

MAGE

Can Complementary Signals
Bridge Similarity Islands?
Manifold-Augmented Graph Embedding
for Multimodal Recommendation

Similar items cluster.

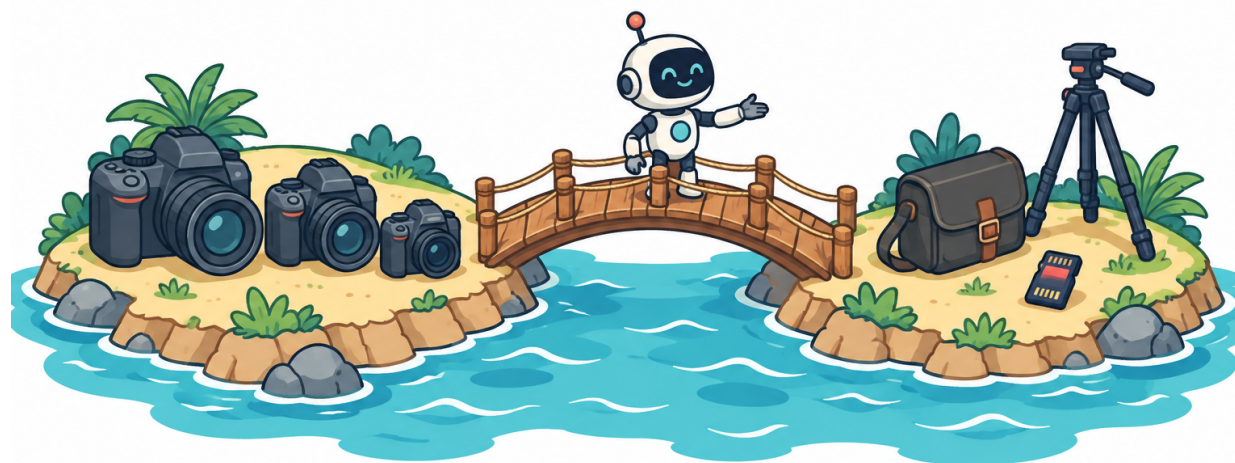
Complements can stay distant.

Use complementary signals to connect useful
products across similarity islands.

Zhenye Yang · Jinpeng Chen* · Wenbo Fu · Jun Ma · Huan Li
Qimin Zhou · Tao Wang · Li Sun · Senzhang Wang

Another camera?

What goes with it?



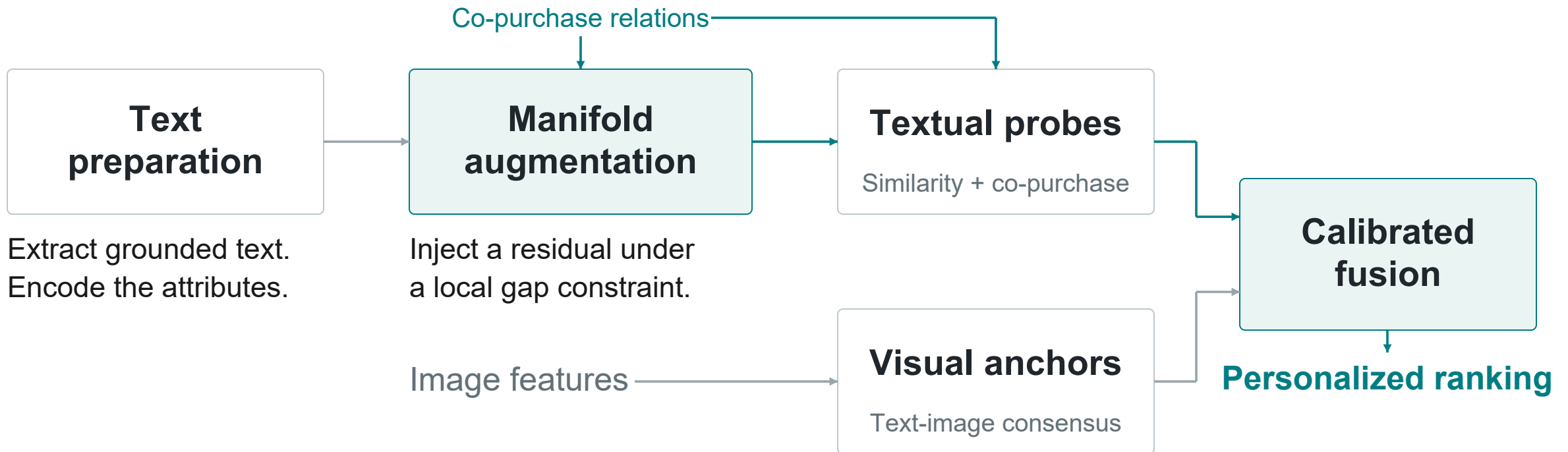
Conceptual illustration

Reshape text, then learn across modalities

Offline augmentation feeds asymmetric graph learning for personalized user-item ranking.

OFFLINE

ONLINE



Fusion also uses collaborative ID embeddings. No LLM calls are needed during training or inference.

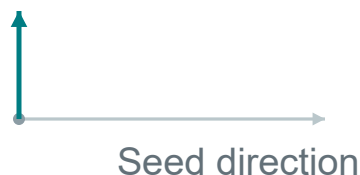
Control the geometric update

Complement-aware residuals enter the text representation under a local gap constraint.

01

Extract the residual

Split co-purchase neighbors by text similarity. Local SVD and a Soft Conceptor suppress the dominant semantic subspace.



Orthogonal residual (schematic)

Δ is the strong-minus-weak neighbor mean direction. g is the original local gap.

