Understanding Transformers for Time Series: Rank Structure, Flow-of-ranks, and Compressibility

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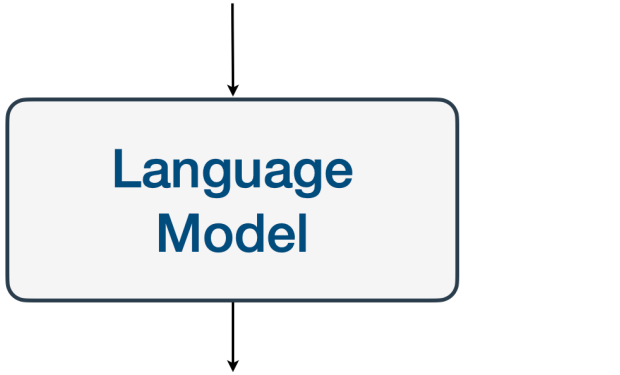
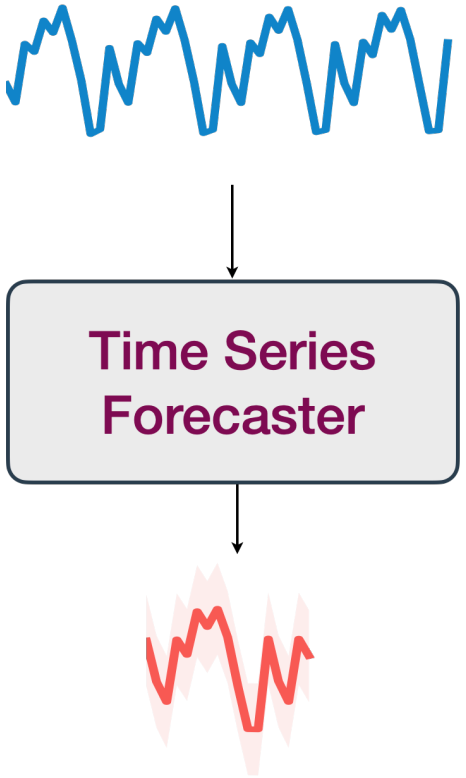
Introduction

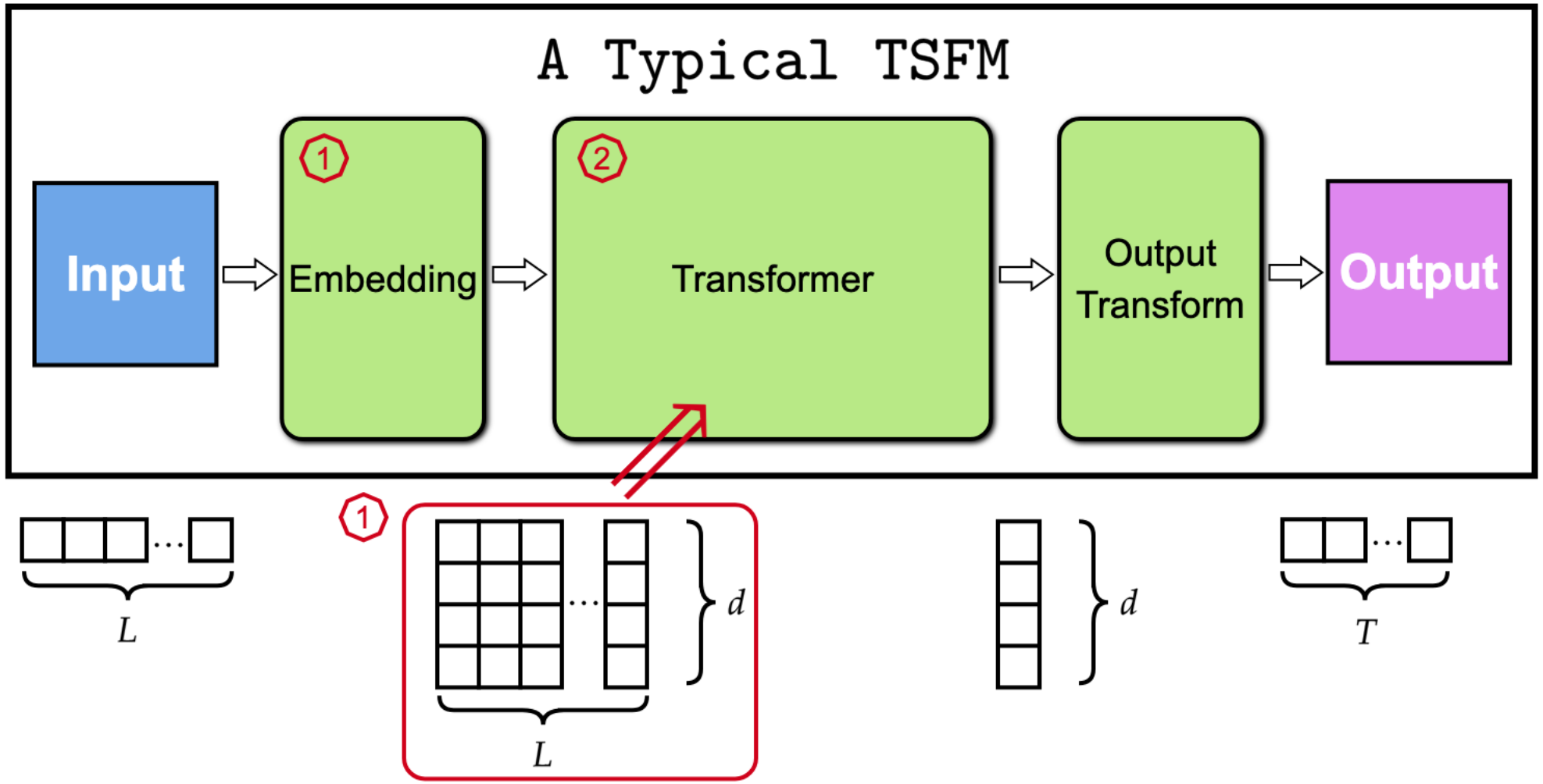
“Three Rings for the Elven-kings under the sky,
Seven for the Dwarf-lords in their halls of stone,
Nine for Mortal Men doomed to die,
One for the Dark Lord on his dark throne
In the Land of Mordor where the Shadows lie.”



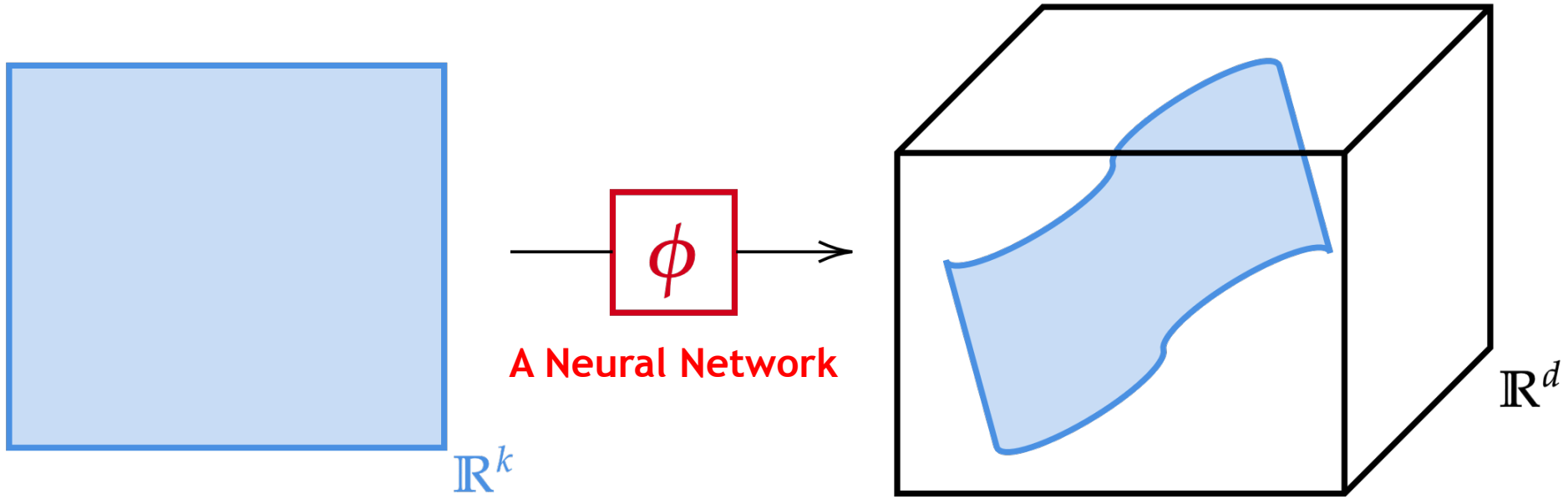
“One Ring to rule them all, One Ring to find them,
One Ring to bring them all and in the darkness bind them
In the Land of Mordor where the Shadows lie.”



