Profiling Sets for Preference Querying

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May 18, 2010

Outline

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Motivating Example

Alice is buying 3 books as gifts.

Title	Genre	Rating	Price	Vendor
a_1	sci-fi	5.0	$15.00	Amazon
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a_3	sci-fi	4.5	$25.00	Amazon
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a_5	sci-fi	4.3	$15.00	Amazon
a_6	romance	4.2	$12.00	B&N
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- (C3) Prioritize (C2) over (C1)

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Tuple Preference - Winnow (Chomicki [Cho03])

Definition (Tuple Preference)

Given a relation schema $R = \langle A_1, \ldots, A_m \rangle$, a tuple preference is defined by a *first order formula* C if

$$C(t_1, t_2) \Leftrightarrow t_1 \succ_C t_2$$

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Definition (Winnow Operator)

Winnow operator $\omega_C(R)$ is defined by tuple preference $\succ_C$ if for every instance r of R,

$$\omega_C(r) = \{t \in r | \neg \exists t' \in r.t' \succ_C t\}$$

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Profile-based Set Preference

Set Pref.	Quantities of Interest	Desired Value or Order
(C1)	total cost	$<$
(C2)	# of sci-fi books	1
(C3)	total cost, # of sci-fi books	(C2)$\rhd$(C1)

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preferences over profiles

$$\text{profile} = \langle f_1, f_2, \ldots, f_m \rangle$$

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  subsets of relation r, with *fixed* cardinality k

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  A vector of k-subset features

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- **SQL-based k-subset feature**
  A restricted "mini" SQL query over a k-subset which returns a scalar value
- **profile**
  A vector of k-subset features

Given k-subset feature $\mathcal{F}_1, \ldots, \mathcal{F}_m$ defined over k-subsets of relation r

Profile-based Set Preference

A tuple preference over profiles of all k-subsets of relation r.

Example

Set preferences are defined by *tuple* preferences over *profiles*

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Naive Algorithm

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- Generate all k-subsets of relation r and compute their profiles.
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Too many candidate k-subsets!

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Generate as few candidate k-subsets as possible

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"Superpreference"

Find a "superpreference" ($\succ^+$) over the relation r, such that

$$t_1 \succ^+ t_2 \Leftrightarrow \quad s' \cup \{t_1\} \gg_C s' \cup \{t_2\}.$$

for every (k-1)-subset s' of r containing neither t_1 nor t_2.

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Pruning Condition

Let $cover(t) = \{t' \succ t | t' \succ^+ t\}$.
For every t in the "best" k-subset, $cover(t) < k$.

Find the "Superpreference"

Theorem ("Superpreference" Construction)

If the set preference contains

- *additive k-subset features only, and*
- *can be rewritten as a constant-free DNF formula*

then the superpreference $\succ^+$ can be defined by a first-order formula which is independent of k.

Example - "Superpreference"

Set preference: (C5)$\cap$(C6)
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"Superpreference" formula C^+ (assuming $price > 0$)

$$\begin{aligned} t_1 \succ_{C^+} t_2 \quad \equiv \quad & t_1.rating > t_2.rating \wedge t_2.genre = \text{'sci-fi'} \\ & \wedge (t_1.price < t_2.price \vee t_1.genre \neq \text{'sci-fi'}). \end{aligned}$$

M-relation

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Avoid redundancy in generating candidate k-subsets

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Profile $\Gamma = \{\mathcal{F}_5, \mathcal{F}_6\}$

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Redundancy Example

$$\begin{aligned} & profile_\Gamma(\{a_1, a_2, a_7\}) \\ = \; & profile_\Gamma(\{a_1, a_2, a_9\}) \\ = \; & \{\$15.00, 14\} \end{aligned}$$

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Exchangeable Tuples a_7, a_9

For any 2-subset s of $Book \backslash \{a_7, a_9\}$

$$profile_\Gamma(s \cup \{a_7\}) = profile_\Gamma(s \cup \{a_9\})$$

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M-relation Generation

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M-relation Generation SQL

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SELECT CASE WHEN r.genre='sci-fi' THEN r.price ELSE 0 END AS A5,
       r.rating AS A6, count(*) AS Acnt FROM r
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M-relation:

	A_5	A_6	A_{cnt}
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$m_{7,9,10}$	$0.00	4.0	3
m_8	$18.00	3.5	1

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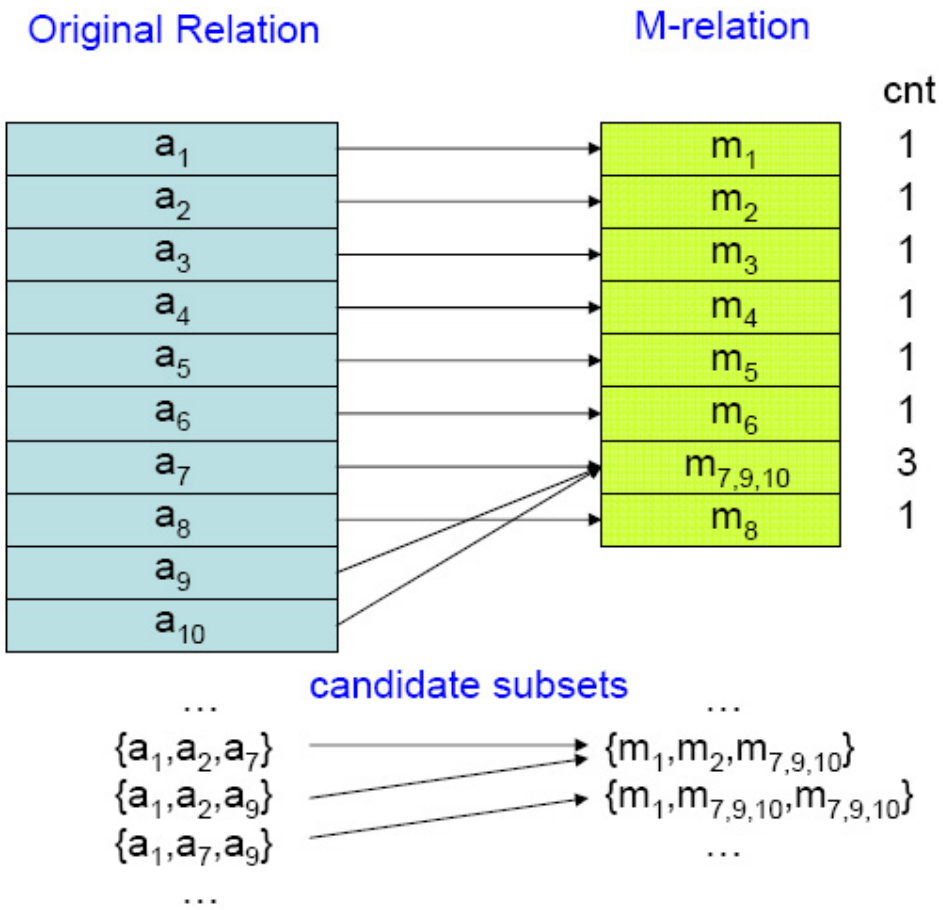
Set Preference via M-relations

- Set preference over the original relations ⇒ set preference over its M-relation



Hybrid

Hybrid Algorithms

- SM: Superpreference followed by M-relation
- MS: M-relation followed by Superpreference

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Dataset and Set Preferences

- **Dataset**
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  - Schema: $\langle title, genre, rating, price, vendor \rangle$

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$\mathcal{F}_6 \equiv$ `SELECT sum(rating) FROM $S`

$\mathcal{F}_9 \equiv$ `SELECT sum(rating) FROM $S WHERE genre='sci-fi'`

$\mathcal{F}_{10} \equiv$ `SELECT sum(price) FROM $S`

$\mathcal{F}_{11} \equiv$ `SELECT count(title) FROM $S WHERE genre='sci-fi' and price < 20.00`

