

Security and Privacy Issues in Multimedia Systems

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SIGMM Multimedia Frontier Workshop @ ACM MM 2015, Brisbane, Australia

Question



Smoking is not good for health

Is
Security and Privacy
no longer an issue
for multimedia
community?

Multimedia Systems vs. Security & Privacy?



Smoking is not good for health

Multimedia Systems for Security of People

- Multimedia surveillance for homeland security

Security of People's Data in Multimedia Systems

- Secure cloud-based multimedia data analytics
- Multimedia authentication and forensics

Privacy of People in Multimedia Systems

- Privacy aware multimedia surveillance systems
- Social networks and communication privacy

Outline

Security and Privacy Issues in Multimedia Systems

- Multimedia surveillance – homeland security and privacy
- Social networks and communication privacy
- Secure cloud-based multimedia data analytics
- Multimedia authentication and forensics

Collaborators

Collaborators include:

- Abed @Univ of Ottawa, Canada
- Mohan @NUS, Singapore
- Sharad @UCI, USA
- Jonathan@Univ of Windsor, Canada
- Ramesh @UCI, USA
- Mvek @Rutgers, USA
- Shervin@ Univ of Ottawa, Canada
- John @Carleton Univ, Canada
- Ankita Lathrey
- Robert Bisewski
- Saeed Alharthi
- James Colp
- Majid@Univ of Alberta, Canada
- Nishant Joshi
- Khaled Amriri
- Shreelatha B.S.
- Himanshu
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- Gaurav@IIT, Jodhpur, India
- Mano@ Sweden
- XRR @IISc, India
- Bala @IIT, Secrebe, India
- Taylor Budzan
- Mukesh @Univ of Ottawa, Canada
- Wei-Tsang @ NUS, Singapore
- Chidansh @IDIAP, Switzerland
- Xiangyu @NUS, Singapore
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Multimedia surveillance – homeland security

9/11 terrorist attack (2001)

London bombing (2005)

Mumbai attack (2008)

Boston Marathon blast (2013)

Multimedia Surveillance System
 [Atrey et al. MMSJ 2007, Atrey et al. TOMM 2007]

Active Cooperative Sensing
 [Singh et al. MVA 2007]

Bus Surveillance
 [Amriki and Atrey, MTAP 2012]

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Multimedia surveillance – people’s privacy?

- Large number of CCTV cameras
- “4.2million CCTV cameras in Britain”, and the “person can be captured on 300 different cameras in a day”



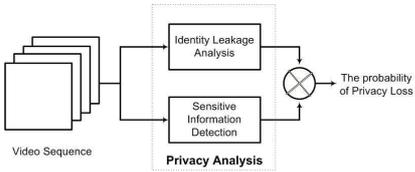
Is Hiding Facial Information Enough?

Place (Where) **Smart Lab**

Time (When) 19:32:16 2000/01/09

Behavior (What) **Implicit Channels!**





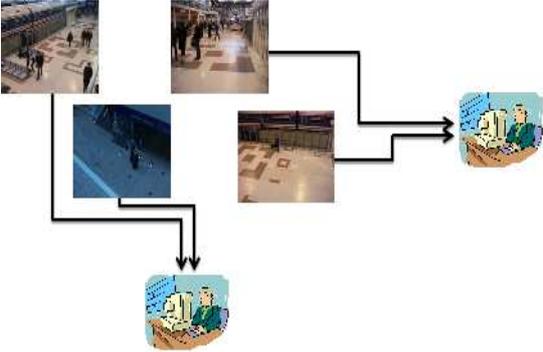
W3-Privacy Model
 [Saini et al. MTAP, 2014]

[Privacy aware publication of surveillance video](#)

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Multimedia surveillance – current and future work



Anonymous Surveillance
 (Live Demo)

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Multimedia surveillance – current and future work

Camera networks surveillance

Multi-source surveillance

Social networks surveillance

Phone surveillance

Email surveillance

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- **Social networks and communication privacy**
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Security and Privacy Issues in Multimedia Systems

