User Profiling through Deep Multimodal Fusion

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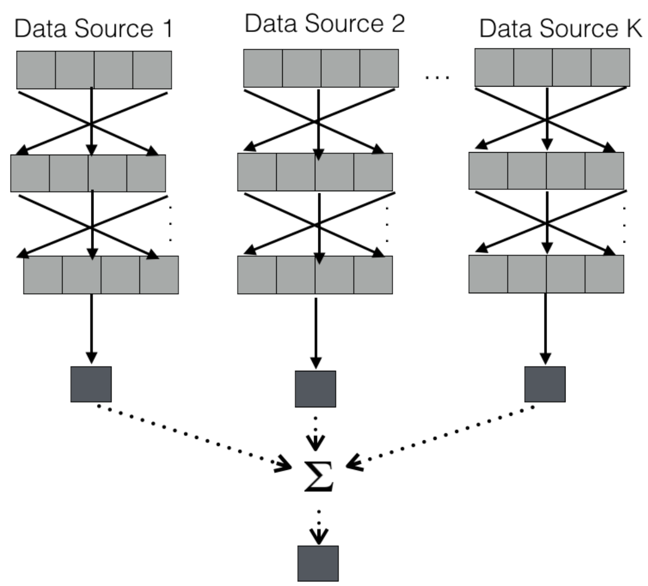
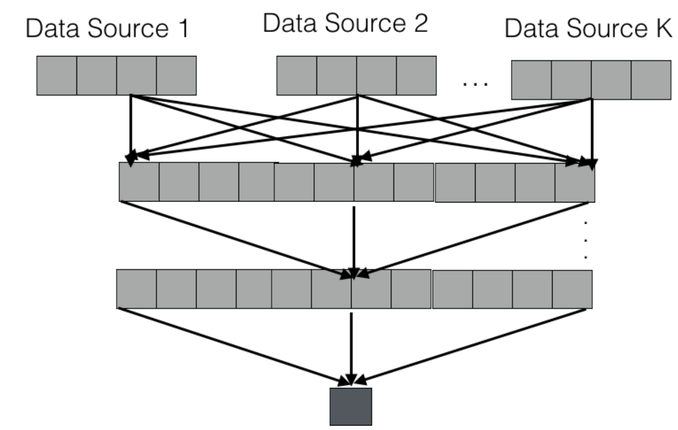
Data Fusion in DNNs

