Are There Wireless Hidden Cameras Spying on Me?

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Motivation

Increasing crime cases

Difficult to find
Design consideration

Spy camera detection CASE 1

Spy camera detection CASE 2

Detected by a lens detection APP
Design consideration

Our approach: Network traffic pattern analysis with smartphone

- High accuracy
- High usability
- No need for dedicated device
Network traffic characteristics of spy cameras

- **Video Compression**
  - Intra-Frame (I-Frame): Include whole information of a scene
  - Inter-frame (P/B-Frame): Encode residuals after frame prediction
    - Inter-frame size increases when changes in video increases

- **Previous works**
  - Network traffic size pattern according to the user’s movement
Challenges

- Challenges to detect spy cameras on wireless networks
  - Encrypted packets
  - Large size I-frames
  - Other types of packets
Challenges

- Challenges to infer inter-frame sizes

  - Video frame size reconstruction
    - Challenge 1: Packet losses

  - Inter-frame size extraction
    - Challenge 2: Remove I-frames
    - Challenge 3: Remove noises
Video frame size reconstruction

- **Challenge 1: Packet losses**

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Packet loss!
Challenges

Video frame size reconstruction

Challenge 1: Packet losses

Inter-frame size extraction

Challenge 2: Remove I-frames
Challenge 3: Remove noises
Inter-frame size extraction

- Challenge2: Remove I-frames
- Challenge3: Remove noises

![Graph showing frame size over time](image)

- Remove I-frames
- Remove same sized and small noise frames
- Remove noise frames which shows bimodal distribution
3 Steps of SCamF

- Propose SCamF to detect and localize wireless spy camera

- Camera Traffic Classification
- Spy Camera Detection
- Spy Camera Localization
3 Steps of SCamF

- SCamF classifies camera and non-camera traffic to reduce the number of candidate spy cameras

Diagram:

1. Camera Traffic Classification
2. Spy Camera Detection
3. Spy Camera Localization
# Camera Traffic Classification

## Traffic Types

- **Camera traffic**
  - Burst traffic
  - Frame unit transmission

- **Non-camera traffic**

## Table

<table>
<thead>
<tr>
<th>Traffic type</th>
<th>Minimum traffic volume (kbps)</th>
<th>Minimum FPS</th>
<th>Average inter-packet time interval (msec)</th>
<th>FU rate</th>
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<td>Game</td>
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3 Steps of SCamF

- SCamF verifies the thus-identified devices are indeed spy cameras recording the user’s movements.
Spy camera detection

- SCamF calculates the correlation between inter-frame size changes and the user movement to minimize false positives.
Spy camera detection

Sensor data measured by smartphone

Gyroscope value (rad/s)

Inter-frame size

Frame size (KB)

Time (second)

Spy Camera

Matched

Spy camera!
3 Steps of SCamF

- SCamF localizes the detected spy cameras by observing the video frame size pattern according to the distance between a spy camera and a user.
Spy camera localization

Spy Camera

SCamF

Apply adaptive threshold
### Experimental Setup

#### System Diagram

![Diagram showing setup with Spy Camera and AP](https://via.placeholder.com/150)

#### Table of Wireless Cameras

<table>
<thead>
<tr>
<th>No.</th>
<th>Brand</th>
<th>Model</th>
<th>Video/Audio Encoding</th>
<th>Resolution</th>
<th>Other Supported Functions</th>
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#### Summary

20 wireless cameras in online stores
Performance of SCamF

<table>
<thead>
<tr>
<th>Spy camera classification</th>
<th>Precision</th>
<th>Recall</th>
<th>Accuracy</th>
<th>F1 score</th>
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Spy camera detection

Spy camera localization

Propose a fine-grained encrypted traffic analysis approach, SCamF to detect and localize spy cameras

- Extract Inter-frame size information from encrypted Wi-Fi traffic
- Determine both the presence and the location of spy cameras
- Achieve high accuracy and low false positives
Thank You

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