Award 2018611 - Annual Project Report Y3 – Technical Sections

2023-10 Note: The original report submitted 7/2/2023 had an error, corrected herein by removing Paragraph II.3 of Accomplishments (New Algorithms and Modules) and the corresponding reprint from the appendix. Said item should not have been included in the original report because it had never been submitted to NSF PAR nor posted at https://www.nsf.gov/awardsearch/showAward?AWD_ID=2018611
Unfortunately, the FIU SRO has obstructed the timely correction of this report at NSF. Therefore, the correction is posted here and will be uploaded to NSF when the reporting window reopens.

Cover

Federal Agency and Organization Element to Which Report is Submitted:	4900
Federal Grant or Other Identifying Number Assigned by Agency:	2018611
Project Title:	MRI: Development of an Instrument for Student and Faculty Research on Multimodal Environmental Observations
PD/PI Name:	Naphtali D Rishe, Principal Investigator Todd A Crowl, Co-Principal Investigator Daniel Gann, Co-Principal Investigator Sitharama S Iyengar, Co-Principal Investigator Shahin Vassigh, Co-Principal Investigator
Recipient Organization:	Florida International University
Project/Grant Period:	10/01/2020 - 09/30/2025
Reporting Period:	10/01/2022 - 09/30/2023
Submitting Official (if other than PD\PI):	N/A
Submission Date:	N/A
Signature of Submitting Official (signature shall be submitted in accordance with agency specific instructions)	N/A

Accomplishments

*** What are the major goals of the project?**

Scientists are increasingly challenged to understand spatial and temporal synergies in ecosystem dynamics, assess the impact of human activities, and predict complex ecosystem responses. Yet, their ability to interpret data, discover knowledge, and forecast the future is tethered to how well they can synthesize the vast amounts of environmental observations produced by the evolving and diverse sensing and imaging technologies.

The Instrument being developed supports faculty research that requires the integration of large multimodal heterogeneous datasets. It will also enable guided research conducted by students. It will provide a platform to experiment and analyze the effects of data scaling on the relationships of ecosystem variables retrieved from remotely-sensed datasets and to evaluate the effect of merging and scaling algorithms on ecological model outputs.

Existing large repositories of global datasets do not readily allow the incorporation of vast amounts of multidimensional, historical locally-acquired datasets. The Instrument will provide comprehensive local data integration and its correlation to global data. The enabled ecological research will be focused on the Everglades, with multiple agencies acquiring data and possessing extensive historical collections.

Using the Instrument, ecologists will be able to address major scientific questions related to ecosystem productivity, geomorphological landscape dynamics, and their feedbacks on the biota. Computer scientists will utilize the Instrument to solve problems in multimodal image analysis, machine learning, spatiotemporal data analytics and mining, fuzzy logic, and data visualization.

*** What was accomplished under these goals and objectives (you must provide information for at least one of the 4 categories below)?**

Major Activities: We have significantly advanced the development of the Instrument, as summarized in the Outcomes below, with more detail in the Appendices.

Specific Objectives:

Using the Instrument, ecologists will be able to address major scientific questions related to ecosystem productivity, geomorphological landscape dynamics, and their feedback on the biota. Computer scientists will utilize the Instrument to solve problems in multimodal image analysis, machine learning, spatiotemporal data analytics and mining, fuzzy logic, and data visualization.

Significant Results:

Key outcomes or Other achievements:

Major technological accomplishments are summarized below; and more details and figures can be found in the attached PDF appendices.

I. New Multi-band satellite imagery subsystem

Specifications and screenshots of this new Y3 subsystem are in Appendix 1. Below is a brief summary of the modules of this subsystem.

1. Multi-band Satellite Imagery Management System

This system is designed to handle the challenge of storing and querying massive amounts of Multi-band Satellite Imagery data. It is comprised of three components:

* a hybrid database that is specifically designed to store massive multi-band satellite imagery data and their corresponding geospatial metadata for fast data search and retrieval

* a dataset batch-loading program that can load large amounts of satellite images into the hybrid database

* a RESTful API that enables querying the database with flexible searching criteria

2. Multi-band Satellite Imagery Rendering Service and API

This service can render any multi-band satellite images that are already loaded in the system. The API provided allows advanced users to integrate this service into their programs and scripts, creating more powerful applications.

3. Multi-band Satellite Imagery Querying Tool

This web-based, user-friendly tool enables the fast search of satellite image datasets within the system. Users can specify the following multiple search criteria.

4. Vector Dataset Rendering Tool

This front-end-based rendering tool can fetch vector data from the TerraFly SKS system and render the returned vector features on the map. Users can then click any point to view the detailed properties of the vector record.

