Byunghwee Lee

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My research lies at the intersection of Data science, AI, humanities and society, where I develop computational methods to study art and culture, human beliefs, and social dynamics at scale.

CONTACT INFORMATION

Postdoctoral Research Associate
School of Data Science, University of Virginia
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RESEARCH INTERESTS

Computational Social Science, Cultural Analytics, Computational Art History, Network Science, Representation Learning, Generative/Multimodal AI.

HIGHLIGHTS

AI and Human Beliefs

- **Belief representation with LLMs**: *Nature Human Behavior*, 2025; *arXiv preprint*, 2025

Network Science, Social Systems, and Online Media

- **Network Dynamics of Social Media**: *Physica A*, 2025; *Phys. Rev. Res.*, 2021
- **Online Discourse and Infodemics**: *Explainable AI in Healthcare and Medicine*, 2020; *Public Health and Informatics*, 2021; 한국사회, 2020

Data-driven Analysis of Art, Culture, and Creativity

- **Computational Art History**: *PNAS*, 2020; *Sci. Rep.*, 2025; *PLOS One*, 2018; *New Phys.*: *Sae Mulli*, 2016
- **Multimodal AI for Art**: *arXiv preprint*, 2025; *SSRN preprint*, 2025
- **Stylometry and Historical Texts**: *JKPS*, 2020; *New Phys.*: *Sae Mulli*, 2016

SELECTED PUBLICATIONS

Belief and AI — A semantic embedding space based on large language models for modelling human beliefs. Byunghwee Lee, Rachith Aiyappa, Yong-Yeol Ahn, Haewoon Kwak, and Jisun An. *Nature Human Behaviour*, 2025. [Link]

- Highlighted by *Phys.org* [News]

Art and Data Science — Dissecting landscape art history using information theory. **Byunghwee Lee**†, Min Kyung Seo†, Daniel Kim, In-Seob Shin, Maximilian Schich, Hawoong Jeong*, and Seung Kee Han*. *Proceedings of the National Academy of Sciences* (*PNAS*), 117(43), 26580–26590 (2020). [Link]

- Featured in the *PNAS* "*In This Issue*" section
- Accompanied by a commentary paper [Link]
- Highlighted by media including *Forbes*, *Inverse*, *Science Daily*, KAIST News, *Donga Science*, and 과학동아.

Social Media and Network Science — Network analysis reveals news press landscape and asymmetric user polarization. Byunghwee Lee, Hyo-sun Ryu, Jae Kook Lee, Hawoong Jeong, Beom Jun Kim. *Physica A*: *Statistical Mechanics and its Applications*, p.130842 (2025) [Link]

- Highlighted by *SKKU Media* [News]

EDUCATION

Ph.D. Physics, KAIST (Daejeon, South Korea) — Feb. 2021
Dissertation: *Art and Complexity in the Era of Big Data* (빅데이터 시대의 예술과 복잡성)
Advisor: Hawoong Jeong

B.S. Physics, KAIST (Daejeon, South Korea) — Feb. 2013

ACADEMIC & PROFESSIONAL POSITIONS

University of Virginia, Charlottesville, VA, USA
Postdoctoral Research Associate, School of Data Science
Advisor: Yong-Yeol Ahn — Aug. 2025–

Indiana University, Bloomington, IN, USA

Postdoctoral Researcher, Luddy School of Informatics, Computing, and Engineering
Advisor: Jisun An, Haewoon Kwak, and Yong-Yeol Ahn Mar. 2023 – Aug. 2025

Sungkyunkwan University, South Korea
Senior researcher, Institute of Basic Science (Advisor: Beom Jun Kim) Sep. 2022 – Feb. 2023

National Science Museum, Daejeon, South Korea
Researcher / Curator Jun. 2021 – Sep. 2022
Contributed to the advancement of museum data management system

Korea Advanced Institute of Science and Technology (KAIST), South Korea
Post-doctoral researcher, Natural Science Research Institute
(Advisor: Hawoong Jeong) Mar. 2021 – Jun. 2021

Professional License

National Certificate on Museum and Art Gallery Curator (level 3)
Ministry of Culture, Sports and Tourism, South Korea Oct. 2022

