Ankush Khandelwal

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Education

University of Minnesota *Minneapolis, USA | 2012 - 2019*

PhD in Computer Science

International Institute of Information Technology, Hyderabad. India *Hyderabad, India | 2006 - 2012*

MS by Research Dual Degree (B.Tech + MS) in Computer Science and Engineering

Experience

Terra Cover | Co-Founder and CTO *Denver, USA | Jan. 2020 - Present*

- Successfully raised $255K from National Science Foundation SBIR grant for startups (≈15 % success rate).
- Established product-market fit for two core products through deep customer engagements and paid pilots.
- Managed ML researchers focusing on semantic segmentation, anomaly detection, and variational inference algorithms to rapidly scale innovative processing of earth observation data on Google Cloud Platform.
- Setup a LLM based pipeline (using OpenAI's API) to achieve 70% reduction in human annotation time to geo-tag news articles for building a catalog of past flood events.

University of Minnesota | Researcher *Minneapolis, USA | May. 2019 - Present*

- Leading a project to create the first high-resolution map of Arctic lakes using deep learning with the aim to reduce uncertainty in estimation of methane emissions from small lakes.
- Supervising a graduate student to test a novel pre-training strategy for building a foundation model for temporal sequences of satellite imagery.
- Built new techniques for modeling long-term dependencies in time series data using RNNs and Transformers.
- Supervised 3 graduate students on different machine learning projects.
- Co-authored 9 peer reviewed publications.

IBM T.J. Watson Research Center | Research Intern *Yorktown Heights, USA | Jun. 2016 - Aug. 2016*

- Contributed to a publication on anomaly detection from multivariate noisy sensor data.
- Implemented key anomaly detection algorithms for IBM's anomaly detection software.

NASA Ames Research Center | Research Intern *Mountain View, USA | Jun. 2015 - Aug. 2015*

- Setup the project to study the dependencies of forest ecosystems on climate variables using satellite imagery and weather data.
- Implemented different regression algorithms on NASA's distributed computing environment.

University of Minnesota | Graduate Research Assistant *Minneapolis, USA | Sep. 2012 - May. 2019*

- Developed new machine learning algorithms for analyzing satellite imagery at scale.
- Actively participated in cross-disciplinary discussions and launched multiple projects for the lab including urbanization, palm oil plantation mapping, surface water mapping, and crop detection.
- Doctoral Dissertation Award winner for research on mapping global water changes with machine learning.
- Mentored 7 undergraduate students supported by the different grants of Prof. Vipin Kumar.
- Co-authored 18 peer-reviewed publications, 7 patents, and created a state-of-the-art dataset.

Patents

- **Khandelwal, A.**, Karpatne, A. and Kumar, V., University of Minnesota, 2023. *Satellite image classification across multiple resolutions and time using ordering constraint among instances.* U.S. Patent 11,625,913.
- Kumar, V., Jia, X., **Khandelwal, A.**. and Karpatne, A., University of Minnesota, 2021. *Predicting land covers from satellite images using temporal and spatial contexts.* U.S. Patent 11,068,737.
- Kumar, V., Jia, X., **Khandelwal, A.**. and Karpatne, A., University of Minnesota, 2021. *Discovery of shifting patterns in sequence classification.* U.S. Patent 11,037,022.
- Kumar, V., Mithal, V., Nayak, G. and **Khandelwal, A.**, University of Minnesota, 2020. *Classification of highly-skewed data.* U.S. Patent 10,776,713.
- Boriah, S., Kumar, V., Mithal, V. and **Khandelwal, A.**, University of Minnesota, 2016. *Unsupervised spatio-temporal data mining framework for burned area mapping.* U.S. Patent 9,478,038.
- Boriah, S., Kumar, V., **Khandelwal, A.** and Chen, X.C., University of Minnesota, 2016. *Unsupervised framework to monitor lake dynamics.* U.S. Patent 9,430,839.

- Boriah, S., **Khandelwal, A.**, Kumar, V., Mithal, V. and Steinhaeuser, K., University of Minnesota, 2015. *Automated mapping of land cover using sequences of aerial imagery.* U.S. Patent 8,958,603.

