

Are There Wireless Hidden Cameras Spying on Me?

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Date

2022. 12. 08.

Organization

SAMSUNG



KSAT 12

Hidden camera found inside fake smoke detector in UTSA student's apartment, police say

SAN ANTONIO – An investigation is underway after a student living at University Oaks found a camera inside of a fake smoke detector in their...

5 hours ago

7 W

Car

DANVILLE, Va. (WDBJ) - Danville Police say they were not notified when a camera was found hidden in a Walmart store restroom.

2 days ago

CityNews Toronto

Family finds hidden camera in Brampton Airbnb

On Airbnb's website, it clearly states, "security measures like security cameras and noise monitoring devices are allowed, as long as they are..."

2022. 7. 30.

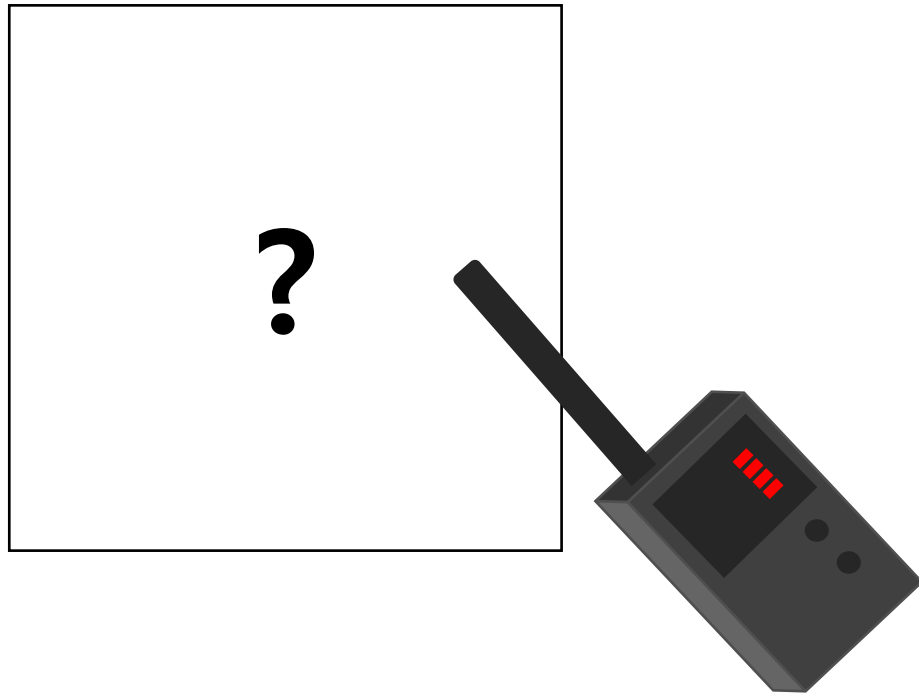


Increasing crime cases

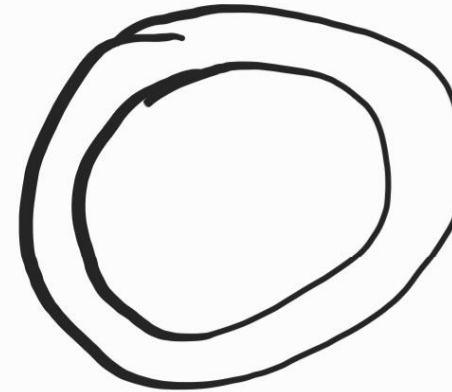


Difficult to find

Spy camera detection CASE 1



Spy camera detection CASE 2



Detected by a lens detection APP

High accuracy

High usability

No need for dedicated device

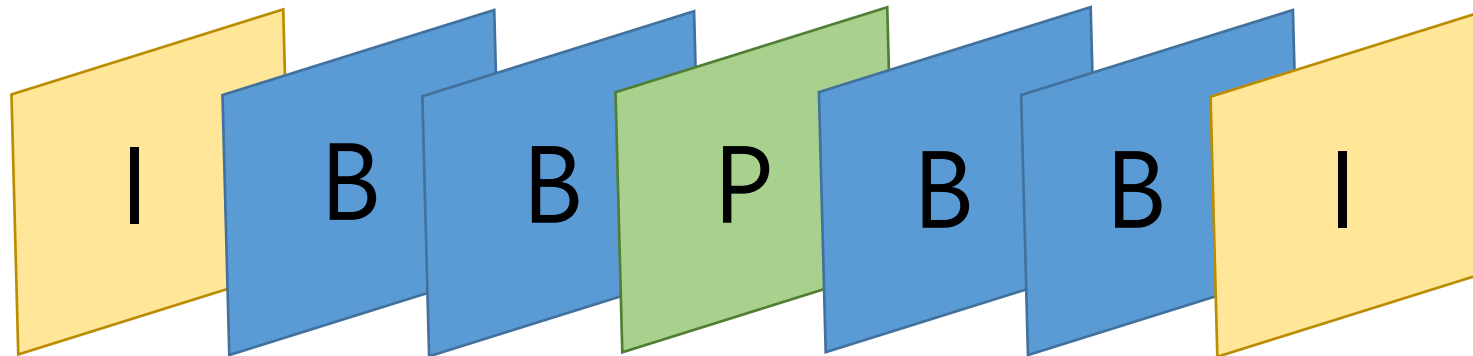
Our approach: Network traffic pattern analysis with smartphone

