, pp. 755-772.
16. Tan, X., Guo, S., Di, L., Deng, M., Huang, F., Ye, X., **Sun, Z.**, Gong, W., Sha, Z., Pan, S., 2017. Parallel Agent-as-a-Service (P-AaaS) Based Geospatial Service in the Cloud. Remote Sensing 9(4) 382.
17. Xicheng Tan, Liping Di, Meixia Deng, Fang Huang, Xinyue Ye, Zongyao Sha, **Ziheng Sun**, Weishu Gong, Yuanzheng Shao, Cheng Huang, Agent-as-a-service-based geospatial service aggregation in the cloud: A case study of flood response, Environmental Modelling & Software, Volume 84, October 2016, Pages 210-225, ISSN 1364-8152.
18. Xicheng Tan, Liping Di, Meixia Deng, Jing Fu, Guiwei Shao, Meng Gao, **Ziheng Sun**, Xinyue Ye, Zongyao Sha, and Baoxuan Jin. Building an Elastic Parallel OGC Web Processing Service on a Cloud-Based Cluster: A Case Study of Remote Sensing Data Processing Service. Sustainability, 2015, vol. 7, no. 10, pp. 14245-14258.
19. Xicheng Tan, Liping Di, Yanfei Zhong, Nengcheng Chen, Fang Huang, Jinchuan Wang, **Ziheng Sun**, and Yahya Khan. "Distributed Geoscience Algorithm Integration Based on OWS Specifications: A Case Study of the Extraction of a River Network." ISPRS International Journal of Geo-Information 8, no. 1 (2019): 12.

Conference Papers:

1. **Sun, Z.**, Di, L., Zhang, C., Fang, H., Yu, E., Lin, L., Tang, J., Tan, X., Liu, Z., Jiang, L., 2017. Building robust geospatial web services for agricultural information extraction and sharing, Agro-Geoinformatics, 2017 6th International Conference on. IEEE, pp. 1-4.
2. **Sun, Z.**, Di, L., Zhang, C., Fang, H., Yu, E., Lin, L., Tan, X., Guo, L., Chen, Z., Yue, P., 2017. Establish cyberinfrastructure to facilitate agricultural drought monitoring, Agro-Geoinformatics, 2017 6th International Conference on. IEEE, pp. 1-4.
3. Lin, L., Di, L., Yu, E.G., Tang, J., Shrestha, R., Rahman, M.S., Kang, L., **Sun, Z.**, Zhang, C., Hu, L., 2017. Extract flood duration from Dartmouth Flood Observatory flood product, Agro-Geoinformatics, 2017 6th International Conference on. IEEE, pp. 1-4.
4. Zhang, C., Di, L., **Sun, Z.**, Eugene, G.Y., Hu, L., Lin, L., Tang, J., Rahman, M.S., 2017. Integrating OGC Web Processing Service with cloud computing environment for Earth Observation data, Agro-Geoinformatics, 2017 6th International Conference on. IEEE, pp. 1-4.
5. Di, L., **Sun, Z.**, Yu, E., Song, J., Tong, D., Huang, H., Wu, X. and Domenico, B., 2016, November. Coupling of Earth science models and earth observations through OGC interoperability specifications. In Geoscience and Remote Sensing Symposium (IGARSS), 2016 IEEE International (pp. 3602-3605). IEEE.
6. Zhang, C., **Sun, Z.**, Heo, G., Di, L., & Lin, L. (2016, July). A GeoPackage implementation of common map API on Google Maps and OpenLayers to manipulate agricultural data on mobile devices. In Agro-Geoinformatics (Agro-Geoinformatics), 2016 Fifth International Conference on

