# Tirtharaj Dash

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## Research Interests

**Main:** Developing deep learning models, including graph neural networks and large language models that incorporate domain knowledge, with a focus on explainability; exploring their application in a diverse range of scientific problems in life sciences, such as drug discovery, gene regulation, and biomarker discovery.

**Current:** Developing foundation models to study gene regulation; designing explainable deep learning models for drug discovery; conducting multi-omic analyses of cancer.

**Keywords:** Neuro-symbolic AI, Explainable AI, Deep Learning, Computational Biology, AI for Health

## Experience (Post-PhD)

**University of Cambridge, UK** Oct 2023 – present

Research Associate (Computational), Susanne Bornelöv Lab
Supervisor: Susanne Bornelöv
Research: AI in Genomics: Developing explainable deep learning models and foundation models to study the molecular mechanisms of gene regulation in animals
Teaching: Mathematical and Computational Biology

**University of California, San Diego** Oct 2022 – Sep 2023

Postdoctoral Scholar-Employee, The Boolean Lab
Supervisor: Debashis Sahoo
Research: AI in Oncology: Utilising Boolean analysis and machine learning to study macrophages, their polarisation in cancer, and developing computational methods for biomarker discovery

## Experience (Pre- and During PhD)

**Birla Institute of Technology and Science Pilani, Goa Campus** Aug 2015 – Aug 2022

Assistant Professor (Grade II, Level 10), Dept. of Computer Science; APPCAIR (from: Jun 2020)
Research: AI and Machine Learning; Collaboration with industries
Teaching: Deep Learning*, Machine Learning*, AI, Database Systems *: frequent
Grants: The TCS DataLab Projects (PI, Co-PI), The Reflexis CoLab Project (Co-PI)
Others: Designing new courses (e.g. Deep Learning), developing laboratories, mentoring undergrad and grad students, Coaching undergrads for ACM-ICPC

**National Institute of Science & Technology Berhampur** May 2016 – Jul 2016

Summer Research Fellow, Center for Multiscale Modelling
Supervisor: Prabhat K. Sahu (Now at: Sambalpur University)
Research: Protein sequence analysis using machine learning methods

**Indian Statistical Institute Kolkata** May 2015 – Jul 2015

IASc-INSA-NASI Summer Research Fellow, ECS Unit
Supervisor: Nikhil R. Pal
Research: Studying the effects of various distance measures on Self Organizing Feature Map

**National Institute of Science & Technology Berhampur** Jun 2014 – Aug 2015

Assistant Professor, School of Computer Science
Research: Member of Center for Multiscale Modelling, Data Science Group
Teaching: Analysis and Design of Algorithms, Object-Oriented Programming

## Education

**Birla Institute of Technology and Science Pilani, India** Jan 2017 – Jul 2022
*Ph.D. in Computer Science* (Thesis submitted: May 13, 2022, defended: Jul 19, 2022)
Thesis: *Inclusion of Symbolic Domain-Knowledge into Deep Neural Networks* ▷www
Supervisor: Ashwin Srinivasan
Co-supervisor: Sukanta Mondal

**Veer Surendra Sai University of Technology Burla, India** Jul 2012 – Jun 2014
*M.Tech. in Computer Science & Engineering* (*GPA: 9.78/10; University medalist*)
Thesis: *Pattern Recognition using Soft Computing Approaches* ▷www
Supervisor: H.S. Behera

**National Institute of Science and Technology, Berhampur, India** Aug 2008 – Jul 2012
*B.Tech. in Information Technology* (*GPA: 8.91/10; Institute medalist*)
Thesis: *Designing Parallel Algorithms for Solving Ordinary Differential Equations*
Supervisor: Motahar Reza

## Selected Honours & Awards

**Postdoctoral Affiliate of Trinity College, Cambridge** 2024
**Best PhD Thesis Award** from BITS Pilani, India 2023
**Best Short Paper Award** from the ACM in ACMSE 2022
**ICML 2021** Workshop on Computational Biology Fellowship 2021
Selected to participate at the **Google Research India Graduate Symposium** 2021
**AWSAR Award 2019** from DST, Govt. of India (Country Rank: **9** in Best-100 Category) 2020
**Best Student Research Paper Award** from the Machine Learning Journal in ILP 2018
**Travel Grant** from EurAI to attend ACAI-2018, Ferrara, Italy 2018
**Summer Research Fellowship** from NIST Berhampur 2016
**IASc-INSA-NASI Summer Research Fellowship** 2015
Qualified **Graduate Aptitude Test in Engineering (GATE)** 2012, 2015
Qualified **UGC National Eligibility Test (NET)** 2014
**University Silver Medal** for Best Post Graduate in Computer Science and Engineering 2014
**GATE Scholarship** from MHRD, India during my masters' studies 2012–2014
Participated in the Regional Round of the **ACM ICPC** 2012, 2013
**Institute Silver Medal** for Best Graduate in Information Technology 2013
**Director's Certificates** for Academic Performances during B.Tech. 2008–2012