Late data fusion



Early data fusion

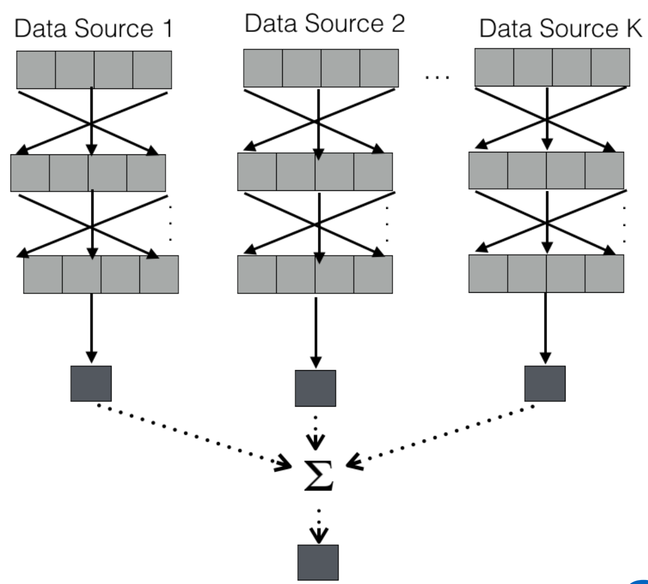


no dependency among data sources

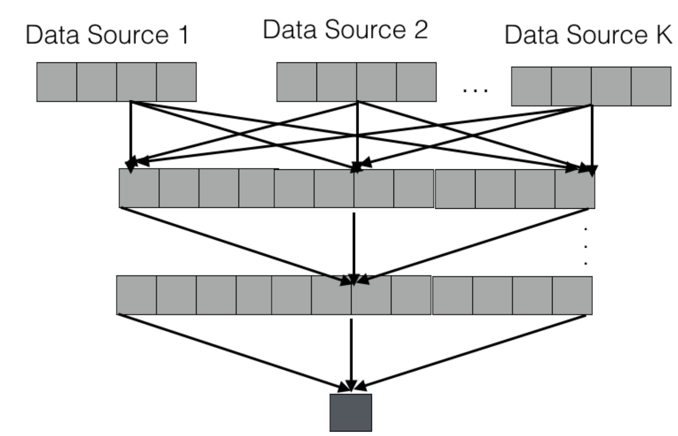
correlation between features

Hybrid Deep Multimedia Fusion

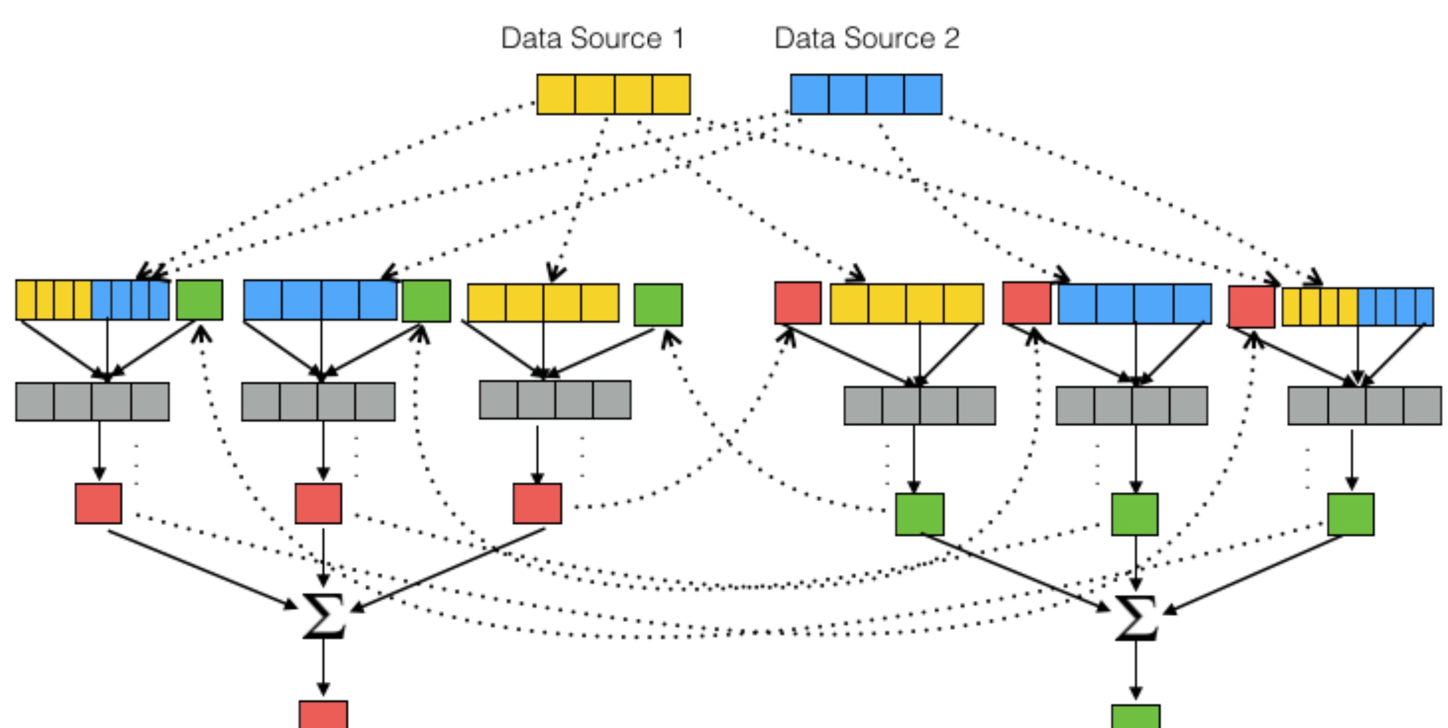
Late data fusion



Early data fusion