- **Video Compression**

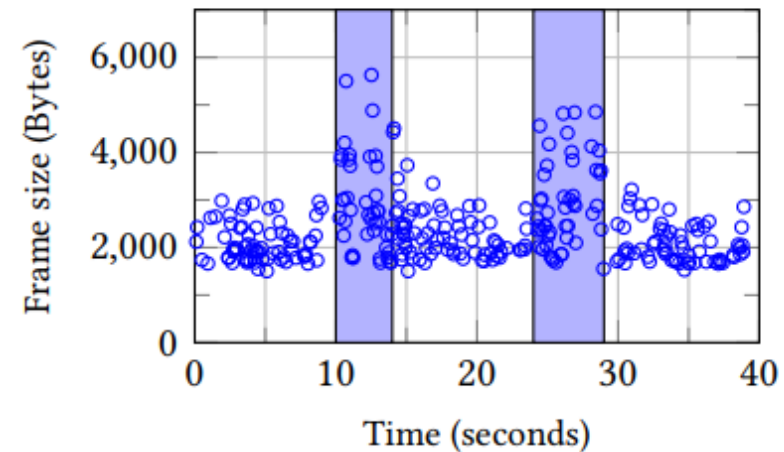
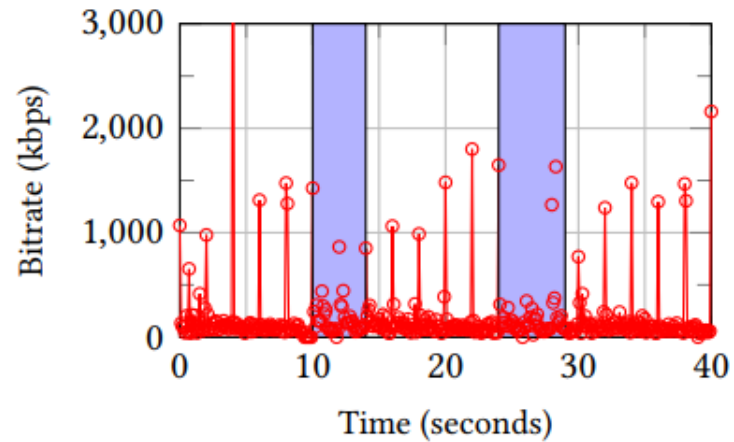
- Intra-Frame (I-Frame): Include whole information of a scene
- Inter-frame (P/B-Frame): Encode residuals after frame prediction
- Inter-frame size increases when changes in video increases