Awards

Oral and Poster Presentation Awards
Datapalooza 2025 Best in Show Award, School of Data Science, University of Virginia
(*$750 Travel award*) [News] Nov. 2025
Korean Physical Society Meeting, Best Poster Presentation Jul. 2020
Korean Physical Society Meeting, Best Oral Presentation Apr. 2019
Korea Academy of Complexity Studies,
Best Oral Presentation Nov. 2013; Nov. 2014; Nov. 2015; Nov. 2017
Conference on Complex Systems (Arizona, USA), Best Poster Award Oct. 2015
STATPHYS25 Satellite Meeting: Computational Methods for Bio and Complex Systems
Best Poster Award Jul. 2013

Selected Media Coverage

Selected media coverage of research

- LLMs delve into online debates to create a detailed map of human beliefs, *Phys.org*, Jun. 2025. [News]
- The human quest for discovering mathematical beauty in the arts, *PNAS* Commentary, October 23, 2020. [Link]
- Math shows How the composition of landscape paintings changed over time, *Forbes*, Oct. 23. 2020. [Link]
- Math uncovers hidden patterns in these historic art masterpieces, *Inverse*, Oct. 13. 2020. [Link]
- Drawing the Line to Answer Art's Big Questions, *KAIST News* [Link]
- 명화 속 빛의 비밀, 데이터는 알고 있다 (*Data reveals the hidden secrets of light in masterpieces*), 과학동아, Mar. 2021. [Link]
- 학제 간 경계를 넘은 융합 연구, 양극화된 댓글 네트워크를 확인하다 (*Interdisciplinary research across boundaries reveals polarized comment networks*), *SKKU Media*, Aug. 2025. [Link]

Publications

Preprints and Manuscripts Under Review
(†: equal contribution; *: Corresponding authors)

[P1] **LLMs Can Infer Political Alignment from Online Conversations**. **Byunghwee Lee**†, Sangyeon Kim†, Filippo Menczer, Yong-Yeol Ahn*, Haewoon Kwak*, Jisun An*. *arXiv preprint*, arXiv:2603.11253 (2026).

[P2] **Context-aware Multimodal AI Reveals Hidden Pathways in Five Centuries of Art Evolution**. Jin Kim, **Byunghwee Lee**, Taekho You*, Jinhyuk Yun*. *arXiv preprint*, arXiv:2503.13531 (2025).

[P3] **Combined influence of artwork and artist features in predicting user generated art valuation**. Seunghwan Kim†, Soomin Lee†, **Byunghwee Lee***, Wonjae Lee*. *SSRN preprint*, SSRN 5443234 (2025).

[P4] **A Benchmark for Zero-Shot Belief Inference in Large Language Models**. Joseph Malone,

Rachith Aiyappa, **Byunghwee Lee**, Haewoon Kwak, Jisun An, Yong-Yeol Ahn*. *arXiv preprint*, arXiv:2511.18616 (2025).

Peer-reviewed Publications

(†: equal contribution; *: Corresponding authors)

[1] **When the Classroom Disappeared: The Paradox of Assortativity in Co-Enrollment Networks**. **Byunghwee Lee**, Jintae Bae, Jaeryong So, Eun Kyong Shin*. *Social Constellations*: *A World Perspective*, 1(1), 92–112 (2026). [Link]

[2] **A semantic embedding space based on large language models for modelling human beliefs**. **Byunghwee Lee**, Rachith Aiyappa, Yong-Yeol Ahn, Haewoon Kwak*, Jisun An*. *Nature Human Behaviour*, 9(9), 1928–1940 (2025). [Link]

[3] **Network analysis reveals news press landscape and asymmetric user polarization**. **Byunghwee Lee**, Hyo-sun Ryu, Jae Kook Lee, Hawoong Jeong, Beom Jun Kim*. *Physica A*: *Statistical Mechanics and its Applications*, 130842 (2025). [Link]

[4] **Investigating the diversity and stylization of contemporary user generated visual arts in the complexity entropy plane**. Seunghwan Kim†, **Byunghwee Lee**†, Wonjae Lee*. *Scientific Reports*, 15(1), 22075 (2025).

[5] **Uncovering hidden dependency in weighted networks via information entropy**. Mi Jin Lee, Eun Lee, **Byunghwee Lee**, Hawoong Jeong, Deok-Sun Lee, Sang Hoon Lee*. *Physical Review Research*, 3(4), 043136 (2021).

