Census TopDown Algorithm (TDA):
A Primer on Its Structure, Properties, and Parameters

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Census TDA: Requirements and Properties I

Inputs:

- Post-edits-and-imputation microdata records (Census Edited File – CEF)
- Required structural zeros & data-dependent invariants

Processing:

- Convert CEF to an equivalent histogram
- Apply DP measurements & perform mathematical optimization
- Create noisy histogram; convert back to microdata

Output:

- Return the Microdata Detail File (the MDF; microdata with same schema as CEF)

Example:

- Schema: geography x relgq x sex x age x Hispanic x cenrace
- This product yields a “histogram” (fully saturated contingency table)
- With shape: ≈ 8M x 42 x 2 x 116 x 2 x 63 = ≈ 8M × 1,227,744

Census TDA: Requirements and Properties II

Data-dependent invariants:

Properties of true data that must hold exactly (*no noise*)

Current data-dependent invariants:

- State population totals
- Count of occupied GQ facilities by type by block (not population)
- Total count of housing units by block (not population)

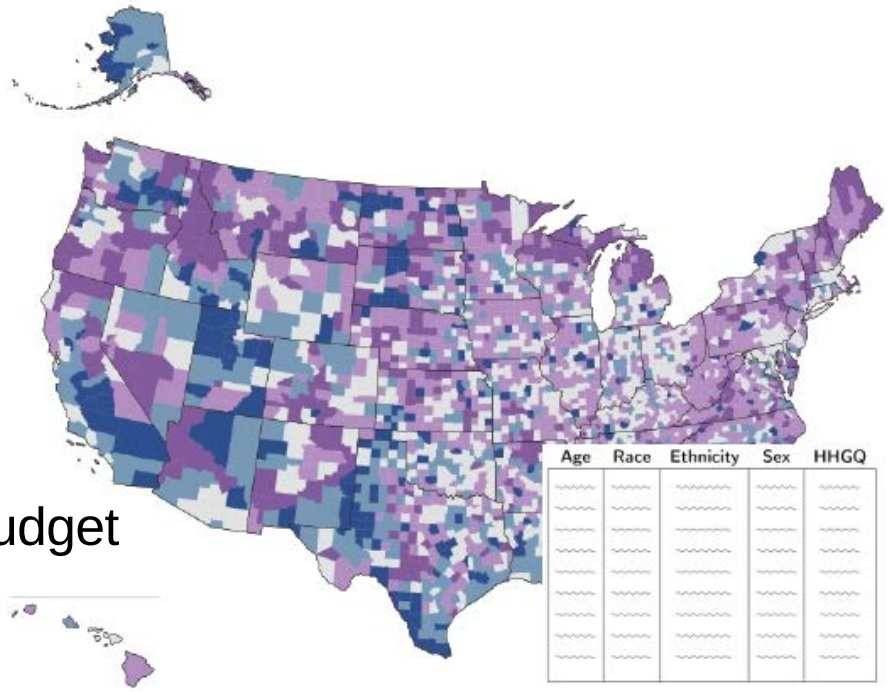
Utility/Accuracy for pre-specified tabulations

- Full privacy + full accuracy for arbitrary uses = impossible
- PL94-171: tabulations used for redistricting
- Demographic and Housing Characteristics File
  - Principal successor to 2010 Summary File 1
  - TDA creates separate Person and Housing Unit microdata sets

ϵ-consistency: error $\to 0$ as privacy loss $\epsilon \to \infty$

Transparency: source code and parameters made public

Basic Structure of TDA



1. Split privacy-loss budget ε into 7 pieces: $\varepsilon_{nat}, \varepsilon_{state}, \ldots$
2. Ignore geography, make national histogram* $\tilde{H}^0$ using ε_{nat} budget
3. Using ε_{state} budget, make state histograms: $\tilde{H}^1_{AK}, \tilde{H}^1_{AL}, \ldots, \tilde{H}^1_{WY}$
   - Must be consistent
   - i.e., $\sum_{s \in states} \tilde{H}^1_s = \tilde{H}^0$
4. Recurse down the hierarchy
5. Invariants imposed as constraints in each optimization problem (with notable complications!)

Note: With the adoption of multi-pass post-processing, TDA produces the histograms for each geographic level in a series of passes. (see slide 7)

Benefits of TDA

- Disclosure-limitation error does not increase with number of contained Census blocks
- A stark contrast with naïve alternatives (e.g., block-by-block or bottom-up)
- Yields increasing accuracy as number of observations increases
- “Borrows strength” from upper geographic levels to improve lower levels (e.g., for sparsity)

Multi-pass Post-processing

To address the sparsity issue, which introduced substantial distortions in the 2010 Demonstration Data Products, TDA processing is now performed in a series of passes.

At each geographic level, the algorithm constructs histograms for a subset of queries in a series of passes for that level, constraining the histogram for each pass to be consistent with the histogram produced in the prior pass.

Pass 1: Total Population
Pass 2: Tabulations supporting PL94-171 Redistricting Data
Pass 3: Tabulations supporting Population Estimates and most demographic use cases
Pass 4: The remainder of the DHC tabulations

Privacy-loss Budget Allocation
(as implemented in 5/27/2020 Detailed Summary Metrics)

By Geographic Level:

Nation	20%
State	20%
County	12%
Tract Group	12%
Tract	12%
Block Group	12%
Block	12%

By Query Set:

DHC-Person Allocations	
total	30%
hhgq	15%
votingage * hispanic * cenrace	29%
age * sex * hispanic * cenrace	25%
detailed	1%

Query Size
(for full Group I product implementation)

DHC-Person Queries (per geographic level)	
total	1
relgq	42
votingage * hispanic * cenrace	252
age * sex * hispanic * cenrace	29,232
detailed	1,227,744

DHC-Household Queries (per geographic level)	
total	1
hisp * race	14
tenvacgq	34
sex * hisp * race * hhtype_dhch	14,616
elderly * sex * hhtype_dhch	4,176
hhage * hhtype_dhch * sex	9,396
detailed	1,052,352

Questions?

Disclosure Avoidance and the 2020 Census Website
https://www.census.gov/about/policies/privacy/statistical_safeguards/disclosure-avoidance-2020-census.html

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