ETDock: An Equivariant Transformer for Protein-Ligand Docking

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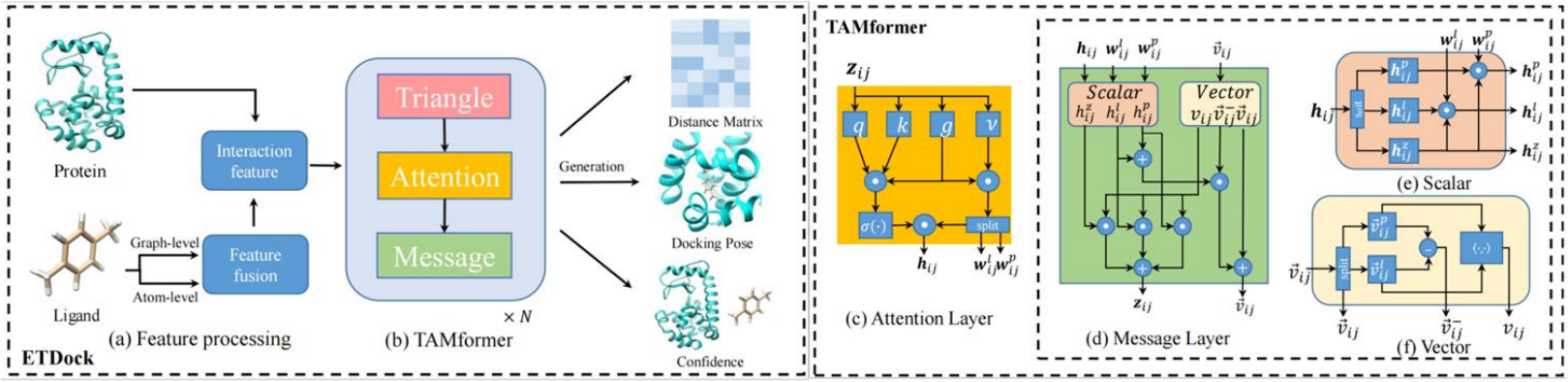
Problems & Ideas

- Problems of Previous approaches:
  - Traditional docking methods are computationally expensive and inefficient for large-scale screening.
  - Deep learning docking models ignore the topological and structural features of ligands.
- Ideas: Equivariant Transformer Docking (ETDock), a molecular docking framework that effectively integrates equivariant transformations with graph-based structural features to enhance prediction accuracy and structural consistency.



Overall architecture of the ETDock model. (a) The feature processing module fuses atom-level and graph-level features of ligands, and computes the interaction features between ligands and proteins; (b) TAMformer consists of triangle layer, attention layer (c), and message layer (d) which includes scalar module (e) and vector module (f).

Main Contributions

- Contributions:
  - We design a feature fusion module to integrate both atom-level and graph-level features, enabling the model to capture molecular flexibility more effectively;
  - We develop a message layer that integrates scalar and equivariant vector information from ligands, proteins, and their interactions;
  - We propose an equivariant Transformer framework that combines chemical features with 3D geometric information to predict docking poses.

	LIGAND RMSD						CENTROID DISTANCE					
	Percentiles ↓				%Below Threshold ↑		Percentiles ↓				%Below Threshold ↑	
Methods	25%	50%	75%	Mean	2 Å	5 Å	25%	50%	75%	Mean	2 Å	5 Å
VINA	5.7	10.7	21.4	14.7	5.5	21.2	1.9	6.2	20.1	12.1	26.5	47.1
SMINA	3.8	8.1	17.9	12.1	13.5	33.9	1.3	3.7	16.2	9.8	38.0	55.9
QVINA-W	2.5	7.7	23.7	13.6	20.9	40.2	0.9	3.7	22.9	11.9	41.0	54.6
GNINA	2.8	8.7	22.1	13.3	21.2	37.1	1.0	4.5	21.2	11.5	36.0	52.0
GLIDE	2.6	9.3	28.1	16.2	21.8	33.6	0.8	5.6	26.9	14.4	36.1	48.7
EquiBind	3.9	6.3	10.5	8.3	4.1	40.2	1.2	2.7	6.9	5.5	40.2	69.7
TankBind	2.5	4.4	8.4	7.9	19.0	56.4	0.8	1.7	4.4	5.8	55.3	77.4
DiffDock	2.4	4.9	8.4	8.3	19.3	51.7	0.7	1.8	4.5	5.8	53.8	77.4
ETDock	**2.1**	**3.8**	**7.7**	**7.4**	**23.2**	**61.1**	**0.7**	**1.4**	**3.8**	**5.5**	**59.1**	**79.3**

Experimental results on the PDBbindv2020 dataset.