[6] **Integrated infodemic surveillance system: the case of COVID-19 in South Korea**. Gil-sung Park, Jintae Bae, Jong Hun Lee, Byung Yeon Yun, **Byunghwee Lee**, Eun Kyong Shin*. In *Public Health and Informatics*, pp. 1036–1040. IOS Press (2021).

[7] **Dissecting landscape art history with information theory**. **Byunghwee Lee**†, Min Kyung Seo†, Daniel Kim, In-seob Shin, Maximilian Schich, Hawoong Jeong*, Seung Kee Han*. *Proceedings of the National Academy of Sciences*, 117(43), 26580–26590 (2020). [Link]

[8] **트위터로 본 메르스(MERS)의 사회적 영향: 대응 시기와 집단에 따른 목소리의 다양성 (Social influence of 2015 MERS outbreak on twitter: Diversity of online discourse over time and social groups)**. **Byunghwee Lee**, Hawoong Jeong*. 한국사회, 21(1), 35–62 (2020).

[9] **On-line (TweetNet) and Off-line (EpiNet): The Distinctive Structures of the Infectious**. **Byunghwee Lee**, Hawoong Jeong, Eun Kyong Shin*. In *Explainable AI in Healthcare and Medicine*: *Building a Culture of Transparency and Accountability*, pp. 187–194. Springer (2020).

[10] **Multi-label classification of historical documents by using hierarchical attention networks**. Dong-Kyum Kim†, **Byunghwee Lee**†, Daniel Kim, Hawoong Jeong*. *Journal of the Korean Physical Society*, 76(5), 368–377 (2020).

[11] **Heterogeneity in chromatic distance in images and characterization of massive painting data set**. **Byunghwee Lee**, Daniel Kim, Seunghye Sun, Hawoong Jeong*, Juyong Park*. *PLoS One*, 13(9), e0204430 (2018).

[12] **Information-theoretic analysis of color interaction in artistic paintings**. Min Kyung Seo, In-Seob Shin, Seung Kee Han*, **Byunghwee Lee**, Hawoong Jeong. *New Physics*: *Sae Mulli*, 68(6), 693–699 (2018).

[13] **N-gram web service and stylometric analysis of Korean historical documents**. **Byunghwee Lee**†, Daniel Kim, Dongwoo Kim, Hawoong Jeong*. *New Physics*: *Sae Mulli*, 66(4), 502–510 (2016).

Manuscripts in Preparation

- **The geometry of persuasion: Quantifying belief change in a latent embedding space**. **Byunghwee Lee**, Jisun An, Haewoon Kwak, Yong-Yeol Ahn. *In preparation*.

ARTICLES AND BOOK CHAPTERS

Articles and Magazines

- **Math reveals the evolution of composition in paintings**, Byunghwee Lee, Hawoong Jeong, *The Science Breaker*, Dec. 29. 2021. [Link]
- **Art history seen through the eyes of physics (in Korean)**, Byunghwee Lee, *APCTP Crossroad Webzine*, Apr. 2021. [Link]
- **네트워크 과학으로 살펴보는 사회적 거리두기와 접촉자 추적의 원리 (Principles of Social Distancing and Contact Tracing through Network Science)**, Byunghwee Lee, Hawoong Jeong, *BT News* (Newsletter of the Korean Society of Biotechnology), Apr. 2021. [Link]

Book Chapters

- **전염의 복잡계 과학적 접근 (Complex Science Approaches to the Contagion Phenomena)**, Byunghwee Lee, Hawoong Jeong, in *Imagination of Contagion*, pp. 101–137, 2017.

Teaching Experience

Courses assisted: Nonlinear Dynamics, Thermal Physics, College Physics, General Physics.

- **Instructor** Python-Based Big Data Analysis Workshop, Department of Sociology, Korea University May–June 2020
  - Designed and taught a six-session workshop on Python-based data analysis covering Python fundamentals, text analysis, topic modeling, and network analysis through lectures and hands-on labs.
- **Undergraduate Research Mentor** 2020–2021
  - Supervised Sang Jin Jeon on *information-spectrum-based analysis of musical structure*.
- **Independent Research Mentor** Institut Teknologi Bandung (ITB) – KAIST Undergraduate Exchange Program Oct.–Nov. 2015
  - Mentored Ridho Muhammad Akbar on *network-based spatial analysis of climate change data*.
- **Teaching Assistant**, Department of Physics, KAIST
  - Nonlinear Dynamics Fall 2015
  - Thermal Physics (led recitation sections) Spring 2015
  - College Physics (led recitation sections) Spring 2014
  - General Physics (led recitation sections) Spring 2013

Peer Review Service

Reviewer for: *EPJ Data Science*, *Scientific Reports*, *ICWSM*, *PLOS ONE*, *The Web Conference PhD Symposium*, *Advances in Complex Systems*, *Humanities and Social Sciences Communications*, *New Physics*: *Sae Mulli*.