$\mathcal{F}_{12} \equiv$ `SELECT sum(rating) FROM $S WHERE rating >= 4.0`

Dataset and Set Preferences

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  - 8000 book quotes from Amazon
  - Schema: $\langle title, genre, rating, price, vendor \rangle$
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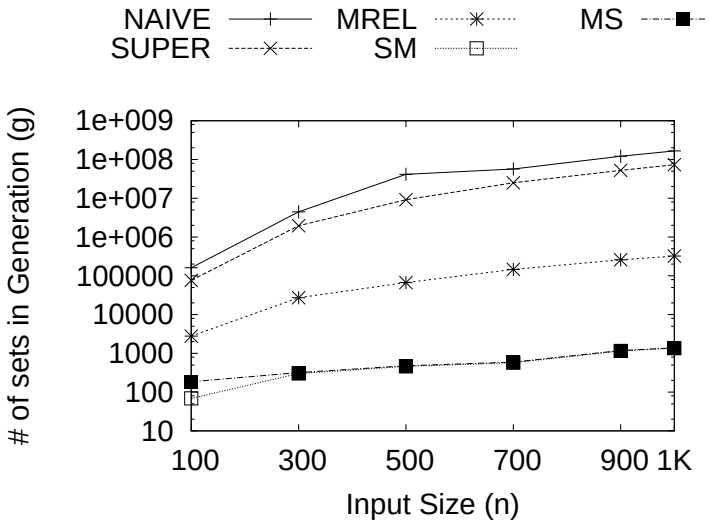
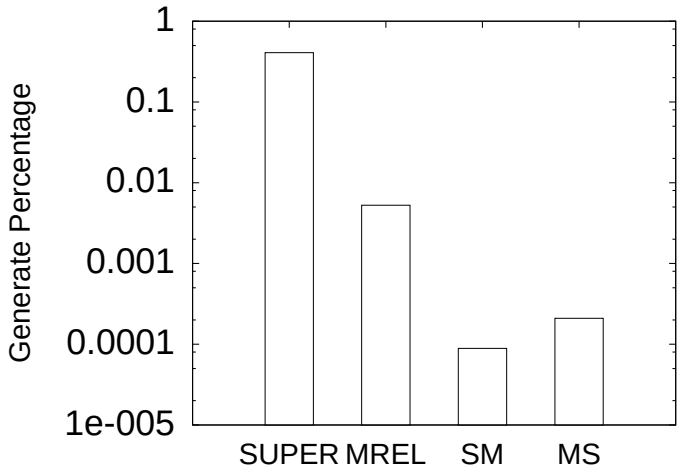
- **Set Preferences**

Set Pref. Name	Profile Schema Γ	Profile Pref. Formula C
SP1	$\langle \mathcal{F}_5, \mathcal{F}_6 \rangle$	$\mathcal{F}_5(s_1) < \mathcal{F}_5(s_2) \wedge \mathcal{F}_6(s_1) > \mathcal{F}_6(s_2)$
SP2	$\langle \mathcal{F}_9, \mathcal{F}_{10} \rangle$	$\mathcal{F}_9(s_1) > \mathcal{F}_9(s_2) \wedge \mathcal{F}_{10}(s_1) < \mathcal{F}_{10}(s_2)$
SP3	$\langle \mathcal{F}_{11}, \mathcal{F}_{12} \rangle$	$\mathcal{F}_{11}(s_1) > \mathcal{F}_{11}(s_2) \wedge \mathcal{F}_{12}(s_1) > \mathcal{F}_{12}(s_2)$

