Formalizing Institutional Data Custody: A Legal-Informatics Approach to Multi-Tier Data Governance in European Data Spaces

Meem Arafat Manab[0000-0002-2336-4160]*

Universidad Politécnica de Madrid, Madrid, Spain
meem.manab@upm.es

Abstract. European municipalities face a governance paradox: citizens cannot manage personal data sovereignty through individual pods, yet institutional custody lacks formal legal standards. This doctoral research will develop a legal-informatics framework for formalizing institutional data custody using Akoma Ntoso and LegalRuleML standards. Three research questions structure the work: How can legal knowledge representation standards formalize multi-stakeholder data governance agreements? What framework enables semantic interoperability when national administrative laws differ across federated municipal data spaces? What legal-philosophical conditions legitimate institutional custody, and can machine learning detect deviations from legitimate use? The research will contribute to legal informatics by extending Akoma Ntoso to data governance agreements and addressing cross-border legal heterogeneity through formal representation. Methodology combines legal ontology development, comparative legal analysis, and validation through DS4SSCC smart city pilots.

Keywords: Legal Knowledge Representation · Akoma Ntoso · Data Governance · Institutional Custody · Legal Ontologies · Data Spaces · Municipal Governance

1 Introduction

The European Strategy for Data envisions federated data spaces enabling secure data sharing while respecting fundamental rights. However, a critical governance gap emerges at the municipal level: the Solid Protocol [26] and similar architectures assume citizens manage their own data pods, yet most citizens lack the

* This research is funded by the European Union's Horizon Europe programme under the Marie Skłodowska-Curie Doctoral Network HARNESS—Harnessing AI and Data-Intensive Technologies (Grant Agreement No. 101169409, <https://harness-network.eu>). HARNESS is a multidisciplinary doctoral network training researchers in ethics, law, and technology.

technical capability for this, while municipalities require aggregated data for legitimate public purposes including climate action and urban planning.

Consider Giuseppe, a Zaragoza resident who insists he's "very good with computers" because he knows how to restart his router. One week, three institutions come knocking: the municipality wants his vehicle emissions data for climate policy, the national water authority needs consumption patterns for drought planning, and the regional waste consortium seeks disposal habits to optimize collection routes across five towns. Giuseppe confidently opens his "data pod settings"—then immediately closes his laptop. "I'll call my nephew," he sighs. Like most citizens, Giuseppe trusts these institutions serve legitimate purposes (cleaner air, secure water, efficient bins), but managing separate pods, granular permissions, and access audits? That requires a nephew.

The DS4SSCC (Data Spaces for Smart and Sustainable Cities and Communities)[1] project exposes deeper complications. When Zaragoza collaborates with neighboring cities on waste optimization, who ensures Giuseppe's water data stays within drought planning? What happens when Valencia shares algorithms with Toulouse? Municipal institutional custody lacks formal standards to specify legitimate use conditions, cross-border sharing rules, or accountability mechanisms.

This doctoral research will address these challenges by developing a legal-informatics framework for formalizing institutional data custody in federated multi-tier data spaces (municipal, regional, and cross-border). The research sits at the convergence of legal knowledge representation (Akoma Ntoso[20], LegalRuleML[18]), European data spaces initiatives (IDSA[2], Gaia-X[3], DS4SSCC[4]), and municipal smart city governance. By extending legal XML standards to multi-stakeholder data governance agreements, this work will enable machine-readable legal specifications supporting automated compliance verification across heterogeneous jurisdictions. The research includes a six-month research stay at the University of Bologna's CIRSFID-AlmaAI center (November 2026 - April 2027) to advance comparative legal analysis and collaboration with the LAST-JD doctoral program.

---

[1] European Union / Project Consortium: Data space for smart and sustainable cities and communities (DS4SSCC) – European Data Space for Smart Communities. <https://www.ds4sscc.eu/> accessed 11 November 2025, preparatory action under the Digital Europe Programme, Grant No. 101123342.

[2] International Data Spaces Association (IDSA), IDSA-RAM 5 (working draft) <https://docs.internationaldataspaces.org/ids-knowledgebase/ids-ram-5-working-draft> accessed 12 November 2025, preliminary draft, reference architecture for data spaces.

[3] Gaia-X European Association for Data and Cloud AISBL: Gaia-x trust framework (version 22.04) release <https://gaia-x.eu/wp-content/uploads/2022/05/Gaia-X-Trust-Framework-22.04.pdf> accessed 8 November 2025, rules and baseline requirements for participation in the Gaia-X Ecosystem.