Software and Datasets

- **Khandelwal, A.**, Karpatne, A., Ravirathinam, P., Ghosh, R., Wei, Z., Dugan, H. A., … Kumar, V. (2022). *ReaLSAT, a global dataset of reservoir and lake surface area variations.* Scientific Data, 9(1), 1–12.
- Schwenk, J., **Khandelwal, A.**, Fratkin, M., Kumar, V., Foufoula-Georgiou, E. (2017a). *High spatiotemporal resolution of river planform dynamics from Landsat: The RivMAP toolbox and results from the Ucayali River.* Earth and Space Science, 4(2), 46–75.

Selected peer-reviewed publications

- Xu, S., **Khandelwal, A.**, Li, X., Jia, X., Liu, L., Willard, J., … Others. (2023). *Mini-Batch Learning Strategies for modeling long term temporal dependencies: A study in environmental applications.* Proceedings of the 2023 SIAM International Conference on Data Mining (SDM), 649–657. Society for Industrial and Applied Mathematics.
- Li, X., **Khandelwal, A.**, Jia, X., Cutler, K., Ghosh, R., Renganathan, A., … Others. (2022). *Regionalization in a global hydrologic deep learning model: from physical descriptors to random vectors.* Water Resources Research, 58(8), e2021WR031794.
- Ghosh, R., Renganathan, A., Tayal, K., Li, X., **Khandelwal, A.**, Jia, X., … Kumar, V. (2022). *Robust Inverse Framework using Knowledge-guided Self-Supervised Learning: An application to Hydrology.* Proceedings of the 28th ACM SIGKDD Conference on Knowledge Discovery and Data Mining, 465–474.
- Jia, X., Li, S., **Khandelwal, A.**, Nayak, G., Karpatne, A. and Kumar, V., 2019, May. *Spatial context-aware networks for mining temporal discriminative period in land cover detection.* In Proceedings of the 2019 SIAM International Conference on Data Mining (pp. 513-521). Society for Industrial and Applied Mathematics.
- **Khandelwal, A.**, Karpatne, A., Marlier, M. E., Kim, J., Lettenmaier, D. P., & Kumar, V. (2017). *An approach for global monitoring of surface water extent variations in reservoirs using MODIS data.* Remote Sensing of Environment, 202, 113–128.
- Mithal, V., Nayak, G., **Khandelwal, A.**, Kumar, V., Oza, N. C., & Nemani, R. (2017). *RAPT: Rare Class Prediction in Absence of True Labels.* IEEE Transactions on Knowledge and Data Engineering, 29(11), 2484–2497.
- Jia, X., **Khandelwal, A.**, Gerber, J., Carlson, K., West, P., & Kumar, V. (2016). *Learning large-scale plantation mapping from imperfect annotators.* 2016 IEEE International Conference on Big Data (Big Data), 1192–1201. IEEE.
- Idé, T., **Khandelwal, A.**, & Kalagnanam, J. (2016). *Sparse Gaussian Markov Random Field Mixtures for Anomaly Detection.* Data Mining (ICDM), 2016 IEEE 16th International Conference On, 955–960. IEEE.
- **Khandelwal, A.**, Mithal, V., & Kumar, V. (2015). *Post Classification Label Refinement Using Implicit Ordering Constraint Among Data Instances.* Data Mining (ICDM), 2015 IEEE International Conference On, 799–804. IEEE.
- Karpatne, A., **Khandelwal, A.** and Kumar, V., 2015, June. *Ensemble learning methods for binary classification with multi-modality within the classes.* In Proceedings of the 2015 SIAM International Conference on Data Mining (pp. 730-738). Society for Industrial and Applied Mathematics.