A Typical TSFM



Low-rank Embeddings



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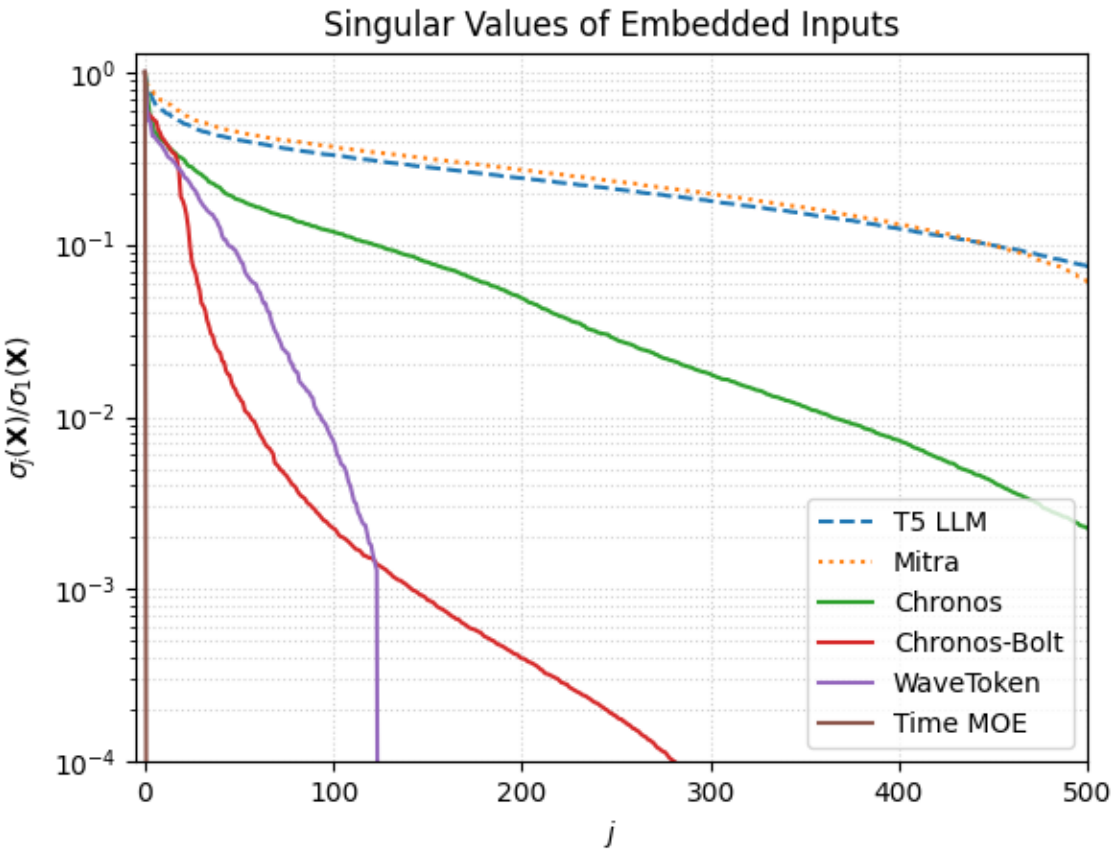
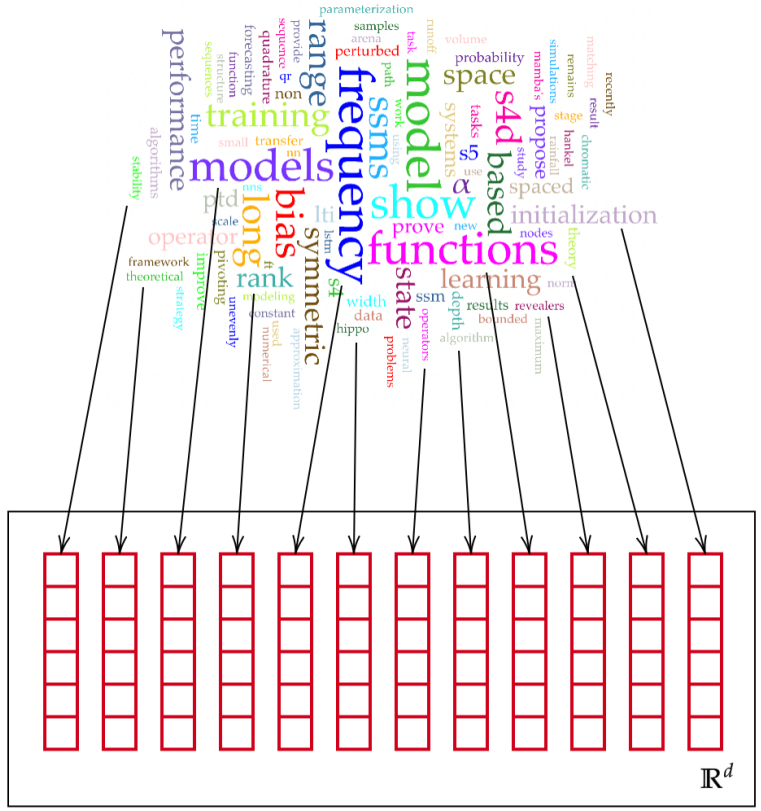
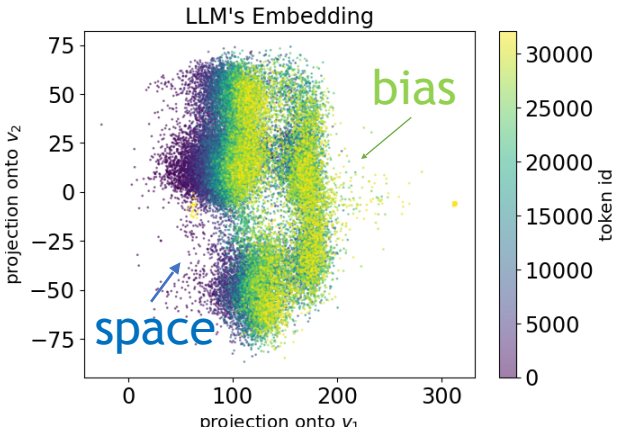
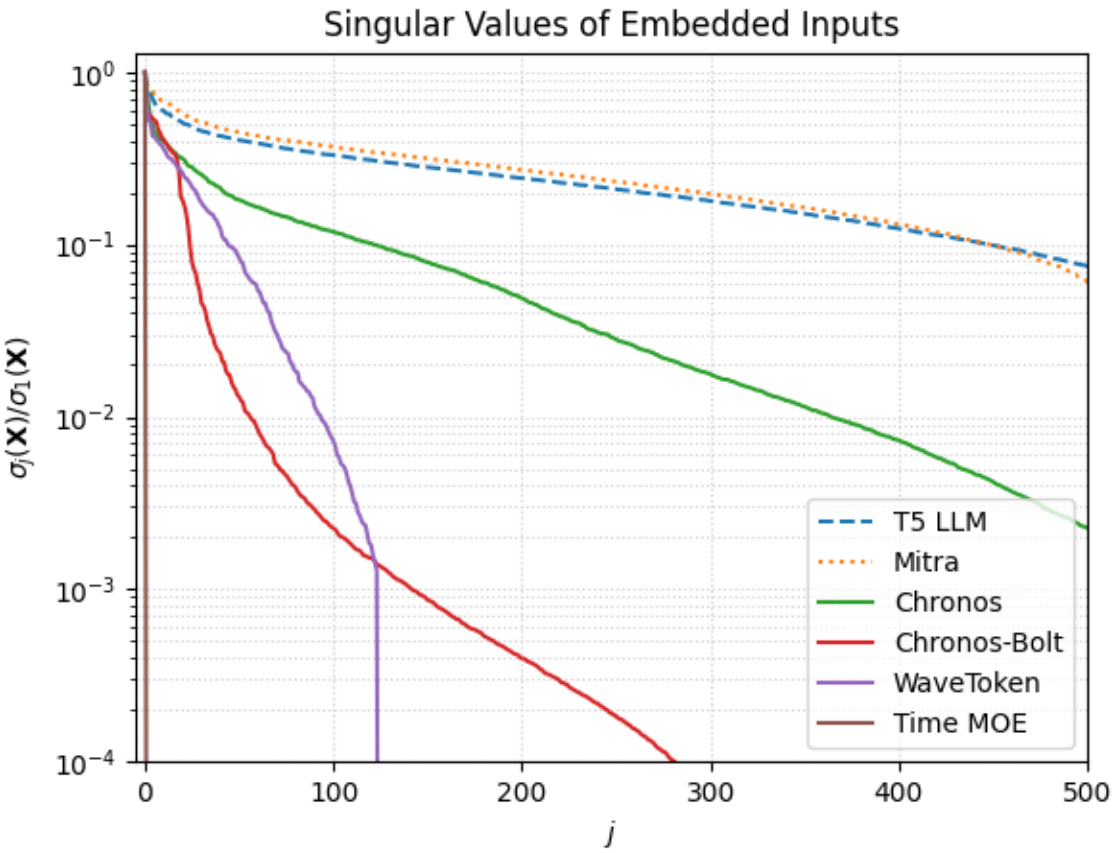
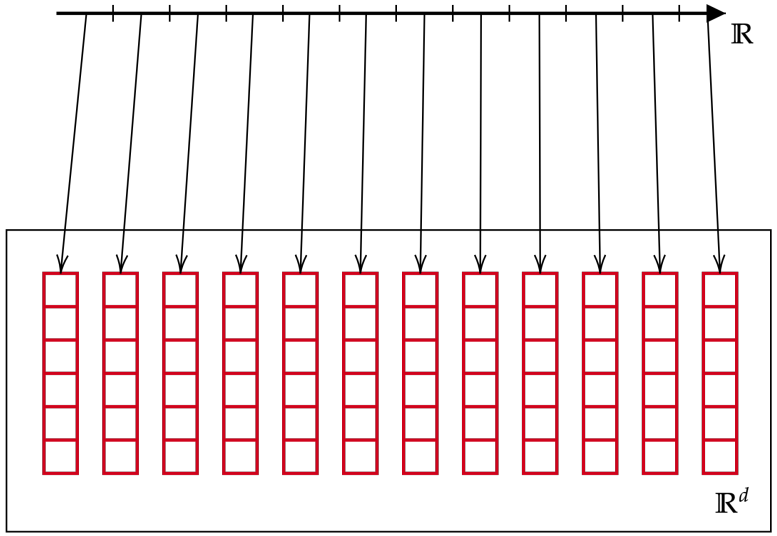


