Multi-column Substring Matching For Database Schema Translation (And other wild thoughts while shaving)

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Where in the world am I from?

Database Integration

- ...seen as a large, monolithic, one-off project.
- ...solved by database and domain experts with the time and motivation.

But!

- The number, size and complexity of databases keeps growing. (+10,000 tables, +1,600 columns)
- Integration is an every day issue. (Semantic web, opportunistic data sources...)
- Multiple representation standards in use. (22 Locales)
- Standardized database access (JDBC, ODBC) possible.
- End user knows the data is available, can't access it and wants it right NOW!

Database Integration

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$\Rightarrow$ Need automation to deal with this problem.

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Database schema matching and translation

Objective

A generalisable method capable of resolving complex schema matches and the translation required to convert the instance data using substrings concatenation.

Example

- Name(Warren, Rob) in database $D \rightarrow$ First(Rob) + Last(Warren) in D'
- 2005/05/29 in database $D \rightarrow$ 05-29-2005 in database D'
- LastName(warner) + Birthdate(980102) in $D \rightarrow$ Userid(warn98) in D'.
- PartNumber(04350306) in $D \rightarrow$ Number(0435) +PlantId(03) + Year(2006) in D'.

Problem formalization

Definition

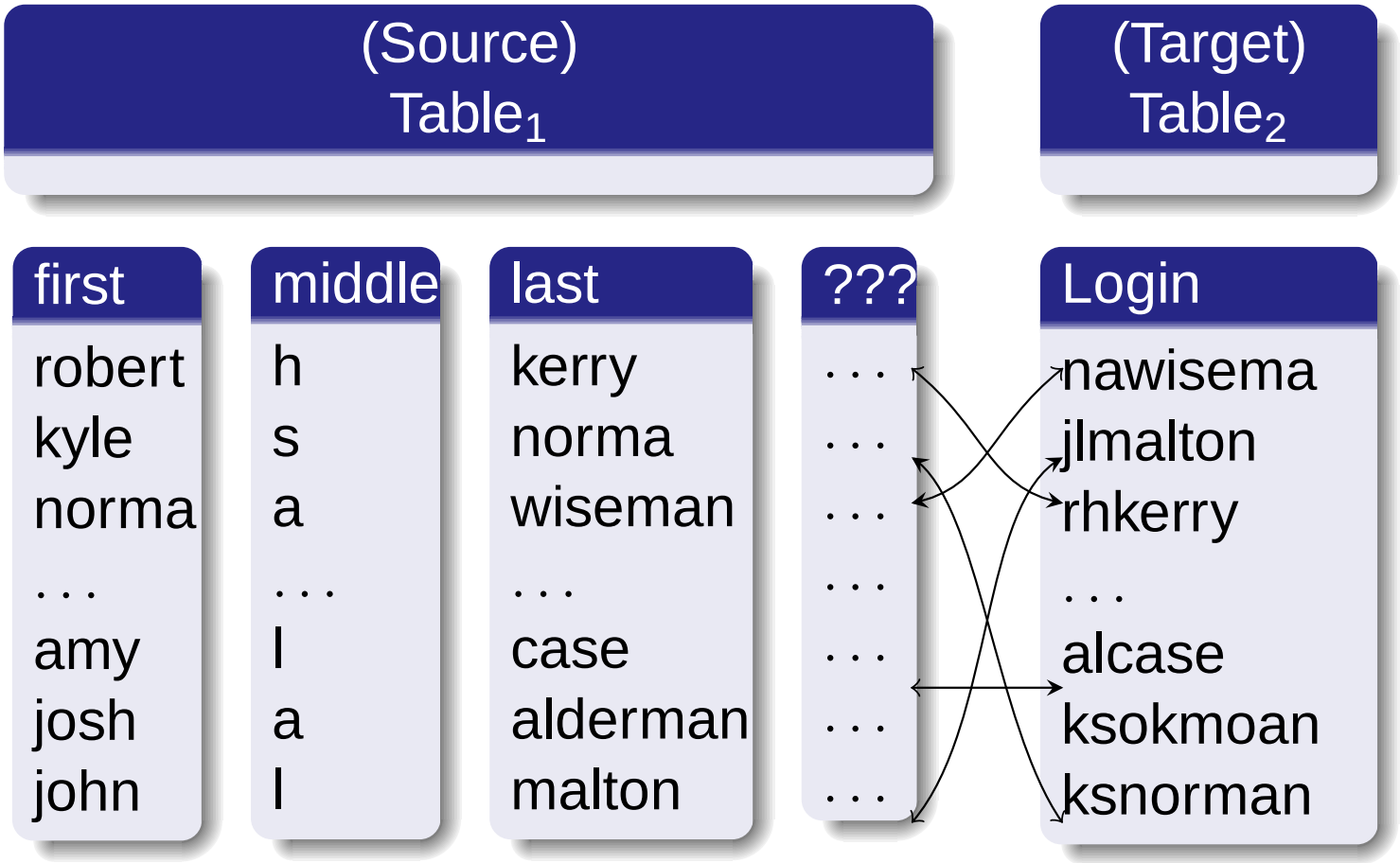
For a given target database table T_2 with a target column A
...and a source table T_1 with a set of likely source columns $(B_1, B_2, ..., B_n)$