The TerraFly SKS system stores multi-billion vector records amounting to close to 1 TB. This tool enables a quick and easy way for the user to utilize data from this geospatial database to their own advantage.

Upon opening the tool, the user will be presented with a list of options to customize the search and only get the desired data from the SKS database.

II. New Algorithms and Modules

The following are new algorithms/modules developed in Year 3 of this project. The paragraph numbers correspond to the section numbers in the attached detailed technical report are in Appendix 2.

1. A Latent Variable Based Approach for Exploring Geographic Datasets

Geographic datasets often exhibit spatial non-stationarity – a phenomenon that the relationship between features varies across space. Nonstationarity can be interpreted as the underlying rule determining how data is generated and changes over space. Traditional machine learning algorithms are not suitable for handling non-stationary geographic datasets, as they only render a single global model. To solve this problem, researchers often adopt the multiple-local-model approach, which uses different models to account for different sub-regions of space. This approach has been proven efficient but not optimal, as it is inherently difficult to decide the size of subregions. Additionally, the fact that local models are only trained on a subset of data also limits their potential. We have innovated an algorithm using an entirely different strategy that interprets nonstationarity as a lack of data and addresses it by introducing latent variables to the original dataset. Backpropagation is then used to find the best values for these latent variables. Experiments show that this method is at least as efficient as multiple-local-model-based approaches and has even greater potential.

2. Crime-Avoiding Routing

Extensive prior work has provided methods for the optimization of routing based on the criteria of travel time and/or on the cost of travel and/or the distance traveled. A typical method of routing involves building a graph comprised of street segments, assigning a normalized weighted value to each segment, and then applying the weighted-shorted path algorithm to the graph in order to find the best route. Some users desire that the routing suggestion include consideration pertaining to the reduction of risk of encountering violent crime. For example, a user desires a leisure walk via a safe route from her hotel in an unknown city. We have developed an algorithm

to quantify such user preferences and the risks of encountering crime and to augment the standard routing methods by giving weight to safety considerations. The proposed method's advantages, in comparison to other crime avoidance routing algorithms, include weighing crime types with respect to their potential detrimental value to the user, with temporal qualification and quantification of crime and its statistical aggregation at the geographic resolution down to a city block.

.

4. Integrating Location Information as Geohash Codes in Convolutional Neural Network-Based Satellite Image Classification

In the present work, first we have manually downloaded satellite images of four different classes in Florida locations using this MRI Instrument's TerraFly Mapping System. We then developed a CNN architecture suitable for extracting features and capable of multi-class classification in our dataset. There are shortcomings in the classification due to the dataset's limited size. To address this, we employ data augmentation and then use transfer learning for feature extraction with VGG16 and ResNet50 models. We use these features to classify satellite imagery of Florida. Analyzing misclassification in our model, we introduce a location-based CNN model. We convert coordinates to geohash codes, use these as an additional feature vector, and feed them into the CNN model. We believe that the new CNN model combined with geohash codes as location features improves the accuracy of our dataset.

5. Spatiotemporal Model of Real Estate Valuation Trend

We have developed a model, an algorithm, and a system module objectivizing real estate prices so that prices across time could be compared to understand historical price trends and also to assist in a property evaluation or appraisal, as well as for the analysis of comparables, and urban/environmental changes.

6. Towards Real-time House Detection in Aerial Imagery Using Faster Region-based Convolutional Neural Network

Detecting the specific types of houses will provide information in urbanization, change detection, and urban monitoring, which play increasingly important roles in modern city planning and natural hazard preparedness. We have made it effective to detect various types of houses in aerial imagery using Faster Region-based Convolutional Neural Network (Faster-RCNN). After formulating the dataset and extracting bounding-box information, pre-trained ResNet50 is used to get the feature maps. The fully convolutional Region Proposal Network (RPN) first predicts the bounds and objectness score of objects (in this case house) from the feature maps. Then, the Region of Interest pooling layer extracts regions to detect objects that are present in the images. This module enables R&D not only in the civil and environmental domains but also in other applied science disciplines.

*** What opportunities for training and professional development has the project provided?**

Students and junior faculty and staff have gained experience.

*** Have the results been disseminated to communities of interest? If so, please provide details.**

We are disseminating the service of the Instrument via http://cake.fiu.edu/MRI and http://terrafly.fiu.edu. The Instrument is also made available to external researchers via the Internet.

*** What do you plan to do during the next reporting period to accomplish the goals?**

Continue the development of the instrument in collaboration with earth scientists.

