# Overcoming the Imbalance Between Tag Recommendation Approaches and Real-World Folksonomy Structures With Cognitive-Inspired Algorithms

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## Abstract

We study the **imbalance** between current state-of-the-art **tag recommendation algorithms** and the **folksonomy structures** of real-world social tagging systems. While algorithms such as FolkRank are **designed for dense folksonomy structures**, most social tagging systems exhibit a **sparse nature**. To overcome this imbalance, we show that **cognitive-inspired algorithms**, which model the tag vocabulary of a user in a cognitive-plausible way, can be helpful. Our present approach does this via implementing the **activation equation of the cognitive architecture ACT-R**, which determines the usefulness of units in human memory (e.g., tags). In this sense, our long-term research goal is to design hybrid recommendation approaches, which **combine the advantages of both worlds in order to adapt to the current setting** (i.e., sparse vs. dense ones).

## Imbalance

- Current tag recommendation algorithms are designed in a **purely data-driven way** (e.g., tag popularity, user similarities, topic modeling, factorization of resource features, etc.)
- This means that they rely on dense folksonomy structures but **most real-world folksonomies are sparse**

| Dataset | \|U\| | \|R\| | \|P\| | \|P\| / \|R\| |
|---|---|---|---|---|
| Flickr | 9,590 | 856,755 | 856,755 | 1.000 |
| CiteULike | 18,474 | 811,175 | 900,794 | 1.110 |
| BibSonomy | 10,179 | 683,478 | 772,108 | 1.129 |
| Delicious | 15,980 | 963,741 | 1,447,267 | 1.501 |
| LastFM | 1,892 | 12,522 | 71,062 | 5.674 |
| MovieLens | 4,009 | 7,601 | 55,484 | 7.299 |

## Approach

- The way users choose tags for their resources strongly corresponds to **processes in human memory and its cognitive structures**
- Activation equation of ACT-R formalizes the usefulness of a memory unit depending on **general usefulness** (i.e., frequency and recency) and **usefulness in current semantic context**

$$A_i = ln(\sum_{j=1}^{n} t_j^{-d}) + \sum_j (W_j \cdot S_{j,i})$$

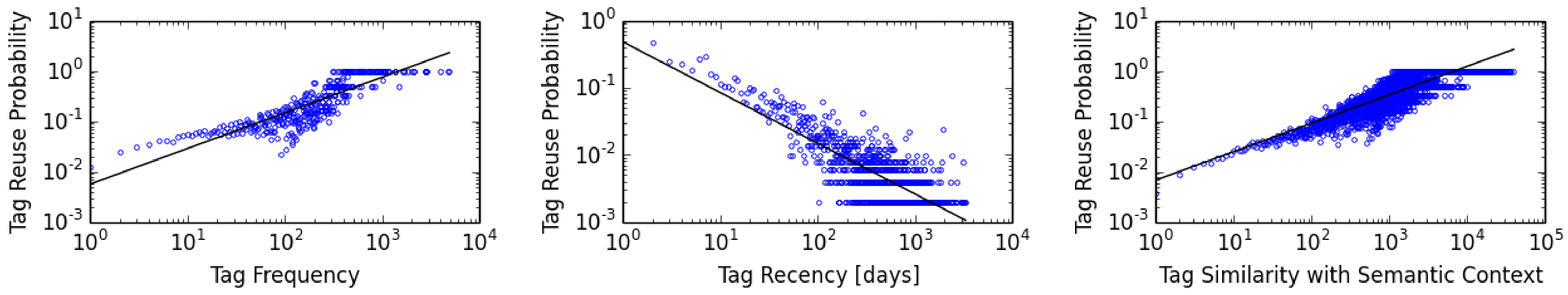
## Evaluation Framework

[1] Kowald, D., Kopeinik, S., and Lex., E. The TagRec Framework as a Toolkit for the Development of Tag-Based Recommender Systems. In *Proc. of UMAP'2017*. ACM.

**https://github.com/learning-layers/TagRec/**

## RQ1: Activation Processes and Reuse of Tags

**How are activation processes in human memory influencing the tag reuse behavior of users in social tagging systems?**




(a) Past Usage Frequency (b) Past Usage Recency (c) Current Semantic Context

- The **more frequently** a tag was used in the past, the higher its reuse probability
- The **more recently** a tag was used in the past, the higher its reuse probability
- The **more similar** a tag is to **current sem. context cues**, the higher its reuse probability

[Kowald, D. and Lex, E. (2016). The influence of frequency, recency and semantic context on the reuse of tags in social tagging systems. In *Proc. of Hypertext'2016*. ACM.]