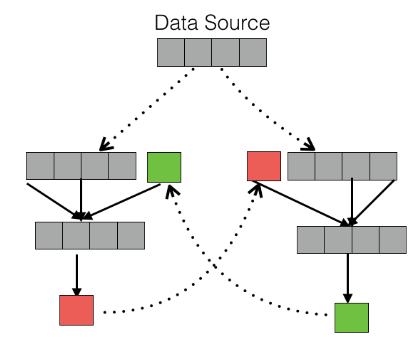


Our hybrid approach

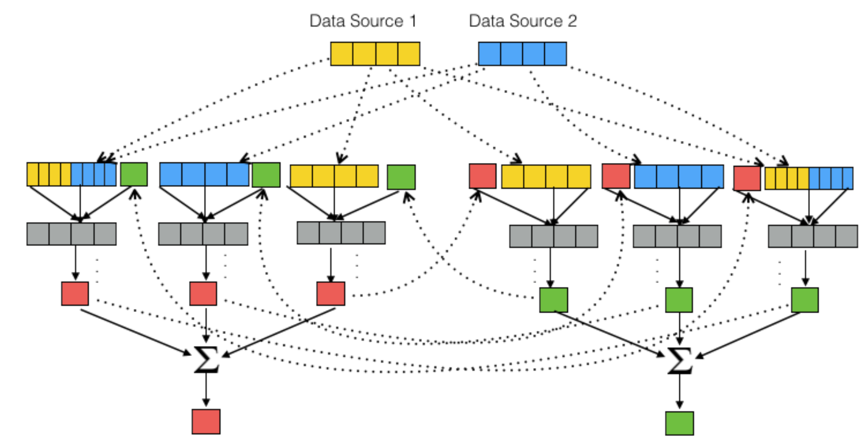


Hybrid Deep Multimedia Fusion

The **stacking** is suitable for **multi-task learning**.



The **powerset combination** incorporates **correlations among features and data sources**