## Grants

1. Indian Ocean Region Seaport and Vessel Traffic Atlas Project; Funded by: TLC, BITS Pilani, Goa Campus; INR 140,000; Period: Oct 2021 to Mar 2022; Role: Co-PI.
2. DataLab Project: TCS-BITS Collaboration; Funded by: TCS Ltd., India; INR 6,289,000; Period: Jan 2019 to Dec 2021; Role: PI (1 year), Co-PI (2 years).
3. CoLab Project: Reflexis-BITS Collaboration; Funded by: Reflexis Systems, USA; INR 2,500,000; Period: Jul 2019 to Dec 2019; Role: Co-PI.
4. Travel Grant; Funded by: European Association for AI; EUR 750; To participate in: Inductive Logic Programming conference in Italy, Sept 2018.

## Refereed Journal Publications

1. M. Mahajan, S. Dhabalia, T. Dash, A. Sarkar, S. Mondal, "A comprehensive multi-omics study reveals potential prognostic and diagnostic biomarkers for colorectal cancer", *International Journal of Biological Macromolecules*, **2025**. **IJBIOMAC**
2. A. Srinivasan, A. Baskar, T. Dash, D. Shah, "Composition of Relational Features with an Application to Explaining Black-Box Predictors", *Machine Learning*, **2023**. **MLJ**
3. T. Dash, S. Chitlangia, A. Ahuja, A. Srinivasan, "A Review of Some Techniques for Inclusion of Domain-Knowledge into Deep Neural Networks", *Scientific Reports*, **2022**. **SCI. REP**
4. I. Olier, O.I. Orhobor, T. Dash, A. Davis, L.N. Soldatova, J. Vanschoren, R.D. King, "Transformational machine learning: Learning how to learn from many related scientific problems", *Proceedings of the National Academy of Sciences*, **2021**. (news) **PNAS**
5. T. Dash, A. Srinivasan, A. Baskar, "Inclusion of domain-knowledge into GNNs using mode-directed inverse entailment", *Machine Learning*, **2021**. **MLJ**
6. T. Dash, A. Srinivasan, L. Vig, "Incorporating symbolic domain knowledge into graph neural networks", *Machine Learning*, **2021**. **MLJ**
7. R. Kaushik, S. Jain, S. Jain, T. Dash, "Performance evaluation of deep neural networks for forecasting time-series with multiple structural breaks and high volatility", *CAAI Transactions on Intelligence Technology*, **2021**. **CAAI TIT**
8. T. Dash, S.N. Dambekodi, P.N. Reddy, A. Abraham, "Adversarial neural networks for playing hide-and-search board game Scotland Yard", *Neural Computing and Applications*, **2018**. **NCAA**
9. T. Dash, H.S. Behera, "A comprehensive study on evolutionary algorithm-based multilayer perceptron for real-world data classification under uncertainty", *Expert Systems*, **2018**. **EXSY**
10. P.P. Pai, T. Dash, S. Mondal, "Sequence-based discrimination of protein-RNA interacting residues using a probabilistic approach", *Journal of Theoretical Biology*, **2017**. **JTB**
11. T. Dash, "A study on intrusion detection using neural networks trained with evolutionary algorithms", *Soft Computing*, **2015**. **SOCO**
12. T. Dash, "Automatic navigation of wall following mobile robot using Adaptive Resonance Theory of Type-1", *Biologically Inspired Cognitive Architectures*, **2015**. **BICA**
13. T. Dash, P.K. Sahu, "Gradient Gravitational Search: An Efficient Metaheuristic Algorithm for Global Optimization", *Journal of Computational Chemistry*, **2015**. **JCC**