(pp. 1-4). IEEE.
7. Liu, Z., **Sun, Z.**, & Di, L. (2016, July). An analysis of land cover change in Northern Virginia in the first decade of 21st century. In Agro-Geoinformatics (Agro-Geoinformatics), 2016 Fifth International Conference on (pp. 1-5). IEEE.
8. Zhang, C., **Sun, Z.**, Heo, G., Di, L., & Lin, L. (2016, July). Developing a GeoPackage mobile app to support field operations in agriculture. In Agro-Geoinformatics (Agro-Geoinformatics), 2016 Fifth International Conference on (pp. 1-4). IEEE.
9. **Sun, Z.**, Di, L., Zhang, C., Lin, L., Fang, H., Tan, X., & Yue, P. (2016, July). Combining OGC WCS with SOAP to faciliate the retrieval of remote sensing imagery about agricultural fields. In Agro-Geoinformatics (Agro-Geoinformatics), 2016 Fifth International Conference on (pp. 1-4). IEEE.
10. **Sun, Z.**, Di, L., Fang, H., Zhang, C., Yu, E., Lin, L., ... & Yue, P. (2016, July). Embedding Pub/Sub mechanism into OGC web services to augment agricultural crop monitoring. In Agro-Geoinformatics (Agro-Geoinformatics), 2016 Fifth International Conference on (pp. 1-4). IEEE.
11. Guo, L., **Sun, Z.**, Di, L., & Lin, L. (2016, July). Spatial distribution and variation analysis of Lyme disease in the Northeastern United States. In Agro-Geoinformatics (Agro-Geoinformatics), 2016 Fifth International Conference on (pp. 1-4). IEEE.
12. Li Lin, Liping Di, Eugene Genong Yu, Lingjun Kang, Ranjay Shrestha, Md. Shahinoor Rahman, Junmei Tang, Meixia Deng, **Ziheng Sun**, Chen Zhang, Lei Hu, A review of remote sensing in flood assessment. In Agro-Geoinformatics (Agro-Geoinformatics), 2016 Fifth International Conference on. IEEE.
13. Tan, X., L. Di, M. Deng, A. Chen, **Z. Sun**, C. Huang, Y. Shao, and X. Ye. "AGENT- AND CLOUD-SUPPORTED GEOSPATIAL SERVICE AGGREGATION FOR FLOOD RESPONSE." ISPRS Annals of the Photogrammetry, Remote Sensing and Spatial Information Sciences II, no. 4 (2015): 13-18.
14. Michael Caleb You, **Ziheng Sun**, Liping Di, Joe Guo. A web-based semi-automated method for semantic annotation of high schools in remote sensing images. In Agro-geoinformatics (Agro-geoinformatics 2014), Third International Conference on (pp. 1-4). IEEE. 2014.
15. **Ziheng Sun**, Liping Di, Aijun Chen, Peng Yue, Jianya Gong. The use of geospatial workflows to support automatic detection of complex geospatial features from high resolution images. Agro-Geoinformatics (Agro-Geoinformatics), 2013 Second International Conference on, IEEE. pp. 159-162.
16. Liping Di, Peng Yue, **Ziheng Sun**. Ontology-supported complex feature discovery in a web service environment. Geoscience and Remote Sensing Symposium (IGARSS), 2012 IEEE International. IEEE, 2012, pp. 2887-2890.
17. **Ziheng Sun**, Peng Yue. The use of Web 2.0 and geoprocessing services to support geoscientific workflows. Geoinformatics, 2010 18th International Conference on. 2010.
18. Peng Yue, **Ziheng Sun**, Jianya Gong, Liping Di, Xianchang Lu. A Provenance Framework for Web Geoprocessing Workflows. In IGRASS International Conference on 2011.
19. Xi Zhai, Jianya Gong, Peng Yue, **Ziheng Sun**, Xianchang Lu. WYSIWYG Geoprocessing: Coupling Sensor Web and Geoprocessing Services in Virtual Globes, In: The 2011 ISPRS Joint-WG Workshop on "Geospatial Data Infrastructure: from data acquisition and updating to smarter services", 2011 GuiLin, China.