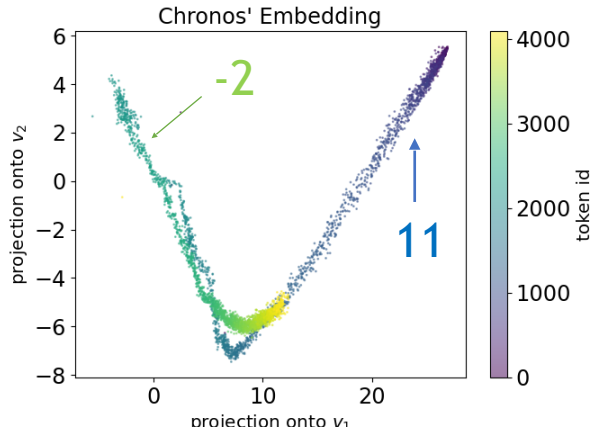




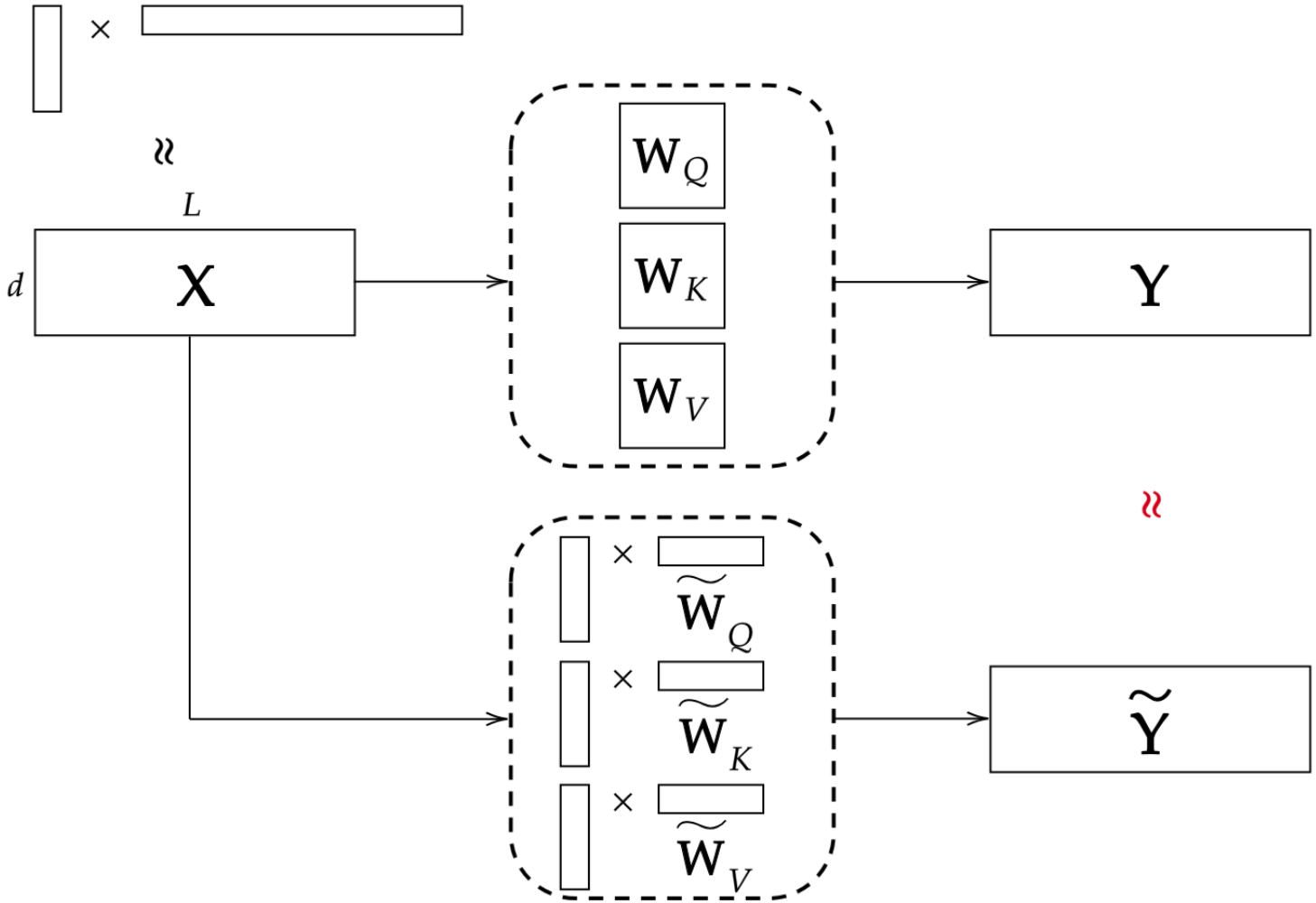
Low-rank Embeddings



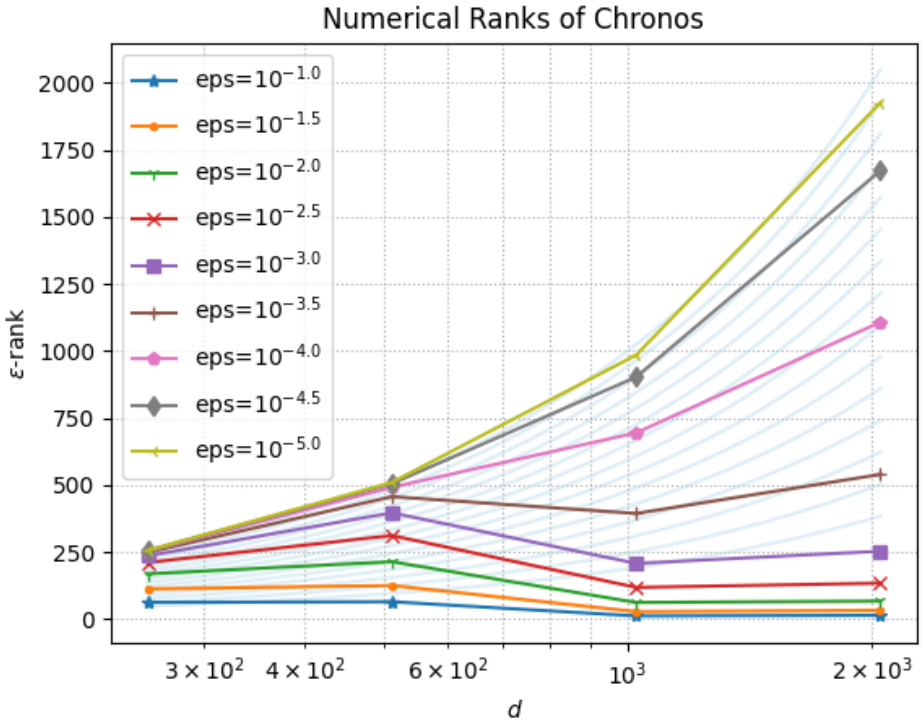


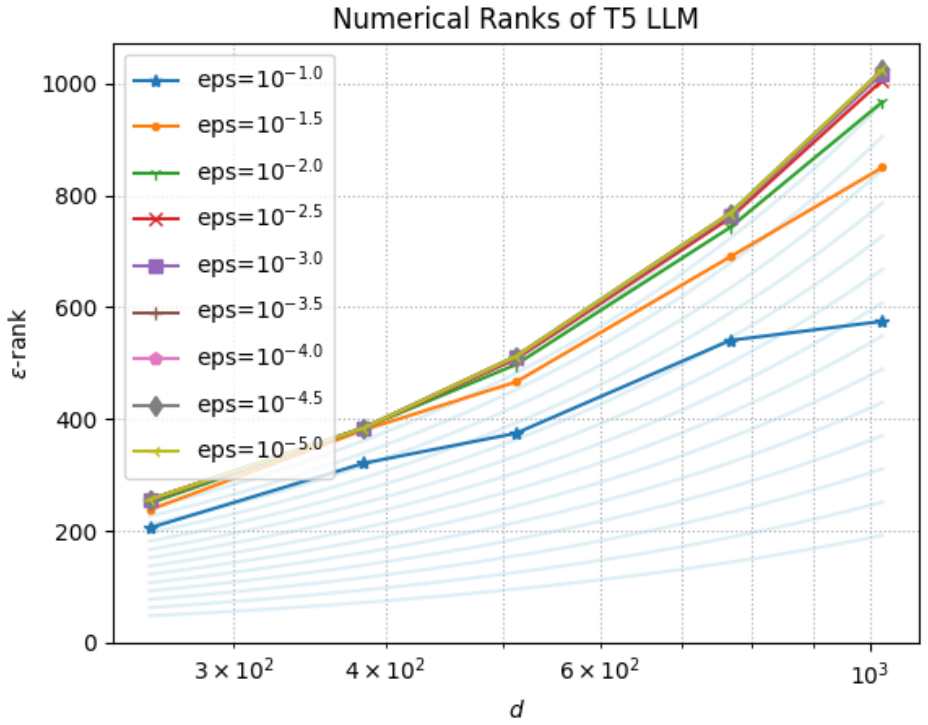


From Low-rank Inputs to Low-rank Attention



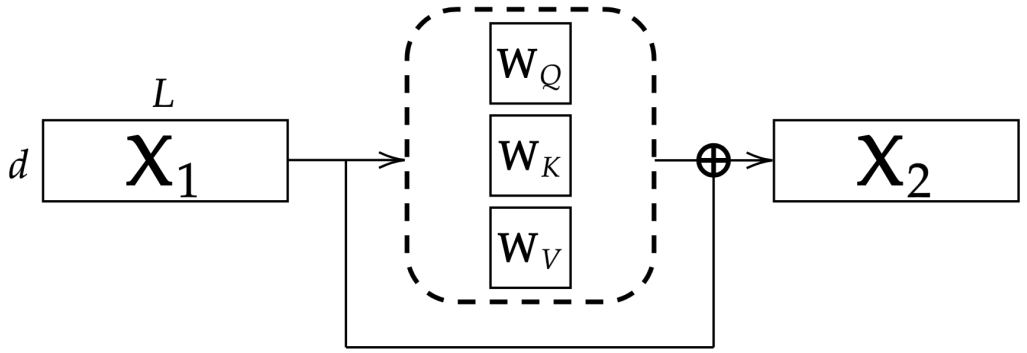
From Low-rank Inputs to Low-rank Attention