[4] DS4SSCC (n 1)

2 Key Definitions

Institutional data custody refers to arrangements whereby institutional entities hold and process personal data on behalf of data subjects with legally enforceable fiduciary obligations. Unlike data ownership (property rights) or GDPR control (controller/processor roles), custody emphasizes stewardship responsibilities grounded in trust law principles across three dimensions: technical custody (infrastructure possession), legal custody (authority over access/use), and fiduciary custody (enforceable duties to act in data subjects' interests).

Legal knowledge representation denotes formal methods for encoding legal concepts in machine-readable formats. The field encompasses legal document modeling (Akoma Ntoso XML standards), legal rule formalization (LegalRuleML logic-based languages), and legal ontologies (OWL/RDF domain models).

Federated data spaces constitute distributed architectures enabling secure data exchange among autonomous participants without centralized control, characterized by decentralized authority, heterogeneous participation, semantic interoperability, policy-based access control, and trust mechanisms. IDSA Reference Architecture Model provides the dominant framework.

Municipal data governance refers to institutional arrangements whereby local authorities regulate and utilize data assets for public services and policymaking, facing unique challenges from varying Member State autonomy grants and administrative law differences creating jurisdictional heterogeneity.

3 State of the Art

3.1 Legal Knowledge Representation Standards

Akoma Ntoso constitutes the most mature legal XML standard, adopted by OASIS as LegalDocML [20]. Despite the charter mentioning "contractual documents," we could not find any published implementations that apply the standard to data sharing agreements.

LegalRuleML formalizes normative content using defeasible logic. The DAPRECO Knowledge Base [25] demonstrates feasibility encoding over 1000 GDPR rules. Governatori et al. [11] show integration with business process compliance. However, all implementations focus on single-jurisdiction regulatory compliance rather than cross-border multi-stakeholder arrangements.

Multiple ontologies formalize GDPR concepts. PrOnto [19] models data types, agents, purposes, and legal bases. GConsent [21] extends privacy modeling with consent lifecycle states. GDPRtEXT [23] provides linked data representation. Data Privacy Vocabulary (DPV)[22] consolidates these into W3C specification. Esteves and Rodríguez-Doncel [6] analyze these ontologies, identifying gaps in modeling data governance obligations. These ontologies model controller/processor distinctions but do not explicitly represent custody relationships.

Mockus and Palmirani [16] developed DARSI ontology for bilateral sharing but lack multi-stakeholder mechanisms. IDSA Contract Negotiation[5] Protocol uses ODRL[29] combined with DPV[22], but these efforts do not integrate with Akoma Ntoso or LegalRuleML, creating fragmented standards ecosystems. Recent work on semantic representation for the Data Governance Act by Esteves and others [7] demonstrates feasibility of formalizing data reuse and altruism obligations, though not addressing institutional custody arrangements specifically.

3.2 Data Spaces Governance Frameworks

Gaia-X[6] specifications apply Self-Descriptions using W3C Verifiable Credentials. Self-Descriptions include legal claims but focus on attestation rather than reasoning. No mechanism exists for automatically checking whether claimed legal basis justifies proposed data use.

DS4SSCC[7] targets cross-sectoral data space for governments supporting Green Deal objectives. However, the framework remains high-level guidance without detailed legal formalization specifications.

3.3 Semantic Interoperability Frameworks

The 2017 European Interoperability Framework establishes four layers: legal, organizational, semantic, and technical. ISA[2] Programme operationalizes semantic interoperability through Core Vocabularies. Real-world implementations like BRIS validate the approach. However, institutional data custody concepts remain undefined with no Core Custody Vocabulary existing.

LKIF Core Ontology [14] offers 15 interconnected modules. Core Legal Ontology [10] built on DOLCE+ distinguishes legal facts, subjects, and acts. Audrito et al.'s EU Criminal Procedural Rights Ontology [1] demonstrates multi-level legal framework integration. Montiel-Ponsoda et al. [17] developed a Legal Knowledge Graph for multilingual compliance services, integrating heterogeneous legal sources across languages and jurisdictions within the LYNX project [**?**]. Filtz et al. [9] document RDF-based metadata. Yet these frameworks address legislative interoperability but not multi-stakeholder data governance agreement interoperability.

3.4 Legal-Philosophical Legitimacy Frameworks

Beetham's threefold legitimacy matrix [2] requires legal foundations, justifiability, and expressed consent. Scharpf's framework [27] examines input, throughput,

[5] International Data Spaces Association: Dataspace Protocol Specification Version 2024-1, Contract Negotiation Protocol. <`https://docs.internationaldataspaces.org/ids-knowledgebase/dataspace-protocol/contract.negotiation/contract.negotiation.protocol`>, accessed 5 November 2025

[6] Gaia-X Trust Framework (n 3)

[7] DS4SSCC (n 1)

and output legitimacy. Grimmelikhuijsen and Meijer [12] apply these to algorithmic governance proposing calibrated institutional responses. These frameworks provide normative grounding but lack operational decision procedures.

