
# Accurate Interpolation for Scattered Data through Hierarchical Residual Refinement

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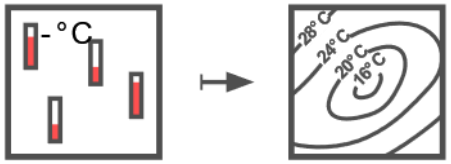
# Scattered data interpolation

- Given $n$ scattered observed points $O = \{(x_i, y_i)\}_{i=1}^{n}$

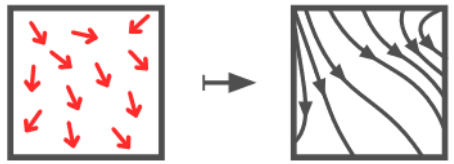
  interpolate $O$ to reconstruct a function $f$

  It is assumed that $f$ belongs to a latent function distribution, denoted by $f \in \mathcal{F}$

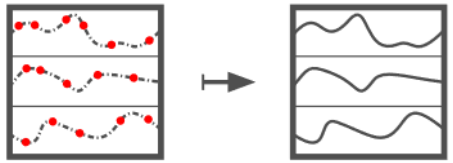
- Wide range of application scenarios




Temperature field reconstruction



Particle tracking velocimetry



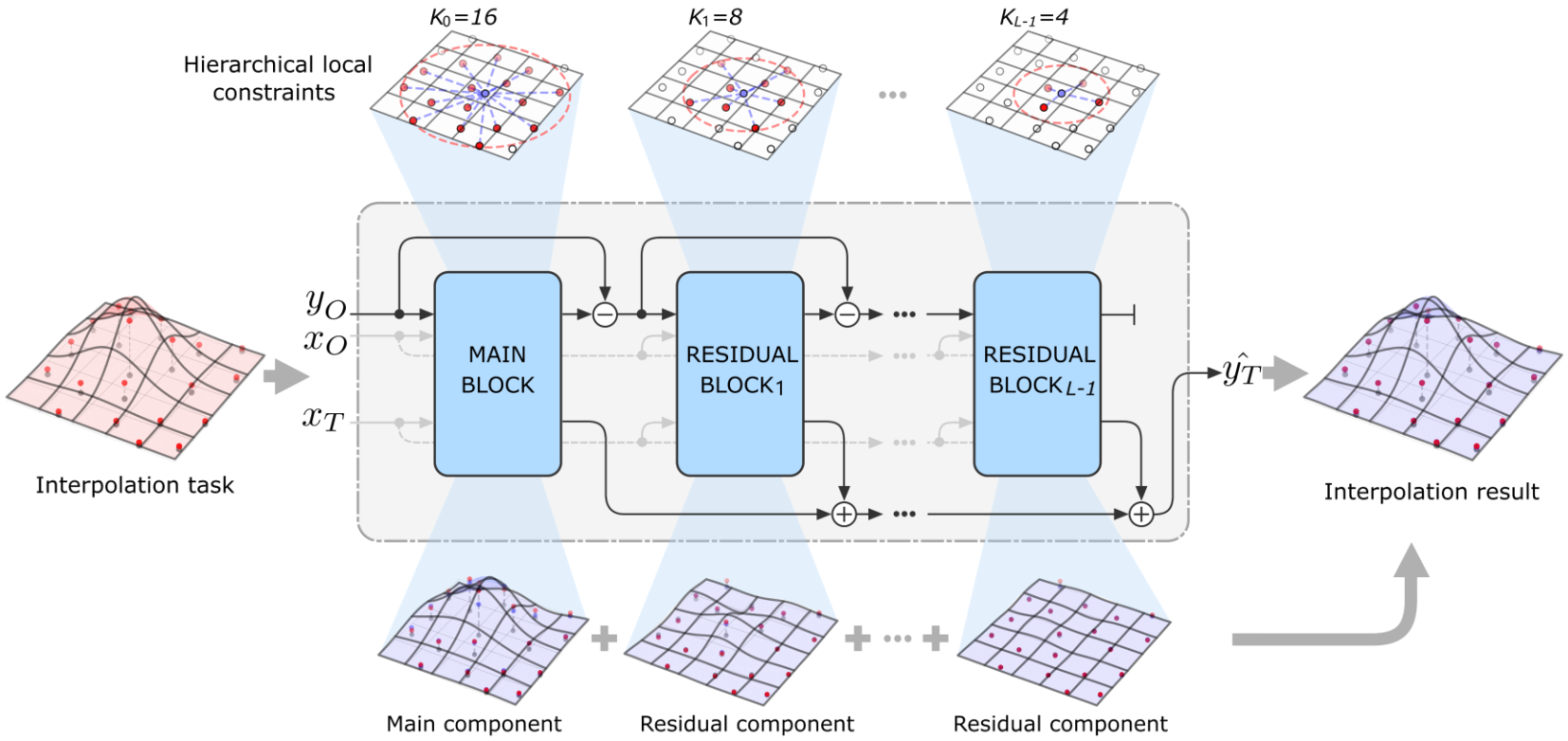
Irregularly-sampled time-series interpolation