## Refereed Conference and Workshop Publications

1. S.B. Brahmavar, A. Srinivasan, T. Dash, S.R. Krishnan, L. Vig, A. Roy, R. Aduri, "Generating Novel Leads for Drug Discovery using LLMs with Logical Feedback", *AAAI Conference on Artificial Intelligence*, **2024**. **AAAI**
2. S.B. Brahmavar, R. Rajesh, T. Dash, L. Vig, T.T. Verlekar, M.M. Hasan, T. Khan, E. Meijering, A. Srinivasan, "IKD+: Reliable Low Complexity Deep Models for Retinopathy Classification", *International Conference on Image Processing*, **2023**. **ICIP**
3. S.R. Chitnis, S. Liu, T. Dash, T.T. Verlekar, A. Di Ieva, S. Berkovsky, L. Vig, A. Srinivasan, "Domain-Specific Pretraining Improves Confidence in Whole Slide Image Classification", *Annual International Conference of the IEEE Engineering in Medicine and Biology Society*, **2023**. **EMBC**
4. R. Patra, R. Hebbalaguppe, T. Dash, G. Shroff, L. Vig, "Calibrating Deep Neural Networks using Explicit Regularisation and Dynamic Data Pruning", *IEEE/CVF Winter Conference on Applications of Computer Vision*, **2023**. (Spotlight Paper) **WACV**

5. V. Shah, A. Sharma, G. Shroff, L. Vig, T. Dash, A. Srinivasan, "Knowledge-based Analogical Reasoning in Neuro-symbolic Latent Spaces", *International Workshop on Neural-Symbolic Learning and Reasoning*, **2022**. **NESY**

6. G. Chhablani, A. Sharma, H. Pandey, T. Dash, "Superpixel-based Knowledge Infusion in Deep Neural Networks for Image Classification", *ACM Southeast Regional Conference*, **2022**. (Best Short Paper Award) **ACMSE**

7. A. Sonwane, G. Shroff, L. Vig, A. Srinivasan, T. Dash, "Solving Visual Analogies Using Neural Algorithmic Reasoning (Student Abstract)", *AAAI Conf on Artificial Intelligence*, **2022**. **AAAI**

8. A. Lalwani, A. Saraiya, A. Singh, A. Jain, T. Dash, "Machine Learning in Sports: A Case Study on Using Explainable Models for Predicting Outcomes of Volleyball Matches", *International Conference on Sports Engineering*, **2022**. **ICSE**

9. S. Chitlangia, A. Sonwane, T. Dash, L. Vig, A. Srinivasan, G. Shroff, "Using Program Synthesis and Inductive Logic Programming to solve Bongard Problems", *International Workshop on Approaches and Applications of Inductive Programming*, **2021**. **AAIP**

10. T. Dash, A. Srinivasan, L. Vig, A. Roy, "Using Domain-Knowledge to Assist Lead Discovery in Early-Stage Drug Design", *Intl Conf on Inductive Logic Programming*, **2021**. **ILP**

11. H. Shah, A. Vaswani, T. Dash, R. Hebbalaguppe, A. Srinivasan, "Empirical Study of Data-Free Iterative Knowledge Distillation", *Intl Conf on Artificial Neural Netw*, **2021**. **ICANN**

12. A. Sharma, H. Pandey, G. Chhablani, Y. Bhartia, T. Dash, "LRG at SemEval-2021 Task 4: Improving Reading Comprehension with Abstract Words using Augmentation, Linguistic Features and Voting", *International Workshop on Semantic Evaluation*, **2021**. **SEMEVAL**

13. K. Mahajan, M. Sharma, L. Vig, R. Khincha, S. Krishnan, A. Niranjan, T. Dash, A. Srinivasan, G. Shroff, "CovidDiagnosis: Deep Diagnosis of Covid-19 Patients using Chest X-rays", *International Workshop on Thoracic Image Analysis*, **2020**. **TIA@MICCAI**

14. S. Krishnan, R. Khincha, L. Vig, T. Dash, A. Srinivasan, "A Case Study of Transfer of Lesion-Knowledge", *International Workshop on Medical Image Learning with Less Labels and Imperfect Data*, **2020**. **MIL3ID@MICCAI**

15. S. Yalburgi, T. Dash, R. Hebbalaguppe, S. Hegde, A. Srinivasan, "An Empirical Study of Iterative Knowledge Distillation for Neural Network Compression", *European Symposium on Artificial Neural Networks, Computational Intelligence and Machine Learning*, **2020**. **ESANN**

16. T. Dash, A. Srinivasan, R.S. Joshi, A. Baskar, "Discrete Stochastic Search and Its Application to Feature-Selection for Deep Relational Machines", *Intl Conf on Artif. Neural Netw*, **2019**. **ICANN**

17. T. Dash, A. Srinivasan, L. Vig, O.I. Orhobor, R.D. King, "Large-Scale Assessment of Deep Relational Machines", *Intl Conf on Inductive Logic Programming*, **2018**. (Best Student Paper Award) **ILP**