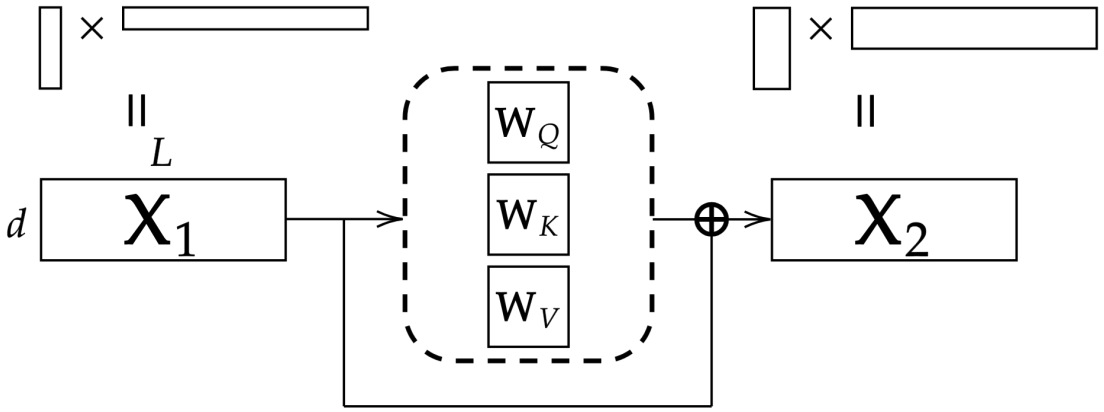


- TSFMs have low-rank attention matrices, but LLMs don’t.

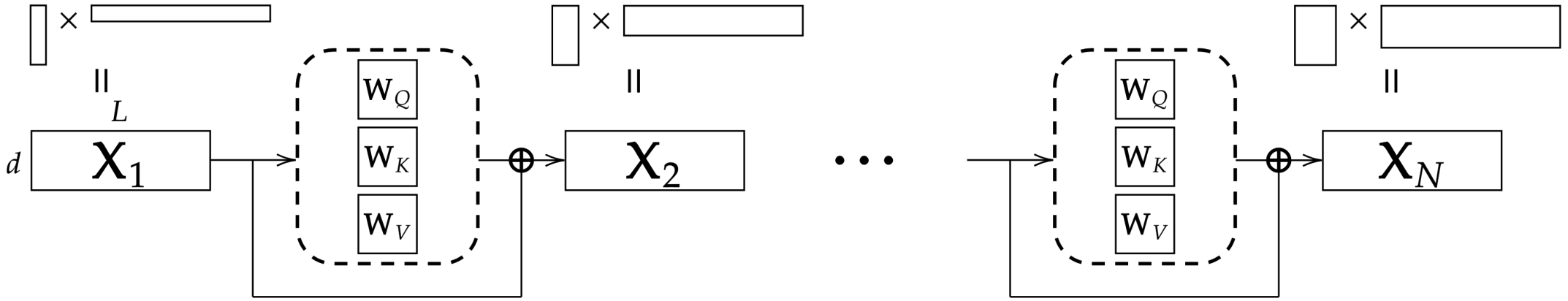
Flow of Ranks



Flow of Ranks



Flow of Ranks



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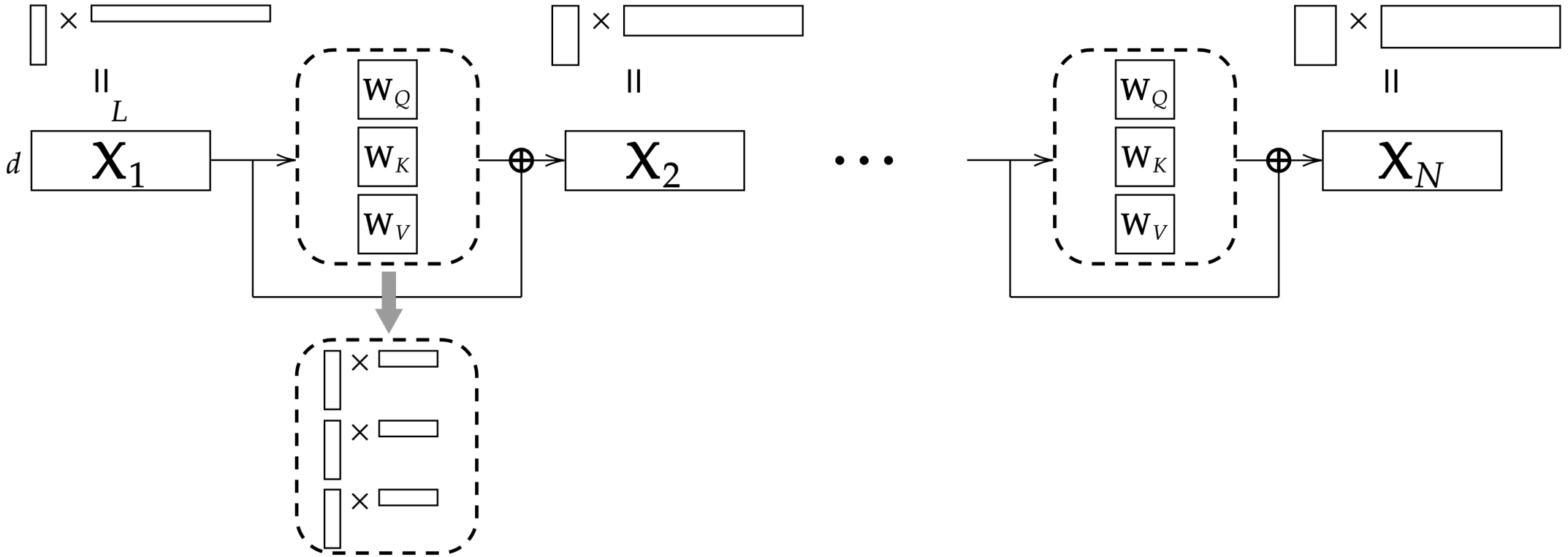

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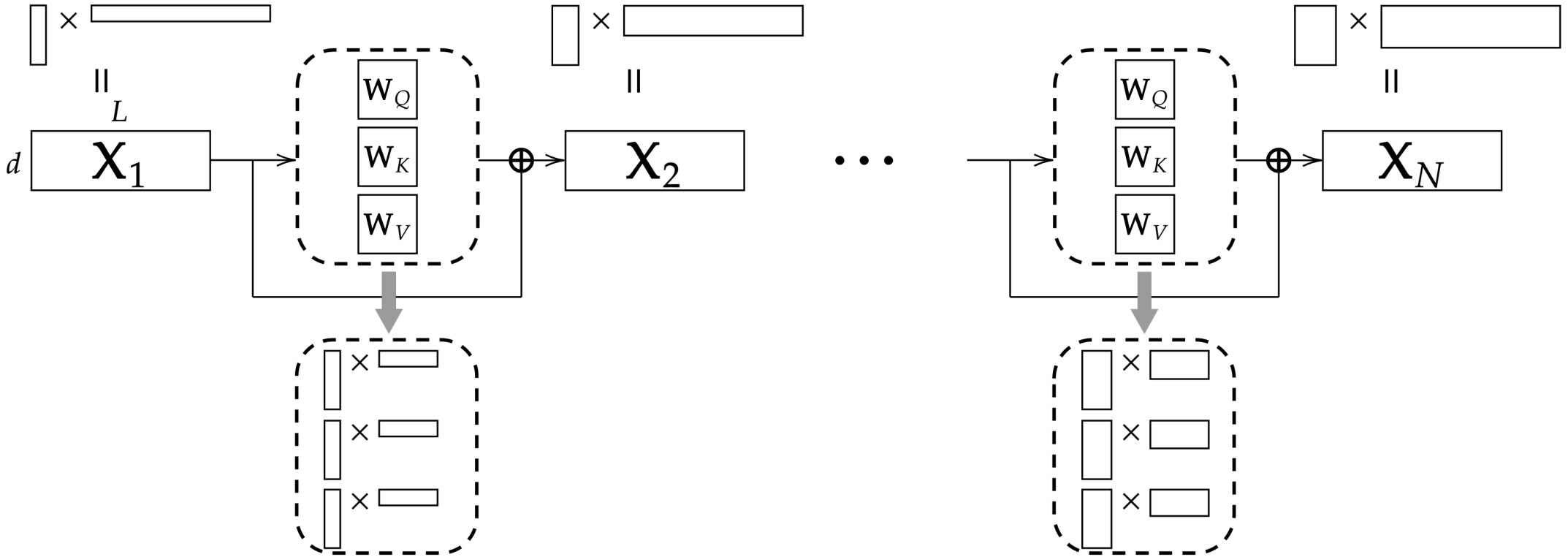