*Ding et al. arXiv:2209.09078, 2023.*

# Motivation

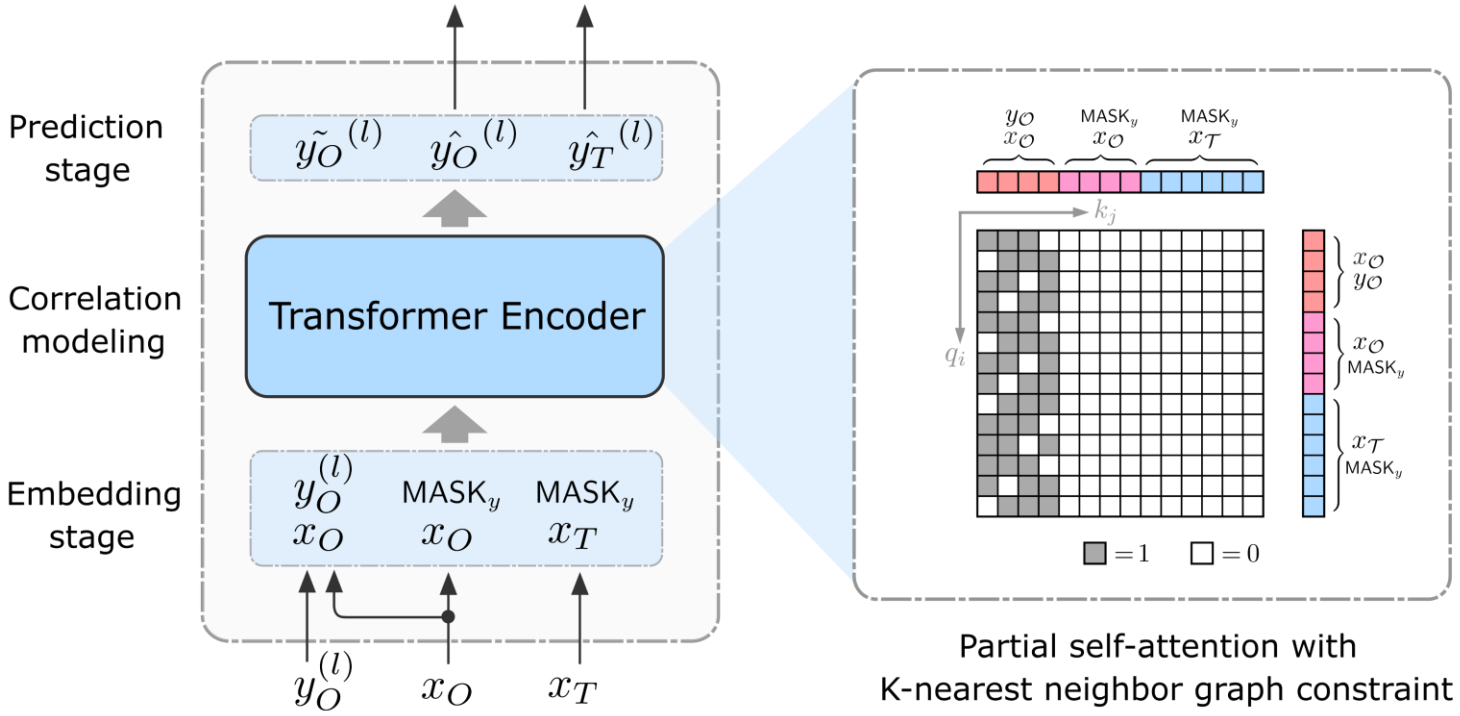
- Existing neural interpolators neglect the information of interpolation residuals
- The interpolation residuals can be progressively and hierarchically exploited

# Our **H**ierarchical **INT**erpolation framework (HINT)




1. Multiple lightweight interpolation block, dual residual linked, utilizing residual of observed points
2. Hierarchical local constraint for better refining residual predictions

# Transformer-based interpolation block




1. Masked Transformer encoder for accurate correlation modeling of scattered points
2. KNN graph mask as local constraint

# Results

- SOTA interpolation accuracy on representative datasets

Table 1: Interpolation accuracy on Mathit dataset.

| Interpolation approach | MSE ($\times 10^{-4}$) on Mathit-2D test set |
|---|---|
| CNP | 24.868 |
| ANP | 14.001 |
| BANP | 8.419 |
| TFR-Transformer | 5.857 |
| NIERT | 3.167 |
| **HINT (ours)** | **2.903** |

↓ 8.34 %

Table 2: Interpolation accuracy on Perlin dataset.