powerset combination **stacking**

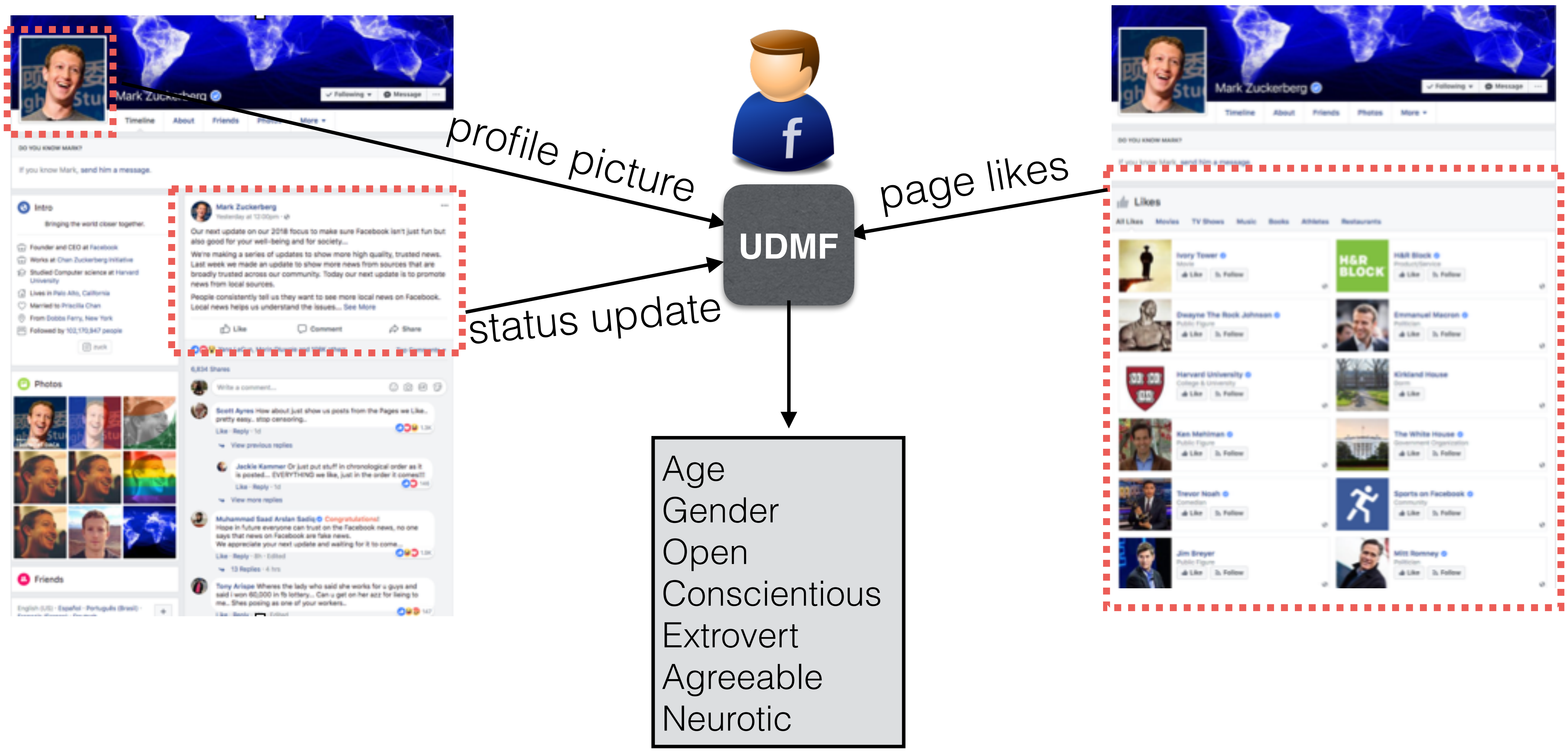
epoch activation function weight weight

$$U_i^{0q}(\mathcal{D}) = f\Big(\boxed{\sum_{D\in\mathcal{D}}}\sum_j w_{ij}\cdot D_j + \boxed{\sum_z w_{iz}\cdot\alpha_z\cdot t_z^{q-1}}\Big)$$

