

# The Crowd Wisdom for Location Privacy of Crowdsensing Photos: Spear or Shield?

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# Background of Photo Crowdsensing

- ❑ Photo crowdsensing incorporates the mobile crowd into visual sensing for monitoring and understanding the physical world.
- ❑ Representative applications include: city viewing<sup>[Geograph<sup>®</sup>, Phototourism'06]</sup> and event sensing<sup>[CrowdStory'17]</sup>.

The **Geograph<sup>®</sup> Britain and Ireland** project aims to collect geographically representative photographs and information for every square kilometre of [Great Britain](#) and [Ireland](#), and you can be part of it.

Since 2005, **13,409 contributors** have submitted **6,914,909 images** covering **281,246 grid squares**, or **84.7%** of the total squares

**Selected photograph** [view previous >](#)



Croydon: tanks and machinery at Manor Farm by John Sutton for square [TL3149](#), taken [Sunday, 10 November, 2013](#)

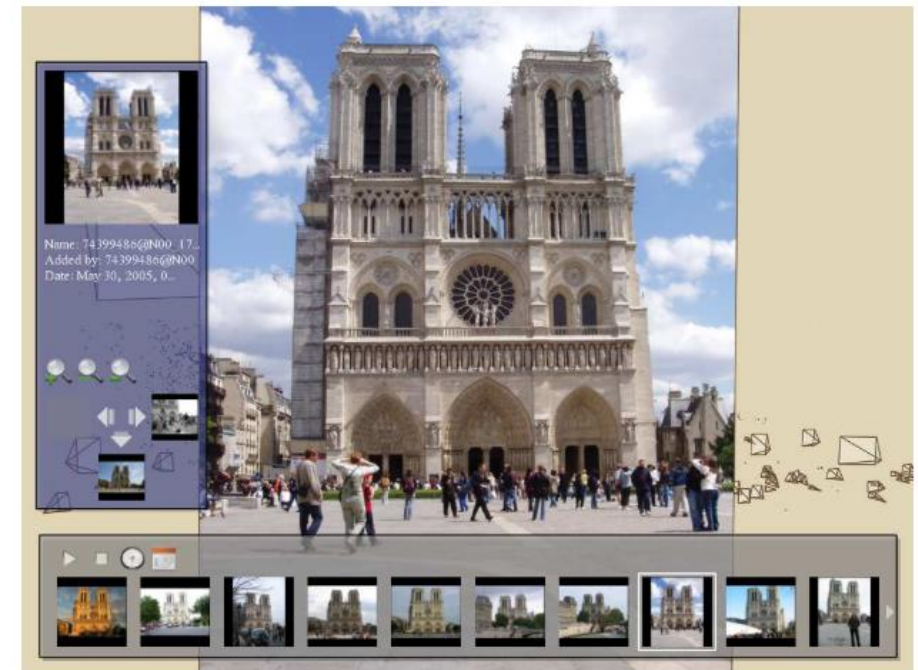
Click the map to start browsing photos



**What is Geographing?**

- It's a game - how many grid squares will you contribute?
- It's a geography project for the people
- It's a national photography project
- It's a good excuse to get out more!
- It's a free and [open online community](#) project for all

[Registration](#) is free so come and join us and see how many grid squares you submit!



Source: <https://www.geography.org.uk>

Source: <http://phototour.cs.washington.edu/>



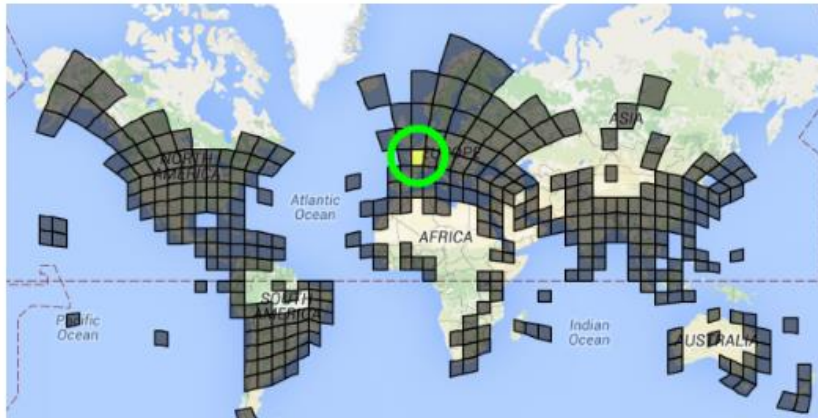
# Privacy of Photo Crowdsensing

- ❑ A serious concern of the crowd/participants: contributing real-world photos may expose their locations.
- ❑ Even perfectly hiding the raw location, a participant's location can still be inferred from its photos.