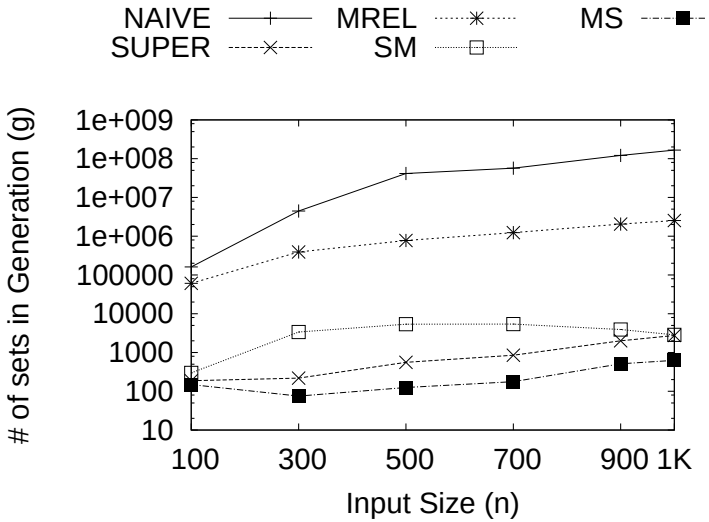
Performance of Different Algorithms

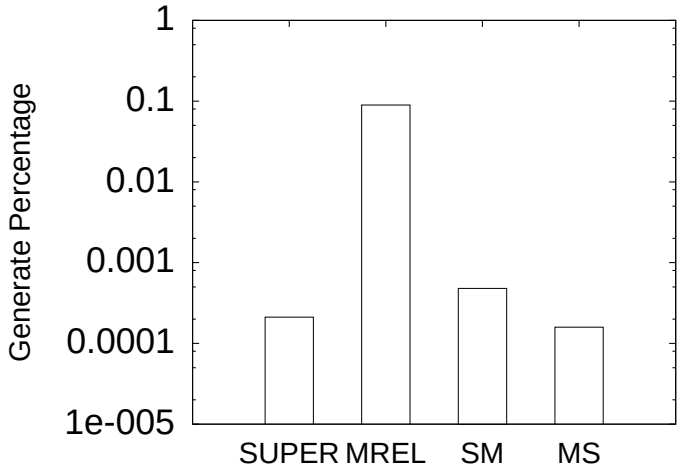
Set Pref 1





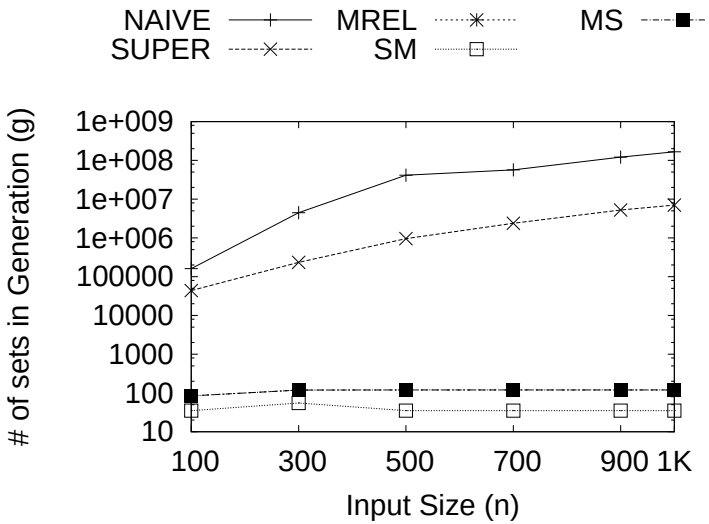
Set Pref 2

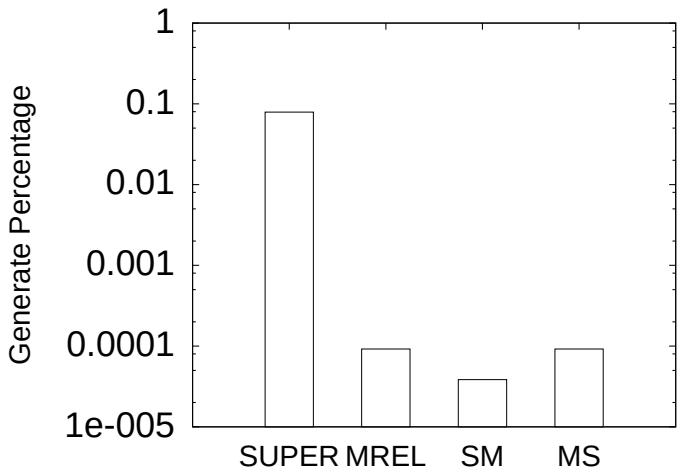




Performance of Different Algorithms

Set
Pref 3





Related Work

- Binshtok et al. [BBS+07]
  - Problem: find an optimal subset of items
  - Set property: predicate
  - Set preference: TCP-net or scoring function
  - Subsets of any cardinality, subsumed by our framework in the fixed-cardinality case
- desJardins and Wagstaff [dW05]
  - Fixed-cardinality set preference
  - Two set features: *diversity* and *depth*
- Guha et al. [GGK+03]
  - Problem: find an optimal subset of tuples
  - Set property: $\mathit{aggr}(A) < \mathit{parameter}$
  - Set preference: objective function $\min / \max$

Outline

Future Work

- Query optimization for non-additive features
- Set preference elicitation
- Embedding "best-subset" generation in relational query language
- Additional set ranking or browsing techniques for navigation of results

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Thank you!