Skills

Programming and Data Science: Python (NumPy, Pandas, SciPy), PyTorch, Scikit-Learn, NetworkX, parallel computing, machine learning, natural language processing, large language model APIs (OpenAI, Hugging Face).
Data Analysis and Visualization: Network analysis, text analysis, topic modeling, data visualization (Matplotlib, d3.js), network visualization tools (Gephi).
Software and Tools: Git, Linux/Unix, LaTeX, Adobe Illustrator, Final Cut Pro.
Other Programming Languages: Matlab, R, Java, HTML/CSS, Processing.
Languages: Korean (Native), English (Professional proficiency).

Conference Presentations

2026

- (Accepted, Poster) **Byunghwee Lee**, Haewoon Kwak, Jisun An, Yong-Yeol Ahn *Social judgement theory in a belief embedding space* NetSci 2026, Boston, MA, USA, June 1-5, 2026.

2025

- (Oral) **Byunghwee Lee**, Sangyeon Kim, Filippo Menczer, Yong-Yeol Ahn, Haewoon Kwak, Jisun An. *Can LLMs infer political affiliation from non-political discourse?* International Conference on Computational Social Science (IC2S2), Norrköping, Sweden, Jul. 2025.

2024

- (Plenary talk) **Byunghwee Lee**, Rachith Aiyappa, Yong-Yeol Ahn, Haewoon Kwak, Jisun An. *Neural embedding of beliefs reveals the role of relative dissonance in human decision-making*. International Conference on Computational Social Science (IC2S2), Philadelphia, USA, Jul. 2024.

- (Poster) Taekho You (presenter), Jin Kim, **Byunghwee Lee**, Jinhyuk Yun.
  Understanding the Creativity through Evolution of Western Painting Art Using the Stable Diffusion Model. International Conference on Computational Social Science (IC2S2), Philadelphia, USA, Jul. 2024.

2020

- (Poster) **Byunghwee Lee**, Min Kyung Seo, Daniel Kim, In-seob Shin, Maximilian Schich, Hawoong Jeong, Seung Kee Han.
  Information-theoretic dissection of painting reveals the evolution of composition of landscape painting. NetSci, Rome (Virtual), Sep. 2020.
- (Poster) **Byunghwee Lee**, Min Kyung Seo, Daniel Kim, In-seob Shin, Maximilian Schich, Hawoong Jeong, Seung Kee Han.
  Revealing the evolution of composition of landscape painting through the lens of information theory. Korean Physical Society Meeting (Virtual), Jul. 2020.

2019

- (Oral) **Byunghwee Lee**, Min Kyung Seo, Daniel Kim, In-seob Shin, Hawoong Jeong, Seung Kee Han
  Information-theoretic dissection of landscape paintings reveals conceptual overlap in art historiography. Statistical Physics Workshop, Oct. 2019.
- (Poster) **Byunghwee Lee**, Min Kyung Seo, Daniel Kim, In-seob Shin, Hawoong Jeong, Seung Kee Han.
  Information-theoretic analysis of composition in painting and the composition-similarity network of painters. NetSci, University of Vermont, May 2019.
- (Oral) **Byunghwee Lee**, Min Kyung Seo, Daniel Kim, In-seob Shin, Hawoong Jeong, Seung Kee Han.
  Large-scale information theoretic analysis of composition in painting. Korean Physical Society Meeting, Apr. 2019.

2017

- (Oral) **Byunghwee Lee**, Daniel Kim, Hawoong Jeong.
  Inferring Posthumous Fame from Social Network Location Using a Half Millennium Historical Documents. Korean Society of Complex Systems Conference, Sookmyung Women's University, Seoul, Nov. 2017.
- (Oral) **Byunghwee Lee**, Daniel Kim, Hawoong Jeong.
  역사기록물에서의 인물 등장 패턴과 명성 (*Appearance Patterns and Fame of Historical Figures in Archival Records*). KAIST Econophysics Workshop, Daejeon, Nov. 2017.
- (Oral) **Byunghwee Lee**, Daniel Kim, Hawoong Jeong.
  Inferring Posthumous Fame from Social Network Location Using a Half Millennium Historical Documents. Statistical Physics Workshop, Mungyeong, Korea, Oct. 2017.