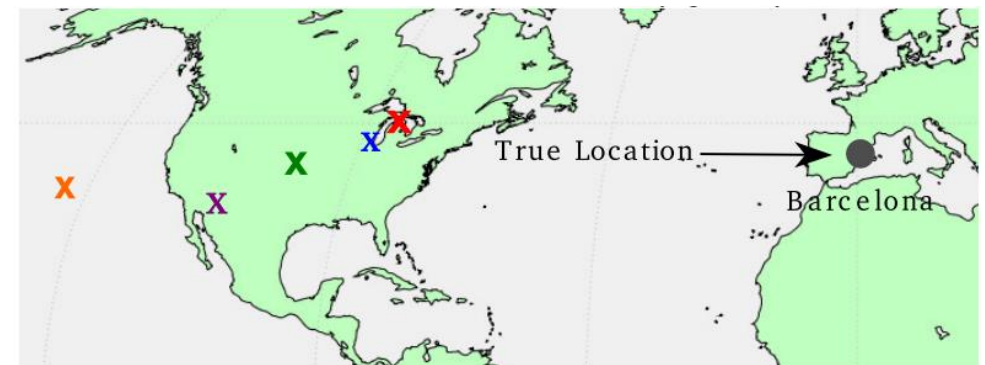
## **Threat:** Google's PlaNet [ECCV'16]

Regarding each location with sufficient photos as a class and training a deep learning model for location inference.

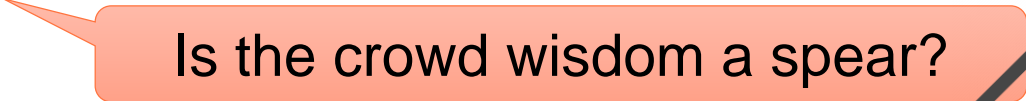




## **Protection:** Photo pruning [AAAI'20]

Degrading the classifier's inference accuracy by pruning the submission photo collection before posted publicly.