| Interpolation approach | MSE ($\times 10^{-5}$) on Perlin test set |
|---|---|
| CNP | 48.642 |
| ANP | 23.731 |
| BANP | 20.737 |
| TFR-Transformer | 12.101 |
| NIERT | 7.185 |
| **HINT (ours)** | **5.848** |

↓ 18.61 %

Table 3: Interpolation accuracy on PTV dataset.

| Interpolation approach | MSE ($\times 10^{-3}$) on PTV test set |
|---|---|
| CNP | 137.573 |
| ANP | 32.111 |
| BANP | 33.585 |
| TFR-Transformer | 17.125 |
| NIERT | 5.167 |
| **HINT (ours)** | **3.507** |

↓ 32.13 %

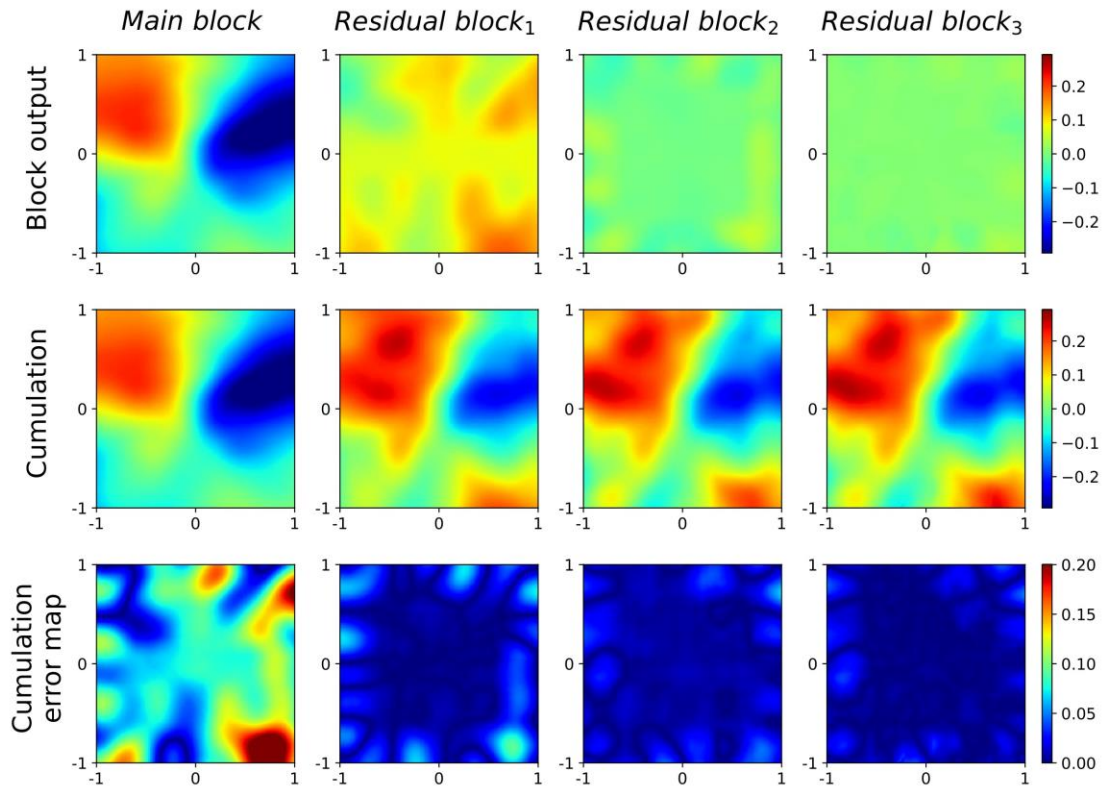
Table 4: Interpolation accuracy on TFRD dataset.

| Interpolation approach | MAE ($\times 10^{-3}$) on TFRD test set | | |
|---|---|---|---|
| | HSink | ADlet | DSine |
| CNP | 204.351 | 91.782 | 92.456 |
| ANP | 164.491 | 54.684 | 58.589 |
| BANP | 59.728 | 28.671 | 19.107 |
| TFR-Transformer | 64.987 | 27.074 | 29.961 |
| NIERT | 23.519 | 3.473 | 8.785 |
| **HINT (ours)** | **13.758** | **1.761** | **4.912** |

↓ 44.96 % on Avg.

# Case study and analysis

- Progressively predict of the main function components and interpolation residuals
- Decouple the function at different scales




Output from each interpolation block on an interpolation task from Perlin dataset

# Conclusion

- We introduce HINT, a novel hierarchical framework for scattered point interpolation
- HINT enhances accuracy using coarse-to-fine interpolation blocks and outperforms SOTA methods

- Paper:

  https://nips.cc/virtual/2023/poster/72636
- Source code:

  https://github.com/DingShizhe/HINT



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# Thanks


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