- **Previous works**

- Network traffic size pattern according to the user's movement



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



- **Challenges to infer inter-frame sizes**

Video frame size reconstruction

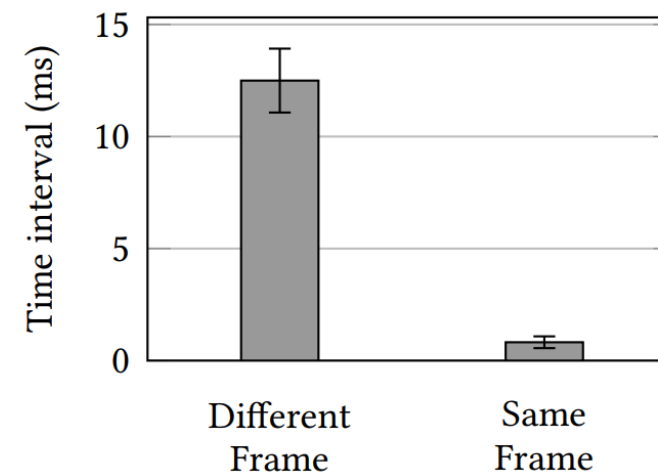
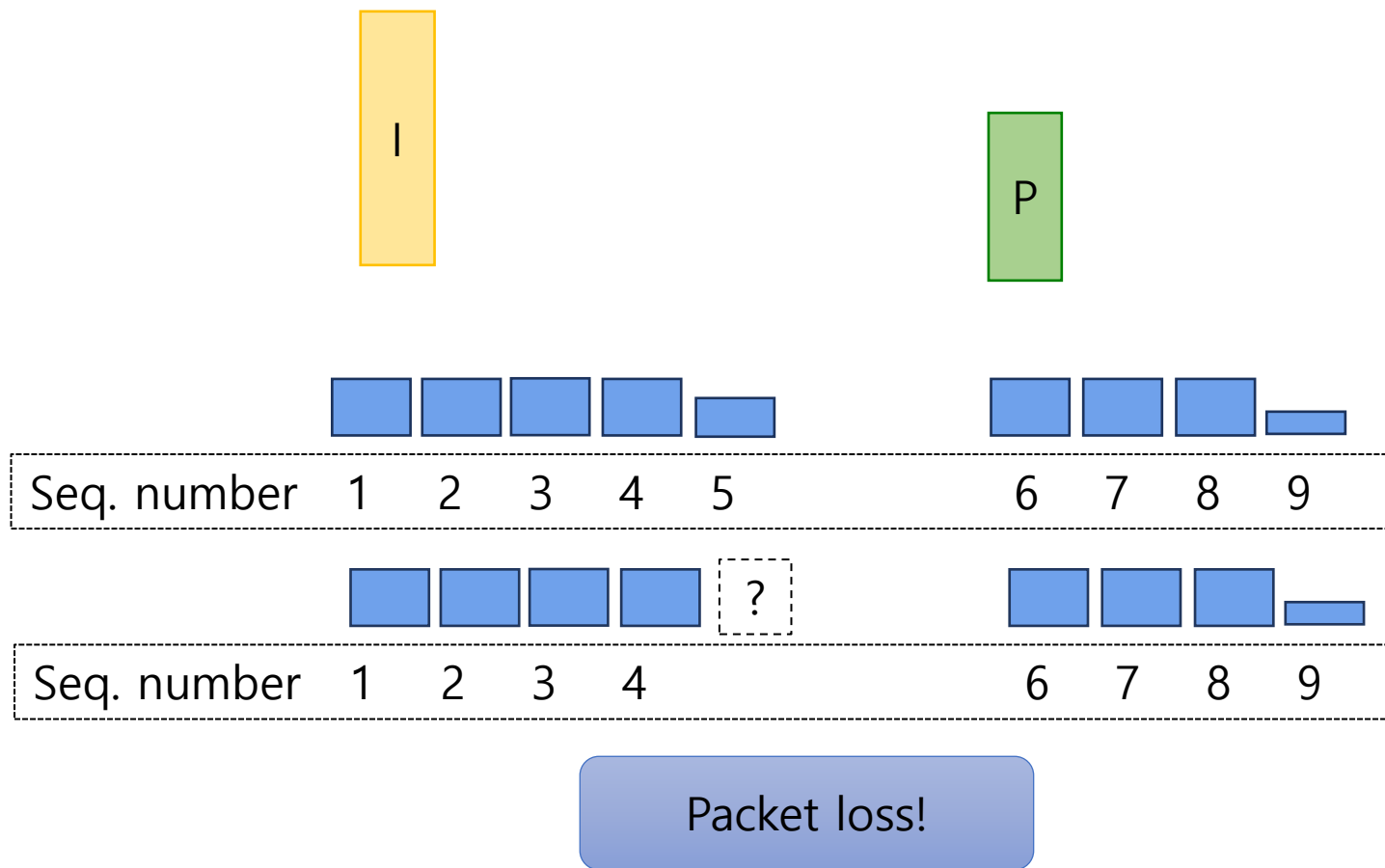
Challenge1: Packet losses