18. P.S.M. Saladi, T. Dash, "Genetic Algorithm-Based Oversampling Technique to Learn from Imbalanced Data", *Intl Conf on Soft Computing for Problem Solving*, **2017**. **SocProS**

19. S. Iyer, S. Chaturvedi, T. Dash, "Image Captioning-Based Image Search Engine: An Alternative to Retrieval by Metadata", *Intl Conf on Soft Computing for Problem Solving*, **2017**. **SocProS**

20. A. Saboo, A. Sharma, T. Dash, "GASOM: Genetic Algorithm Assisted Architecture Learning in Self Organizing Maps", *International Conf on Neural Information Processing*, **2017**. **ICONIP**

21. P.N. Reddy, S.N. Dambekodi, T. Dash, "Towards Continuous Monitoring of Environment under Uncertainty: A Fuzzy Granular Decision Tree Approach", *ISEC Workshop on Development aspects of Intelligent Adaptive Systems workshop*, **2017**. **DIAS@ISEC**

22. T. Dash, T. Nayak, R.R. Swain, "Controlling Wall Following Robot Navigation Based on Gravitational Search and Feed Forward Neural Network", *International Conference on Perception and Machine Intelligence*, **2015**. **PerMIn**

23. T. Dash, S.K. Nayak, H.S. Behera, "Hybrid Gravitational Search and Particle Swarm Based Fuzzy MLP for Medical Data Classification", *International Conference on Computational Intelligence in Data Mining*, **2014**. **ICCIDM**

## Other Refereed Publications: Collaborative Interests

1. B.R. Senapati, P.M. Khilar, T. Dash, R.R. Swain, "AI-assisted Emergency Healthcare using Vehicular Network and Support Vector Machine", *Wireless Personal Communication*, **2023**. **WPC**

2. R.R. Swain, T. Dash, P.M. Khilar, "Automated Fault Diagnosis in Wireless Sensor Networks: A Comprehensive Survey", *Wireless Personal Communications*, **2022**. **WPC**

3. R.R. Swain, T. Dash, P.M. Khilar, "Lightweight approach to automated fault diagnosis in WSNs", *IET Networks*, **2020**. **IET NETW**

4. R.R. Swain, T. Dash, P.M. Khilar, "A complete diagnosis of faulty sensor modules in a wireless sensor network", *Ad Hoc Networks*, **2019**. **ADHOC**

5. R.R. Swain, P.M. Khilar, T. Dash, "Fault diagnosis and its prediction in wireless sensor networks using regressional learning to achieve fault tolerance", *International Journal of Communication Systems*, **2018**. **IJCS**

6. R.R. Swain, P.M. Khilar, T. Dash, "Multifault diagnosis in WSN using a hybrid metaheuristic trained neural network", *Digital Communications and Networks*, **2018**. **DCAN**

7. R.R. Swain, P.M. Khilar, T. Dash, "Neural network based automated detection of link failures in wireless sensor networks and extension to a study on the detection of disjoint nodes", *Journal of Ambient Intelligence and Humanized Computing*, **2018**. **JAIHC**

8. R.R. Swain, T. Dash, P.M. Khilar, "An effective graph-theoretic approach towards simultaneous detection of fault(s) and cut(s) in wireless sensor networks", *International Journal of Communication Systems*, **2017**. **IJCS**

9. R.R. Swain, T. Dash, P.M. Khilar, "Investigation of RBF Kernelized ANFIS for Fault Diagnosis in Wireless Sensor Networks", *International Conf on Computational Intelligence*, **2017**. **ICCI**

10. R. Mohanty, T. Dash, B. Khan, S.P. Dash, "An Experimental Study of a Novel Move-to-Front-or-Middle (MFM) List Update Algorithm", *Intl Conf on Applied Algorithms*, **2014**. **ICAA**

## Selected Preprints

1. A. Srinivasan, T. Dash, A. Baskar, S.K. Dey, M. Banerjee, "Identifying a logical specification and a program for an LLM-based generator of lead molecules", *bioRxiv*, **2025**. **bioRxiv**

2. T. Dash, S. Bornelöv, "Predicting gene expression using millions of yeast promoters reveals *cis*-regulatory logic", *bioRxiv*, **2025**. **bioRxiv**

3. E. Dadlani, T. Dash, D. Sahoo, "Investigating tumor-associated macrophages and their polarization in colorectal cancer using Boolean implication networks", *bioRxiv*, **2023**. **bioRxiv**

4. R. Khincha, S. Krishnan, T. Dash, L. Vig, A. Srinivasan, "Constructing and Evaluating an Explainable Model for COVID-19 Diagnosis from Chest X-rays", *arXiv*, **2020**. **arXiv**

## Patents

1. Method and System for Iterative Knowledge Distillation for Neural Network Compression (Filed at Indian Patent Office, Appl. No. 202021055409, **2020**).