PROJECT EXPERIENCE

1. **Principal Investigator** of ESIP lab project "Geoweaver: a web-based system for managing compound geospatial workflows of large-scale distributed deep networks" ($7,000).
2. **Co-Principal Investigator of NASA funded project** "Satellite-aided regional dust forecasting for Valley fever surveillance, highway accident prevention, and air quality management in the Southwestern United States" ($928,604).
3. **Participant of** OGC Disaster Pilot project for hurricane and flooding scenarios.
4. **Team Leader & Core Developer of** OGC Testbed 15. GMU CSISS is responsible for three threads in Testbed 15. Responsible for one component: D145 Scale Data Center environment.
5. **Team Leader & Core Developer** of NSF project #1740693 "CyberWay: Integrated Capabilities of EarthCube Building Blocks for Facilitating Cyber-based Innovative Way of Interdisciplinary Geoscience Studies" ($1,100,000.00).
6. **Team Leader & Core Developer** of NSF project #1440294 "CyberConnector: an EarthCube building block for facilitating the automatic preparation and feeding of both historic and near-real time Earth Observation customized data and on-demand derived products into Earth science models". ($1,000,000.00)
7. **Team Leader & Core Developer of** OGC Testbed 13. GMU CSISS is responsible for three threads in Testbed 13. Responsible for two components: NR101 Cloud based WPS development; NA101 Agriculture scientist client.
8. **Team Leader & Core Developer of** OGC Testbed 12. GMU CSISS is responsible for eight threads in Testbed 12. Responsible for five components: A027 GeoPackages Mobile App Data Implementation; A054 Mobile Device GeoPackage Common Map API Implementation; A109 Browser Based Client; A043 WCS SOAP server and A045 WCS Conventional Server. ($97,360.00)
9. **Developer** in OGC Testbed 11: GMU CSISS is responsible for five threads in Testbed 11. Responsible for the implementation of A020 WCS implementation with JPIP supporting the scenario.
10. **Developer** of GADMFS: An online operational geospatial service system of agricultural drought monitoring. I am responsible for maintaining the system normal running, generating latest drought data product, developing new functions to enhance the system capabilities and reconstructing the system code to improve user experience.
11. **Team Leader & Core Developer** of DOE project #DE-NA0001123 A Prototypical Ontology-supported Intelligent Geospatial Feature Discovery System (iGFDS) for Proliferation Detection. ($897,114)
12. **Developer** of VegScape: A web service based online system to monitor U.S. national vegetation condition and provide an operational hosting and maintenance service to USDA/NASS. I worked on using the vegetation product provided by VegScape, testing the robustness of the system, providing suggestions for system improving and building Web services to demonstrate and promote the advantages of VegScape.
13. **Developer** of the project: Metadata Tracking in Geospatial Service Chaining and Geospatial Data Provenance, funded by National Natural Science Fundation of China.
14. **Developer** of Spatial Analysis Service in EPGIS Server (a web GIS platform for national power grid). Wuhan Geo Information Engineering Technology Ltd. China (2010).

15. **Developer** of Task-oriented Information Aggregation Service Model in Earth Observation Sensor Web. National Basic Research Program of China (973), Ministry of Science and Technology of China (2011-2013).
16. **Principal Investigator** of project Construct, track and evaluate geospatial service chain in a task-oriented approach, funded by the Doctor Independent Research Fund of Wuhan University.

On Campus:

1. Developed a Campus Geographic System with my teammates using Visual Basic in March 2008. In the system new students can search classrooms, bedrooms, dining hall and library. It also implemented the functions of optimal path and buffer analysis.
2. Developed a City GISystem of Wuhan with teammates using Visual C++ and MapX plugin of MapInfo Co. Ltd in June 2008.
3. Visited Mountain Lu to study the geographical features in September 2007.
4. Developed a GIS software using Visual C++ language in December 2007. The software can open geospatial data in DXF format, and also able to display, zoom in or out, pan the map in the workspace window.
5. Surveyed the informatics campus of Wuhan University with teammates and produced a map on paper. I learnt using the instruments of surveying and mapping, such as total station and hydrostatic level.