Inter-frame size extraction

Challenge2: Remove I-frames

Challenge3: Remove noises

- Challenge1: Packet losses



Video frame size reconstruction

Challenge1: Packet losses

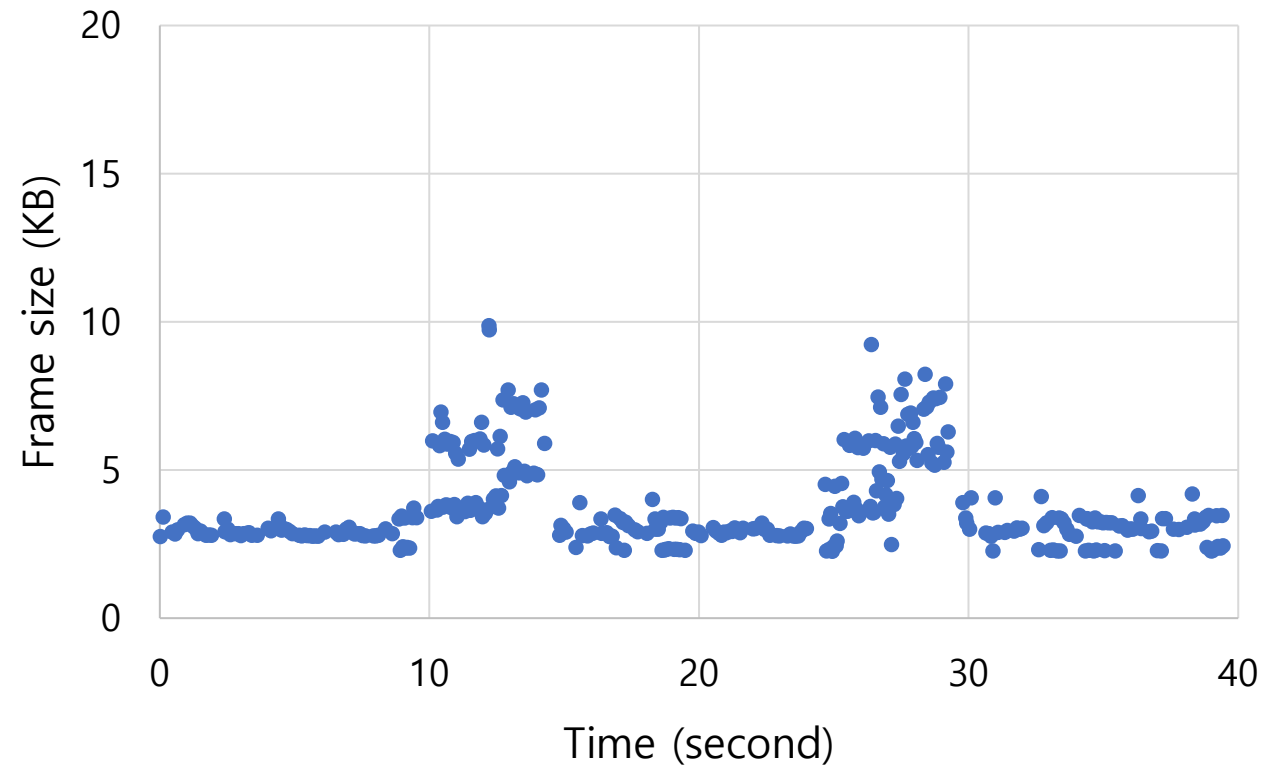
Inter-frame size extraction

Challenge2: Remove I-frames

Challenge3: Remove noises

Inter-frame size extraction

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



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

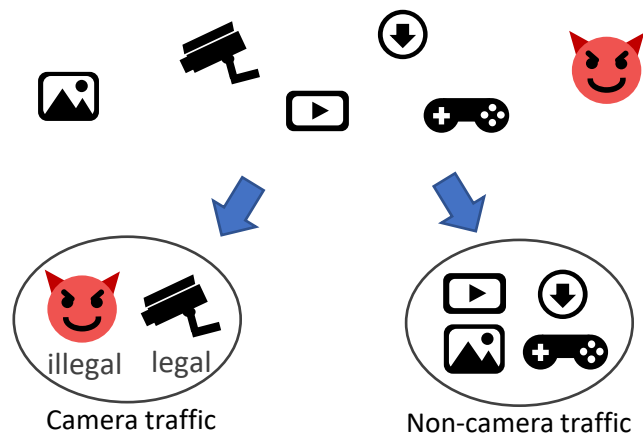


3 Steps of SCamF

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



Camera Traffic Classification



Traffic type	Minimum traffic volume (kbps)			Minimum FPS			Average inter-packet time interval (msec)			FU rate		
	Min.	Max.	Avg.	Min.	Max.	Avg.	Min.	Max.	Avg.	Min.	Max.	Avg.
Camera	5.2	241.0	52.5	1	75.3	26.4	4.5	62.3	15.3	0.09	0.91	0.51
VOD	0	1585.8	175.4	0	2.33	0.2	0.3	41.2	2.1	0	1	0.95
Download	614.0	2043.9	1450.9	0	1	0.1	0.4	0.8	0.5	1	1	1
Picture	0	897.3	28.4	0	16.7	1.5	0.6	111.7	5.8	0	0.99	0.83
Game	0	4.0	1.3	0	12	4.3	8.1	73.0	50.2	0	0.62	0.05

