Adformer: An Adaptive Unified Framework for Multivariate Time Series Forecasting

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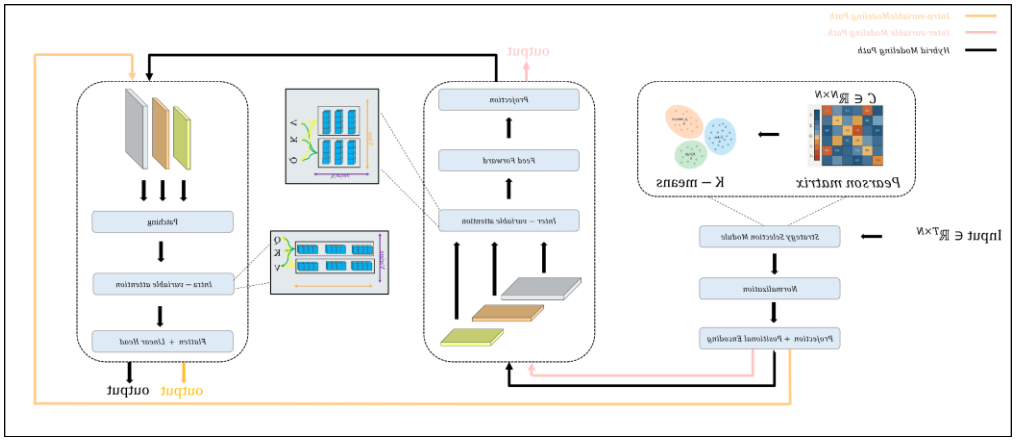
Problems & Ideas

- Problems of conventional forecasting approaches:
  - Existing models use a fixed paradigm (either intra-variable or inter-variable), which fails to adapt to diverse, real-world time series data
  - Conventional loss functions (like MSE) are highly sensitive to high-frequency noise, leading to unstable predictions 。
- Ideas: An adaptive unified framework that uses data-driven strategy selection and a frequency-aware loss function to improve forecasting robustness and accuracy.



The overall architecture of Adformer. A data-driven Strategy Selection Module analyzes the input to dynamically guide the hybrid modeling path, which integrates both inter-variable and intra-variable modeling

Main Contributions

- Contributions:
  - An adaptive unified forecasting framework (Adformer) with a built-in strategy selection module that automatically adjusts its modeling strategy based on the data's intrinsic characteristics.
  - An innovative hybrid modeling architecture that synergistically captures dependencies across both the inter-variable and intra-variable dimensions.
  - A novel frequency-aware loss function that performs adaptive weighted optimization in the frequency domain, effectively improving the model's forecasting robustness in complex, noisy scenarios.