Leahy's fiduciary commons framework [15] reframes data relationships as entrustment with enforceable fiduciary duties. Legitimacy conditions emerge requiring collective action problems, technical expertise needs, public interest necessities, and democratic accountability. While providing strong normative foundation, precise threshold criteria remain undefined.

The Solid Protocol [26] exemplifies infrastructure for user-controlled datastores. Yet Esposito et al. [5] identify critical vulnerabilities including malicious pod threats and access control semantics insufficient for institutional policies. Scalability concerns and emergency access scenarios demonstrate why purely individual custody models fail for institutional governance.

3.5 Machine Learning for Legal Compliance

ML-based compliance detection enables anomaly detection, predictive analytics, and real-time monitoring. Deeks [4] argues that courts must demand algorithmic explanations. Hacker et al. [13] demonstrate contract and tort law create incentives for explainable models. Richmond et al. [24] reveal heterogeneity requirements across legal sub-domains. Binns [3] situates algorithmic accountability within Rawlsian public reason. However, no framework exists linking LegalRuleML-encoded obligations to machine learning-based monitoring systems.

4 Research Questions

This research will address three interconnected questions:

4.1 RQ1: Extending Legal Standards for Data Governance

How can Akoma Ntoso and LegalRuleML be extended to formalize multi-stakeholder data governance agreements for institutional custody?

The research will develop new Akoma Ntoso document types for data governance agreements with elements for parties, data flows, purposes, and temporal obligations. It will extend LegalRuleML for multi-party normative obligations and create legal ontology modeling custody chains, authority, obligations, and oversight. Validation will occur through encoding municipal agreements from DS4SSCC pilots.

4.2 RQ2: Semantic Interoperability Across Jurisdictions

What legal-informatics framework enables semantic interoperability when national administrative laws differ across federated municipal and mult-tier data spaces?

The research will conduct comparative analysis across multiple EU Member States identifying mapping rules, develop Core Custody Vocabulary following SEMIC methodology[8], design semantic mapping framework linking national concepts to EU-level vocabulary, and implement reference architecture with semantic reasoning. While focusing on EU contexts (e.g., Slovenia-Spain data sharing in DS4SSCC's IPPCP pilot[8]), the framework must address potential extra-EU cooperation where strong data protection regimes exist (Kenya's Data Protection Act, UK-Japan island nation collaborations), as climate and urban challenges increasingly require global municipal knowledge exchange. Validation will occur through DS4SSCC pilot deployment.

4.3 RQ3: Legitimacy Conditions and ML-Based Monitoring

Under what conditions is institutional custody legitimate, and can machine learning algorithms detect deviations from legitimate use?

The research will develop normative framework operationalizing fiduciary commons theory into concrete decision criteria, encode legitimacy conditions in LegalRuleML, design anomaly detection systems using machine learning, implement uncertainty quantification, and validate through DS4SSCC pilot data comparing automatically detected anomalies to expert legal assessments.

5 Research Objectives

5.1 Objective 1: Legal XML Standards for Municipality Data Governance

Develop extended Akoma Ntoso schema and LegalRuleML ontology for institutional custody. Deliverables will include XSD files extending Akoma Ntoso 4.0, OWL ontology integrated with GDPR ontologies, automated reasoning system, and validation through at least five municipal agreements.

5.2 Objective 2: Cross-Border Interoperability Framework

Conduct comparative legal analysis producing machine-readable semantic mappings. Deliverables will include comparative analysis report, Core Custody Vocabulary following SEMIC methodology, semantic mapping framework, and test suite with 100+ cross-border scenarios.

5.3 Objective 3: Normative Legitimacy Framework

Articulate normative framework for institutional custody legitimacy grounded in fiduciary commons theory. Deliverables will include framework specifying legitimacy conditions, LegalRuleML encoding, decision support tool for municipal DPOs, and validation achieving 80% expert agreement.

[8] Data Space for Smart and Sustainable Cities and Communities (DS4SSCC), IPP/CP Framework <https://www.ds4sscc.eu/ippcp> accessed 14 November 2025.

5.4 Objective 4: Machine learning-Based Legitimacy Monitoring

Develop machine learning tools for detecting deviations from legitimate use. Deliverables will include anomaly detection system, uncertainty quantification, explainable AI mechanisms using SHAP values, and empirical validation using DS4SSCC pilot data.

6 Research Timeline

6.1 Year 1: Foundation (Months 1-12)

Complete literature review and engage DS4SSCC pilots. Implement extended Akoma Ntoso schema with validation tools. Develop custody ontology in OWL with LegalRuleML rules. Encode three pilot municipal agreements.