Burst traffic

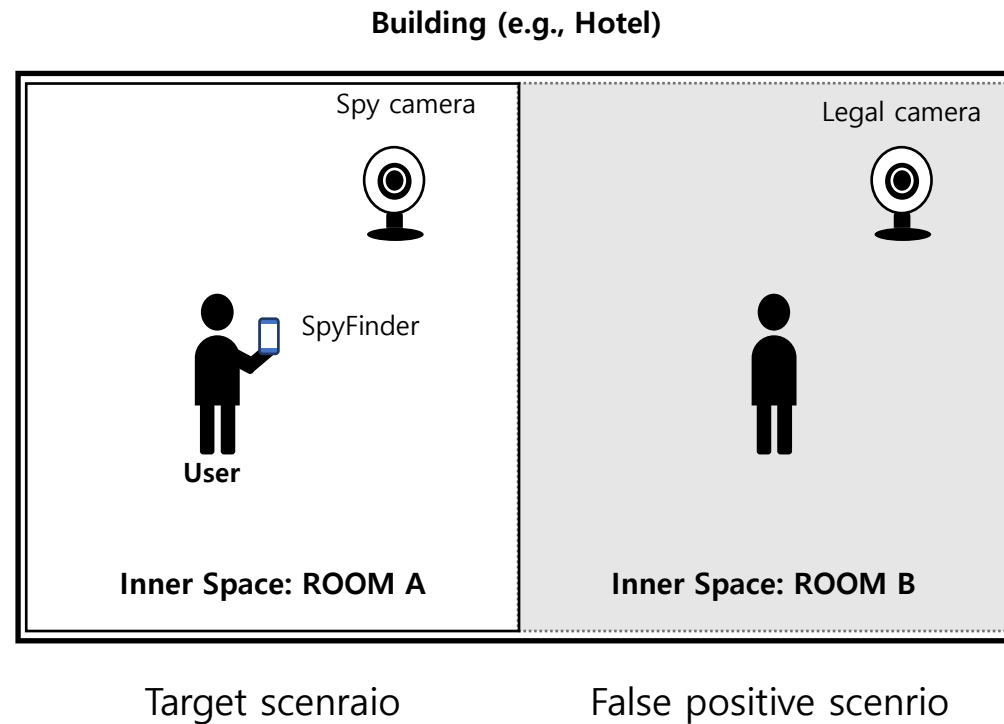
Frame unit transmission

3 Steps of SCamF

- **SCamF verifies the thus-identified devices are indeed spy cameras recording the user's movements**