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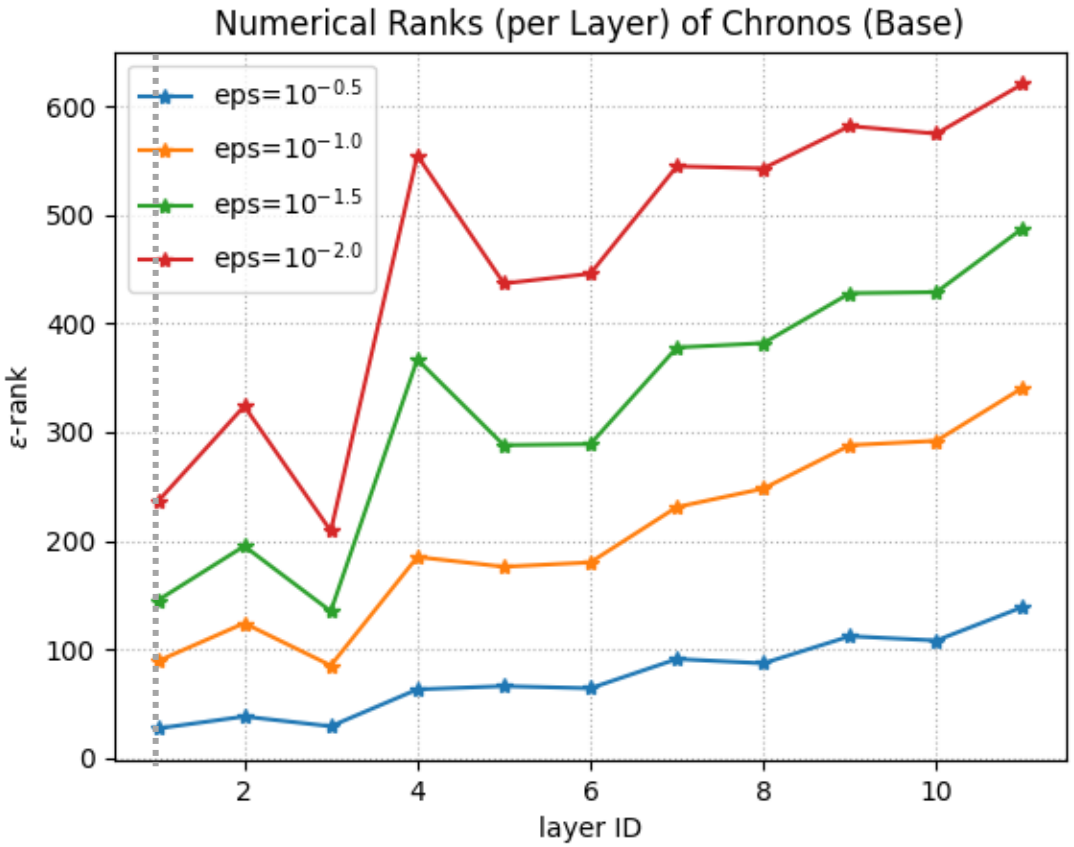
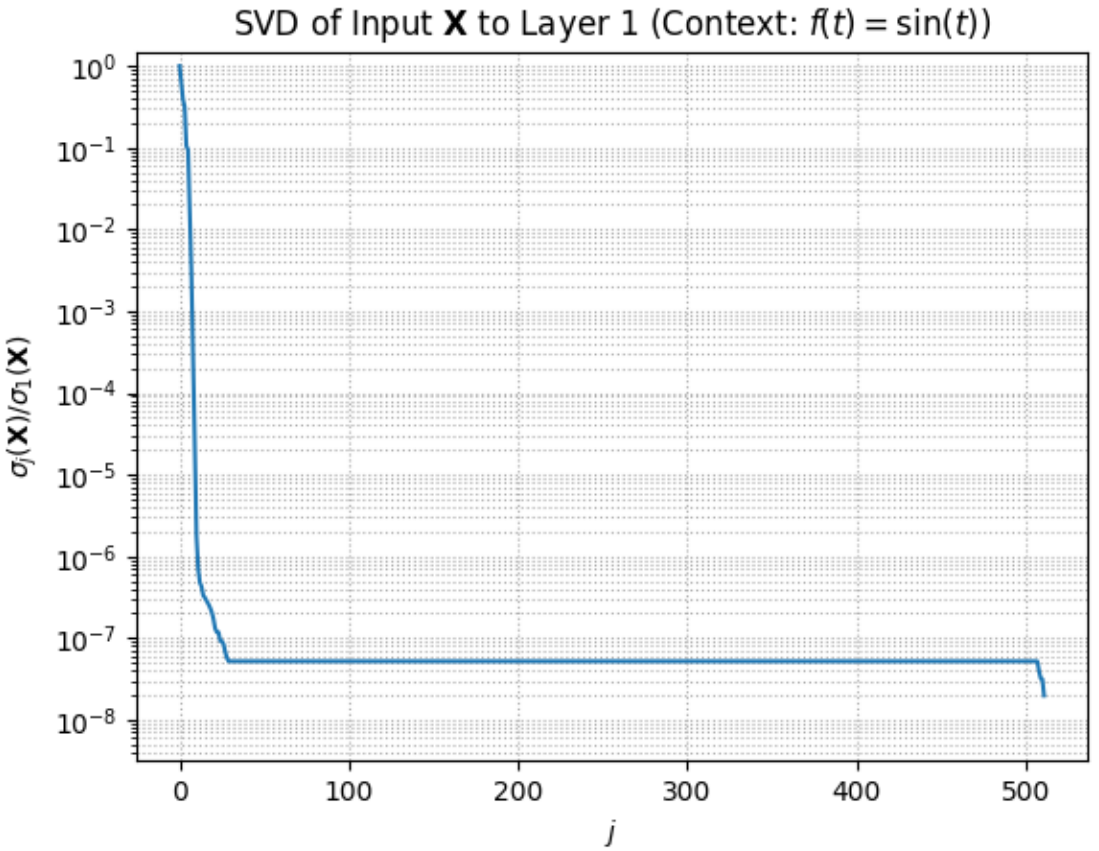
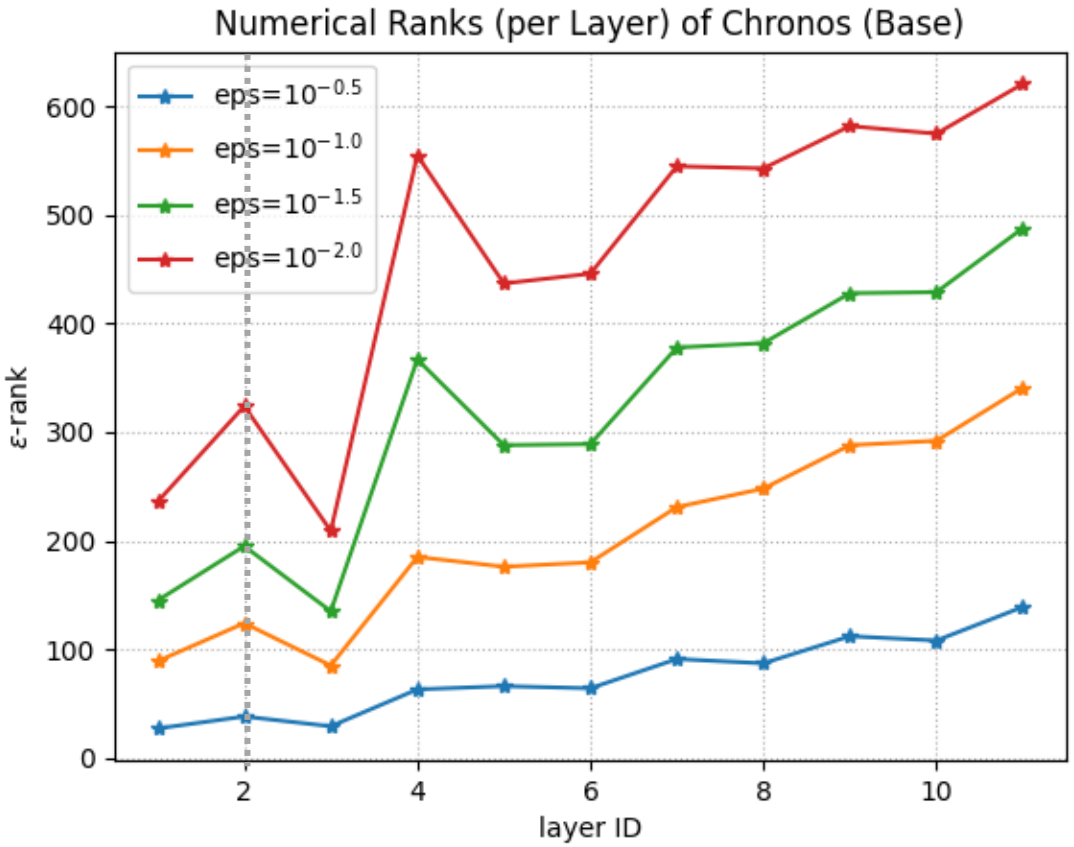
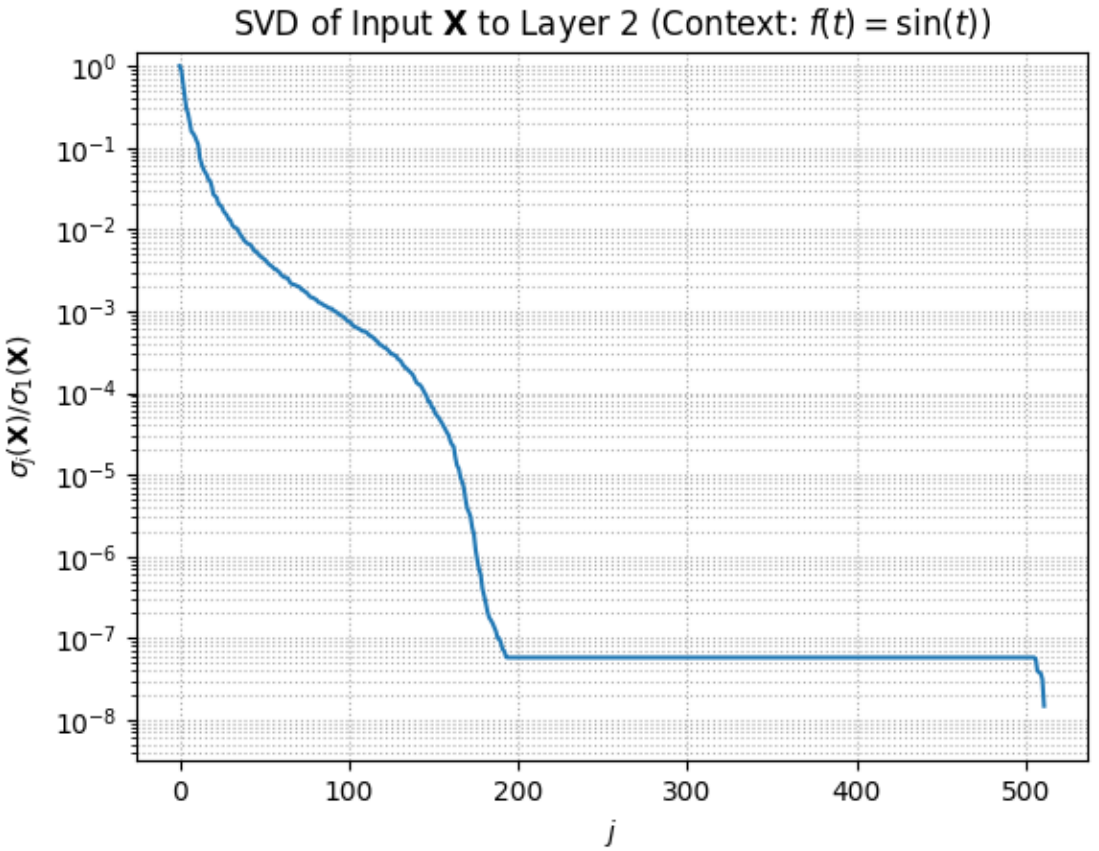