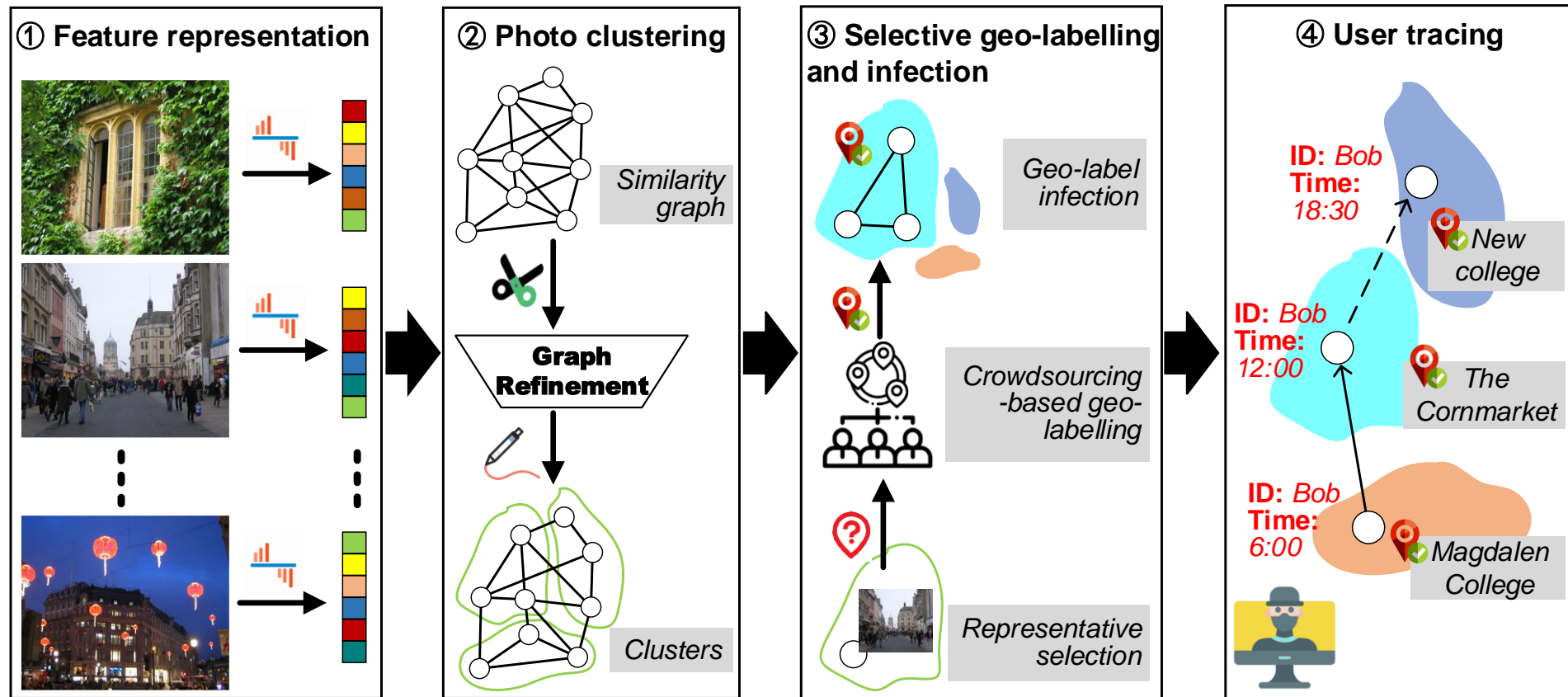
# Our Motivations

- ❑ Usually no prior knowledge for the uncharted target of photo crowdsensing.
- ❑ Hence, for the practically no-references-situations, we investigate:
  - Would one's involvement in a crowd during sensing increase its risk of location disclosure?  
Is the crowd wisdom a spear?
  - Can the crowd of users take active measures collaboratively to avoid such information leakage?  
Is the crowd wisdom a shield? 



# The Spear: No-reference Location Inference

- ❑ Building blocks: ① feature representation knowledge of an existed crowd of photos; ② visual correlations of crowdsensing photos; ③ mobile crowdsourcing for geo-annotation.





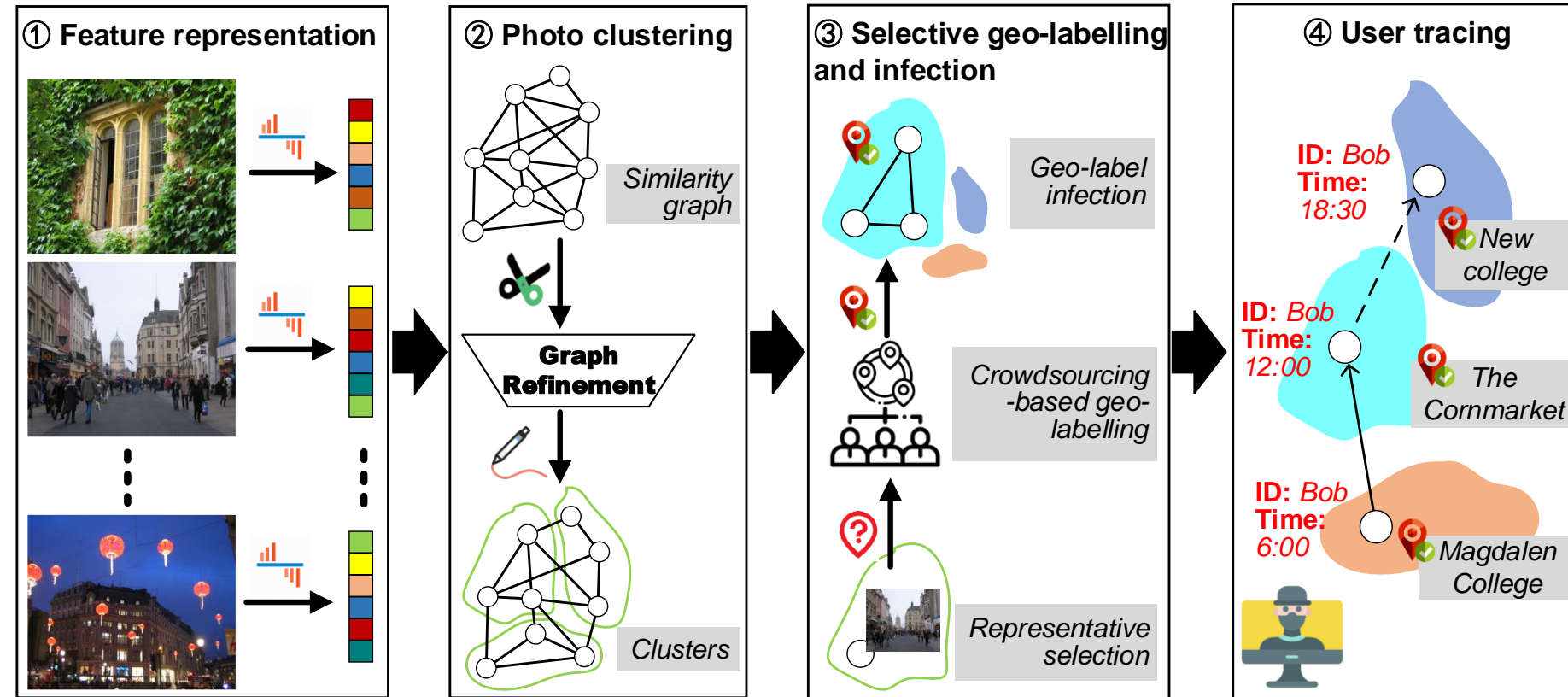
# The Spear: No-reference Location Inference

