



PAPER ANALYSIS

PAPER ANALYSIS

From foundations to current research in representation learning

Four sessions, five papers per session, group presentations, and joint synthesis

PRESS – OR SPACE. →

Four Paper Analysis Sessions

Session	Topic	Focus
1 · Nov 27	Implicit Neural Representations and Approximation	Continuous representations, function approximation, coordinate networks, Fourier features, neural fields
2 · Dec 4	Location Encoders	Geographic coordinates, spatial inductive biases, spherical geometry, learned location representations
3 · Dec 11	Self-Supervised Representation Learning	Contrastive learning, self-distillation, masked reconstruction, multimodal learning
4 · Dec 18	Geospatial Embeddings	Earth representations, explicit and implicit embeddings, global embedding systems, embedding spaces

Progression: INRs → Location Encoders → Self-Supervised Learning → Geospatial Embeddings

Your Paper Presentation

Each group presents one paper for approximately **20 minutes**. Explain the paper rather than only summarizing it.

1. **Problem and motivation:** What problem does the paper address, and why does it matter?
2. **Main idea:** What is the central contribution? Explain it in your own words.
3. **Technical method:** Explain the key mechanism, representation, architecture, or mathematical idea. Focus on why it works.
4. **Evidence and results:** Which experiments support the claims? What are the most important results?
5. **Limitations:** What does the method leave unresolved? Which assumptions or weaknesses matter?
6. **Technical impact:** What did the paper introduce, popularize, clarify, or enable? How does it connect to the other papers?
7. **Two exam questions:** Write open-ended questions with answer sketches that test concepts rather than facts.

Prefer “Why does the method need this representation, and what would likely happen without it?” over “Which dataset did the authors use?”

Paper Analysis Session Timeline

Time	Activity
10:00–10:10	Topic framing and introduction
10:10–10:40	Group 1 presentation and discussion
10:40–11:10	Group 2 presentation and discussion
11:10–11:40	Group 3 presentation and discussion
11:40–12:00	Cross-paper discussion and buffer
12:00–13:00	Break
13:00–13:30	Group 4 presentation and discussion
13:30–14:00	Group 5 presentation and discussion
14:00–14:50	Synthesis across all five papers: shared findings, differences, and impact on the field
14:50–15:00	Wrap-up and assignment of the next session's papers

Session 1: Implicit Neural Representations

November 27

How can neural networks represent continuous signals, functions, and scenes?

1. **Review:** Neural Fields in Visual Computing and Beyond
Xie, Takikawa, Saito, Litany et al. *Computer Graphics Forum* 41(2), 2022.
2. **SIREN:** Implicit Neural Representations with Periodic Activation Functions
Sitzmann, Martel, Bergman, Lindell, Wetzstein. *NeurIPS* 2020.
3. **Fourier Features:** Fourier Features Let Networks Learn High Frequency Functions in Low Dimensional Domains
Tancik, Srinivasan, Mildenhall, Fridovich-Keil et al. *NeurIPS* 2020.
4. **NeRF:** NeRF: Representing Scenes as Neural Radiance Fields for View Synthesis
Mildenhall, Srinivasan, Tancik, Barron, Ramamoorthi, Ng. *ECCV* 2020.
5. **Generalisation:** Generalised Implicit Neural Representations
Grattarola, Vandergheynst. 2022.

Synthesis: representation, frequency, architecture, application, and generalization

Session 2: Location Encoders

December 4

How should a machine-learning model represent a location on Earth?

1. **Review:** A Review of Location Encoding for GeoAI: Methods and Applications
Mai, Janowicz, Hu, Gao et al. *International Journal of Geographical Information Science* 36(4), 2022.
2. **Spherical Harmonics and SIREN:** Geographic Location Encoding with Spherical Harmonics and Sinusoidal Representation Networks
Rußwurm, Klemmer, Rolf, Zbinden, Tuia. *ICLR 2024*.
3. **Spatial INR:** Spatial Implicit Neural Representations for Global-Scale Species Mapping
Cole, Van Horn, Lange, Shepard et al. *ICML 2023*, PMLR 202:6320–6342.
4. **Spherical Attention:** Attention on the Sphere
Bonev, Rietmann, Paris, Carpentieri, Kurth. *NeurIPS 2025*.
5. **To be announced:** Paper 5

Synthesis: Where should spatial geometry enter the model: encoding, representation, or architecture?

Session 3: Self-Supervised Learning

December 11

How can useful representations emerge without task-specific labels?

1. **SimCLR:** A Simple Framework for Contrastive Learning of Visual Representations
Chen, Kornblith, Norouzi, Hinton. *ICML 2020*, PMLR 119:1597–1607.
2. **DINO:** Emerging Properties in Self-Supervised Vision Transformers
Caron, Touvron, Misra, Jégou et al. *ICCV 2021*, pp. 9650–9660.
3. **MAE:** Masked Autoencoders Are Scalable Vision Learners
He, Chen, Xie, Li, Dollár, Girshick. *CVPR 2022*, pp. 16000–16009.
4. **CLIP:** Learning Transferable Visual Models From Natural Language Supervision
Radford, Kim, Hallacy, Ramesh et al. *ICML 2021*, PMLR 139:8748–8763.
5. **Analysis:** What Do Self-Supervised Vision Transformers Learn?
Park, Kim, Heo, Kim, Yun. *ICLR 2023*.

Synthesis: contrastive learning, self-distillation, masked reconstruction, multimodal learning, and representation analysis

Session 4: Geospatial Embeddings

December 18

Can information about the Earth be compressed into reusable embedding spaces?

1. **Perspective:** Earth Embeddings: Toward Artificial Intelligence-Centric Representations of Our Planet
Klemmer, Rolf, Rußwurm, Camps-Valls et al. *IEEE Geoscience and Remote Sensing Magazine*, 2026.
2. **AlphaEarth:** AlphaEarth Foundations: An Embedding Field Model for Accurate and Efficient Global Mapping from Sparse Label Data
Brown, Kazmierski, Pasquarella et al. 2025.
3. **Analysis:** Measuring the Intrinsic Dimension of Earth Representations
Rao, Rußwurm, Klemmer, Rolf. 2025/2026.
4. **SatCLIP:** SatCLIP: Global, General-Purpose Location Embeddings with Satellite Imagery
Klemmer, Rolf, Robinson, Mackey, Rußwurm. *AAAI* 2025, 39(4):4347–4355.
5. **TESSERA:** TESSERA: Temporal Embeddings of Surface Spectra for Earth Representation and Analysis
Feng, Atzberger, Jaffer, Knezevic et al. *CVPR* 2026.

Synthesis: What is an Earth embedding, what information does it contain, and how should we evaluate it?