Deliverables: Extended schema (XSD), custody ontology (OWL), three encoded agreements, conference publication.

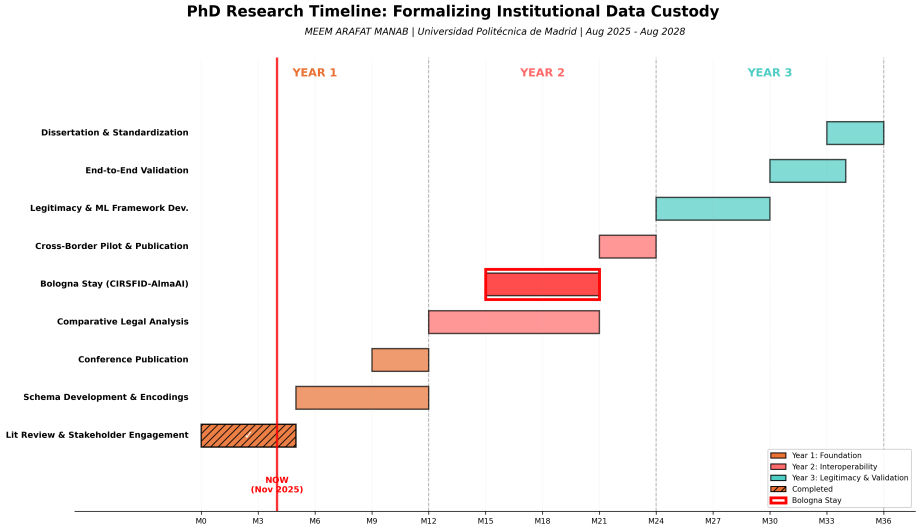

Fig. 1. Three-year doctoral research timeline

6.2 Year 2: Interoperability (Months 13-24)

Conduct comparative analysis of administrative law in five Member States during a six-month research stay at University of Bologna's CIRSFID-AlmaAI (November 2026 - April 2027). Develop Core Custody Vocabulary. Implement reference architecture for federated data space. Deploy pilot between municipalities in different Member States.

Deliverables: Comparative report, Core Custody Vocabulary (RDF/OWL), semantic reasoning system, validated implementation, journal publication.

6.3 Year 3: Legitimacy and Validation (Months 25-36)

Develop normative legitimacy framework with expert validation. Design and implement machine learning-based anomaly detection system. Integrate all components with end-to-end validation through DS4SSCC deployments. Prepare dissertation and standardization proposals.

Deliverables: Extended legitimacy framework, monitoring system based on machine learning, decision support tool, dissertation, journal publications, OASIS proposals.

7 Conclusion

This doctoral research addresses a critical gap at the intersection of legal informatics, European data spaces, and municipal governance. While technical architectures (IDSA, Gaia-X) and policy frameworks (Data Governance Act, Data Act) have matured, no standardized approach exists for representing institutional data custody in machine-readable legal formats. The research will make three primary contributions. First, extending legal XML standards (Akoma Ntoso, LegalRuleML) to multi-stakeholder data governance agreements. Second, developing semantic interoperability frameworks for institutional data custody across multi-tier jurisdictions. Third, articulating legal-philosophical legitimacy conditions grounded in fiduciary commons theory, operationalized through machine learning-based compliance monitoring. The research converges three JURIX traditions: legal knowledge representation [20,28,11], semantic interoperability [14,9], and AI applications in law [4,13,24]. Practical impact derives from DS4SSCC integration[9], providing legal formalization for 10-12 pilot projects (15M EUR). Municipal data protection officers will gain decision support tools, while semantic mapping frameworks enable cross-border collaboration.

The timing is optimal. Technical infrastructure (IDSA RAM v5.0[10], Eclipse Dataspace Connector[11], Gaia-X[12]) and policy frameworks (DGA[13] since September 2023, Data Act[14] effective September 2025) are established, yet legal formal-

[9] DS4SSCC (n 1)

[10] IDSA-RAM 5 (working draft) (n 2)

[11] Eclipse Foundation: Eclipse dataspace components / connector. <`https://projects.eclipse.org/projects/technology.edc`> (2022), open-source framework implementing IDS/GAIA-X specifications for dataspaces.

[12] Gaia-X Trust Framework (n 3)

[13] Regulation (EU) 2022/868 of the European Parliament and of the Council of 30 May 2022 on European data governance and amending Regulation (EU) 2018/1724 [2022] OJ L152/1.

[14] Regulation (EU) 2023/2854 of the European Parliament and of the Council of 13 December 2023 on harmonised rules on fair access to and use of data (Data Act) [2023] OJ L2023/2854.

ization gaps impede deployment. This research bridges this gap when formal legal specifications become critical.