Other peer-reviewed publications

- Ravirathinam, P., Ghosh, R., Wang, K., Xuan, K., **Khandelwal, A.**, Dugan, H., … Kumar, V. (2023). *Spatiotemporal Classification with limited labels using Constrained Clustering for large datasets.* Proceedings of the 2023 SIAM International Conference on Data Mining (SDM), 487–495. Society for Industrial and Applied Mathematics.
- Ghosh, R., Ravirathinam, P., Jia, X., **Khandelwal, A.**, Mulla, D. and Kumar, V., 2021, December. *Calcrop21: A georeferenced multi-spectral dataset of satellite imagery and crop labels.* In 2021 IEEE International Conference on Big Data (Big Data) (pp. 1625-1632). IEEE.
- Wei, Z., Jia, K., Jia, X., **Khandelwal, A.** and Kumar, V., 2020. *Global river monitoring using semantic fusion networks.* Water, 12(8), p.2258.
- Jia, X., **Khandelwal, A.**, Carlson, K. M., Gerber, J. S., West, P. C., Samberg, L. H., Kumar, V. (2020). *Automated plantation mapping in southeast asia using modis data and imperfect visual annotations.* Remote Sensing, 12(4), 636.
- Jia, X., **Khandelwal, A.**, Mulla, D. J., Pardey, P. G., Kumar, V. (2019). *Bringing automated, remote-sensed, machine learning methods to monitoring crop landscapes at scale.* Agricultural Economics, 50, 41–50.
- Jia, X., Wang, M., **Khandelwal, A.**, Karpatne, A. and Kumar, V., 2019, August. *Recurrent Generative Networks for Multi-Resolution Satellite Data: An Application in Cropland Monitoring.* In IJCAI.
- Jia, X., Nayak, G., **Khandelwal, A.**, Karpatne, A. and Kumar, V., 2019, May. *Classifying heterogeneous sequential data by cyclic domain adaptation: An application in land cover detection.* In Proceedings of the 2019 SIAM International Conference on Data Mining (pp. 540-548). Society for Industrial and Applied Mathematics.
- Mithal, V., Nayak, G., **Khandelwal, A.**, Kumar, V., Nemani, R., Oza, N. C. (2018). *Mapping Burned Areas in Tropical Forests Using a Novel Machine Learning Framework.* Remote Sensing, 10(1), 69.
- Jia, X., **Khandelwal, A.**, Nayak, G., Gerber, J., Carlson, K., West, P., & Kumar, V. (2017b). *Predict land covers with transition modeling and incremental learning.* Proceedings of the 2017 SIAM International Conference on Data Mining, 171–179. SIAM.
- Jia, X., **Khandelwal, A.**, Nayak, G., Gerber, J., Carlson, K., West, P., & Kumar, V. (2017a). *Incremental Dual-memory LSTM in Land Cover Prediction.* Proceedings of the 23rd ACM SIGKDD International Conference on Knowledge Discovery and

Data Mining, 867–876. ACM.
- Jia, X., Hu, Y., **Khandelwal, A.**, Karpatne, A. and Kumar, V., 2017, December. *Joint sparse auto-encoder: A semi-supervised spatio-temporal approach in mapping large-scale croplands.* In 2017 IEEE International Conference on Big Data (Big Data) (pp. 1173-1182). IEEE.
- Karpatne, A., **Khandelwal, A.**, Chen, X., Mithal, V., Faghmous, J., & Kumar, V. (2016). *Global monitoring of inland water dynamics: state-of-the-art, challenges, and opportunities.* In Computational Sustainability (pp. 121–147). Springer International Publishing.
- **Khandelwal, A.**, & Rajan, K. S. (2014). *Sensor Simulation based Hyperspectral Image Enhancement with Minimal Spectral Distortion.* ISPRS Annals of the Photogrammetry, Remote Sensing and Spatial Information Sciences, 2(8), 179.
- Karpatne, A., **Khandelwal, A.**, Boriah, S., & Kumar, V. (2014). *Predictive learning in the presence of heterogeneity and limited training data.* Proceedings of the 2014 SIAM International Conference on Data Mining, 253–261.
- Mithal, V., **Khandelwal, A.**, Boriah, S., Steinhaeuser, K., & Kumar, V. (2013). *Change detection from temporal sequences of class labels: Application to land cover change mapping.* Proceedings of the 2013 SIAM International Conference on Data Mining, 650–658. Society for Industrial and Applied Mathematics.
- **Khandelwal, A.**, & Rajan, K. S. (2011). *Hyperspectral image enhancement based on sensor simulation and vector decomposition.* 14th International Conference on Information Fusion, 1–6. IEEE.