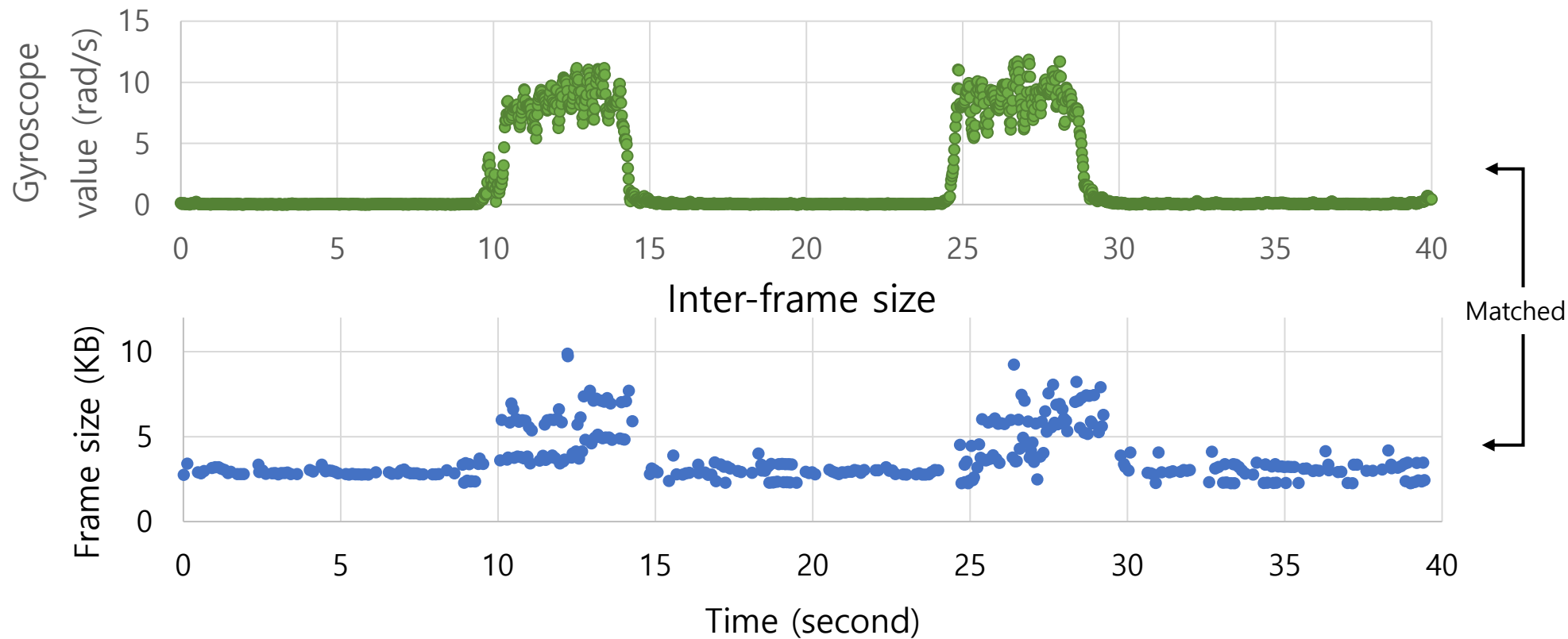


- **SCamF calculates the correlation between inter-frame size changes and the user movement to minimize false positives**

