Evolution of Privacy Loss in Wikipedia

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Motivation

• Social media and online privacy are two of today's hot topics.

• Given that we know that digital traces reveal more than users might think [Kosinski, PNAS 2013], we ask the next questions.

• Goals of this work:
  ➢ Does online user's privacy degrade over time?
  ➢ What factors contribute most to revealing private traits?
  ➢ Can I stop leaking personal information if I stop posting online?
Presentation outline

➢ Case study: Wikipedia dataset
➢ Profiling of editing behavior
➢ Measuring predictability of personal traits
➢ Marginal utility of features over time
➢ Conclusion and the way ahead

Why Wikipedia?

➢ 13 years long, public: ideal for longitudinal study;
➢ tens of thousands of editors, of different geographic locations, religious, educational and political backgrounds;
➢ apparently harmless dataset: a reservoir of knowledge, no focus on personal information.

Dataset dimensionality:

➢ 188,805,088 revisions
➢ 117,523 editors
➢ 8,679 editor badges
➢ 22,172,813 edited pages
➢ 430,410 page categories
Encoding editing behavior (1)

Editor activity profiles:

- **basic set**: #revisions over 6 predefined categories (Wiki namespaces);
- **extended set**: adding Wikipedia's 23 high level thematic categories (Math, Geography, History etc.)

<table>
<thead>
<tr>
<th>Basic feature set</th>
<th>Feature name</th>
</tr>
</thead>
<tbody>
<tr>
<td>CONTENT</td>
<td>TALK-C</td>
</tr>
<tr>
<td>USER</td>
<td>TALK-U</td>
</tr>
<tr>
<td>WIKI</td>
<td>INFRA</td>
</tr>
</tbody>
</table>

Editor personal information:

- Extracted from the badges editors put on their editor pages;
- **Gender** (6936 out of more than 117k), ethnic origin, **religious views** (7685), education (9224), sexual orientation etc.
Encoding editing behavior (2)

- 3-month timeframes
- Description for each editor per timeframe, each feature counts revision over categories
- Feature set temporally embeds increasing amounts of information

![Diagram showing timeframes with categories: CONTENT, TALK-C, USER, TALK-U, WIKI, INFRA. The bars for each timeframe show the evolution of features over time.](image)
Profiling of editing behavior (1)

Decline of editorship and rise of maintenance

While the Wikipedia “slowdown” has been previously reported [Suh '09, Halfaker '12], we break down this evolution per category and detect a rise of maintenance effort.
Different growth trends across editor demographics

Evolution trends across editor categories are unequal, providing plausible explanations for the slowdown [Gibbons '12], as well as personal identification clues.
Edit behavior correlates with private traits

Gender - aggregated basic features

Mean editing behavior analysis shows regularities in the editing patterns for each sub-population.
Predictability improves over time

Privacy Loss as a *prediction problem*

Prediction of gender (basic features)

Prediction of education - undergrads (basic features)

Prediction of religion - Muslim (basic features)
Sources of Privacy Loss (1)

Richer features: improve prediction, but not Privacy Loss
Newcomers: information from newcomers hurts privacy
Marginal utility of features over time

Information theory measures:

- Uncertainty about private information $\rightarrow$ entropy of target variable $Y$
  \[ H(Y) \]
- Amount of information disclosed by a feature $X$ about $Y$ $\rightarrow$ mutual information of $X$ and $Y$
  \[ I(Y; X) \]
- Amount of new information disclosed by a feature at time $t$ $X_t$
  $\rightarrow$ Information Transfer
  \[ I(Y; X_t | X_{1:t-1}) \]
While later edits contain just as much information about a user’s privacy as the earlier edits, they tend to be less harmful since most of the information they bring has already been learned.
The information inferred from newcomers seems to be moderate, but consistent over time.
Privacy erodes even for retired editors

Plausible explanation: observed prediction improvement originates with currently active editors, whose activity overlaps with exited editors
Conclusion

3 main conclusions:

- Time has an adverse effect on privacy
- Factors influencing Privacy Loss:
  - *online breadcrumbs* (i.e. editor's own activity)
  - activity of other editors and newcomers
- Privacy erodes even for *retired* editors

Users don't have complete control over the consequences of the information they release
The way ahead

Issues to address / Perspectives:

➢ not specific to Wikipedia: additional online platforms, richer in social data;
➢ editor disclosure bias;
➢ effective conditions for preserving privacy.
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