Kaleidoscope: Computer-Assisted Ideation Through Idea Network Exploration

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Introduction

"Ideation" is an essential process in creativity and problem-solving. Golden rules in brainstorming include: "ideas build on each other", "defer judgment", "seek quantity and diversity". Following these rules, we develop a novel approach to assisting human brainstorming by idea recommendation.

We construct ***idea networks*** from heterogeneous datasets, define objectives to recommend ideas, design algorithms to achieve these objectives, and craft a working, interactive brainstorming system.

Model

Idea Networks

Nodes: ideas (pieces of information that gives information or convey thought)

Edges: connections between ideas

PIN: Problem Idea Network

captures all the ideas in one specific human brainstorm process;

BIN: Backend Idea Network

a knowledge base where our system retrieves ideas to recommend;

Our BINs are constructed from heterogeneous datasets: basic concepts (ConceptNet), Images (MIRFLICKR), and Wikipedia (DBPedia).

Figure 1: Dataset Statistics

Data type	Dataset	Nodes	Edges
Basic concepts	ConceptNet	4303083	10426726
Labeled images	MIRFLICKR	25000	404243
Encyclopedia	DBPedia English	9743	261920

Goal:

Recommend a set of nodes *(S)* in BIN that maximizes some objective function related to PIN's mapping in BIN *(P)*. We propose *Connections, Coverage and Combination* as objectives to craft out the objectives.

Connections

ideas are built on each other

Ideas that have a path to existing PIN network are suggested. Act as a constraint.

$$NumCC(S \cup P) <= NumCC(P)$$

Coverage

diversity of ideas is encouraged

We maximize the incremental coverage when suggesting a set of new ideas. Intuitively, we want to suggest ideas in BIN-communities that have not or seldom been covered in PIN.

$$cover_{PIN}(w) = 1 - \prod_{idea \in PIN} (1 - cover_{idea}(w))$$

$$Cover(PIN) = \sum_{w} \lambda_w \, cover_{PIN}(w)$$

Combination

seeking combination of ideas is a golden rule in brainstorming

We suggest ideas that have the most links to all nodes in PIN and we use a log function to measure combination.

$$comb(idea, PIN) = log \sum_{j \in PIN} q_j \, IsEdge(idea, j)$$

$$Comb(SUGG, PIN) = \sum_{i \in SUGG} log \sum_{j \in PIN} q_j \, IsEdge(i, j)$$

Formalizing Objective Function:

Maximize coverage and combination under the constraint of connection.

$$\max_{W} \; \alpha \, Cover(S \cup P) + \beta \, Comb(S, P)$$

$$s.t. \; NumCC(S \cup P) <= NumCC(P)$$

Algorithms

Network Construction

Built multiple idea networks: one for each dataset.

Constructing edges:

- Wikipedia: internal page links
- ConceptNet: phrase relations
- Images: tag similarities based on the Wu-Palmer similarities of tokens.

Community Detection

We choose BigCLAM algorithm for community detection.

BigCLAM assumes dense over-laps among communities, and that the probability of two given nodes having an edge is positively relevant to their number of common communities.

Mapping PINs to BINs

Inverted Index:

search keywords in users' ideas on indexed BINs; retrieve a ranked list of matched nodes.

Query Expansion:

we utilize WordNet to expand the query with words from close synset.

Online Search Engine:

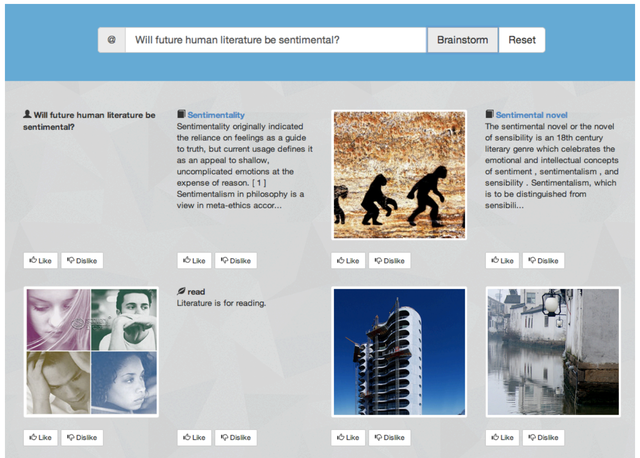
For the Wikipedia network, We use Bing to retrieve a set of Wikipedia pages related to user's idea, and choose a highest-ranked page within our network.