**Step 1.** Extract features using a **BoVW model** and a **deep model**.

**Step 2.** Perform **spectral clustering** on the top-k refined similarity graph.

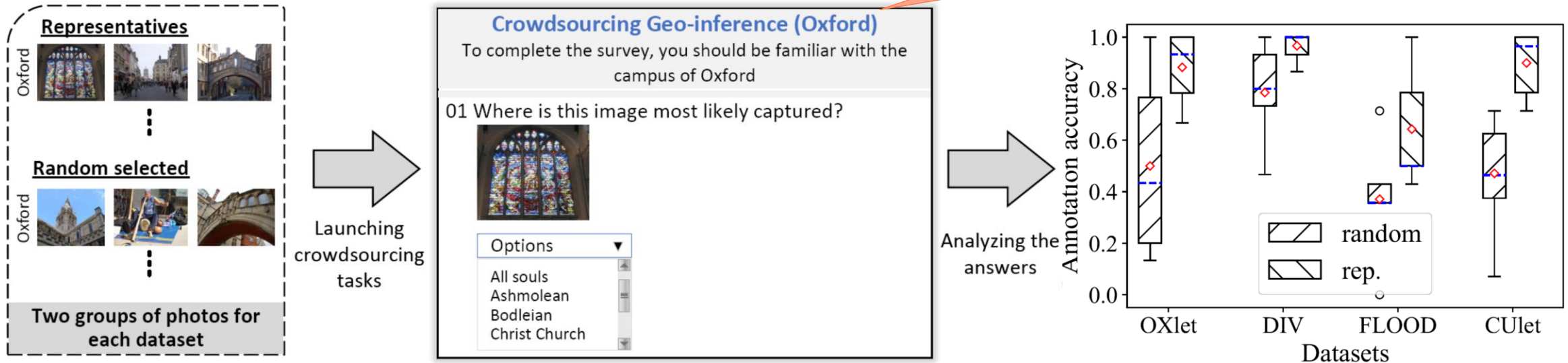
**Step 3.** Select a **seed** in each cluster for geo-labelling and infer the rests.

**Step 4.** Combine several inferred locations into a track.



# Experiments on the Spear

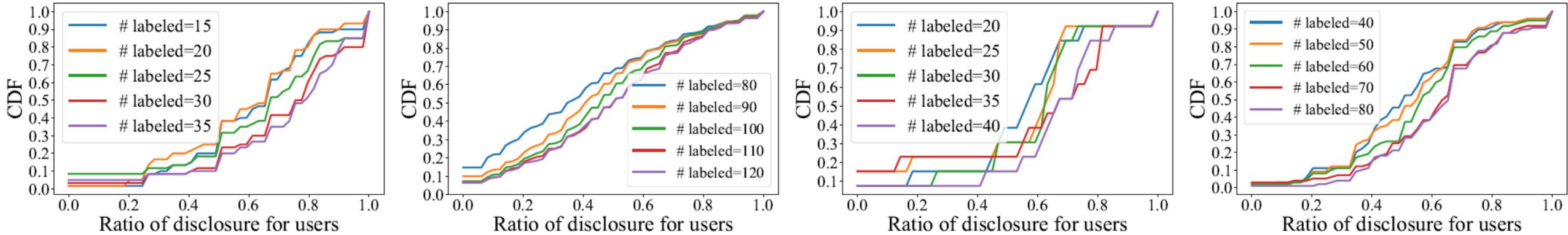
Using the Oxlet dataset  
as an example



- We construct crowdsourcing tasks for the selected photos using the Tencent Questionnaire.
- The **correlations among a crowd** of photos can lead to **more accurate geographic annotation**.



