Multimodal Data Exchange Systems for Enhanced Interaction and Management

Yeison N. Cardona-Alvarez

Advisor: Andrés Marino Álvarez-Meza, Ph.D
Co-Advisor: César Germán Castellanos-Domínguez, Ph.D

Universidad Nacional de Colombia
Signal Processing and Recognition Group - SPRG
Manizales, Colombia

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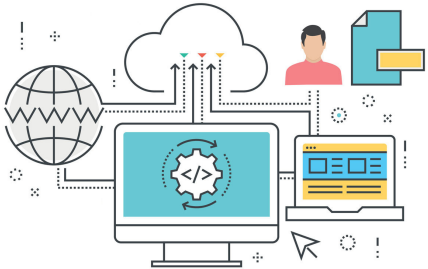
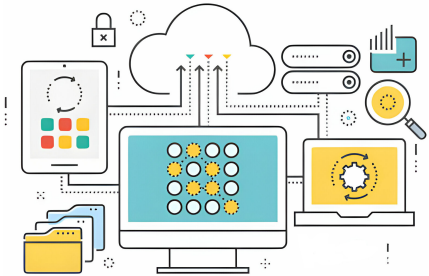
Outline

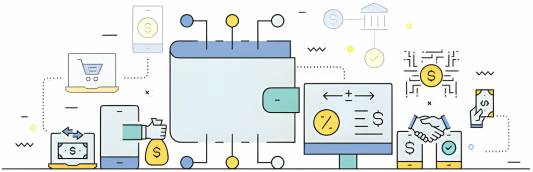
Data Exchange refers to the **efficient and secure** flow of data between different platforms and procedures [Zhang et al., 2021, Thakare and Kim, 2021].





Despite its benefits, data exchange requires strong security and encryption, data quality and dependability, and industry-specific **compliance standards** [Attiogbé et al., 2021].

- Business intelligence and analytics
  [Kouper and Cook, 2021]
- Marketing and advertising [Mishra and Kaushik, 2023]
- Finance and banking **[TODO]**
- Healthcare [Al-Kahtani et al., 2022]
- Government and public services **[TODO]**
- Research and academia
  [Qiu et al., 2021, Paltun et al., 2021, Adiga et al., 2022]



Motivation

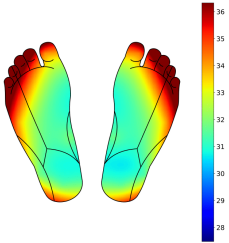
Innovating Research through Advanced Information Integration

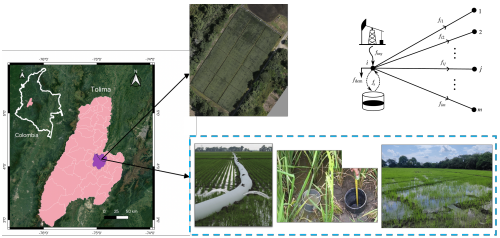
Data exchange in research plays a crucial role as a fundamental **basis for innovation**, bringing together several fields into a **cohesive force** that drives forward revolutionary discoveries [Cappiello et al., 2020].

- Exploring the potential of multimodal information [Zhang et al., 2020]
- Advancing data exchange techniques [Deng et al., 2020]
- Designing future-ready data exchange architectures [Srijith et al., 2022]
- Encouraging interdisciplinary collaboration in research [Talebkhah et al., 2023]

Our research group is dedicated to developing the field of **multidisciplinary data interchange**, as we understand its crucial role in unlocking new solutions and fostering collaborative discoveries across **several academic domains**

[Gomez Rivera, , Aguirre-Arango et al., 2023, Martinez et al., 2023].





Scientific data sharing requires combining **methods** while resolving their constraints.

- **APIs:** Request rate, security, and provider stability/changes limit them [Velepucha and Flores, 2023].
- **Messaging:** Distributed system scalability, delivery assurance, state management, and security issues [Fang et al., 2019].
- **ETL:** Data quality-dependent performance and complexity concerns with big amounts of different data [Abdelhafiz and Elhadef, 2021].
- **File Transfer:** Security, file size, and bandwidth issues [Ordóñez et al., 2023, Yi et al., 2023].

Request rate limits might cause data transmission **bottlenecks** and make it hard to keep running after provider API modifications.

Scalability and **delivery assurance** issues may cause message loss or delays, impacting communication system efficiency and dependability.

Problem statement

ETL Optimization: Enhancing Data Processing Efficiency

Inefficient handling of big data volumes and sophisticated transformations may cause processing mistakes and **data delays**.

Security vulnerabilities, file size limits, and excessive bandwidth usage may affect **network operations** and file transfers.

State-of-the-Art

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Question research

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General aim

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Specific aims

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Development [obj1]

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Conclusions

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Future work

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Academic discussion

Papers, patents and software registers

- [2022] Paper submitted to SoftwareX - Journals | Elsevier with the name **"A real-time acquisition, visualization, and stimuli delivery Python-based tool for neurophysiological experiments"**.
- [2022] The systems were submitted to the **Crearlo no es suficiente** summons for a patentability search process with the Universidad Nacional de Colombia sede Manizales as main beneficiary with the title **"MÉTODO Y SISTEMA PARA LA SINCRONIZACIÓN DE MARCADORES ASOCIADOS A SISTEMAS DE INTERFAZ CEREBRO-COMPUTADOR"**, postulation ID 343 and Application number NC2022/0007405 from May 28, 2022.
- [2022] A script developed with BCI-Framework for **Motor imagery paradigm with game-based stimulus (Pacman interface)** was submitted to the software register in the Universidad Nacional de Colombia sede Manizales.