Multimedia surveillance – homeland security and privacy

Social networks and communication privacy

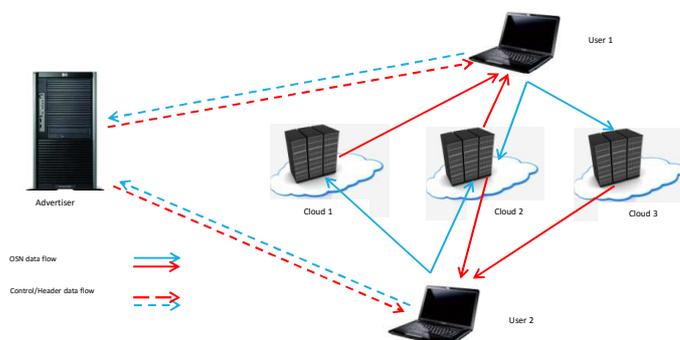
Secure cloud-based multimedia data analytics

Multimedia authentication and forensics

Social networks - privacy

[Motivation video](#)

A Secure and Privacy-aware Cloud-Based Architecture for Online Social Networks



Demo: <http://www.cs.albany.edu/~patrey/research/SecureOSN/feasibility.html>

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Cryptosystem - Shamir's Secret Sharing



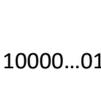




01110...0001

11000...1101





10000...0101



00011...1100

Sharing a Secret

$$F(x) = (S + \sum_{i=1}^{k-1} a_i x^i) \text{ mod } q$$

↓

Secret

↓

Random Number

↓



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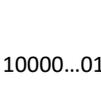




01110...0001

11000...1101





10000...0101



00011...1100

Sharing a Secret

$$F(x) = (S + \sum_{i=1}^{k-1} a_i x^i) \text{ mod } q$$

↓

Secret

↓

Random Number

↓



Trash



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01110...0001



11000...1101





10000...0101



00011...1100

Source: <http://www.ocss-va.org/jrotc/chain.html>

Reconstructing a Secret

$$L(x) = \left(\sum_{i=0}^{k-1} F(i)t_i(x) \right) \text{ mod } q$$

*i*th Share $\prod_{j=0, j \neq i}^{k-1} \frac{x - x_j}{x_i - x_j}$



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01110...0001







10000...0101



00011...1100

Source: <http://www.ocss-va.org/jrotc/chain.html>

Homomorphic property: $E(A) + E(B) = E(A+B)$



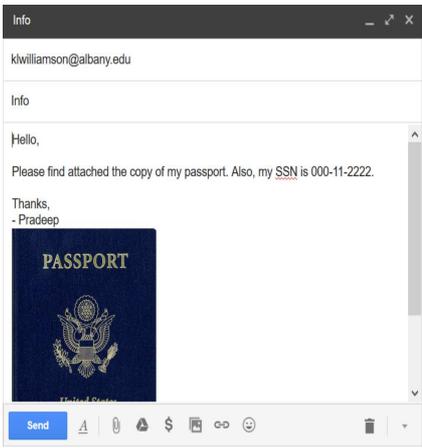
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Email communication - privacy

Have you ever sent your confidential information such as passport and credit card over email?