Acknowledgments. This research is funded by the European Union's Horizon Europe programme under the Marie Skłodowska-Curie Actions Doctoral Network HARNESS—Harnessing AI and Data-Intensive Technologies (Grant Agreement No. 101169409, `https://harness-network.eu`).

References

1. Audrito, D., Sulis, E., Humphreys, L., Di Caro, L.: Analogical lightweight ontology of eu criminal procedural rights in judicial cooperation. Artificial Intelligence and Law **31**(3), 629–652 (2023)
2. Beetham, D.: The legitimation of power. Bloomsbury Publishing (2013)
3. Binns, R.: Algorithmic accountability and public reason. Philosophy & technology **31**(4), 543–556 (2018)
4. Deeks, A.: The judicial demand for explainable artificial intelligence. Columbia Law Review **119**(7), 1829–1850 (2019)
5. Esposito, C., Horne, R., Robaldo, L., Buelens, B., Goesaert, E.: Assessing the solid protocol in relation to security and privacy obligations. Information **14**(7), 411 (2023)
6. Esteves, B., Rodríguez-Doncel, V.: Analysis of ontologies and policy languages to represent information flows in gdpr. Semantic Web **15**(3), 709–743 (2024)
7. Esteves, B., Rodríguez Doncel, V., Pandit, H.J., Lewis, D.: Semantics for implementing data reuse and altruism under eu's data governance act. In: Knowledge Graphs: Semantics, Machine Learning, and Languages, pp. 210–226. IOS Press (2023)
8. European Commission: Isa^2 handbook for using core vocabularies (2019), `https://interoperable-europe.ec.europa.eu/sites/default/files/inline-files/ISA%20Handbook%20for%20using%20Core%20Vocabularies.pdf`, accessed: 2025-11-14
9. Filtz, E., Kirrane, S., Polleres, A.: The linked legal data landscape: linking legal data across different countries. Artificial Intelligence and Law **29**(4), 485–539 (2021)
10. Gangemi, A., Sagri, M., Tiscornia, D.: A constructive framework for legal ontologies. In: Law and the Semantic Web: Legal Ontologies, Methodologies, pp. 97–124. Springer (2005)
11. Governatori, G., Hashmi, M., Lam, H.P., Villata, S., Palmirani, M.: Semantic business process regulatory compliance checking using legalruleml. In: European Knowledge Acquisition Workshop 2016. LNCS, vol. 10024, pp. 746–761. Springer (2016)
12. Grimmelikhuijsen, S., Meijer, A.: Legitimacy of algorithmic decision-making: Six threats and the need for a calibrated institutional response. Perspectives on Public Management and Governance **5**(3), 232–242 (2022)
13. Hacker, P., Krestel, R., Grundmann, S., Naumann, F.: Explainable ai under contract and tort law: legal incentives and technical challenges. Artificial Intelligence and Law **28**(4), 415–439 (2020)