CONFERENCE AND SEMINAR PRESENTATIONS

1. AGU, 2018 November, Washington, D.C. (Poster: COVALI)
2. AAG, 2019 April, Washington, D.C. (Oral & Session Chair)
3. AAG, 2018 April, New Orleans, LA. 2018. (Oral & Poster)
4. AAG, 2017 April, Boston, MA. 2017. (Oral)
5. NSF EarthCube All Hands meeting, Denver, CO. 2016. (Oral & Poster)
6. NSF EarthCube All Hands meeting, Alexandria, VA. 2018. (Oral & Poster)
7. ISPRS International Workshop on Spatiotemporal Computing, Fairfax, VA. 2015.07.13-15 (Oral, Proceedings).
8. ESIP Summer Meeting, Tacoma, WA, 2019. (Plenary Lightning Talk; Session Chair & Speaker; Talk: Advanced Geospatial Cyberinfrastructure for Deep Learning)
9. ESIP Winter Meeting, Bethesda, MD, 2019. (Poster: Geoweaver & Oral Presenter & Panelist)
10. ESIP Winter Meeting, Bethesda, MD, 2018.1.9-12. (Poster: CyberConnector & Geofairy)
11. ESIP Winter Meeting, Bethesda, MD, 2017.1.11-13. (Poster: CyberConnector & CMAQ)
12. ESIP summer meeting, Durham, NC. 2016.07.19-22.
13. ESIP Winter Meeting 2016, Washington D.C. (Oral & Poster: CyberConnector).
14. ESIP Winter Meeting 2015, Washington D.C. (Poster: Geofairy).
15. OGC Testbed 13 Demonstration & Exposition, USGS headquarters, Reston, VA. 2017.12.12-13. (Presentation).
16. OGC TC meeting in World Bank, Washington, D.C. 2016.
17. OGC Testbed 12 Demonstration & Exposition, USGS headquarters, Reston, VA. 2016.11.29. (Poster).
18. OGC Testbed 12 Kickoff Meeting, USGS Headquater Building, Reston, VA. 2016. (Oral).
19. OGC Testbed 11 Kickoff meeting, George Mason University, Fairfax, 12-14 Jan 2015.

20. OGC Testbed 10 Kickoff meeting, George Mason University, Fairfax, 7-9 Oct, 2013.
21. Agro-Geoinformatics 2019, Istanbul, Turkey. (Oral & Proceedings)
22. Agro-Geoinformatics 2017, Fairfax, VA. (Oral & Proceedings)
23. Agro-Geoinformatics 2016, Tianjin, China. (Oral & Proceedings)
24. Agro-Geoinformatics 2015, Istanbul, Turkey. (Proceedings)
25. Agro-Geoinformatics 2014, Beijing, China. (Proceedings)
26. Agro-Geoinformatics 2013, Washington, D.C. 2013.08.12-16. (Oral & Proceedings).
27. Geoinformatics 2010 conference on 19 Jun 2010, Beijing, China (Oral, Student competition).

DEVELOPED SERVICES & SOFTWARE

1. **Geoweaver**: a web system to allow users to easily compose and execute full-stack deep learning workflows in web browsers by taking advantage of the online spatial data facilities, high-performance computation platforms, and open-source deep learning libraries.
2. **COVALI**: a web system for climate scientists to search, visualize, analyze, compare and validate both local and remote netCDF files.
3. **CyberConnector**: a system can automatically process the EO data into the right products in the right form needed for ESM initialization, validation, and inter-comparison.
4. **Geoprocessing Service Kit**: A bundle of Web services to complete various kinds of geospatial processing goals. The URL of the service kit entry is:
5. **GeoFairy** – A mobile phone app which succeeds to collect and display nine kinds of the mostly used geospatial information: vegetation (VegScape), weather (OpenWeatherMap), precipitation (NASA AIRS), atmosphere, soil moisture (NASA), altitude (DEMExplorer), agriculture (USDA), land cover (GLCNMO) and land use (CropScape). Geofairy has been published on Google Play and Apple store.
6. **GADMFS** – A Web GIS that provides global NDVI, VCI and Drought datasets derived using tile-based MODIS datasets and implements Web Map Service (WMS) and Web Coverage Service (WCS) to support visualization and acquisition of the global data. I am responsible for developing module functions in the system like customizing VCI product according to specific user requirements.
7. **MOGRAW** – (MODIS-GRASS-WCPS) is an online web prototype system to provide geoprocessing services through OGC WCPS standard interfaces.
8. **BPELPower** – A BPEL execution engine for composing geospatial web services. I am responsible for developing some external functions modules to combine BPELPower into specific application scenario and perform the significant role to link all the distributed resources together to complete a complex task.
9. **WMD** – workflow model designer, a tool for general users to design a workflow based on BPELPower. I write code to extend WMD into a system which helps people be aware of all the resources they can use and compose them according to a particular goal in a more intelligent pattern.
10. **GeoPWProv** – A Web prototype system to capture, record, query and visualize the provenance information generated by geoscientific workflow.
11. **GeoPWDesigner** – A Web application to compose Geoprocessing Web Services into a logic workflow, instantiate the logic workflow to an executable workflow which is deployed on an ActiveBPEL engine.