02

Inject and constrain

$$\tilde{\mathbf{x}}_{i,t} = \frac{\mathbf{x}_{i,t} + \alpha_i \mathbf{r}_i}{\|\mathbf{x}_{i,t} + \alpha_i \mathbf{r}_i\|_2}$$

$$\tilde{\mathbf{x}}_{i,t}^\top \Delta_i \geq \rho g_i \quad (g_i > 0)$$

Adaptive injection retains at least fraction ρ of the original positive gap after normalization.

03

Learn asymmetric roles

Visual anchors

Consensus similarity edges stabilize the visual stream.

Textual probes

Augmented text carries co-purchase signals.

Better results on every evaluated dataset

Recall@20 on the full test set. Relative gains are against the strongest reported baseline.

16/16

Best reported
dataset-metric
combinations

4 datasets

Recall / NDCG @ 10 / 20

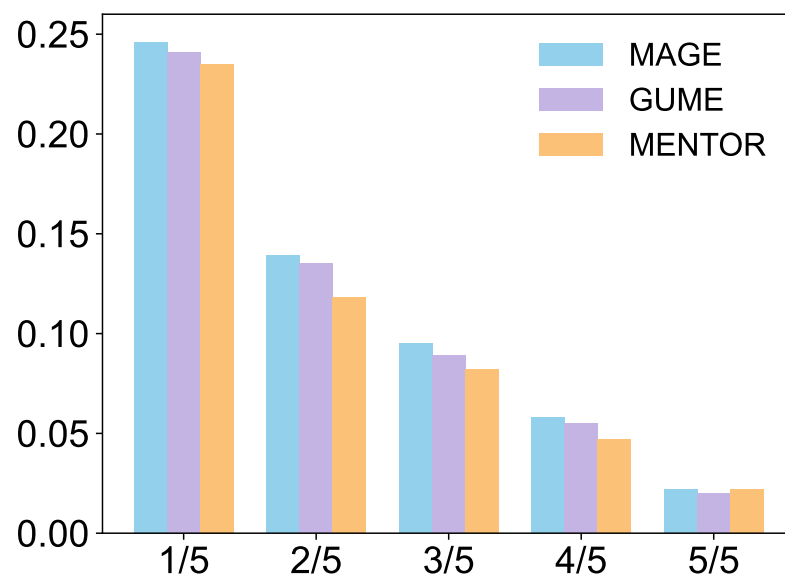
Dataset	Baseline	MAGE	Gain
Baby	0.1048	0.1077	+2.77%
Sports	0.1165	0.1221	+4.81%
Clothing	0.1024	0.1088	+6.25%
Electronics	0.0551	0.0587	+6.53%

Baby: MENTOR. Other datasets: GUME. Five seeds. Paired t-test $p < 0.01$, as reported in Table 1.

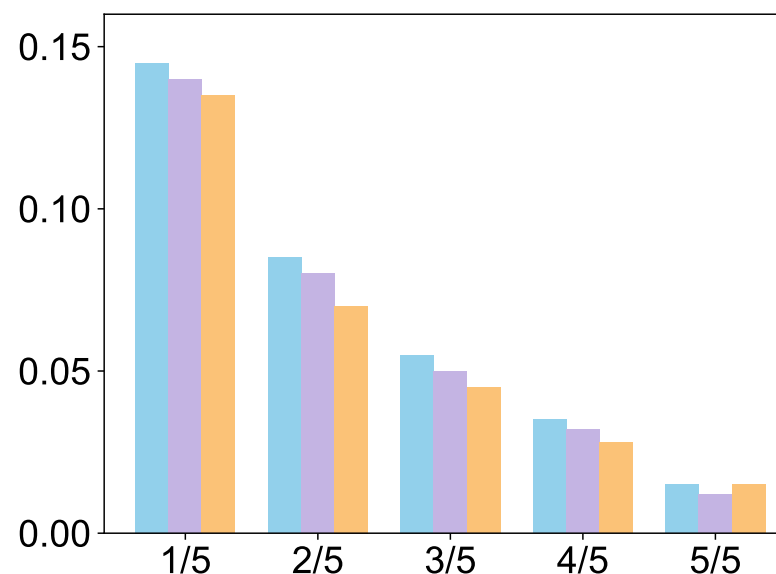
Gains reach tail items and hard complements

Supporting analyses beyond the full-test average.

Popularity groups on Clothing



(a) Recall@20



(b) NDCG@20

Group 1: head. Groups 2-5: tail.

+9.87%

Hard-complement subset

Mean relative gain
over 16 comparisons.

Co-purchase-linked test
positives in the bottom 30% of
both text and image similarity
in the eligible pool.

Reference: stronger of
GUME and MENTOR.

Geometry and complementarity work together

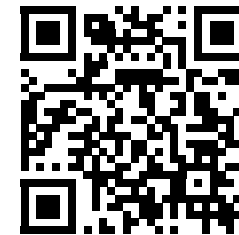
Improve personalized
multimodal ranking.

Reshape text offline.

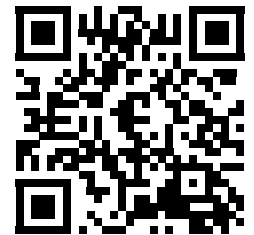
Learn distinct visual and textual roles.

Keep training and inference free of LLM calls.

Paper



Code



github.com/Alex-bupt/mage

* Corresponding author

jpchen@bupt.edu.cn

Evaluated on Baby, Sports, Clothing and Electronics. Complementarity uses behavioral and geometric proxies.