Find a transformation such that:
$A = \omega_1 + \omega_2 + \cdots + \omega_\nu$ Where ω_i represents a substring of column B_i

Translation model

$t' = t\ [\beta_1^{x_1 \ldots y_1} + \beta_2^{x_2 \ldots y_2} + \cdots + \beta_\nu^{x_\nu \ldots y_\nu}]$ (chars $x_\nu \ldots y_\nu$ of col B_ν)

Basic example



Basic example

(Source) Table$_1$

(Target) Table$_2$

How to infer translation?

select substring(first from 1 for 1) || substring(middle from 1 for 1) || last as login into target_table from . . .

Solution:

Iteratively select substrings from “best-fit” columns while performing a simple form of record linkage.

Basic example - Find initial column. (1)

(Source) Table$_1$				(Target) Table$_2$
first	middle	last	???	Login
robert	h	kerry	...	nawisema
kyle	s	norma	...	jlmalton
norma	a	wiseman	?	rhkerry
...	...	...		...
amy	l	case	...	alcase
josh	a	alderman	...	ksokmoan
john	l	malton	...	ksnorman

Basic example - Find a partial translation. (1)

(Source) Table

(Target) Table

Generate candidate translations

malton + wiseman $\longrightarrow$ %[1-2]%
malton + jlmalton $\longrightarrow$ %[1-EOL]
malton + alcase $\longrightarrow$ %[2-3]%
. . .
kerry + rhkerry $\longrightarrow$ %[1-EOL]
. . .
Highest occurrence: %last[1-EOL]

josh	a	aldeman	. . .	ksokmoan
john	l	malton	. . .	ksnorman

Use string edit distance to create candidate translation.

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Basic example - Search for additional columns. (1)

(Source) Table$_1$				(Target) Table$_2$
first	middle	last	???	Login
robert	h	kerry	...	nawisema
kyle	s	norma	...	jlmalton
norma	a	wiseman	...	rhkerry
...	...	...	...	...
amy	l	case	...	alcase
josh	a	alderman	...	ksokmoan
john	l	malton	...	ksnorman

Sample the tuples formed from translation formula.

Basic example - Search for additional columns. (1)

(Source) Table

(Target) Table

Generate candidate translations

robert + rhkerry $\rightarrow$ first[1-1]%last[1-EOL]

. . .

. . .

(Keep track of all candidates and their frequencies.)

norma	a	wiseman	. . .	rhkerry
. . .	. . .	. . .	. . .	. . .
amy	l	case	. . .	alcase
josh	a	alderman	. . .	ksokmoan
john	l	malton	. . .	ksnorman

Sample the tuples formed from translation formula.

Basic example - Search for additional columns. (2)

(Source) Table$_1$				(Target) Table$_2$
first	middle	last	???	Login
robert	h	kerry	...	nawisema
kyle	s	norma	...	jlmalton
norma	a	wiseman	...	rhkerry
...	...	...	...	...
amy	l	case	...	alcase
josh	a	alderman	...	ksokmoan
john	l	malton	...	ksnorman

Sample the tuples formed from current translation formula

Basic example - Search for additional columns. (2)

(Source) Table

(Target) Table

Generate candidate translations

h + rhkerry $\longrightarrow$ first[1-1]middle[1-1]last[1-EOL]

. . .

. . .

(Keep track of all candidates and their frequencies.)

norma	a	wiseman	. . .	rhkerry
. . .	. . .	. . .	. . .	. . .
amy	l	case	. . .	alcase
josh	a	alderman	. . .	ksokmoan
john	l	malton	. . .	ksnorman

Sample the tuples formed from current translation formula

Basic example - Search for additional columns. (2)

(Source) Table

(Target) Table

Ending condition

No unknowns remain within:

$$t' = t\ [\beta_1^{x_1 \ldots y_1} + \beta_2^{x_2 \ldots y_2} + \cdots + \beta_\nu^{x_\nu \ldots y_\nu}]$$

Login = first[1-1] + middle[1-1] + last[1-EOL]

...	...	...	...	...
amy	l	case	...	alcase
josh	a	alderman	...	ksokmoan
john	l	malton	...	ksnorman

Sample the tuples formed from current translation formula

Experimental setup - Noise column

Add and populate the following noise columns:

- A random RFC-2822 timestamp.
- A random street address.
- A random long integer.
- A random value, variable length string.
- *War and peace* by Leo Tolstoy.

Definition

Simulate noisy matching environment and ensure proper algorithmic behavior.

Citeseer & DBLP Dataset

Citeseer

Extracted 526,000 records from OAI dump.
Created Title, Year and Author (15) columns.
Created Citation column from Title, Year and First Author.
(Successfully matched at 1% sampling.)