14. Hoekstra, R., Breuker, J., Di Bello, M., Boer, A.: Lkif core: Principled ontology development for the legal domain. In: Law, Ontologies and the Semantic Web, pp. 21–52. IOS Press (2009)
15. Leahy, M.: The fiduciary commons: restoring ordered liberty in the age of data. https://identityweek.net/the-fiduciary-commons-restoring-ordered-liberty-in-the-age-of-data/ (5 November 2025), posted on Identity Week – Guest Opinion
16. Mockus, M., Palmirani, M.: Legal ontology for open government data mashups. In: Conference for E-Democracy and Open Government (CeDEM) 2017. pp. 113–124. IEEE (2017)
17. Montiel-Ponsoda, E., Gracia, J., Rodríguez-Doncel, V.: Building the legal knowledge graph for smart compliance services in multilingual europe. In: CEUR workshop proc. No. ART-2018-105821 (2018)
18. Palmirani, M., Governatori, G., Rotolo, A., Tabet, S., Boley, H., Paschke, A.: Legalruleml: Xml-based rules and norms. In: International Workshop on Rules and Rule Markup Languages for the Semantic Web. pp. 298–312. Springer (2011)
19. Palmirani, M., Martoni, M., Rossi, A., Bartolini, C., Robaldo, L.: Pronto: Privacy ontology for legal reasoning. In: International Conference on Electronic Government and the Information Systems Perspective (EGOVIS) 2018. LNCS, vol. 11032, pp. 139–152. Springer (2018)
20. Palmirani, M., Vitali, F.: Akoma-ntoso for legal documents. In: Legislative XML for the semantic web: Principles, models, standards for document management, Law, Governance and Technology Series, vol. 4, pp. 75–100. Springer (2011)
21. Pandit, H.J., Debruyne, C., O'Sullivan, D., Lewis, D.: Gconsent - a consent ontology based on the gdpr. In: European Semantic Web Conference (ESWC) 2019. LNCS, vol. 11503, pp. 270–282. Springer (2019)
22. Pandit, H.J., Esteves, B., Krog, G.P., Ryan, P., Golpayegani, D., Flake, J.: Data privacy vocabulary (dpv) – version 2.0. In: The Semantic Web – ISWC 2024. Lecture Notes in Computer Science, vol. 15233, pp. 171–193. Springer (2025). https://doi.org/10.1007/978-3-031-77847-6_10
23. Pandit, H.J., Fatema, K., O'Sullivan, D., Lewis, D.: Gdprtext-gdpr as a linked data resource. In: European semantic web conference (ESWC) 2018. LNCS, vol. 10843, pp. 481–495. Springer (2018)
24. Richmond, K.M., Muddamsetty, S.M., Gammeltoft-Hansen, T., Olsen, H.P., Moeslund, T.B.: Explainable ai and law: An evidential survey. Digital Society **3**(1), 1 (2024)
25. Robaldo, L., Bartolini, C., Palmirani, M., Rossi, A., Martoni, M., Lenzini, G.: Formalizing gdpr provisions in reified i/o logic: The dapreco knowledge base. Journal of Logic, Language and Information **29**(4), 401–449 (2020)
26. Sambra, A.V., Mansour, E., Hawke, S., Zereba, M., Greco, N., Ghanem, A., Zagidulin, D., Aboulnaga, A., Berners-Lee, T.: Solid: a platform for decentralized social applications based on linked data. MIT CSAIL & Qatar Computing Research Institute, Tech. Rep. **2016** (2016)
27. Scharpf, F.W.: Legitimacy in the multilevel european polity. European political science review **1**(2), 173–204 (2009)
28. Vitali, F., Palmirani, M.: Akoma ntoso: Flexibility and customization to meet different legal traditions. Balisage Series on Markup Technologies **24**, 1–9 (2019)
29. W3C: ODRL information model 2.2 (2018), https://www.w3.org/TR/odrl-model/, w3C Recommendation

Meem Arafat Manab

Marie Skłodowska-Curie Doctoral Fellow, Law, Ethics, and Computer Science

meem.arafat@bracu.ac.bd
meem-arafat-manab
0000-0002-2336-4160
Meem-Arafat-Manab

Research Overview

I am a Marie Skłodowska-Curie doctoral fellow and researcher based in Universidad Politécnica de Madrid, Spain and Trinity College Dublin, Ireland. My research dwells in the intersection of law, artificial intelligence, and cybersecurity. I can bring multiple perspectives and research methods, both data-driven and empirical, to a research project.

Research Career

2025– **Marie Sklodowska-Curie Doctoral Fellow**, *Harness Doctoral Network, focusing on law, artificial intelligence, ethics, and European Data Spaces*, Spain, Ireland, *Coordinator: Dr. Victor Rodríguez-Doncel, Supervisor: Dr. Elena Montiel-Ponsoda, Universidad Politécnica de Madrid*

2024–2025 **Research Fellow**, *Panacea Cooperative Research and Universidad de León*, Spain, *Supervisors: Dr. Laura Robles, Dr. Victor Gonzalez Castro, Dr. Oscar Ibañez (Universidad da Coruña), and Dr. Guillermo Gomez Trenado (Universidad de Granada)*

2024–2025 **Editor**, *EMILDAI Blog*, *Supervisor: Dr. Edoardo Celeste, Co-Editor: Nauani Schades Benevides*

2024 – **Research Associate**, *School of Religion, Theology, and Peace Studies, Trinity College Dublin*, Ireland, *Supervisor: Dr. Maja Halilovic-Pastuovic*

2024 – **Contributor**, *AIAAIC Repository*, UK, *Supervisor: Charlie Pownall*

Summer 2024 **Research Intern**, *ADAPT Center, Trinity College Dublin*, Ireland, *Supervisors: Dr. David Lewis and Delaram Golpayegani*

Summer 2024 **Visiting Researcher**, *Insight SFI Research Centre, Dublin City University*, Ireland, *Supervisor: Dr. Alessandra Mileo*

2020–2023 **Lecturer**, *Department of Computer Science and Engineering, BRAC University*, Bangladesh

2022–2023 **Programme Manager**, *OSUN Science Shop, BRAC University*, Bangladesh, *Supervisors: Dr. Samia Huq, Andras Martoni*
Joint project with Central European University in Austria, European Humanities University in Lithuania, and American University of Central Asia in Kyrgyzstan

SP 2023 **Affiliated Faculty**, *Bard College, New York*, USA, *Host: Dr. Jordan Ayala and the Levy Economics Institute of Bard College*

2021–2022 **Workshop Facilitator**, *Oboyob Diversity Circle*, Bangladesh, *Co-facilitator: Nazia Zebin*