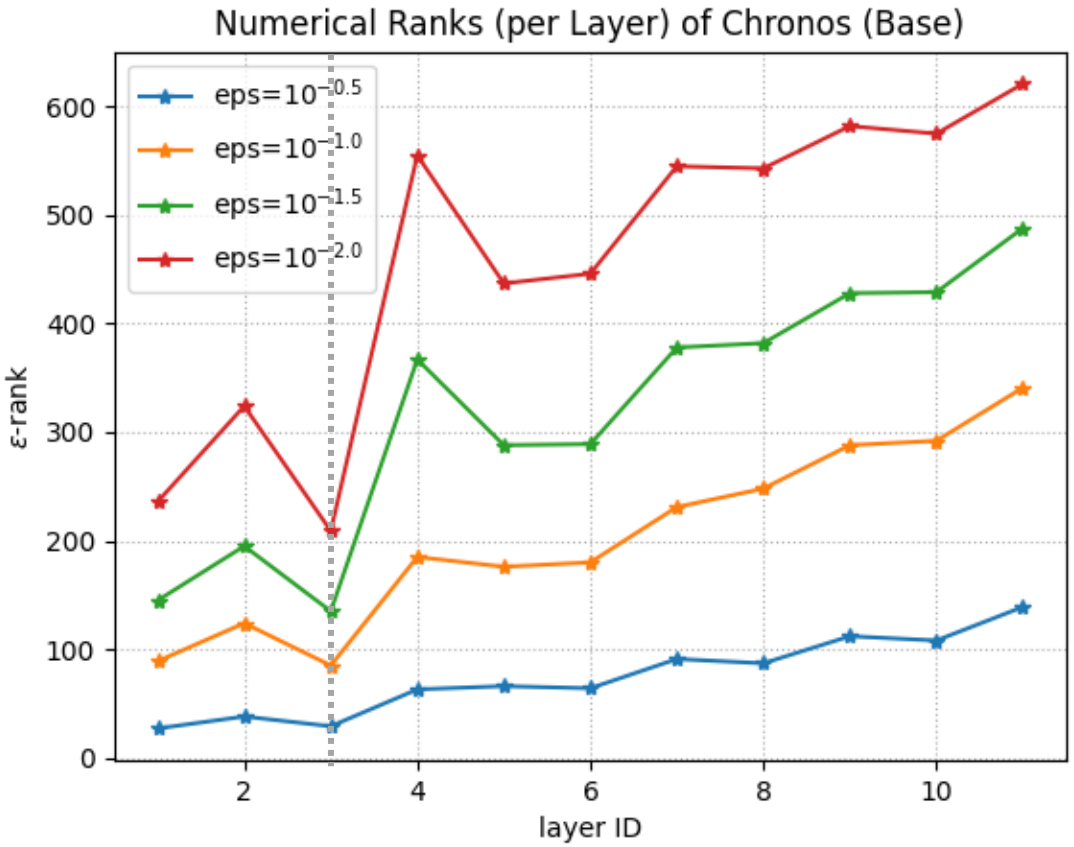


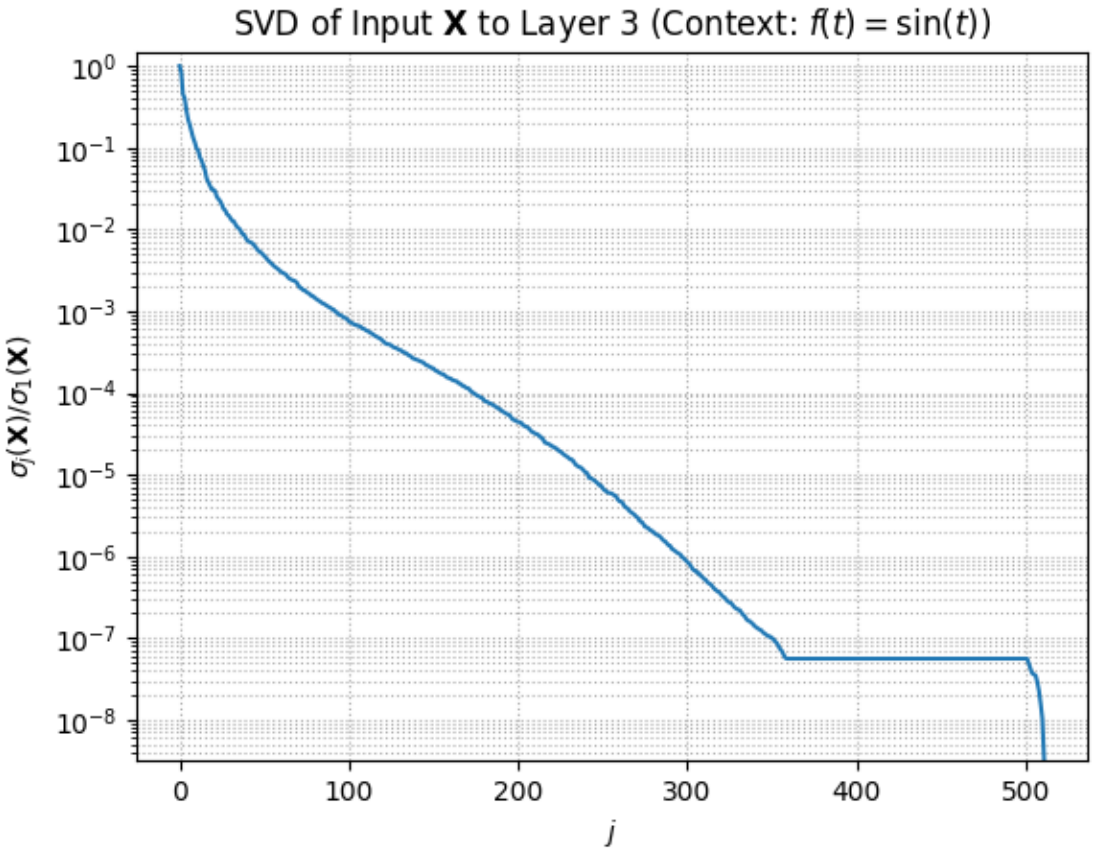
Flow of Ranks



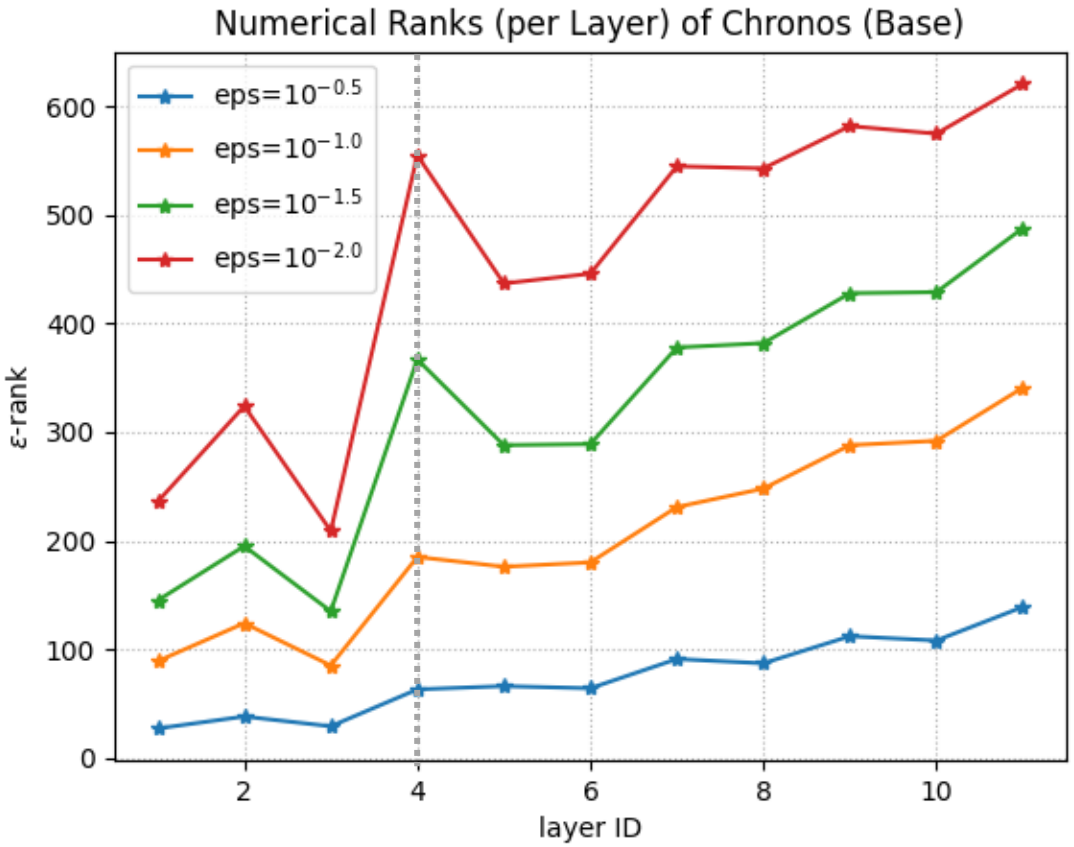


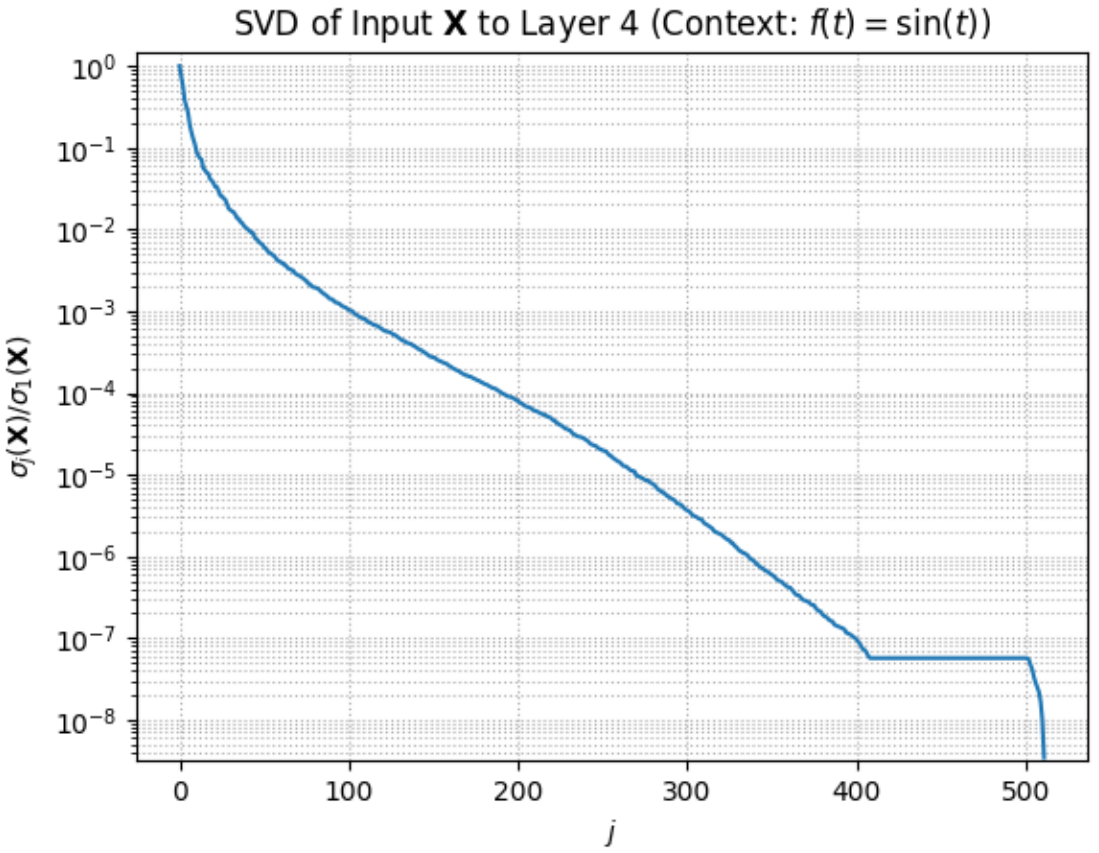
Flow of Ranks



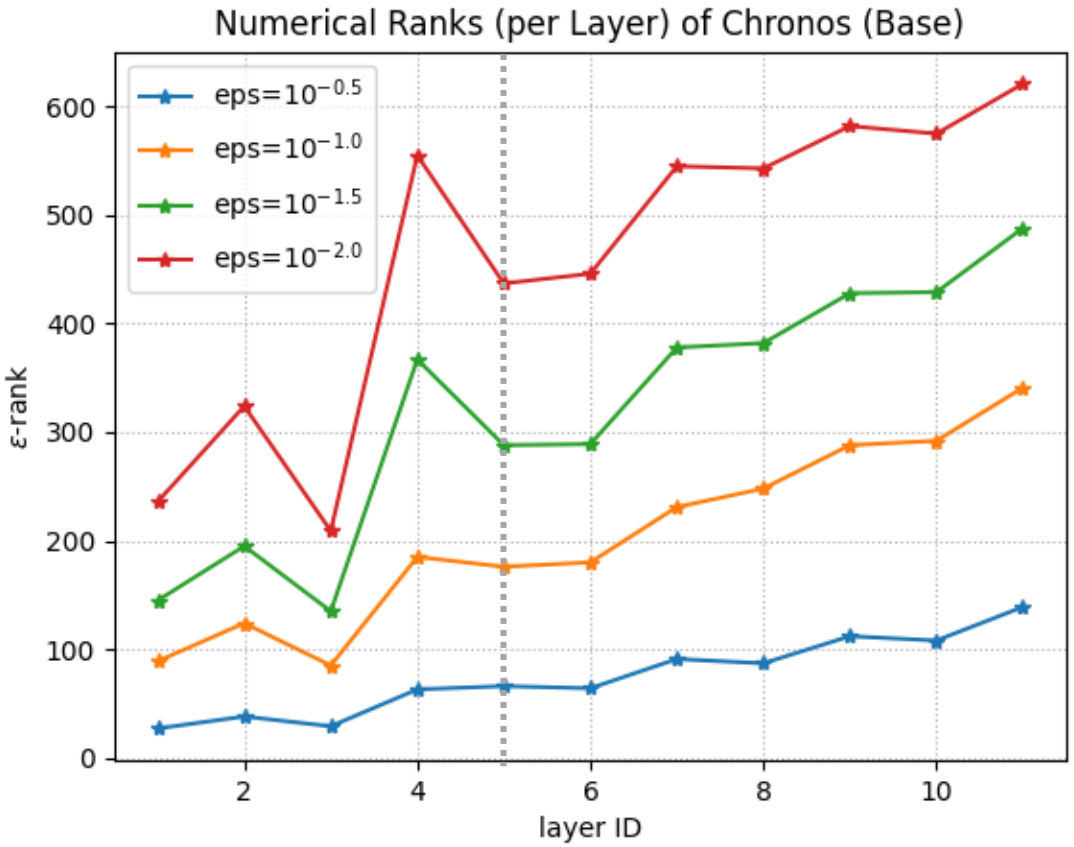