neuron data sources input neuron gate target variable

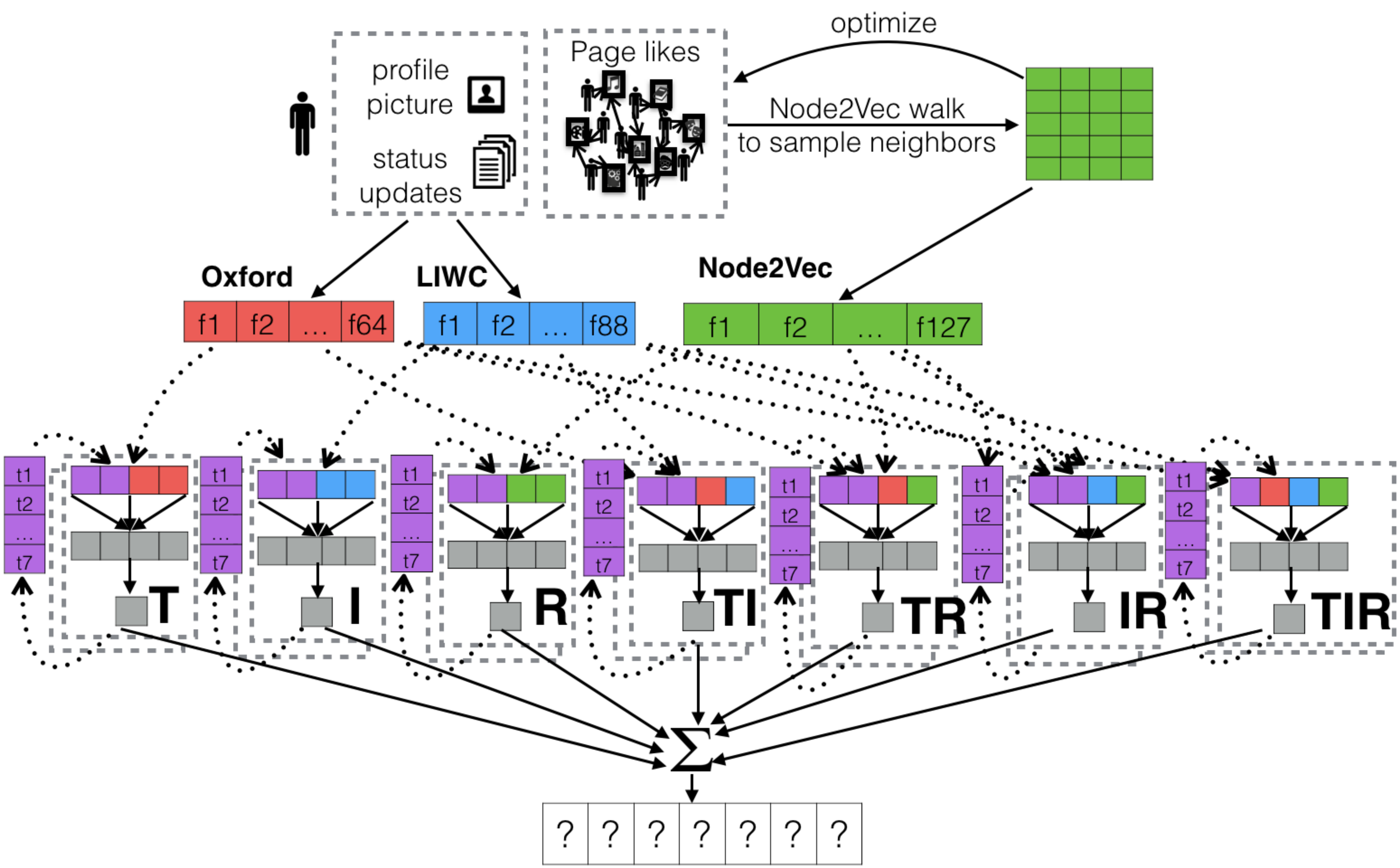
subset of the input data sources

User profiling



Infer Facebook users’ age, gender and personality traits

User Profiling in Facebook using UDMF



3 data sources

7 combinations

7 targets

Experimental results

- **Data fusion** improves **user profiling**
- **Stacking** works w/o data fusion