Acknowledgements

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References I

Abdelhafiz, B. M. and Elhadef, M. (2021).
Sharding database for fault tolerance and scalability of data.
In 2021 2nd International Conference on Computation, Automation and Knowledge Management (ICCAKM), pages 17–24. IEEE.

Adiga, A., Kaur, G., Hurt, B., Wang, L., Porebski, P., Venkatramanan, S., Lewis, B., and Marathe, M. (2022).
Enhancing covid-19 ensemble forecasting model performance using auxiliary data sources.
In 2022 IEEE International Conference on Big Data (Big Data), pages 1594–1603. IEEE.

Aguirre-Arango, J. C., Álvarez-Meza, A. M., and Castellanos-Dominguez, G. (2023).
Feet segmentation for regional analgesia monitoring using convolutional rff and layer-wise weighted cam interpretability.
Computation, 11(6):113.

Al-Kahtani, M. S., Khan, F., and Taekeun, W. (2022).
Application of internet of things and sensors in healthcare.
Sensors, 22(15):5738.

Attiogbé, J. C., Ferrarotti, F., and Maabout, S. (2021).
Advances and challenges for model and data engineering.
J. Univers. Comput. Sci., 27(7):646–649.

Cappiello, C., Gal, A., Jarke, M., and Rehof, J. (2020).
Data ecosystems: sovereign data exchange among organizations (dagstuhl seminar 19391).
In Dagstuhl Reports, volume 9. Schloss Dagstuhl-Leibniz-Zentrum fuer Informatik.

References II

Deng, H., Qin, Z., Sha, L., and Yin, H. (2020).
A flexible privacy-preserving data sharing scheme in cloud-assisted iot.
IEEE Internet of Things Journal, 7:11601–11611.

Fang, J., Chao, P., Zhang, R., and Zhou, X. (2019).
Integrating workload balancing and fault tolerance in distributed stream processing system.
World Wide Web, 22:2471–2496.

Gomez Rivera, Y. A.
Estrategia de procesamiento de señales EEG en sistemas BCI utilizando aprendizaje profundo y medidas de conectividad.
PhD thesis, Universidad Nacional de Colombia.

Kouper, I. and Cook, K. (2021).
Challenges in curating interdisciplinary data in the biodiversity research community.
Biodiversity Information Science and Standards, 5:e79084.

Martinez, J. C. T., De Swaef, T., Borra-Serrano, I., Lootens, P., Barrero, O., and Fernandez-Gallego, J. A. (2023).
Comparative leaf area index estimation using multispectral and rgb images from a uav platform.
In Autonomous Air and Ground Sensing Systems for Agricultural Optimization and Phenotyping VIII, volume 12539, pages 56–67. SPIE.

Mishra, L. and Kaushik, V. (2023).
Application of blockchain in dealing with sustainability issues and challenges of financial sector.
Journal of Sustainable Finance & Investment, 13(3):1318–1333.

References III

Ordóñez, J., Alexopoulos, A., Koutras, K., Kalogeras, A., Stefanidis, K., and Martos, V. (2023).
Blockchain in agriculture: A pestels analysis.
IEEE Access.

Paltun, B. G., Kaski, S., and Mamitsuka, H. (2021).
Diverse: Bayesian data integrative learning for precise drug response prediction.
IEEE/ACM Transactions on Computational Biology and Bioinformatics, 19(4):2197–2207.

Qiu, Y., Zhang, Y., Deng, Y., Liu, S., and Zhang, W. (2021).
A comprehensive review of computational methods for drug-drug interaction detection.
IEEE/ACM transactions on computational biology and bioinformatics, 19(4):1968–1985.

Srijith, R, K. B., N, G., and R, A. (2022).
Inter-service communication among microservices using kafka connect.
2022 IEEE 13th International Conference on Software Engineering and Service Science (ICSESS), pages 43–47.

Talebkhah, M., Sali, A., Gordan, M., Hashim, S. J., and Rokhani, F. Z. (2023).
Comprehensive review on development of smart cities using industry 4.0 technologies.
IEEE Access.

Thakare, A. and Kim, Y.-G. (2021).
Secure and efficient authentication scheme in iot environments.
Applied Sciences, 11(3):1260.

References IV

Velepucha, V. and Flores, P. (2023).
A survey on microservices architecture: Principles, patterns and migration challenges.
IEEE Access.

Yi, D., Baltov, P., Hua, Y., Philip, S., and Sharma, P. K. (2023).
Compound scaling encoder-decoder (cosed) network for diabetic retinopathy related bio-marker detection.
IEEE journal of biomedical and health informatics.

Zhang, C., Yang, Z., He, X., and Deng, L. (2020).
Multimodal intelligence: Representation learning, information fusion, and applications.
IEEE Journal of Selected Topics in Signal Processing, 14(3):478–493.

Zhang, X., Xu, L., and Li, A. (2021).
Fault-tolerant secure routing of bh_n-based data center networks.
Security and Communication Networks, 2021:1–10.