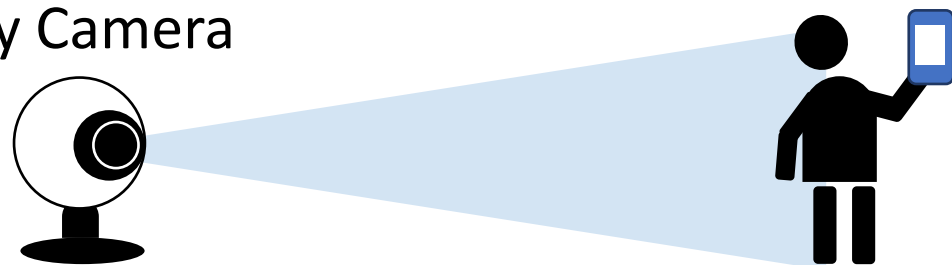


Spy camera detection

Sensor data measured by smartphone



Spy Camera

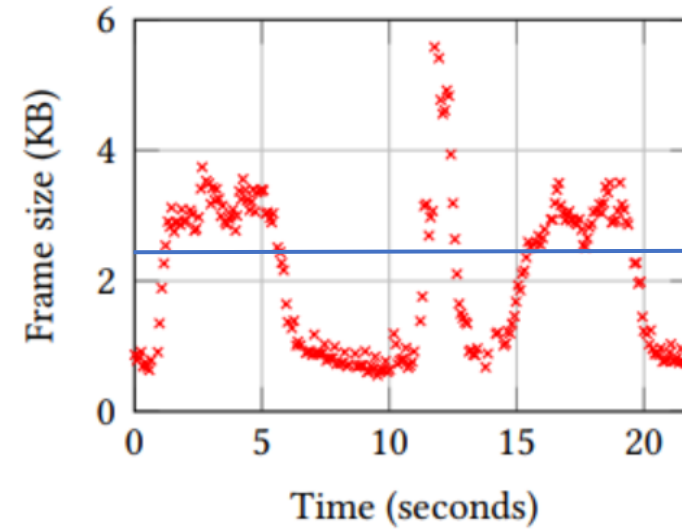
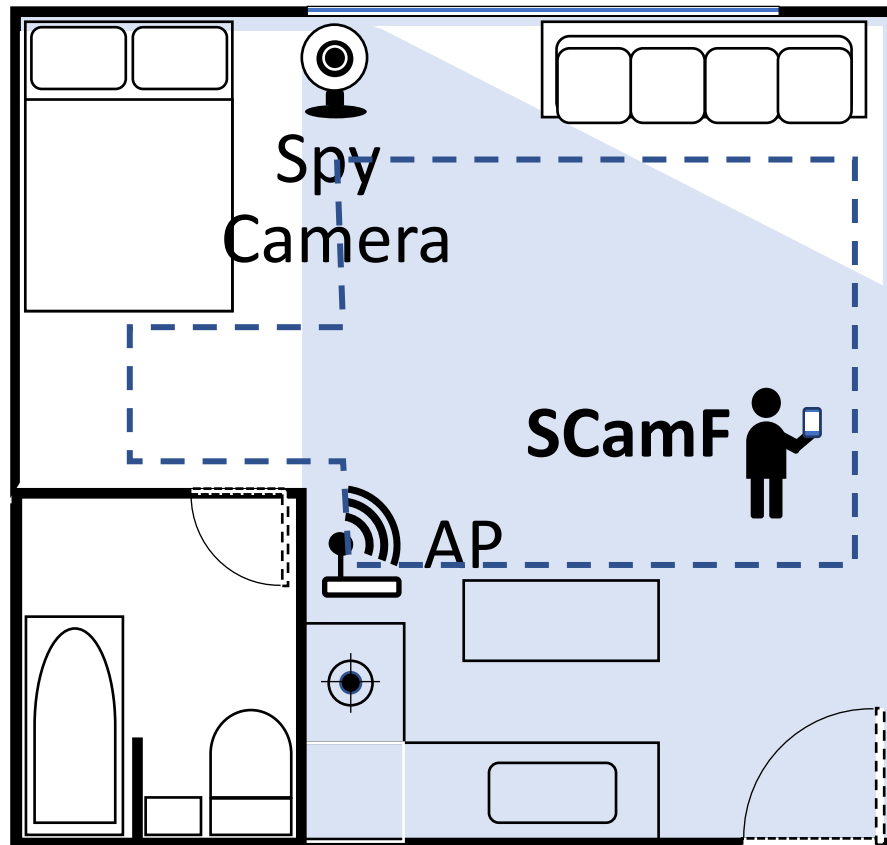