2020–2021 **Short Term Consultant**, *The World Bank Group, Disaster Management Unit*, South Asia Region, *Supervisor: Partha Pratim Nath*

Fall 2020 **Research Assistant**, *Oboyob Diversity Circle*, Bangladesh, *Supervisor: Nazia Zebin*
In cooperation with ILGA Asia

Fall 2019 **Graduate Trainee**, *Fujitsu Research Institute, Tokyo*, Japan

2013–2018 **Academic Team Member**, *Bangladesh Mathematics Olympiad Committee*, Bangladesh, *Supervisor: Dr. Mahbubul Alam Majumdar*

SP 2017 **Teaching Assistant**, *Department of Computer Science and Engineering, University of Dhaka*, Bangladesh
Course: CSE3205: Mathematics for Computer Science, *Supervisor: Dr. Amin Ahsan Ali*

Education

2025– **Ph.D. in Artificial Intelligence**, *Universidad Politécnica de Madrid and Trinity College Dublin*, Spain, Ireland
- Topic: Risks and Opportunities of European Data Spaces
- Supervisors: Dr. Elena Montiel-Ponsoda and Dr. Harshavardhan Pandit

2023–2025 **European Master in Law, Data and AI**, *Dublin City University and University of León*, Ireland, Spain
- Grade: 1H1 (Irish Standard), 8.72/10 (Spanish Standard)
- Master thesis: Age detection from images and video streams applied to forensic analysis.
- Key Modules: European Data Protection Law, AI and Information Seeking, Comparative Privacy Law, Data Governance, Data Management and Visualization, Cybercrime and Cyberdefense, Secure Design and Programming, Trustworthy Systems, Forensic Analysis.
- Supervisors: Dr. Edoardo Celeste and Dr. Victor González Castro.
- Erasmus Mundus Masters with Full Scholarship.
- Exepected graduation: July 2025 with First Class Honours (1H1).
- Internship: ADAPT Center, Trinity College Dublin (8 weeks) – Converted parts of the EU AI Act to industry standards.
- Internship: Insight SFI Research Center, Dublin City University (12 weeks) – Extracted classification taxonomy from graph-like structure derived from SOTA neural network models.

2014–2018 **Bachelor of Science in Computer Science and Engineering**, *University of Dhaka*, Bangladesh
- Grade: 3.60/4.00.
- Key Modules: Data Mining and Machine Learning, Data Structures, Algorithms, Object-Oriented Programming, Human-Computer Interaction.
- Supervisors: Dr. Muhammad Asif Hossain Khan.

Publications, Editorials and Conferences

Book Chapters

M.I. Rakib, S. Rahman, J.J. Mondal, X. Xiao, D. Lewis, A. Mileo and M.A. Manab. TWIG: Two-Step Image Generation Using Segmentation Masks as an Intermediary in Diffusion Models to Prevent Copyright Infringement. In *Privacy and Identity Management. Generating Futures. Privacy and Identity 2024. IFIP Advances in Information and Communication Technology, vol 705* (Ed. F. Bieker, S. De Conca, J.M. Del Alamo, Y.S. Martín). Springer, Cham, Switzerland, 2025. ISBN: 978-3-031-91053-1.

M.A. Manab and N.S. Benevides. Barriers to geographic data in having a data cooperative: Satellites, privacy, and the dual monopoly of states and big techs. In *EU Data Cooperatives: L'ingresso delle cooperative di dati nell'ordinamento europeo* (Ed. F. Bravo), G. Giappichelli Editore, Torino, Italy, 2025. ISBN/EAN: 979-12-211-1146-0.

M.A. Manab. Mourning for my women. In *Himal Southasian*, vol. 29, no. 3. 2016.

Journals

M.F. Islam, M.T. Reza, M.A. Manab, S. Zabeen, M.F.U. Islam, M.F. Shahriar, M. Kaykobad, M.G.Z.A. Husna, and J. Noor. Involution-based efficient autoencoder for denoising histopathological images with enhanced hybrid feature extraction *Computers in Biology and Medicine*, 192:110174, 2025.

M.F. Islam, M.A. Manab, J.J. Mondal, S. Zabeen, F.B. Rahman, M.Z. Hasan, F. Sadeque, and J. Noor. Involution fused convolution for classifying eye-tracking patterns of children with autism spectrum disorder. *Engineering Applications of Artificial Intelligence*, 139:109475, 2025.

S. Labib, J.J. Mondal, M.A. Manab, X. Xiao, and S. Newaz. Tailoring adversarial attacks on deep neural networks for targeted class manipulation using deepfool algorithm. *Scientific Reports*, 15:10790, 2025.

