Modern Bayesian Record Linkage: Some Recent Developments and Open Challenges

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Dayi Fang

Department of Statistical Science
Duke University

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Outline

1. Introduction to Record Linkage
    - Motivation and Examples
    - History and Recent Developments
    - Two major methods and problems

2. Bayesian Methods
    - Advantages and disadvantages
    - Two interesting papers

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Motivation and Examples

- Basic idea: remove duplicated administrative, medical, or other type of records.
- In practise: link information that under different tags

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History and Recent Developments

- Genetics: A Theory for Record Linkage (1969).
- Health, government, privacy, Bayesian methods (1980 - 2000).
- Modern Bayesian methods, machine learning, and clustering (2000 - 2016).

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Two major methods and problems

- Hand matching (scalability, cost).
- Fellegi and Sunter (contains transitive closures, but is still not scalable).
- Two major concerns: scalability and the level of interest.

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Advantages and disadvantages

- Bayesian methods can provide exact uncertainty from the linkage process.
- Bayesian methods are hard to generalize for multiple record linkage.
- Most methods do not scale well.

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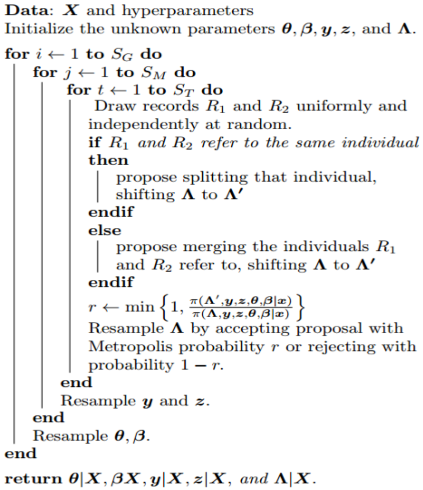
A Bayesian Approach to Graphical Record Linkage and De-duplication

- Split and MErge REcord linkage and De-duplication (SMERED)



```
Data: $\boldsymbol{X}$ and hyperparameters
Initialize the unknown parameters $\boldsymbol{\theta}, \boldsymbol{\beta}, \boldsymbol{y}, \boldsymbol{z}$, and $\boldsymbol{\Lambda}$.
for $i \leftarrow 1$ to $S_G$ do
    for $j \leftarrow 1$ to $S_M$ do
        for $t \leftarrow 1$ to $S_T$ do
            Draw records $R_1$ and $R_2$ uniformly and
            independently at random.
            if $R_1$ and $R_2$ refer to the same individual
            then
                propose splitting that individual,
                shifting $\boldsymbol{\Lambda}$ to $\boldsymbol{\Lambda'}$
            endif
            else
                propose merging the individuals $R_1$
                and $R_2$ refer to, shifting $\boldsymbol{\Lambda}$ to $\boldsymbol{\Lambda'}$
            endif
            $r \leftarrow \min\left\{1, \frac{\pi(\boldsymbol{\Lambda'}, \boldsymbol{y}, \boldsymbol{z}, \boldsymbol{\theta}, \boldsymbol{\beta} | \boldsymbol{x})}{\pi(\boldsymbol{\Lambda}, \boldsymbol{y}, \boldsymbol{z}, \boldsymbol{\theta}, \boldsymbol{\beta} | \boldsymbol{x})}\right\}$
            Resample $\boldsymbol{\Lambda}$ by accepting proposal with
            Metropolis probability $r$ or rejecting with
            probability $1 - r$.
        end
        Resample $\boldsymbol{y}$ and $\boldsymbol{z}$.
    end
    Resample $\boldsymbol{\theta}, \boldsymbol{\beta}$.
end
return $\boldsymbol{\theta}|\boldsymbol{X}, \boldsymbol{\beta}\boldsymbol{X}, \boldsymbol{y}|\boldsymbol{X}, \boldsymbol{z}|\boldsymbol{X}$, and $\boldsymbol{\Lambda}|\boldsymbol{X}$.
```

A Comparison of Blocking Methods for Record Linkage

- Simple Alternatives to Blocking: with the knowledge of the types of errors that are unlikely happened for a certain field or a combination of them, we can identify a pair of records as a non-match when it has strong disagreements in a combination of fields.
- Cluster-Based Blocking: based on the idea that the records in a cluster should be similar, selecting good candidate pairs for linkage
- Locality-Sensitive Hashing (LSH) based methods: LSH uses all of the information contained in each record to build manageably small blocks. High speed and high recall rate, low precision and a lot of flase positive.