Abstracts

- Li, X., **Khandelwal, A.**., Ghosh, R., Renganathan, A., Nieber, J., Duffy, C., Steinbach, M. and Kumar, V., 2021, December. *Effectiveness of Basin Aware Modulation in a Global Hydrologic Deep Learning Model: from Physical Descriptors to Random Vectors.* In AGU Fall Meeting Abstracts (Vol. 2021, pp. H22G-08).
- Mulla, D., Olmanson, L.G., Gelder, B.K., **Khandelwal, A.** and Kumar, V., 2018, December. *Land Cover Classification for Soil Conservation Assessment Based on Remote Sensing, Deep Learning and Simulation Modeling.* In AGU Fall Meeting Abstracts (Vol. 2018, pp. GC43B-03).
- Tortini, R., Noujdina, N., Yeo, S.M., Ricko, M., Birkett, C.M., Coss, S.P., Durand, M.T., **Khandelwal, A.**, Kumar, V. and Lettenmaier, D.P., 2018, December. *Global surface water storage dynamics using satellite remote sensing.* In AGU Fall Meeting Abstracts (Vol. 2018, pp. H51V-1631).
- **Khandelwal, A.**, Karpatne, A. and Kumar, V., 2017, December. *Building Daily 30-meter Spatial Resolution Maps of Surface Water Bodies from MODIS Data Using a Novel Technique for Transferring Information Across Space and Time.* In AGU Fall Meeting Abstracts (Vol. 2017, pp. IN13E-07).
- Schwenk, J., **Khandelwal, A.**, Fratkin, M., Kumar, V., & Foufoula-Georgiou, E. (2017b). *River morphodynamics from space: the Landsat frontier.* EGU General Assembly Conference Abstracts, 19, 11858.
- Marlier, M.E., Kim, J., **Khandelwal, A.**, Karpatne, A., Kumar, V., Zhou, T. and Lettenmaier, D.P., 2016, December. *Variations in lake and reservoir storage associated with Middle East droughts.* In AGU Fall Meeting Abstracts (Vol. 2016, pp. H53N-02).
- Schwenk, J., **Khandelwal, A.**, Fratkin, M., Kumar, V. and Foufoula-Georgiou, E., 2016, December. *The Secret Lives of Migrating Rivers.* In AGU Fall Meeting Abstracts (Vol. 2016, pp. EP51A-0882).
- Kodali, A., **Khandelwal, A.**, Ganguly, S., Bongard, J., & Das, K. (2015). *Regression based modeling of vegetation and climate variables for the Amazon rainforests.* AGU Fall Meeting Abstracts, 2015, IN51A-1799.
- Mithal, V., Nayak, G., **Khandelwal, A.**, Kumar, V., Oza, N. and Nemani, R.R., 2015, December. *Global monitoring of tropical forest fires using a new predictive modeling approach for rare classes.* In AGU Fall Meeting Abstracts (Vol. 2015, pp. IN53B-1844).
- Oza, N., Kumar, V., Nemani, R.R., Boriah, S., Das, K., **Khandelwal, A.**, Matthews, B., Michaelis, A., Mithal, V., Nayak, G. and Votava, P., 2014, December. *Integrating Parallel and Distributed Data Mining Algorithms into the NASA Earth Exchange (NEX)*. In AGU Fall Meeting Abstracts (Vol. 2014, pp. IN53A-3794).
- **Khandelwal, A.**, Van Den Hoek, J., Sedano, F., Kumar, V. and Tucker, C.J., 2014, December. *Mapping changes in agricultural cropping frequency across Zimbabwe using cross-scale time-series remote sensing data and a novel signal decomposition method.* In AGU Fall Meeting Abstracts (Vol. 2014, pp. B33E-0227).

Synergistic Activities

NSF I-Corps Customer Discovery Bootcamp | Entrepreneurial Lead *Detroit, USA | Sep. 2018 - Oct. 2018*

- Conducted 100 interviews with stakeholders in commodity trading, and hydro-power generation market segments.
- Used lean startup methodologies to assess problem-solution fit for satellite imagery processing technology.

Grant Writing *Detroit, USA | Sep. 2018 - Oct. 2018*

- *SBIR Phase I: A Physics Guided Machine Learning Framework for Monitoring Rivers using Satellite Imagery.* NSF Small Business Innovation Research Program, $255,000, Jul 2021 - Dec 2022. **(Principal Investigator)** NSF Grant #2045444.
- *BIGDATA: Advancing Deep Learning to Monitor Global Change*. NSF Translational Impacts Program, $1.43 million, Nov 2018 - Jul 2023. **(Lead Contributor)** NSF Grant #1838159.