Privacy-Aware Tag Recommendation for Image Sharing  
Ashwini Tonge, Cornelia Caragea and Anna Squicciarini  
1Kansas State University, 2Pennsylvania State University

**Image Privacy Prediction?**  
- Rapid increase in social media can cause threat to user’s privacy.  
- Many users are quick to share private images without realizing the consequences of an unwanted disclosure of these images.  
- Users rarely change default privacy settings, which could jeopardize their privacy [Zerr et al., 2012].  
- Current social networking sites do not assist users in making privacy decisions for images that they share online.  
- Image Privacy Prediction predicts privacy setting for images and avoid a possible loss of users’ privacy.

**Prior Works**  
- Recently, [Squicciarini et al., 2014] and [Zerr et al., 2012] found that user tags are informative for classifying images as private or public.  
- [Tonge and Caragea, 2016, Tonge and Caragea, 2018, Tonge et al., 2018] automatically obtained image tags from the visual content using convolutional neural networks and also showed their performance for privacy prediction.

**Motivation**  
- (a) Private, Elegant  
- (b) Public, Parisi, Sabrina  
- Corporate, Style  
- Fashion, Girl, Woman, Famous, Girl  
- Skirt, Top, Bag, Pretty  
- Woman, Hollywood  

**Our Contributions**  
- Present a privacy-aware approach to image tagging.  
- Improve the quality of user tags.  
- Preserving the images original privacy sharing patterns.  
- Recommends potential tags for a target image by mining privacy-aware tags from the most similar images.  
- Although the user-input tags comprise noise or even some images do not have any tags at all, our approach is able to recommend accurate tags.  
- Results show that the predicted tags can exhibit relevant cues for specific privacy settings.

**Datasets**  
- We evaluated our approach on Flickr images sampled from the Picalert dataset [Zerr et al., 2012].  
- Picalert consists of Flickr images on various subjects, which are manually labeled as public or private by external viewers.  
- The public and private images are in the ratio of 3:1.  
- Private: Private image discloses sensitive information about a user, e.g., images with self-portraits, family, friends, someone’s home, etc.  
- Public: Remaining images are labeled as public.

**Experiments and Results**  

### Algorithm Illustration - I

![Image of privacy-aware tag recommendation algorithm example](image)

**Figure:** Illustration of the privacy-aware tag recommendation algorithm using an example.

### Algorithm Illustration - II

| Candidate Tags | Count | P(e|p) | P(p|e) | P(e|p) * P(p|e) | w_t | P(e) | k=5.1 |
|----------------|-------|-------|-------|-----------------|------|-------|-------|
| Doll           | 0.15  | 0.10  | 0.5   | 0.25            | 0    | 0.85  | 1     |
| Toy            | 0.15  | 0.10  | 0.5   | 0.25            | 0    | 0.85  | 1     |
| Cute           | 0.15  | 0.10  | 0.5   | 0.25            | 0    | 0.85  | 1     |
| Shop           | 0.15  | 0.10  | 0.5   | 0.25            | 0    | 0.85  | 1     |
| Eyechips       | 0.15  | 0.10  | 0.5   | 0.25            | 0    | 0.85  | 1     |
| Indoor         | 0.15  | 0.10  | 0.5   | 0.25            | 0    | 0.85  | 1     |
| Happiness      | 0.15  | 0.10  | 0.5   | 0.25            | 0    | 0.85  | 1     |

Table: Privacy-aware weighted sum of tag occurrences (K = 5, r = 3).

**Evaluation by Privacy Prediction**  

![Image of F1-measure for various parameter values of scoring methods, k and r.](image)

**Figure:** F1-measure obtained for various parameter values of scoring methods, k and r.

### References
- Future directions.  
  - Multiple sharing needs of the user.
  - Computing images similarity by combining both tags and visual content.

**Conclusions**  
- Improve the original set of user tags and preserve images privacy.  
- Draw ideas from collaborative filtering (CF).  
- Although the user-input tags are prone to noise, we were able to integrate them in our approach and recommend accurate tags.  
- Simulated the recommendation strategy for newly-posted images, which had no tags attached.  
- Simulated the recommendation strategy for newly-posted images, which had no tags attached.  
- Achieved better performance for privacy prediction with recommended tags than user tags.  
- Indicate that the suggested tags comply to the images privacy.

**Experimental Results**  

<table>
<thead>
<tr>
<th>Features</th>
<th>Acc.</th>
<th>P</th>
<th>F</th>
<th>Precision</th>
<th>Recall</th>
</tr>
</thead>
<tbody>
<tr>
<td>k=1</td>
<td>0.75</td>
<td>0.72</td>
<td>0.75</td>
<td>0.72</td>
<td></td>
</tr>
<tr>
<td>k=2</td>
<td>0.74</td>
<td>0.72</td>
<td>0.74</td>
<td>0.72</td>
<td></td>
</tr>
<tr>
<td>k=3</td>
<td>0.74</td>
<td>0.72</td>
<td>0.74</td>
<td>0.72</td>
<td></td>
</tr>
<tr>
<td>k=4</td>
<td>0.74</td>
<td>0.72</td>
<td>0.74</td>
<td>0.72</td>
<td></td>
</tr>
<tr>
<td>k=5</td>
<td>0.74</td>
<td>0.72</td>
<td>0.74</td>
<td>0.72</td>
<td></td>
</tr>
</tbody>
</table>

Table: Performance for privacy prediction after adding recommended tags.