J.J. Mondal, M.F. Islam, R. Islam, N.K. Rhidi, S. Newaz, M.A. Manab, A.A.A. Islam, and J. Noor. Uncovering local aggregated air quality index with smartphone captured images leveraging efficient deep convolutional neural network. *Scientific Reports*, 14(1):1627, 2024.

Conference Proceedings

M.A. Manab and A. Nowshin. Return of the headless king: Panopticon, surveillance, and machine intelligence. In *Building Trust in CUIs: A Hybrid Workshop at the ACM CHI 2024 Conference*, 2024.

M.F. Islam, S. Zabeen, F.B. Rahman, M.A. Islam, F.B. Kibria, M.A. Manab, D.Z. Karim, and A.A. Rasel. Unic-net: Uncertainty aware involution-convolution hybrid network for two-level disease identification. In *Proceedings of IEEE Region 3 Technical, Professional, and Student Conference SoutheastCon 2023*, pages 305–312. IEEE, 2023.

M.F. Islam, S. Zabeen, F.B. Rahman, M.A. Islam, F.B. Kibria, M.A. Manab, D.Z. Karim, and A.A. Rasel. Exploring node classification uncertainty in graph neural networks. In *Proceedings of the 2023 ACM Southeast Conference*, pages 186–190, 2023.

M.F. Islam, S. Zabeen, M.A. Islam, F.B. Rahman, A. Ahmed, D.Z. Karim, A.A. Rasel, and M.A. Manab. How certain are transformers in image classification: Uncertainty analysis with Monte Carlo dropout. In *Fifteenth International Conference on Machine Vision (ICMV 2022)*, volume 12701, pages 158–165. SPIE, 2022.

Symposiums, Talks, and Conference Presentations

M.A. Manab. Siliconwashing: How Tech Ethics Discourse undermines Human Rights for the Marginalized. *Congreso Internacional de Direitos Humanos de Coimbra*, Universidade de Coimbra, Portugal, October 2025.

M.A. Manab and V.G. Castro. Private Information is Language Knowledge: GDPR Compliance, Privacy Rights, and the Catastrophe of Systematic Linguistic Degradation. *20th IFIP Summer School on Privacy and Identity Management*, Technical University of Denmark, Copenhagen, Denmark, August 2025.

M.A. Manab. Eternal sunshine of the mechanical mind: How the right to privacy and the right to be forgotten is subsumed by generative AI. *DPSN International Data Protection Day work-in-progress event*, Online. January 2025.

M. Mahmud and M. A. Manab. Analyzing University Reactions to Student Movements in the Palestinian Conflict: The Response-Counter-Response of Higher Education Institutions. *Annual Postgraduate Research Conference, Senator George Mitchell Institute*, Queen's University Belfast, June 2024

M.A. Manab and M.F. Islam. Adversarial Attack against A.I.for Pedagogical Purposes: Designing Prompts for Students and not ChatGPT. *First Elkana Symposium on Reimagining Teaching and Learning*, Central European University, Austria, June 2023

A.A. Chowdhury and M.A. Manab. The New Path to – or the New Face of –Domination? Some Emerging Technologies that Show Signs of a Growing Cold/Closed Society. *Workshop on "The Road to Domination? The Open Society and New Technologies", Open Society Research Platform*, Central European University, Austria, April 2022

Community Services

External reviewer IEEE TNNLS (Transactions on Neural Networks and Learning Systems, 2025), IJCCE (International Journal of Cognitive Computing in Engineering, 2025), CSCW (ACM SIGCHI Conference on Computer-Supported Cooperative Work and Social Computing, 2025), WACV Workshop on Vision-Based Understanding for Low-Resource Languages (2024), ACM Journal on Computing and Sustainable Societies (2024, 2023), NeurIPS (ethics review, 2025, 2023)

Volunteer Democratic Odyssey at the European University Institute, Florence, Italy (2025), British and Irish Law, Education and Technology Association (BILETA) Annual Conference, Dublin, Ireland (2024)

Member International Federation for Information Processing (IFIP) Working Group 9.6/11.7 on Information Technology: Misuse & the Law (2024–)

Languages

Bengali	Mother tongue	
English	Bilingual proficiency,	*IELTS Score: 8.5 (2020); lived in Ireland 2023 – 2024*
Spanish	Professional proficiency,	*B2 Certfifcate (2021); lives in Spain 2024 onwards*
German	Limited proficiency,	*A2 (2023)*

Additional Skills

Programming	Python, R, Bash Scripting, Java, C, C++, MATLAB
Data Science	TensorFlow, Pytorch, Keras, OpenCV, PCL, Geopandas, QGIS, Langchain
Development	Git, Docker, Kubernetes, AWS, Flask
Blockchain	Smart Contracts (Solidity)