# Experiments on the Spear



Ratios of correctly geo-identified photos for each user (From Left to Right: OXlet, DIV, FLOOD, CUlet)

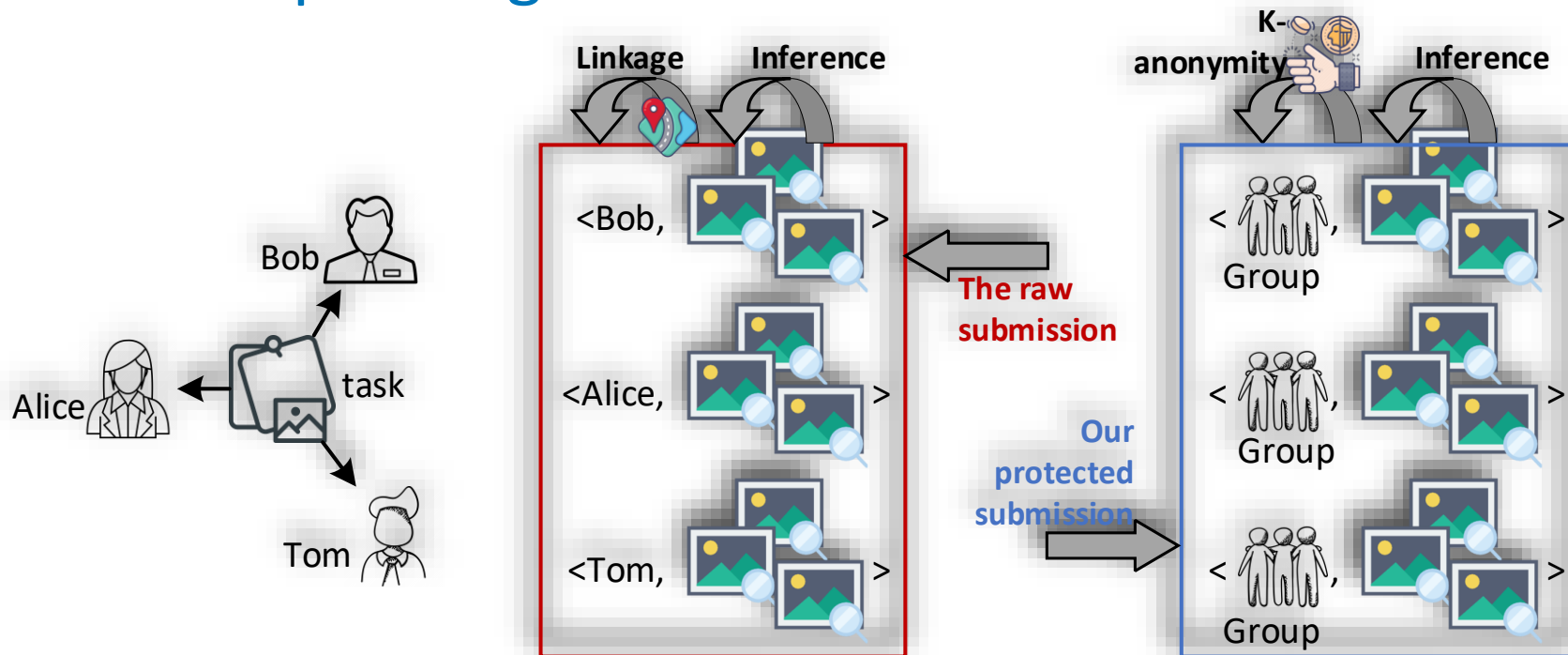
- Almost over 80% of users get at least one location correctly inferred (y-values of the curves for the ratio of disclosure 0), indicating **serious privacy threats**.
- Contributing submissions together with a crowd of photos will, unfortunately, increase one's risk of being geo-identified.