## RQ2: ACT-R for Social Tag Recommendations

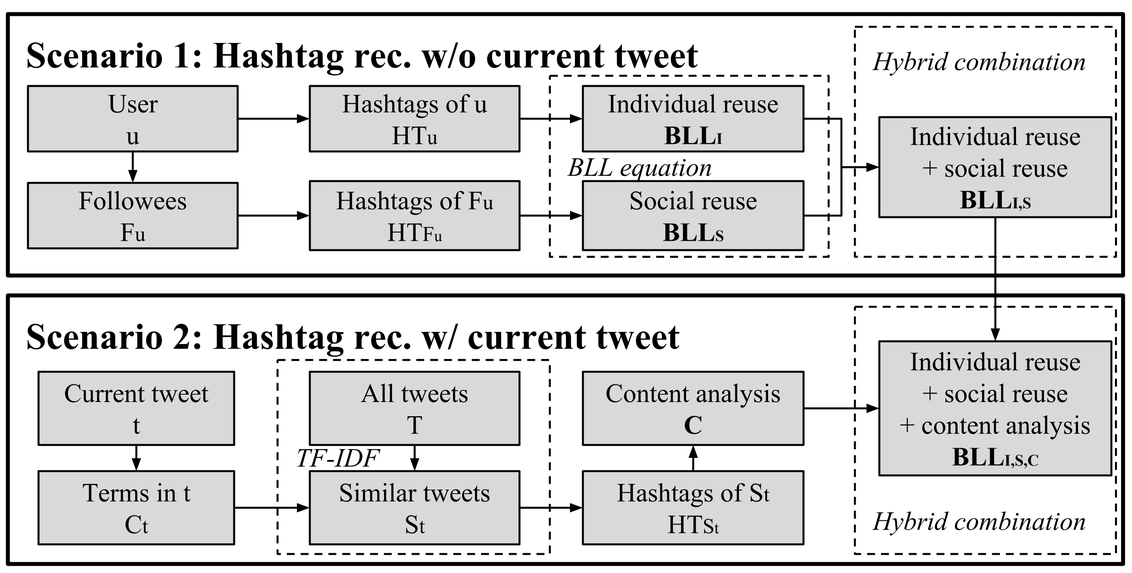
**Can the activation equation of the cognitive architecture ACT-R be exploited to develop a tag recommendation algorithm, which is capable of overcoming the imbalance between current approaches and real-world folksonomy structures?**

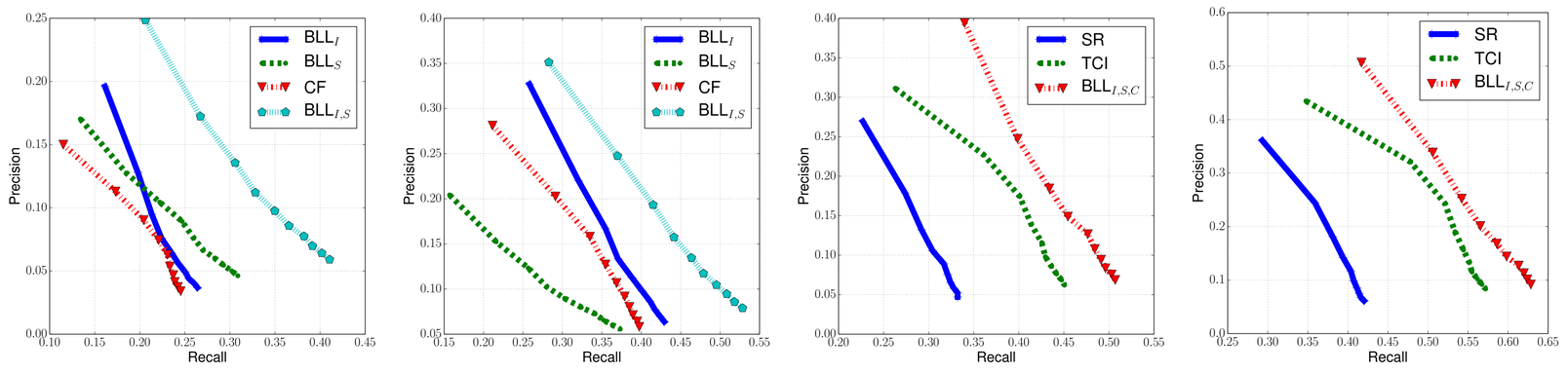
| Dataset | $MP_r$ | $MP_{u,r}$ | CF | LDA | PITF | FR | GIRPTM | **ACT-R** |
|---|---|---|---|---|---|---|---|---|
| Flickr | - | .569 | .666 | .280 | .535 | .561 | .686 | **.711** |
| CiteULike | .063 | .392 | .359 | .138 | .294 | .392 | .422 | **.438** |
| BibSonomy | .091 | .407 | .369 | .219 | .327 | .408 | .409 | **.434** |
| Delicious | .187 | .358 | .356 | .271 | .302 | .292 | .393 | **.431** |
| LastFM | .283 | .386 | .317 | .388 | .414 | .399 | .397 | **.425** |
| MovieLens | .271 | .328 | .254 | .296 | .324 | .319 | .326 | **.338** |

[Kowald, D. and Lex, E. (2015). Evaluating tag recommender algorithms in real-world folksonomies: A comparative study. In *Proc. of RecSys'2015*. ACM.]

## RQ3: Hashtag Recommendations in Twitter

**Can ACT-R be generalized for related use cases in the research area of tag-based recommender systems, such as hashtag recommendations in Twitter?**




(a) *Scenario 1*: *CompSci* (b) *Scenario 1*: *Random* (c) *Scenario 2*: *CompSci* (d) *Scenario 2*: *Random*

[Kowald, D., Pujari, S., and Lex, E. (2017). Temporal effects on hashtag reuse in Twitter: A cognitive-inspired hashtag recommendation approach. In *Proc. of WWW'2017*. ACM.]