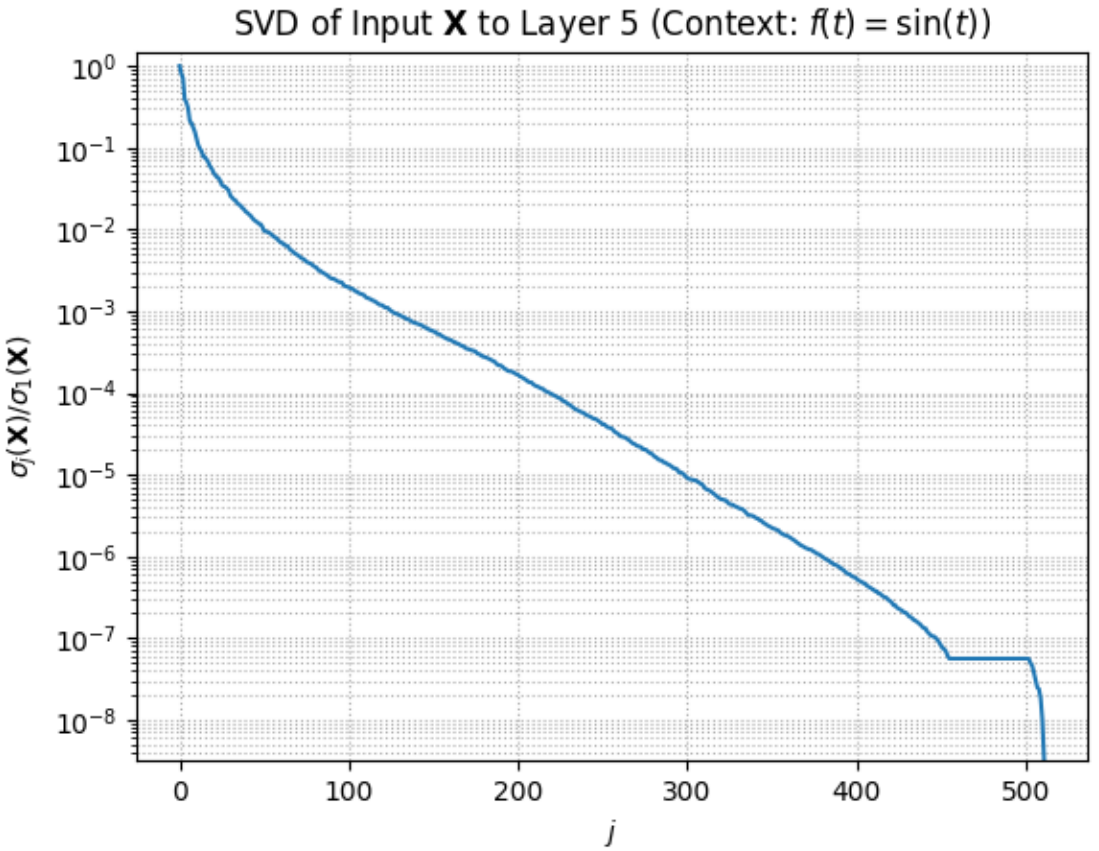
Flow of Ranks





Flow of Ranks





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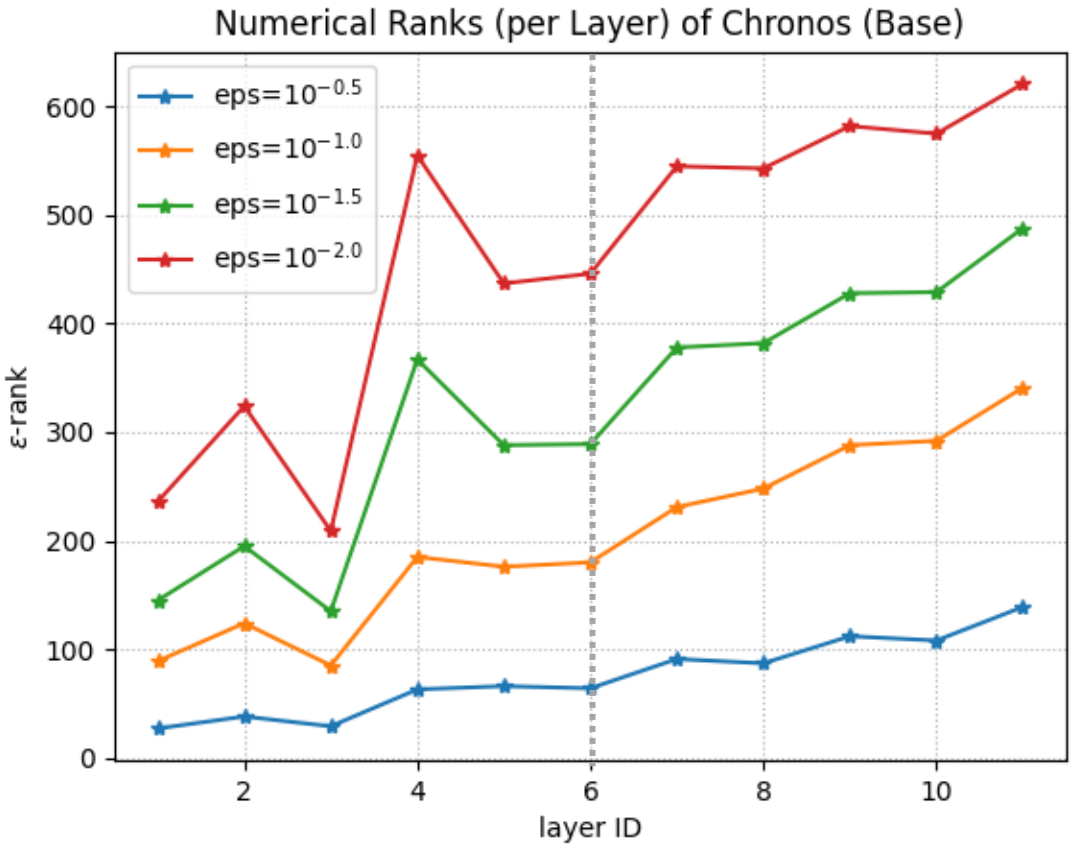
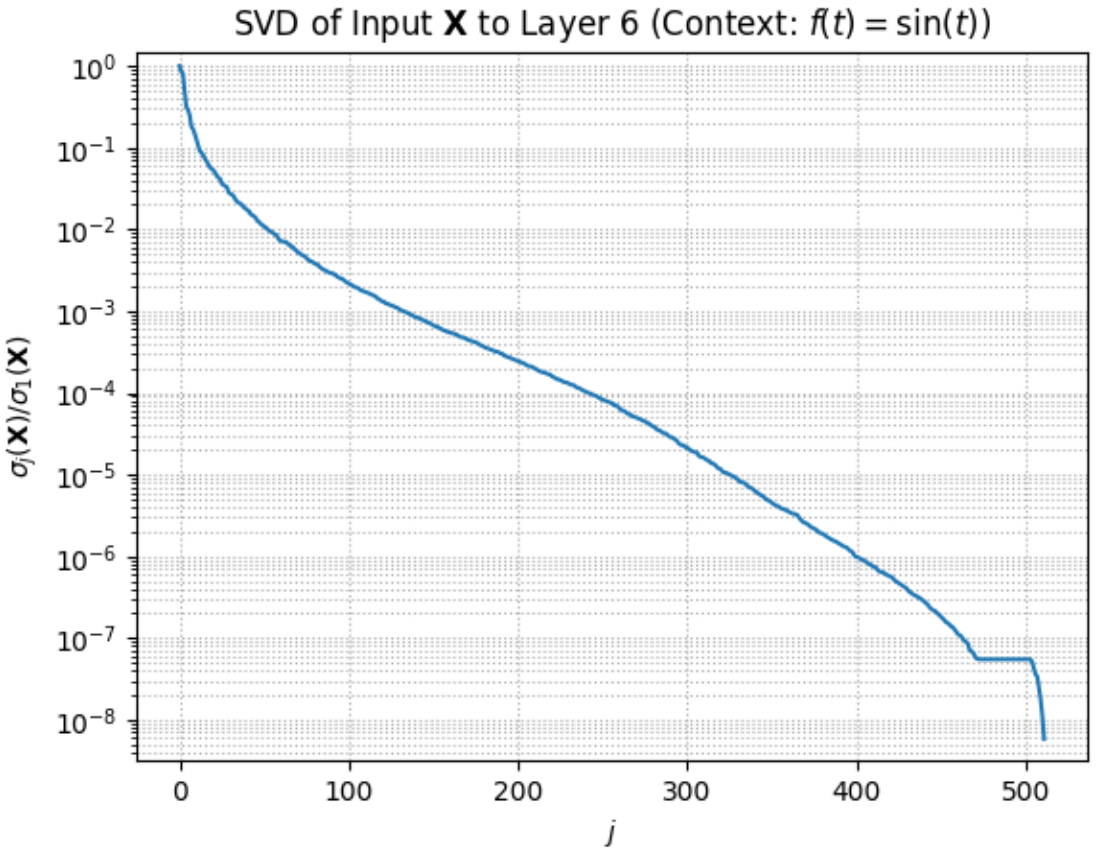