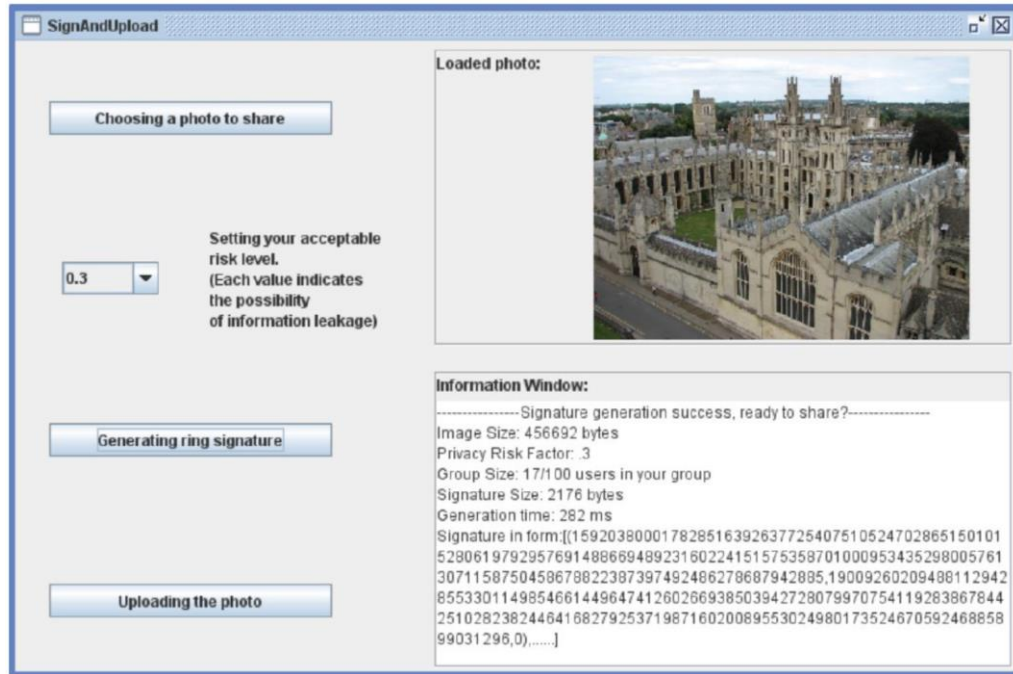


# The Shield: Signing photos with ring signature

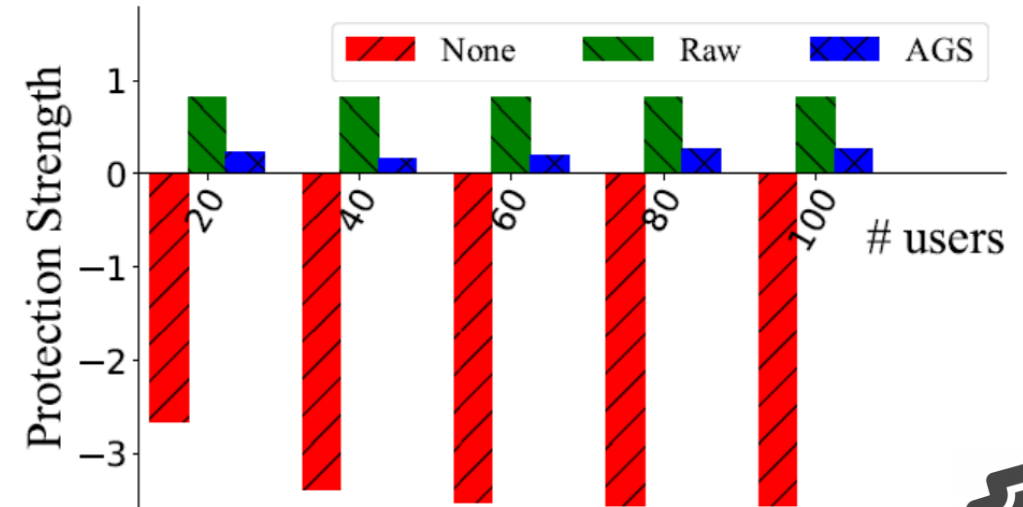
- ❑ Basic idea: Users of the same task share the same security concern, thus making their community itself a nature camouflage.
- ❑ Overview: Modify the ring signature technique to **adaptatively grouping users** and **cut off the linkage between inferred locations and their corresponding users**.



# The Shield: Implementation & Experiments



- We develop a light-weight prototype for the defense model.
- Supporting user to specify its privacy preferences.



- We theoretically prove the security of our defense model (i.e., AGS).
- Our AGS can provide efficient privacy protection given all the preferences.

# Thanks for your attention!

## Q&A

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