2016

- (Oral) **Byunghwee Lee**, Daniel Kim, Hawoong Jeong.
  Analysis of Spatio-temporal Pattern of Historical Cities in the Annals of the Joseon Dynasty. Workshop on Special Topics in Statistical Physics & Complex Systems (SPnCs), Dec. 2016.
- (Oral) **Byunghwee Lee**, Kibum Kim, Daniel Kim, Beom Jun Kim, Hawoong Jeong.
  Understanding spatiotemporal patterns in the Annals of the Joseon Dynasty. Korean Physical Society Fall Meeting, Oct. 2016.
- (Oral) **Byunghwee Lee**, Daniel Kim, Hawoong Jeong, Seunghye Sun, Juyong Park.
  Quantitative analysis on contrast effect in the evolution of paintings. STATPHYS 26, Lyon, France, Jul. 2016.
- (Oral) **Byunghwee Lee**, Daniel Kim, Hawoong Jeong, Seunghye Sun, Juyong Park.
  Quantitative analysis of color contrast in the evolution of painting. NetSci, May. 2016.

2015

- (Oral) **Byunghwee Lee**, Daniel Kim, Hawoong Jeong, Juyong Park.
  Evolution of color contrast in art history. Korean Society of Complex Systems Conference, Seoul, Nov. 2015.
- (Oral) **Byunghwee Lee**, Daniel Kim, Hang-Hyun Jo, Hawoong Jeong.
  Quantitative analysis of Joseon history using chronological data. Korean Physical Society Meeting,

Oct. 2015.

- (Poster) **Byunghwee Lee**, Daniel Kim, Hang-Hyun Jo, Hawoong Jeong.
  Understanding motives of historical events through the Annals of the Joseon Dynasty. Conference on Complex Systems, Tempe, Arizona, USA, Sep. 2015.

2014

- (Oral) **Byunghwee Lee**, Daniel Kim, Kihong Chung, Hawoong Jeong.
  Network structure in the Annals of the Joseon Dynasty. Korean Society of Complex Systems Conference, Ewha Womans Univeristy, Seoul, Nov. 2014.
- (Poster) **Byunghwee Lee**, Daniel Kim, Kihong Chung, Hawoong Jeong.
  Stylometry and Network Analysis on the Annals of the Joseon Dynasty. Korean Physical Society Meeting, Daejeon, Korea, Apr. 2014.

2013

- (Oral) **Byung-hwee Lee**, Daniel Kim, Hawoong Jeong.
  Statistical analysis of the Annals of the Joseon Dynasty. Complex Systems Conference, Gachon University, Sungnam, Korea, Nov. 2013.
- (Poster) **Byung-hwee Lee**, Daniel Kim, Hawoong Jeong.
  Web Search Trend Based Social Network Construction. Korean Physical Society Meeting, Changwon, Korea, Oct. 2013.
- (Poster) **Byung-hwee Lee**, Daniel Kim, Hawoong Jeong.
  Quantitative Analysis of the Annals of the Joseon Dynasty. STATPHYS 25 Sattelite meeting: Computational Methods for Bio and Complex Systems, Seoul, Korea, Jul. 2013.

Selected Invited Talks and Seminars

2025

- **A Semantic Embedding Space Based on Large Language Models for Modeling Human Beliefs**.
  Max Planck Institute for Security and Privacy (MPI-SP) DSLAB Seminar, Aug. 2025.
- **A Semantic Embedding Space Based on Large Language Models for Modeling Human Beliefs**.
  KDI School, Jun. 2025.
- **A Semantic Embedding Space Based on Large Language Models for Modeling Human Beliefs**.
  Soongsil University, Jun. 2025.

2024

- **Network Analysis Reveals News Press Landscape and User Polarization**.
  Sungkyunkwan University, Feb. 2024.

2023

- **Understanding Art and Culture through Data Science**.
  Chonnam National University, Dec. 2023.

2022

- **Art and Artists through the Lens of Statistical Physics**.
  Chosun University, Dec. 2022.

2021

- **Can We Understand Art through Physics? Art through the Lens of Complex Systems and Big Data**.
  Chosun University, Oct. 2021.