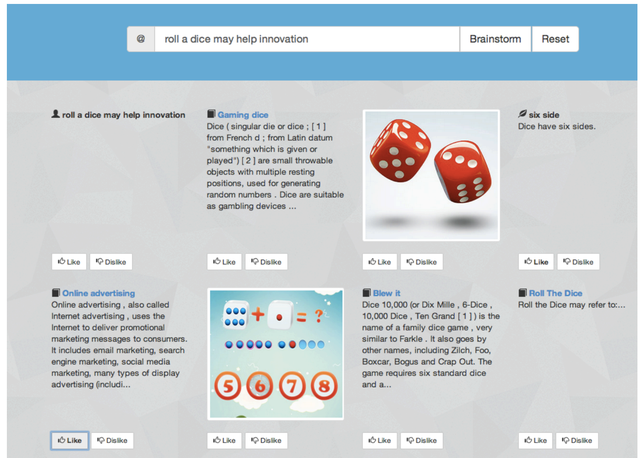
Recommender

Suggest K nodes that maximize the objective function, with a greedy algorithm.

In each iteration, we recommend a node with the maximum gain within the set of L' = Nbr(v)∪maxk(L), where v is the last added node that maximizes the objective, and L denotes a list of K nodes with highest score in L of the last iteration.

Frontend Interface of Kaleidoscope System





System Overview

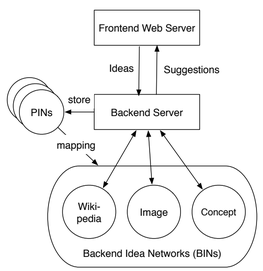


Figure 2: Kaleidoscope Architecture

We implement Kaleidoscope system to integrate-it-all:

Network Construction: 2 networks in local storage; ConceptNet retrieving by API. (See Figure 1)

Community Detection: 2500 communities for Image, 974 communities for Wikipedia.

Recommender Choice: a = 1, b = 3, l_w = 1 for all communities, $cover_{idea}(w)$ = 0.2; set different weights for user's ideas and suggested ideas; assign a weight decay for users' ideas in favor of recent ideas.

Try our system: *http://www.zifeishan.org/kaleidoscope/*

Future Work

- Combine Problem Idea Networks (PINs) together as another Backend Idea Network, thus storing all users' ideas into a uniform network --- *Crowdsourcing* ideas!
- Craft our system into a public ideation platform, and deploy our algorithms into a real-time online brainstorming system named Sparkl (*http://sparkl.us/*).

Evaluation

We design a blind-test system with build-in like / dislike feedbacks to evaluate our suggestions, compared to baselines of "most relevant ideas" given by search engines (i.e. Bing Wikipedia search, Bing Image search).

We design some *brainstorming problems* for subjects who are Stanford students that have a knowledge of brainstorming, e.g.:

- *Think about things to do in next quarter.*
- *Design a new transportation in Stanford.*
- *Describe human literature after 50 years*
- …

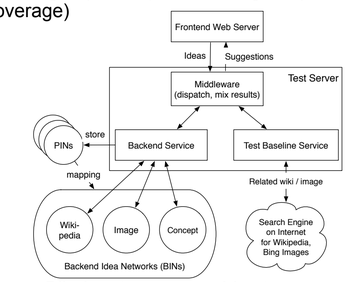
Evaluation Results

Type	Like	Dislike	Mutual
Suggested Image	38	14	44
Related Wiki	30	8	46
Related Bing Image	29	13	52
Suggested Concept	26	8	50
Suggested Wiki	20	15	63

Two interesting comparisons are:

- Suggested images are more insightful than related images retrieved from Internet.
- Related Wikipedia pages are more liked than suggested.

Explanation: two phases of ideation: seeking knowledge (related) & seeking inspiration (coverage)



Blind-test system architecture

Contribution

1. We initiate the methodology of computer-assisted ideation.
2. Objectives for knowledge recom -mendation in information networks based on user knowledge;
3. A working interactive brainstorming system to facilitate ideation.

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