Dataset	Horizon	Adformer		iTransformer		RLinear		PatchTST		Autoformer		FEDformer		DLinear	
		MSE	MAE	MSE	MAE	MSE	MAE	MSE	MAE	MSE	MAE	MSE	MAE	MSE	MAE
ETTh1	96	0.382	0.402	0.386	0.405	0.386	**0.395**	0.414	0.419	0.449	0.459	**0.376**	0.419	0.386	0.400
	192	0.436	0.429	0.441	0.436	0.437	**0.424**	0.460	0.445	0.500	0.482	**0.420**	0.448	0.437	0.432
	336	0.470	**0.443**	0.487	0.458	0.479	0.446	0.501	0.466	0.521	0.496	**0.459**	0.465	0.481	0.459
	720	**0.475**	**0.469**	0.503	0.491	0.481	0.470	0.500	0.488	0.514	0.512	0.506	0.507	0.519	0.516
	Avg	0.441	0.436	0.454	0.447	0.446	**0.434**	0.469	0.454	0.496	0.487	**0.440**	0.460	0.456	0.452
ETTh2	96	0.289	**0.338**	0.297	0.349	**0.288**	**0.338**	0.302	0.348	0.346	0.388	0.358	0.397	0.333	0.387
	192	**0.372**	0.391	0.380	0.400	0.374	**0.390**	0.388	0.400	0.456	0.452	0.429	0.439	0.477	0.476
	336	**0.397**	**0.420**	0.428	0.432	0.415	0.426	0.426	0.433	0.482	0.486	0.496	0.487	0.594	0.541
	720	**0.418**	**0.437**	0.427	0.445	0.420	0.440	0.431	0.446	0.515	0.511	0.463	0.474	0.831	0.657
	Avg	**0.369**	**0.397**	0.383	0.407	0.374	0.398	0.387	0.407	0.450	0.459	0.437	0.449	0.559	0.515
ETTm1	96	**0.318**	**0.352**	0.334	0.368	0.355	0.376	0.329	0.367	0.505	0.475	0.379	0.419	0.345	0.372
	192	**0.363**	**0.381**	0.377	0.391	0.391	0.392	0.367	0.385	0.553	0.496	0.426	0.441	0.380	0.389
	336	**0.385**	**0.399**	0.426	0.420	0.424	0.415	0.399	0.410	0.621	0.537	0.445	0.459	0.413	0.413
	720	**0.442**	**0.438**	0.491	0.459	0.487	0.450	0.454	0.439	0.671	0.561	0.543	0.490	0.474	0.453
	Avg	**0.377**	**0.393**	0.407	0.410	0.414	0.407	0.387	0.400	0.588	0.517	0.448	0.452	0.403	0.407
ETTm2	96	**0.168**	**0.249**	0.180	0.264	0.182	0.265	0.175	0.259	0.255	0.339	0.203	0.287	0.193	0.292
	192	**0.238**	**0.296**	0.250	0.309	0.246	0.304	0.241	0.302	0.281	0.340	0.269	0.328	0.284	0.362
	336	**0.300**	**0.336**	0.311	0.348	0.307	0.342	0.305	0.343	0.339	0.372	0.325	0.366	0.369	0.427
	720	**0.395**	**0.392**	0.412	0.407	0.407	0.398	0.402	0.400	0.433	0.432	0.421	0.415	0.554	0.522
	Avg	**0.275**	**0.318**	0.288	0.332	0.286	0.327	0.281	0.326	0.327	0.371	0.305	0.349	0.350	0.401
Weather	96	**0.157**	**0.201**	0.174	0.214	0.192	0.232	0.177	0.218	0.266	0.336	0.217	0.296	0.196	0.255
	192	**0.208**	**0.248**	0.221	0.254	0.240	0.271	0.225	0.259	0.307	0.367	0.276	0.336	0.237	0.296
	336	**0.264**	**0.291**	0.278	0.296	0.292	0.307	0.278	0.297	0.359	0.395	0.339	0.380	0.283	0.335
	720	**0.338**	**0.342**	0.358	0.347	0.364	0.353	0.354	0.348	0.419	0.428	0.403	0.428	0.345	0.381
	Avg	**0.242**	**0.271**	0.258	0.278	0.272	0.291	0.259	0.281	0.338	0.382	0.309	0.360	0.265	0.317
Electricity	96	**0.138**	**0.229**	0.148	0.240	0.201	0.281	0.181	0.270	0.201	0.317	0.193	0.308	0.197	0.282
	192	**0.158**	**0.250**	0.162	0.253	0.201	0.283	0.188	0.274	0.222	0.334	0.201	0.315	0.196	0.285
	336	**0.172**	**0.264**	0.178	0.269	0.215	0.298	0.204	0.293	0.231	0.338	0.214	0.329	0.209	0.301
	720	**0.216**	**0.300**	0.225	0.317	0.257	0.331	0.246	0.324	0.254	0.361	0.246	0.355	0.245	0.333
	Avg	**0.171**	**0.261**	0.178	0.270	0.219	0.298	0.205	0.290	0.227	0.338	0.214	0.327	0.212	0.300
Traffic	96	**0.392**	**0.263**	0.395	0.268	0.649	0.389	0.462	0.295	0.613	0.388	0.587	0.366	0.650	0.396
	192	**0.412**	**0.271**	0.417	0.276	0.601	0.366	0.466	0.296	0.616	0.382	0.604	0.373	0.598	0.370
	336	**0.426**	**0.279**	0.433	0.283	0.609	0.369	0.482	0.304	0.622	0.377	0.621	0.383	0.605	0.373
	720	**0.463**	**0.299**	0.467	0.302	0.647	0.387	0.514	0.322	0.660	0.408	0.626	0.382	0.645	0.394
	Avg	**0.423**	**0.278**	0.428	0.282	0.626	0.378	0.481	0.304	0.628	0.389	0.610	0.376	0.625	0.383
Solar	96	**0.179**	**0.217**	0.203	0.237	0.322	0.339	0.234	0.286	0.884	0.711	0.242	0.342	0.290	0.378
	192	**0.217**	**0.254**	0.233	0.261	0.359	0.356	0.267	0.310	0.834	0.692	0.285	0.380	0.320	0.398
	336	**0.243**	**0.275**	0.248	0.273	0.397	0.369	0.290	0.315	0.941	0.723	0.282	0.376	0.353	0.415
	720	0.262	0.288	**0.249**	**0.275**	0.397	0.356	0.289	0.317	0.882	0.717	0.357	0.427	0.356	0.413
	Avg	**0.225**	**0.259**	0.233	0.262	0.369	0.356	0.270	0.307	0.885	0.711	0.291	0.381	0.330	0.401

Adformer (underlined) achieves state-of-the-art performance (lower MSE/MAE is better) against strong baselines across eight benchmark datasets, validating its adaptive approach