Supporting Files

Filename	Description	Uploaded By	Uploaded On

Products

Books

Cliff Wang, S. S. Iyengar, Kun Sun (2023). AI Embeded Assurance for Cyber System Springer Nature. Status = AWAITING_PUBLICATION; Acknowledgment of Federal Support = Yes; Peer Reviewed = Yes ; OTHER:

Jayakumar, S S Iyengar, Azad Madni (2023). Deep Learning Networks: Design, Development and Deployment, Introduction to Tool Set and its use in Deep Learning Programming Springer Nature. Status = AWAITING_PUBLICATION; Acknowledgment of Federal Support = Yes; Peer Reviewed = Yes; OTHER:

Book Chapters

Inventions

Journals or Juried Conference Papers

View all journal publications currently available in the NSF Public Access Repository for this award.

The results in the NSF Public Access Repository will include a comprehensive listing of all journal publications recorded to date that are associated with this award.

Wang, Wenjia and Sadjadi, Seyed Masoud and Rishe, Naphtali. (2022). Curse of Feature Selection: a Comparison Experiment of DDoS Detection Using Classification Techniques. Proceedings of the 12th IEEE International Conference on Big Data and Cloud Computing (BDCloud 2022). 262 to 269. Status = Added in NSF-PAR doi:https://doi.org/10.1109/ISPA-BDCloud-SocialCom-SustainCom57177.2022.00040
Federal Government's License = Acknowledged. (Completed by Rishe, Naphtali on 06/14/2023) Full text Citation details

Yu, Dylan and Yang, Ethan and Shen, Alissa and Tamir, Dan and Rishe, Naphtali.. (2023). Fibereum: A Novel Distributed Ledger Technology System. Lecture notes in computer science. 13828 669 - 684. Status = Added in NSF-PAR Federal Government's License = Acknowledged. (Completed by Rishe, Naphtali on 06/14/2023) Full text Citation details

Rishe, Naphtali and Amini, M. Hadi and Adjouadi, Malek. (2023). Scenic routing navigation using property valuation. Journal of Big Data. 10 (1) . Status = Added in NSF-PAR doi:https://doi.org/10.1186/s40537-023-00736-1
Federal Government's License = Acknowledged. (Completed by Rishe, Naphtali on 06/14/2023) Full text Citation details

Shojaie, Mehdi and Tabarestani, Solale and Cabrerizo, Mercedes and DeKosky, Steven T. and Vaillancourt, David E. and Loewenstein, David and Duara, Ranjan and Adjouadi, Malek. (2021). PET Imaging of Tau Pathology and Amyloid-β, and MRI for Alzheimer's Disease Feature Fusion and Multimodal Classification. *Journal of Alzheimer's Disease*. 84 (4) 1497 to 1514. Status = Deposited in NSF-PAR doi:https://doi.org/10.3233/JAD-210064 ; Federal Government's License = Acknowledged. (Completed by Rishe, Naphtali on 08/15/2022) Full text Citation details

Chen, Ian and Huang, Lucy and Qiao, Jack and Tamir, Dan E. and Rishe, Naphtali. (2022). Combining Perception Considerations with Artificial Intelligence in Maritime Threat Detection Systems. *2022 17th Annual System of Systems Engineering Conference (SOSE)*. 417 to 422. Status = Deposited in NSF-PAR doi:https://doi.org/10.1109/SOSE55472.2022.9812640 ; Federal Government's License = Acknowledged. (Completed by Rishe, Naphtali on 08/10/2022) Full text Citation details

Aghili, Maryamossadat and Tabarestani, Solale and Adjouadi, Malek. (2022). Addressing the missing data challenge in multi-modal datasets for the diagnosis of Alzheimer's disease. *Journal of Neuroscience Methods*. 375 (C) 109582. Status = Deposited in NSF-PAR doi:https://doi.org/10.1016/j.jneumeth.2022.109582 ; Federal Government's License = Acknowledged. (Completed by Rishe, Naphtali on 08/05/2022) Full text Citation details

Morar, Ulyana and Izquierdo, Walter and Martin, Harold and Forouzannezhad, Parisa and Zarafshan, Elaheh and Unger, Elona and Bursac, Zoran and Cabrerizo, Mercedes and Barreto, Armando and Vaillancourt, David E. and DeKosky, Steven T. and Loewenstein, David and Duara, Ranjan and Adjouadi, Malek. (2022). A study of the longitudinal changes in multiple cerebrospinal fluid and volumetric magnetic resonance imaging biomarkers on converter and non-converter Alzheimer's disease subjects with consideration for their amyloid beta status. *Alzheimer's & Dementia: Diagnosis, Assessment & Disease Monitoring*. 14 (1) . Status = Deposited in NSF-PAR doi:https://doi.org/10.1002/dad2.12258 ; Federal Government's License = Acknowledged. (Completed by Rishe, Naphtali on 08/05/2022) Full text Citation details