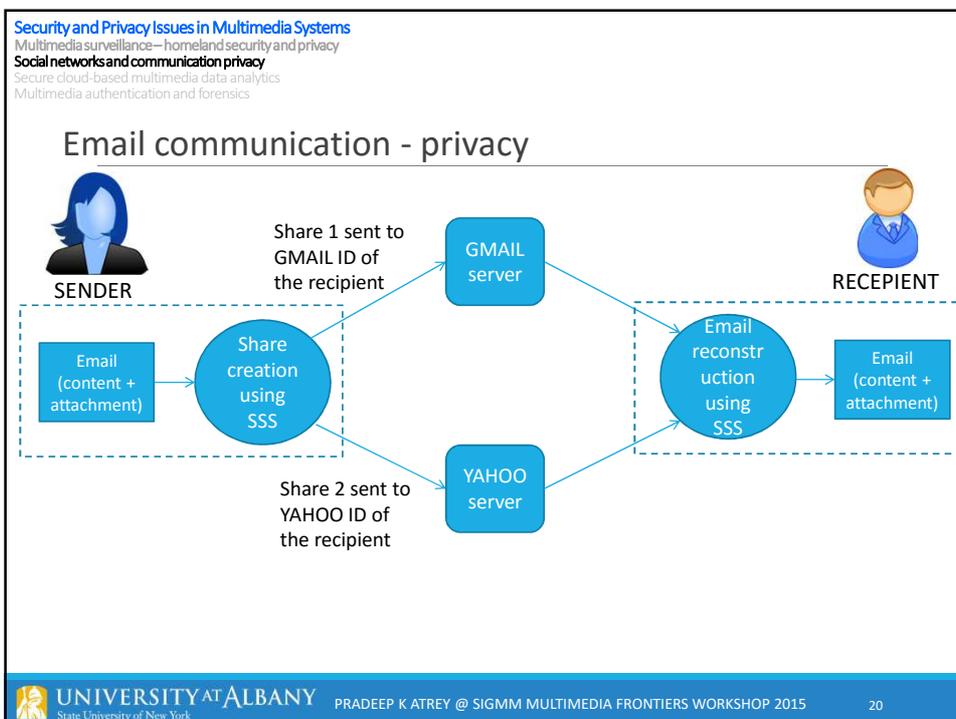


Info
 kwilliamson@albany.edu
 Info
 Hello,
 Please find attached the copy of my passport. Also, my SSN is 000-11-2222.
 Thanks,
 - Pradeep

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Outline

My Security and Privacy Research

- Multimedia surveillance – homeland security and privacy
- Social networks and communication privacy
- Secure cloud-based multimedia data analytics
- Multimedia authentication and forensics

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My Security and Privacy Research

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Motivation

Motivation [video](#)

The world is filled with “Big Data”

- every minute
 - 204 million emails are sent,
 - six million Facebook pages are viewed
 - 1.3 million YouTube clips are downloaded
 - 98,000 tweets
 - 695,000 status updates
 - 11 million instant messages
 - 698,000+ Google searches
 - 951 GB Surveillance video

≈ 2000 TB data collected

4 Vs of Big Data

- Volume
- Variety
- Velocity
- Value

Storage & Processing

The diagram illustrates the flow of data from various sources to a central cloud. A list of statistics on the left is grouped by a blue bracket and points to a cloud labeled 'Storage & Processing'. A red arrow points from the '4 Vs of Big Data' list to the same cloud. The cloud contains the text 'Storage & Processing' with 'Processing' in red. Above the cloud, a thought bubble contains the text '≈ 2000 TB data collected'.

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Cloud-based Multimedia Data Analytics

Very popular these days

Companies Offering 2D Imaging

- AT&T, Dell, Intel etc.

Companies Offering 3D Imaging

- Microsoft, KDDI, Sinha Systems etc.

The illustration shows a central cloud icon with a document symbol inside. Lines connect this cloud to several devices: two smartphones, a laptop, a desktop monitor, and a tablet. All devices are displaying what appears to be a software interface or data visualization.

Image source:
<http://www.msimaging.com/Content/themes/MSI/images/cloud-based-software-image-silo-cloud-file.jpg>

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Cloud-based Multimedia Storage and Processing

The diagram illustrates a cloud-based workflow for 3D image visualization. On the left, a box labeled 'Server' contains an image of a patient in an MRI scanner, with the text 'Capturing and Preprocessing'. An arrow labeled 'Network' points from the server to a central cloud labeled 'Datacenter'. Inside the cloud, the text 'Data-to-image Conversion' is shown above an image of a brain scan. A second arrow labeled 'Network' points from the cloud to a box on the right labeled 'Client'. The client box contains an image of a person at a computer workstation with the text 'Image Display'.

3D Image Visualization

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Cloud-based Multimedia Storage and Processing

The diagram illustrates a cloud-based workflow for surveillance video quality enhancement. On the left, a box labeled 'Server' contains an image of surveillance cameras, with the text 'Capturing and Preprocessing'. An arrow labeled 'Network' points from the server to a central cloud labeled 'Datacenter'. Inside the cloud, the text 'Quality enhancement' is shown above two images of a surveillance room. A second arrow labeled 'Network' points from the cloud to a box on the right labeled 'Client'. The client box contains an image of a person at a computer workstation with the text 'Image Display'.