## Participations & Talks

1. Invited Talk: "Predicting gene expression using millions of yeast promoters reveals *cis*-regulatory logic", International Conference on Sustainable Healthcare from Biological Resources, BITS Pilani, Goa Campus, 20-22 May, 2025.
2. Invited Talk: "Logically Explainable Deep Neural Networks", AI Club for Biomedicine, University of Cambridge, December 5, 2024.
3. Participated in "Auditing Accountability in Trustworthy Artificial Intelligence with applications in Personalised Medicine", University of Oxford, UK, November 12, 2024.
4. Invited Talk: "Explainable Deep Learning" at Time-Series Forecasting Workshop, NIT Rourkela, India, September 28, 2024.
5. Participated in "2nd Workshop on Codon Usage: Function, Mechanism, and Evolution", Edinburgh, UK, May 24–27, 2024.
6. Participated in "C2D3 Computational Biology Annual Symposium", Centre for Mathematical Sciences, University of Cambridge, Uk, May 15, 2024.
7. Participated in "AI and Large Language Model Workshop", Department of Computer Science and Technology, University of Cambridge, February 26, 2024.
8. Poster Talk (with Ekta Dadlani): "Tumor Associated Macrophages and Colorectal Cancer: AI-assisted Predictive Modeling of Macrophage Polarization in Colorectal Cancer" at Structural & Functional Genomics 2023 Retreat, Moores Cancer Center, UC San Diego, May 5, 2023.
9. Invited Talk: "Graph Neural Networks: Concepts, Implementations and Application" at SAiDL-APPCAIR AI Symposium 2022, BITS Pilani, Goa Campus, India, October 9, 2022.
10. Invited Lecture: "Deep Learning in a Human-in-the-Loop Setting" at Amity University, Patna, India, September 2, 2022.
11. Invited Talk: "Deep Learning in a Human-in-the-Loop Setting" at IISER Pune, India, July 28, 2022.
12. Invited Talk: "Inclusion of domain-knowledge into GNNs using mode-directed inverse entailment" at The Intelligent Data Analysis Lab, Czech Technical University, Prague, June 30, 2022.
13. Invited Talk: "Human-in-the-Loop Machine Learning: Inclusion of Domain-Knowledge into Deep Neural Networks" at Davis Institute for Artificial Intelligence, USA, February 25, 2022.
14. Google Research India Graduate Symposium, April 7-10, 2021.
15. Indo-German Spring School on Algorithms for Big Data, IIT Bombay, February 18-22, 2019 (also delivered a talk on: "Learning in the Presence of Expert Knowledge: A talk on Inductive Logic Programming").
16. Google Faculty Institute Program, Google India, December 11, 2018. I actively participated in various practical sessions on ML@Google.
17. Summer School on Statistical Relational AI, Univ. of Ferrara, Italy, August 27-31, 2018. I was awarded official credit for this course: 30 Hours, 5 ECTS credits.

## Professional Services and Memberships

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|---|---|
| **Memberships** | ACM, Trinity College Postdoc Society, C2D3 Cambridge |
| **Peer review** | J: PLOS ONE (Editor), IEEE (TIE, CYB, TFS, CEM, IS), Scientific Data, NEPL<br>C: IJCAI, AAAI, CLeaR, ILP, DASFAA, IJCNN, ICANN |
| **Co-organising** | Cambridge AI Club for Biomedicine, ICCI 2017 (IITK) |

## Computer Skills

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|---|---|
| **GitHub** | https://github.com/tirtharajdash |
| **Languages** | Python, MATLAB, Julia†, C, C++, Java, Unix shell (†Learning) |
| **Programming** | ACM ICPC (Regionals: 2012, 2013), Oracle Certified (SQL, DBA) |
| **OS** | Unix, Windows, MacOS |

## Personal Details

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| **DOB** | July 3, 1991 |
| **Gender** | Male |
| **Nationality** | India |
| **Languages** | English, Hindi, Odia, Sambalpuri |
| **Postal Address** | Flat B30, Forster Court<br>7 Charles Babbage Road<br>Cambridge CB3 0FT<br>UK |

## References

Available upon request.