Masouleh, Mahmoud Sharafi and Behbahani, Amin Kargar and Adjouadi, Malek. (2021). Design, Analysis, and Optimization of the Array of Axial Rectangular Slots on a Cylindrical Waveguide. *IEEE Access*. 9 98218-98230. Status = Deposited in NSF-PAR doi:https://doi.org/10.1109/ACCESS.2021.3092997 ; Federal Government's License = Acknowledged. (Completed by Rishe, null on 07/16/2021) Full text Citation details

Deng, Liangdong and Adjouadi, Malek and Rishe, Naphtali. (2020). Geographic Boosting Tree: Modeling Non-Stationary Spatial Data. *2020 19th IEEE International Conference on Machine Learning and Applications (ICMLA)*. 1205 to 1210. Status = Deposited in NSF-PAR doi:https://doi.org/10.1109/ICMLA51294.2020.00190 ; Federal Government's License = Acknowledged. (Completed by Rishe, null on 07/15/2021) Full text Citation details

Morar, Ulyana and Martin, Harold and Izquierdo, Walter and Forouzannezhad, Parisa and Zarafshan, Elaheh and Curiel, Rosie E. and Roselli, Monica and Loewenstein, David and Duara, Ranjan and Unger, Elona and Adjouadi, Malek. (2020). A Deep-Learning Approach for the Prediction of Mini-Mental State Examination Scores in a Multimodal Longitudinal Study. *2020 International Conference on Computational Science and Computational Intelligence (CSCI)*. 761 to 766. Status = Deposited in NSF-PAR doi:https://doi.org/10.1109/CSCI51800.2020.00144 ; Federal Government's License = Acknowledged. (Completed by Rishe, null on 07/15/2021) Full text Citation details

Deng, Liangdong and Adjouadi, Malek and Rishe, Naphtali. (2020). Inverse Distance Weighted Random Forests: Modeling Unevenly Distributed Non-Stationary Geographic Data. *2020 International Conference on Advanced Computer Science and Information Systems (ICACSIS)*. 41 to 46. Status = Deposited in NSF-PAR doi:https://doi.org/10.1109/ICACSIS51025.2020.9263208 ; Federal Government's License = Acknowledged. (Completed by Rishe, null on 07/15/2021) Full text Citation details

Mafi, Mehdi and Izquierdo, Walter and Martin, Harold and Cabrerizo, Mercedes and Adjouadi, Malek. (2020). Deep convolutional neural network for mixed random impulse and Gaussian noise reduction in digital images. *IET Image Processing*. 14 (15) 3791 to 3801. Status = Deposited in NSF-PAR doi:https://doi.org/10.1049/iet-ipr.2019.0931 ; Federal Government's License = Acknowledged. (Completed by Rishe, null on 07/15/2021) Full text Citation details

Mafi, Mehdi and Izquierdo, Walter and Cabrerizo, Mercedes and Barreto, Armando and Andrian, Jean and David Rishe, Naphtali and Adjouadi, Malek. (2020). Survey on mixed impulse and Gaussian denoising filters. *IET Image Processing*. 14 (16) 4027 to 4038. Status = Deposited in NSF-PAR

doi:https://doi.org/10.1049/iet-ipr.2018.6335 ; Federal Government's License = Acknowledged. (Completed by Rishe, null on 07/15/2021) Full text Citation details

Licenses

Other Conference Presentations / Papers

Other Products

Other Publications

Patent Applications

Systems and Methods for Determining Document Section Types, USPTO Patent Application Publication US20220237210A1, Published on: July 28, 2022 . UNITED STATES. Application Date = 01/28/2021. Status = Granted

Systems and Methods for Navigating Based on Scenic Quality. UNITED STATES. Application Date = 06/30/2022. Status = Pending

Systems and Methods for Predicting Pain Level. Patent No. US11537888B2. UNITED STATES. Application Date = 05/15/2020. Date Issued = 12/27/2022. Status = Granted

Systems and Methods for Terrain Mapping Using Lidar. UNITED STATES. Application Date = 06/25/2021. Status = Pending

Technologies or Techniques

Thesis/Dissertations

Websites or Other Internet Sites
NSF MRI Instrument at FIU
http://cake.fiu.edu/MRI

A portal to the Instrument's interactive web tools, publications, and documentation.