Surveillance Video Quality Enhancement

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Cloud-based Multimedia Storage and Processing

Image Zooming and Cropping

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Who can be adversary?

How many of us would mind if our medical image data is available to an adversary?

What can an adversary do with an image?

Image source: <http://greenberg-art.com/.Toons/Toons,%20social/qxsgMedical%20privacy.gif>

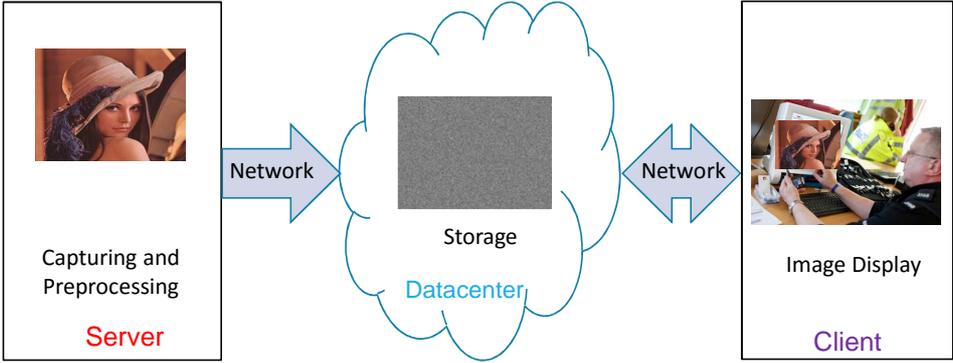
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Smoking is not good for health

Multimedia Storage over Cloud



The diagram illustrates the architecture for multimedia storage over a cloud. On the left, a box labeled 'Server' contains an image of a woman and the text 'Capturing and Preprocessing'. An arrow labeled 'Network' points from the server to a central cloud labeled 'Datacenter'. Inside the cloud is a box labeled 'Storage'. Another arrow labeled 'Network' points from the cloud to a box on the right labeled 'Client'. The client box contains an image of a person at a computer and the text 'Image Display'.

Encryption techniques – Watermarking – Secret sharing

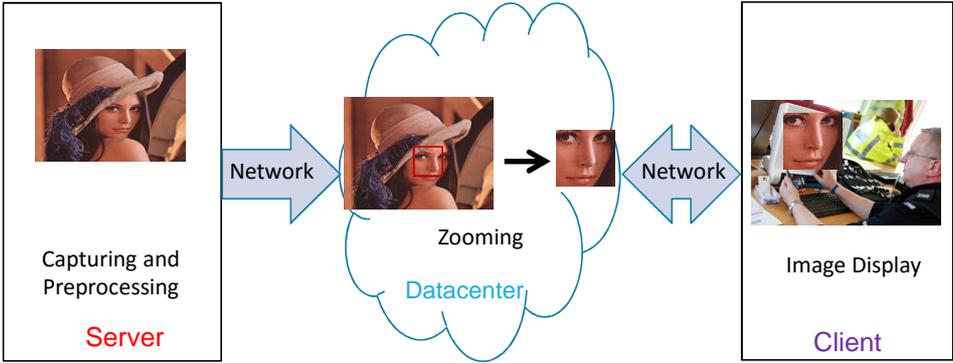
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Multimedia Processing over Cloud



The diagram illustrates the architecture for multimedia processing over a cloud. On the left, a box labeled 'Server' contains an image of a woman and the text 'Capturing and Preprocessing'. An arrow labeled 'Network' points from the server to a central cloud labeled 'Datacenter'. Inside the cloud, an image of the woman is shown with a red box around her face, and an arrow points to a zoomed-in crop of her face. This process is labeled 'Zooming'. Another arrow labeled 'Network' points from the cloud to a box on the right labeled 'Client'. The client box contains an image of a person at a computer and the text 'Image Display'.