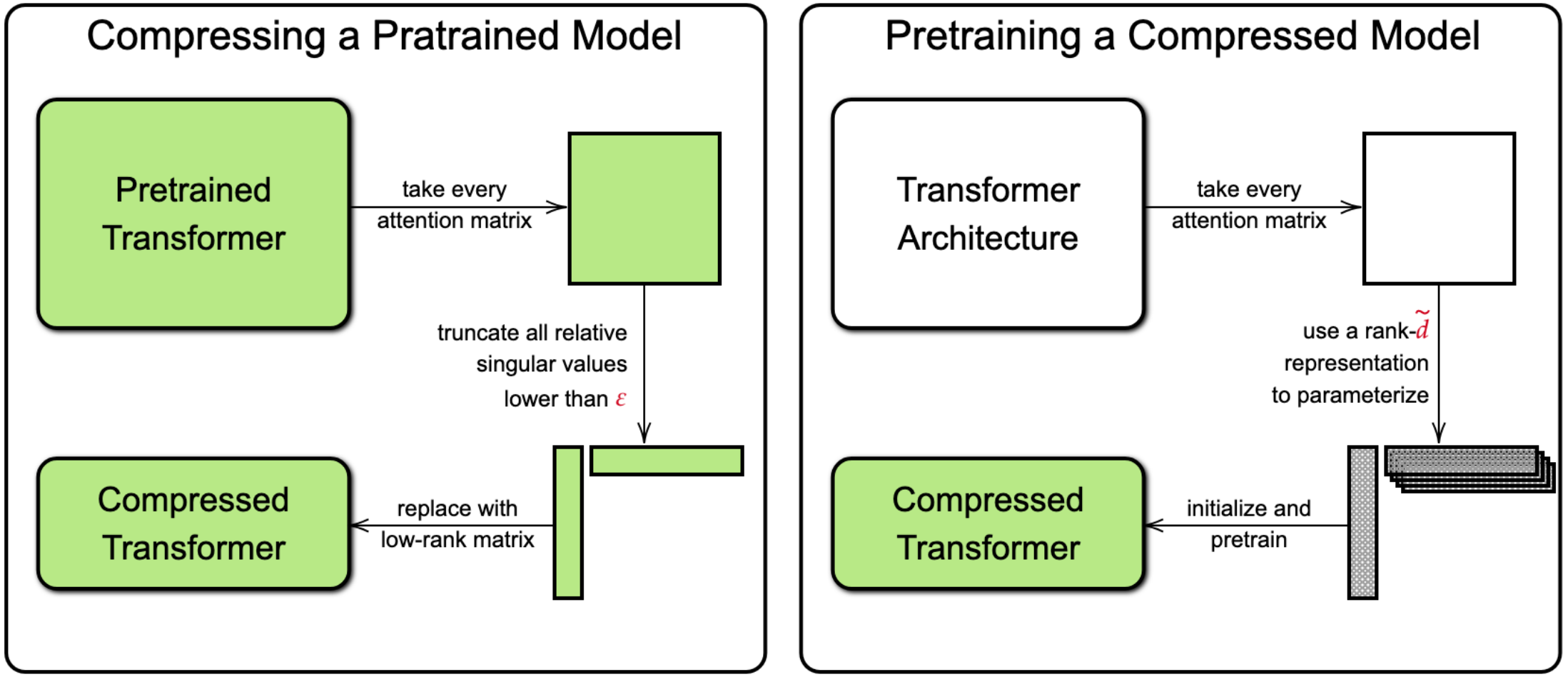




Compressibility of TSFMs



Compressing Chronos reduces its inference time by 65% and its memory requirement by 81%, without loss of accuracy. More results (on Moirai, Chronos-Bolt, etc.) are found in our paper!