Model	Stack	Age	Gender	Opn	Con	Ext	Agr	Neu
Baseline		0.488	0.492	0.502	0.502	0.506	0.506	0.486
One source								
Text	✗	0.741±0.022	0.668±0.020	0.550±0.016	0.575±0.017	0.536±0.016	0.547±0.016	0.523±0.016
	✓	0.748±0.022	0.668±0.020	0.553±0.017	0.574±0.017	0.545±0.016	0.550±0.016	0.524±0.016
Image	✗	0.552±0.016	0.915±0.027	0.502±0.015	0.500±0.015	0.504±0.015	0.512±0.015	0.520±0.016
	✓	0.550±0.016	0.897±0.027	0.516±0.015	0.511±0.015	0.518±0.015	0.519±0.015	0.541±0.016
Relation	✗	0.875±0.026	0.886±0.027	0.601±0.018	0.571±0.017	0.567±0.017	0.525±0.016	0.558±0.017
	✓	0.893±0.027	0.898±0.027	0.622±0.018	0.589±0.018	0.573±0.017	0.533±0.016	0.563±0.016
Two sources								
Early approach	✗	0.734±0.022	0.873±0.026	0.569±0.017	0.588±0.018	0.536±0.016	0.545±0.016	0.547±0.016
TI	✓	0.746±0.022	0.864±0.026	0.546±0.016	0.568±0.017	0.542±0.016	0.546±0.016	0.536±0.016
Early approach	✗	0.878±0.026	0.896±0.027	0.610±0.018	0.586±0.018	0.567±0.017	0.535±0.016	0.554±0.017
TR	✓	0.891±0.027	0.899±0.027	0.627±0.019	0.601±0.019	0.572±0.017	0.551±0.016	**0.574±0.017**
Early approach	✗	0.878±0.026	0.951±0.028	0.606±0.018	0.574±0.017	0.569±0.017	0.524±0.016	0.562±0.017
IR	✓	0.895±0.027	0.951±0.028	0.633±0.019	0.592±0.018	0.577±0.017	0.537±0.016	0.564±0.017
Three sources								
Ensemble	✗	0.876±0.026	**0.952±0.028**	0.603±0.018	0.587±0.018	0.569±0.017	0.537±0.016	0.562±0.017
(Late approach)	✓	0.893±0.027	0.949±0.028	0.626±0.019	0.606±0.018	**0.582±0.017**	0.549±0.016	0.570±0.017
Early approach	✗	0.887±0.027	0.947±0.028	0.617±0.018	0.577±0.017	0.567±0.017	0.541±0.016	0.566±0.017
TIR	✓	**0.899±0.027**	0.934±0.028	**0.635±0.019**	**0.607±0.018**	0.560±0.018	**0.551±0.016**	0.572±0.017

- HDMF **outperform** state-of-the art user profiling and data fusion frameworks
- We accurately predict **age with AUC 0.90 and gender with 0.96**

Model	Age	Gender	Opn	Con	Ext	Agr	Neu
One/Two sources							
Page likes	0.743±0.020	0.699±0.022	0.605±0.017	0.516±0.016	0.555±0.016	0.540±0.0161	0.527±0.016
LR (T)	0.711±0.021	0.654±0.020	0.564±0.017	0.568±0.017	0.551±0.016	0.548±0.016	0.530±0.016
LR (I)	0.584±0.017	0.858 ±0.026	0.514±0.015	0.520±0.015	0.528±0.016	0.528±0.016	0.525±0.016
LR(T,I)	0.711±0.017	0.852 ±0.025	0.555±0.017	0.564±0.017	0.551±0.016	0.550±0.016	0.542±0.016
UDMF(T,I)	0.756±0.023	0.886±0.027	0.569±0.017	0.575±0.017	0.552±0.017	0.552±0.016	0.539±0.016
UDMF(T,R)	0.879±0.026	0.943±0.028	0.628±0.019	0.607±0.018	0.580±0.017	**0.564±0.017**	0.575±0.017
UDMF(I,R)	0.892±0.027	0.955±0.029	0.630±0.019	0.607±0.018	0.587±0.018	0.551±0.016	0.571±0.017
Three sources							
Weighted Soft Voting	0.656±0.019	0.861±0.026	0.523±0.016	0.0523±0.016	0.508±0.015	0.507±0.015	0.518±0.015
Random Forest (100)(T,I,R)	0.786 ±0.023	0.900±0.027	0.588±0.018	0.564 ±0.017	0.544±0.016	0.549±0.016	0.538±0.016
LR(T,I,R)	0.808 ±0.024	0.888±0.027	0.603±0.018	0.585 ±0.018	0.550±0.017	0.550±0.016	0.572±0.017
UDMF(T,I,R)	**0.903±0.027**	**0.956±0.029**	**0.647±0.019**	**0.615±0.018**	**0.592±0.018**	0.556±0.017	**0.580±0.017**

Thank you!

See you soon

Take away messages

- UDMF is a **hybrid multimodal data fusion**
- **Deep learning fusion** improves the accuracy of predictions
- **Stacking** works when we have multi-task learning (e.g., user profiling)
- **Powerset combination** enhances the fusion power
- We are able to predict your **age, gender and personality traits** given your Facebook activities!