12. **GeoPWTaskManager** – A Web System to create, edit, manage, execute and monitor the geoprocessing workflows composed by several Geospatial Web Services.
13. **GeoPW Ontology Manager** – A Web system, which leverages Web 2.0, Sensor Web, Semantic Web and geoprocessing services, allows the use of task ontology to support live geoprocessing (Fig4). The system is an extension of the GeoPWDesigner by supporting the ontologies and Sensor Web technologies.
14. **PowerGrid GIS Platform (EPGIS)** – A Web platform for the electricity management according to the requirements of the State Grid in China. Responsible the query service, thematic map service, and Web service context.

SCHOLARSHIPS & AWARDS

1. NGA Disparate Data Competition Winter. GeoFairy.Map won one of the fifteen final cash awards in Oct, 2016 ($10,000).
2. Third prize in the GEO GeoAppathon competition in 2014 ($2,500). **Win out of 132 teams from 49 countries**.
3. Winner of NGA Agricultural Field Delineation from Satellite Imagery challenge (link) ($2,500).
4. One of the selected winners to the National Geospatial Intelligence Agency (NGA) Agricultural Field Delineation from Satellite Imagery challenge ($2,500). **Win out of 143 teams.**
5. Third prize in the EarthServer Big Data Contest in 2014 ($600).
6. EarthCube Early Career Travel Grant in 2019. ($500)
7. EarthCube Early Career Travel Grant in 2018. ($500)
8. Invited participant in ESIPLab bootcamp 2018 at University of Colorado Boulder.
9. The 2010-2011th Trimble Scholarship. The Trimble Corporation.
10. Scholarship of Wuhan University Undergraduate Science Innovation in 2012. Wuhan University.
11. Undergraduate Excellent First Scholarship. 2012-2013. Wuhan University.
12. National Scholarship. 2012-2013. Department of Education in China.

PEER REVIEW EXPERIENCES

- AAAS proposal review panel
- Computers & Geosciences
- Computers and Electronics in Agriculture
- Earth Science Informatics
- Geoinformatica
- IEEE Geoscience and Remote Sensing Letters
- IEEE Journal of Selected Topics in Applied Earth Observations and Remote Sensing
- IEEE Access
- IEEE/CAA Journal of Automatica Sinica
- International Journal of Digital Earth
- International Journal of Geoinformation
- Remote Sensing
- Applied Science
- Big Data and Cognitive Computing
- Future Internet

- PLOS One
- Computers and Electrical Engineering
- Data in Brief
- Agro-geinformatics
- ISPRS workshop papers
- Geoinformatics conference

SKILLS

1. Java, JavaScript, C++/C, Python, JSP, Shell, R, and Fortran.
2. Geospatial Software: Quantum GIS, ArcGIS, GeoServer, MapServer, GRASS GIS, OpenLayers, MapWindow, ENVI, ERDAS, eCognition, etc.
3. Other software: Jupyter notebook, Apache Cordova, Oracle BPEL, Oracle Database, BEA WebLogic, Apache Tomcat, Apache Axis2, Apache Ant, ActiveBPEL, PostgreSQL, Eclipse, Netbeans, IntelliJ IDEA, GitHub, ExtJS, RaphealJS, JQuery, Bootstrap.
4. Coding Environment: Windows, Linux (Ubuntu, CentOS, RedHat, Debian, Fedora), macOS, iOS, Android.
5. Cloud computing: Apache CloudStack, OpenStack, Apache Hadoop, Apache Spark, Pangeo, NGA Scale Data Center.
6. Web and mobile phone application design and implementation.
7. AI toolkt: Scikit-learn, Numpy, Tensorflow, DeepLearning4j, PyTorch, and Keras.
8. Framework: Spring and Thymeleaf.