Image Zooming and Cropping on Original Data

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Secure Multimedia Processing over Cloud

Still to be addressed

Capturing and Preprocessing
Server

Network

Zooming
Datacenter

Network

Image Display
Client

Image Zooming and Cropping on Encrypted Data

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Secure Cloud-based Image Scaling/Cropping

- Architecture and Workflow

Secret

Shadow Image Preparation

Shadow 1

Shadow 2

Shadow n

DC 1

DC 2

DC n

Scaled/Cropped Shadow Image 1

Scaled/Cropped Shadow Image 2

Scaled/Cropped Shadow Image k

Scaled/Cropped Shadow Image n

Image Display

Secret Image Recovery

User

Server

Scaling and Cropping

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Secure Cloud-based Image Scaling/Cropping

- Results: **Demo**

[ICME 2013]

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Secure Pre-classification Volume Ray-casting

- Architecture and Workflow

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Secure Pre-classification Volume Ray-casting

- Results: Single View Point

Original → Share 1 → Recovered
 Original → Share 2 → Recovered
 Original → Share 5 → Recovered

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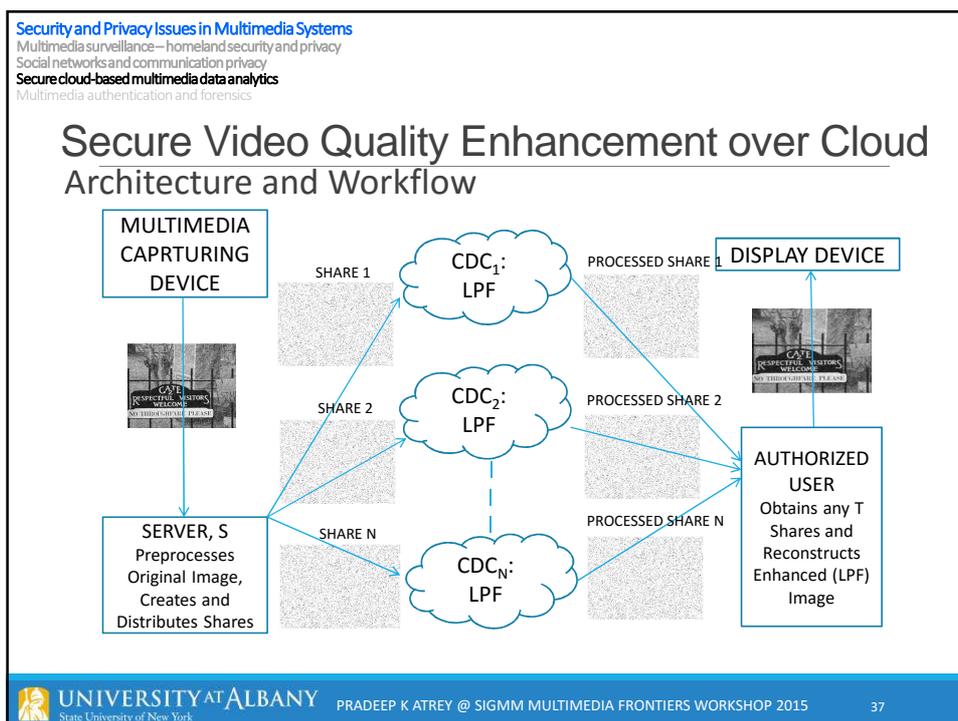
Secure Pre-classification Volume Ray-casting

Demo

[Mohanty et al., MM 2012]

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Secure Video Quality Enhancement over Cloud

The proposed method is demonstrated to work for

- Noise removal and anti-aliasing
 - Results – Scheme 1 ([Demo](#))
 - Results – Scheme 2 ([Demo](#))
- Edge and contrast enhancement ([Demo](#))
- Dehazing ([Demo](#))

More demos available on:

- <https://sites.google.com/site/ankitaresearchdemos/home>

[ICSC 2013, TOMM 2015]

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Speech Data over Cloud



How many of you have revealed your confidential info over phone at least once?



SSN



Passport



**Health
Policy Card**



Credit Card

What is your date of birth?