DBLP

Extracted 233,000 records from web dump.
Created Title, Year and Author (15) columns.
Created Citation column from Title, Year and First Author.
(Successfully matched at 1% sampling.)

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Cross Citeseer and DBLP Dataset translation

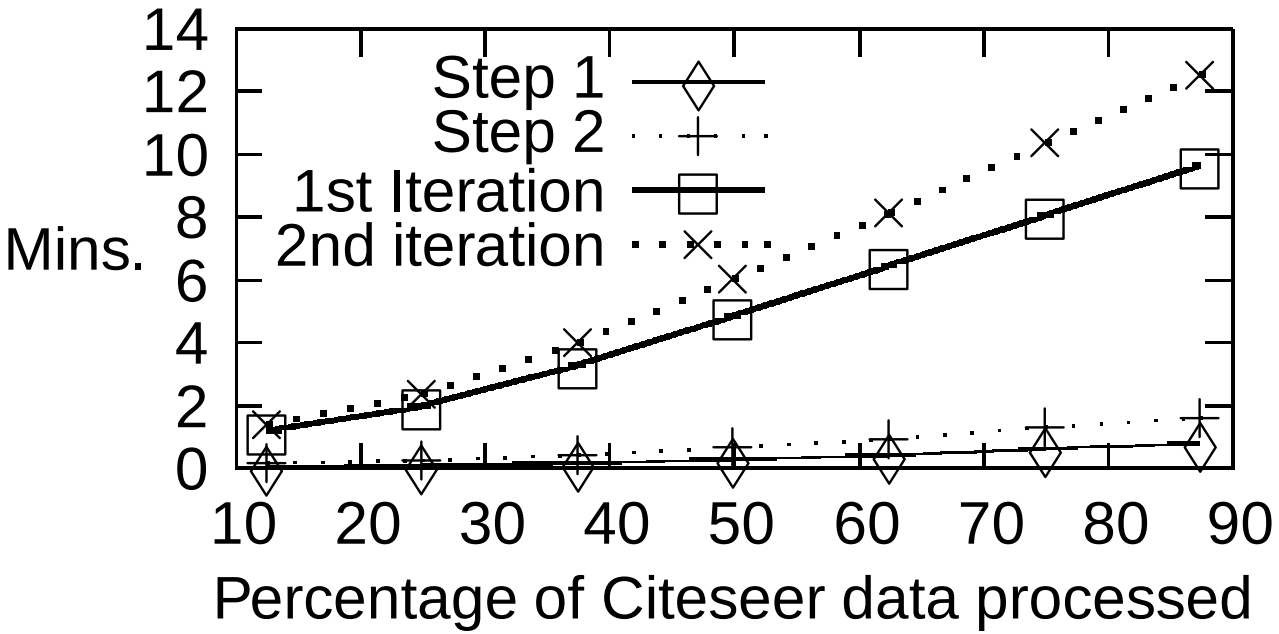
Expected result

Match Citeseer Citation column to DBLP source table.
Only 714 records match across Title, Year and First Author.

Actual result

Citeseer Citation = DBLP Title + DBLP Year + DBLP Second Author.
378 citations have their First and Second authors reversed!
Returned mapping is “correct” according to the data.

Incremental wall-clock performance



Estimated complexity

$O(w * n * s_1 * s_2)$

Overall

- Previous approaches required specialized domain specific matchers to form both the match and the translation.
- This algorithm is a generalized algorithm for string-based concatenations matches.
- Meant to function as part of larger database integration framework.
- It is un-supervised, does not need examples or a known record overlap and can be implemented using basic SQL statement.

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Overall

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This is all old stuff!! Now what?

- Sampling extremely large tables.
- Data-driven, machine readable descriptions of extremely large database.
- Questing for linear time data matching of attributes.
- Using ontologies as integration negotiation documents.

Sampling extremely large tables

...or MY database is bigger that YOUR database.

- Currently two approaches: equidistant and random sampling.
- As the size of a table grows, a traversal can become almost impossible.
- Behavior is like that of a data stream or tape drive.
- Disk access can also be more efficient if we use it as a linear device.
- Can we use clever statistics to guess how deep into the table to go?

Data-driven, machine readable descriptions of extremely large database.

Q:

How are we going to advertise and describe data in a format that automated integration system can actually use. (And maybe not lie about?)

Questing for linear (or better) time data matching of attributes.

- Currently two methods: q-gram or KL-divergence.
- What happens when we can't read the entire table?
- Are information theory methods useful? ...and faster?
- Can we use any clever sampling techniques?

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Using ontologies as integration negotiation documents.

...mostly used for hierarchy of concepts now.

- Ontological standards a good way to document the data exchange process (e.g.: constraints, dependencies, ...) in a machine readable way.
- What about ‘pushing’ database information rules to the outside world? (e.g.: Records are only accepted is they contain attributes (First, Middle and Last) or if the attributes (Name and DOB) are available.

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THE END

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