Photographer anonymity

Joint work with
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The perils of being on camera

Person X is falsely on medical-disability leave but is visiting the UK

Person Y happens to be visiting UK and accidentally takes pictures of X and posts it on the Internet

Defenses: Pixellation, blurring, ...
A different privacy problem: photographer anonymity

1. Photograph
2. Blog article

Citizen journalist

SECRET MEETING

Blogger™
Photographer anonymity problem

1. Photograph

2. Blog article

Citizen journalist with hidden camera

Meeting

Blogger
Naive defense: hidden cameras
Anonymity set with hidden camera
Citizen journalist with hidden camera

1. Photograph

2. Post image on the Internet

3. Image analysis to determine hidden camera location

4. Consult CCTV to deanonymise photographer

Camera-location De-anonymisation attack
Our approach towards a defense technique: View Synthesis

Source: L. Fei-fei, Stanford Vision Lab
Anonymity set with view-synthesis
Citizen journalist with hidden camera

1. Photograph

2. Post image on the Internet

3. Image analysis to determine hidden camera location

4. Consult CCTV to deanonymise photographer

Camera-location De-anonymisation attack
Problem definition

- Input:
  - Two images taken from locations $L$ and $R$ respectively
  - Two projection matrices specifying image viewpoints
  - Output projection matrix specifying synthetic viewpoint

- Output: synthetic image

- Security properties: minimal information about $L$ or $R$ should be leaked

- Threat model: external passive adversary
Privacy enhancing technology: view synthesis
View synthesis process

- Stereo matching
View synthesis process

- Stereo matching
- Disparity computation
View synthesis process

- Stereo matching
- Disparity computation
- Warping
View synthesis process

- Stereo matching
- Disparity computation
- Warping

\[
K_R(u, v) = \left(\frac{x_R - x_S}{b}\right) \cdot I_R(u + D(u, v), v)
\]

\[
K_L(u, v) = \left(\frac{x_S - x_L}{b}\right) \cdot I_L(u, v)
\]

\[
I_S(u, v) = K_L(u, v) + K_R(u, v)
\]

b: distance between the cameras
D: disparity map
View synthesis process

- Stereo matching
- Disparity computation
- Warping
- Occlusion handling
View synthesis with partial occlusion
Challenges: hole handling

Input images

Source: middlebury.edu
View synthesis with partial occlusion

\[ h' = f \left( \frac{s}{Z_o} - \frac{s}{Z_b} \right) = \frac{s}{l} \left( 1 - \frac{Z_o}{Z_b} \right) \]
View synthesis with partial occlusion

\[ h' = f \left( \frac{s}{Z_o} - \frac{s}{Z_b} \right) = \frac{l}{l} \left( 1 - \frac{Z_o}{Z_b} \right) \]

\[ s = \frac{h}{\alpha}, \]

\[ b < \frac{l - h}{\alpha}, \]
View synthesis with full occlusion
View synthesis with full occlusion

\[ h'' = f \left( \frac{l}{Z_o} - \frac{b}{Z_o} + \frac{b}{Z_b} \right) = \hat{l} - \frac{b}{l} \left( 1 - \frac{Z_o}{Z_b} \right) \]
View synthesis with full occlusion

\[ h'' = f \left( \frac{l}{Z_o} - \frac{b}{Z_o} + \frac{b}{Z_b} \right) = \hat{l} - \frac{b}{l} \left( 1 - \frac{Z_o}{Z_b} \right) \]

\[ s > \frac{h}{\alpha}, \]

\[ b = \frac{\hat{l} - h}{\alpha}, \]
Anonymity

\[ A = - \sum_{i=1}^{N_{susp}} \frac{1}{N_{susp}} \log \frac{1}{N_{susp}} - \sum_{i=1}^{N} \frac{1}{N} \log \frac{1}{N} = \log \frac{1}{N_{susp}} = \log_{N_{susp}} \]

- \( n = 20 \) (number of journalists)
- \( l = 0.5 \) m (length of object, in this case shoulder width)
- \( \hat{l} = 5 \) mm (length of projection of the object on the CCD/CMOS)
- \( Z_o = 5 \) m (distance between the focal plane (where the journalists are standing) and the speaker)
- \( Z_b = 7 \) m (distance between the focal plane and the background)
- \( h = 1 \) mm (size of the hole beside the speaker measured on the CCD/CMOS if there is any, otherwise \( h = 0 \))

\[ A = \begin{cases} 0.688 & \text{if } h > 0 \\ 0.958 & \text{if } h = 0 \end{cases} \]
So, does it work?
Artifacts

Narrow baseline
Artifacts

Medium baseline
Conclusions

- We have posed a new privacy problem: camera-location anonymity
- We propose view-synthesis as a defense technique to improve camera-location anonymity and photographer anonymity
- Analytical results
- Preliminary results show some promise
Questions?

(a) Left input image  (b) Right input image  (c) Synthetic image  (d) Ground truth image

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