Date of Birth

Image source: <http://www.teleware.com/solutions/call-recording/>



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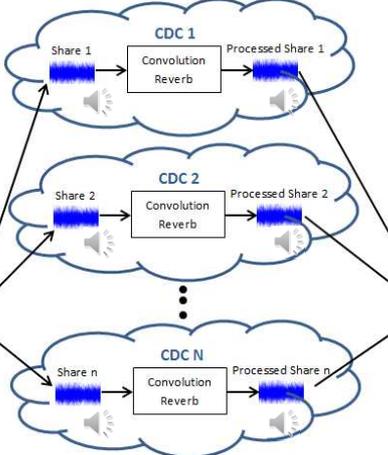
Secure Speech Quality Enhancement over Cloud



Audio secret

1. Preprocessing
 2. Creation of shares with Shamir Secret Sharing Scheme

CLIENT SIDE



Reconstructed reverb effected audio

1. Reconstruction of reverb effected signal with any K out of N shares
 2. Post-processing

CLIENT SIDE

[MMM 2015]



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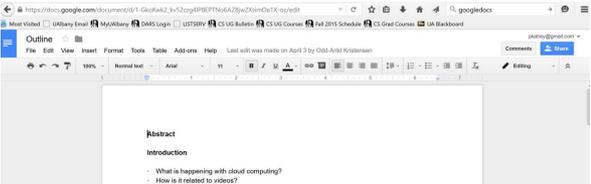
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Secure Multimedia Editing

- Google Docs: Are they secure?



- Online image editing



- Online Audio Editor




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What next?

Table 1: Secure data processing over cloud: from the perspective of application areas, analysis tasks and type of media and features to be processed

Application area	Analysis tasks	Type of media and features used
Social media and networks	Personality detection	Text, images, video, demographic and social features
	Cyber bullying detection	Text and social features
	Spending behavior analysis	Text, social features
	Disease spread detection	Text, social features
Multimedia surveillance	Hate posts detection	Text, audio, images, video and social features
	Face detection and recognition	Image, video
	Suspicious event detection	Image, video
	Data quality improvement	Image, video, audio
	Data search and retrieval	Text, image, video, audio
	Scaling and zooming	Image, video
E-health	3D medical data rendering and visualization	3D data, image
	Scaling and zooming	Image, video
Bio-informatics	DNA sequence analysis	Text and numbers


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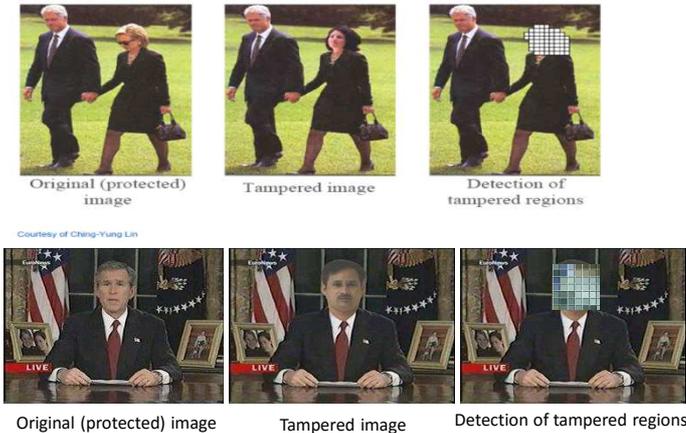
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Multimedia security and forensics – Authentication



Courtesy of Chang-Yung Lin

Original (protected) image Tampered image Detection of tampered regions

Original (protected) image Tampered image Detection of tampered regions

[MTAP 2007]

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Multimedia security and forensics – Source identification

- Given an image or a video, can we identify the source camera?
- Given an audio speech, can we identify the source microphone?
- Given a PDF document, can we identify the computer which created it?

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THANK YOU

Ευχαριστώ

Asante

ขอบคุณ

DMnvwD

धन्यवाद

Dank

Tesekkürler

Hvala

Gracias

Dankie

شكراً

Grazie

Bedankt

go raibh maith agaibh

Obrigado!

Merci

Diky

Köszönettel

ありがとう!

谢谢!

WAD MAHAD

SAN TAHAY

متشكراً

감사합니다

GADDA GUEY

Urakoze

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