3 Steps of SCamF

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

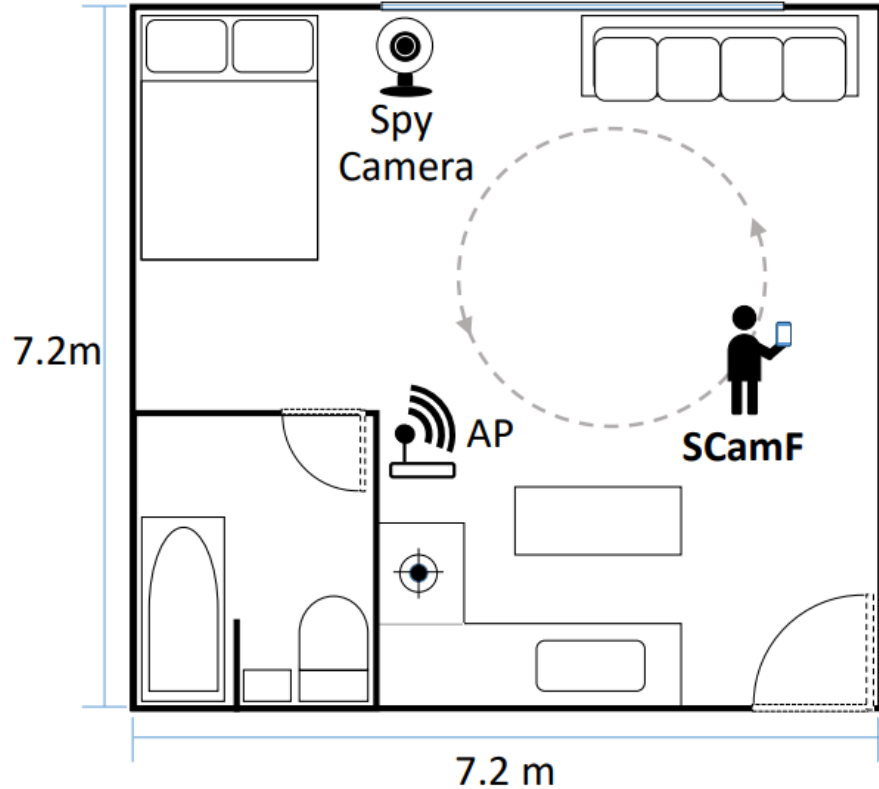


Spy camera localization



Apply adaptive threshold

Experimental Setup



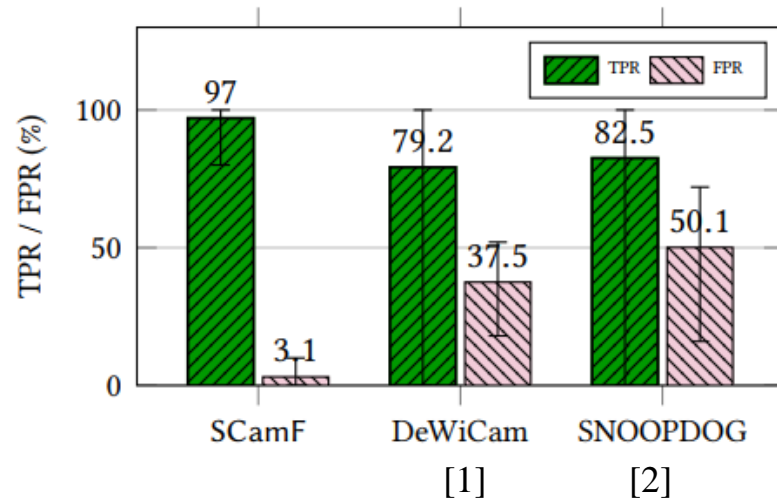
No.	Brand	Model	Video/Audio Encoding	Resolution			Other Supported Functions			
				Default	High	Middle	Low	Sound	Motion	Night Vision
1	Yi	YYS.2016	H.264, AAC	1080p	✓	-	✓	✓	-	✓
2	Yi	YHS.2116	H.264, AAC	1080p	✓	-	✓	✓	✓	✓
3	Xiaomi	SXJ01ZM	H.264, AAC	1080p	✓	-	✓	✓	✓	✓
4	360	D606	H.264, AAC	1080p	✓	-	✓	✓	-	✓
5	TP-Link	TL-IPC20-2.8	H.264	720p	-	✓	-	-	-	✓
6	Amcrest	IP2M-841B-V3	H.264	1080p	✓	✓	✓	-	✓	✓
7	goospy	S64	H.264, AAC	720p	✓	✓	✓	✓	✓	✓
8	ieGeek	2.0 megapixels ip camera	H.264, AAC	720p	-	✓	✓	✓	✓	✓
9	Xiaomi	MJSXJ05CM	H.265, AAC	1080p	✓	-	-	✓	-	✓
10	Egloo	TSC-221A	H.264, AAC	1080p	✓	✓	-	✓	✓	✓
11	Hej	GKW-IC052	H.264, AAC	1080p	✓	✓	-	✓	✓	✓
12	Green	PE204	H.264, AAC	480p	-	-	✓	✓	✓	✓
13	JWC	JCURI-HOME2	H.264, AAC	1080p	✓	-	-	✓	✓	✓
14	Wisenet	SNH-P6410BN	MPEG-4, AAC	480p	✓	✓	✓	✓	-	✓
15	Relohas	S93	H.264, AAC	720p	✓	✓	✓	✓	✓	✓
16	luhoe	C-TOP	H.264	720p	✓	✓	-	-	✓	-
17	YINEW	U21	H.264	720p	-	✓	✓	-	-	✓
18	Geagle	Wi-Fi mini camera	H.264, AAC	720p	-	✓	✓	✓	-	✓
19	Xiaomi	MJSXJ09CM	H.265, AAC	1080p	✓	-	✓	✓	✓	✓
20	Wisenet	HNO-E60	H.264, AAC	1080p	✓	-	✓	✓	✓	✓

20 wireless cameras in online stores

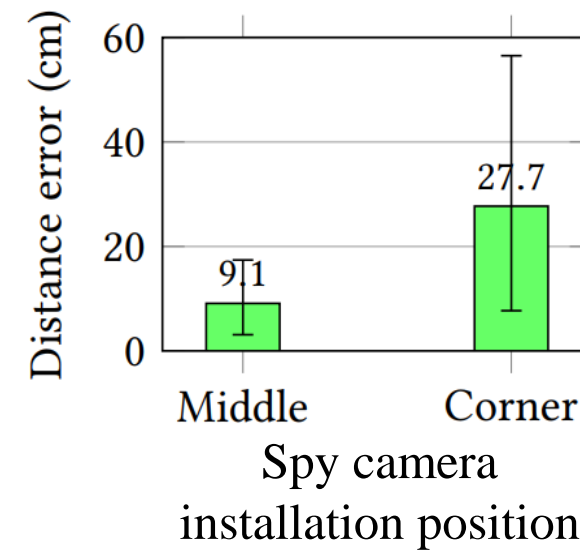
Spy camera classification

Precision	Recall	Accuracy	F1 score
0.935	1	0.978	0.966

Spy camera detection



Spy camera localization



[1] Yushi Cheng, Xiaoyu Ji, Tianyang Lu, and Wenyuan Xu, On Detecting Hidden Wireless Cameras: A Traffic Pattern-based Approach. IEEE TMC 20
[2] Akash Deep Singh, Luis Garcia, Joseph Noor, and Mani Srivastava, I Always Feel Like Somebody's Sensing Me! A Framework to Detect, Identify, and Localize Clandestine Wireless Sensors. USENIX Security 21

- **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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