Multimedia Security: A Viewpoint From A Walking Wounded

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Video and Image Processing Laboratory Research Projects

- Video Compression
  - Low complexity coding
  - Scalable Coding
  - Wyner-Ziv Approaches
  - Texture Based Methods
- Error Concealment, Resilience, and Post-Processing
- Video Databases
  - Indexing user generated content
  - Location awareness
- Multimedia Security and Forensics

Video and Image Processing Laboratory Research Projects

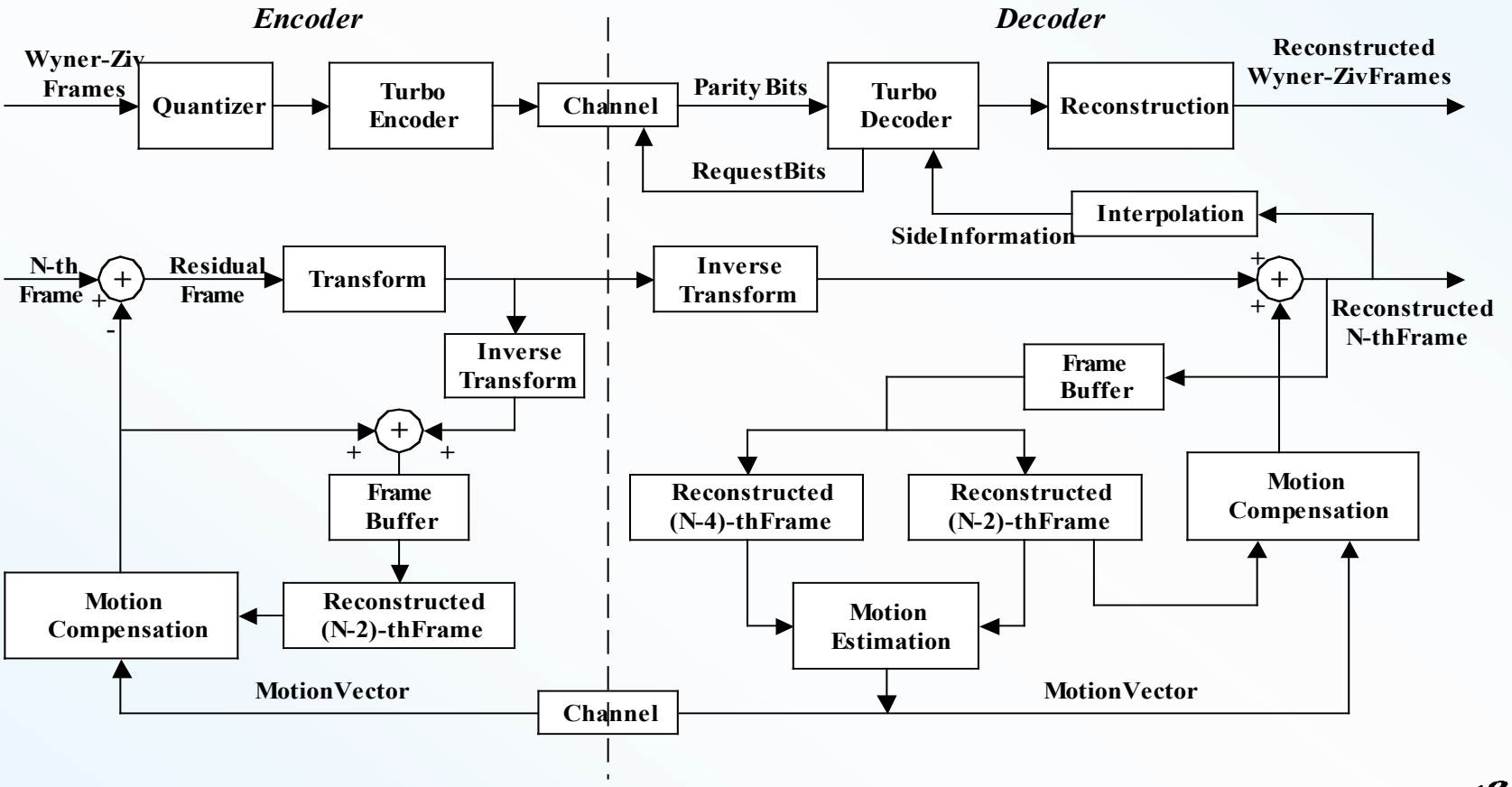
- Video Tracking and Surveillance
- Medical Imaging
  - Microscope image analysis
- Mobile Applications
  - Image Guided Navigation - location awareness
  - Language Translation
  - Food and Dietary Assessment
- Content Adaptation
- Digital Cinema
- Social Networking

Image and Video Processing at Purdue

Purdue has a rich history 75 year history in image and video processing

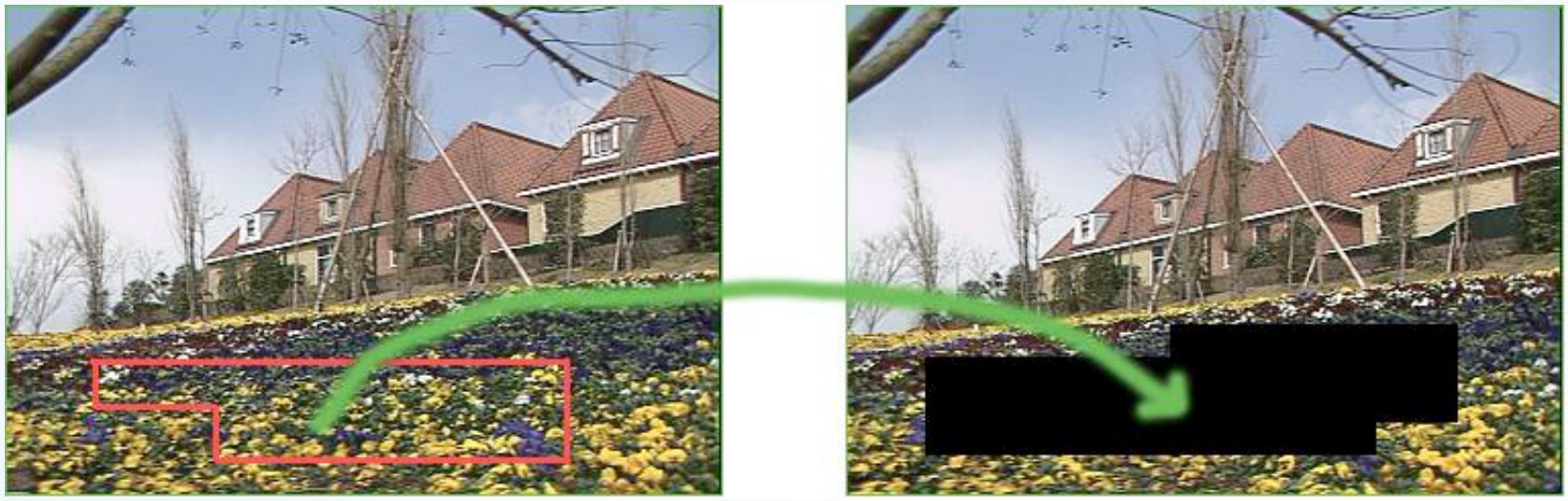
First Ph.D. in digital image processing in 1959

Low Complexity Video Compression System

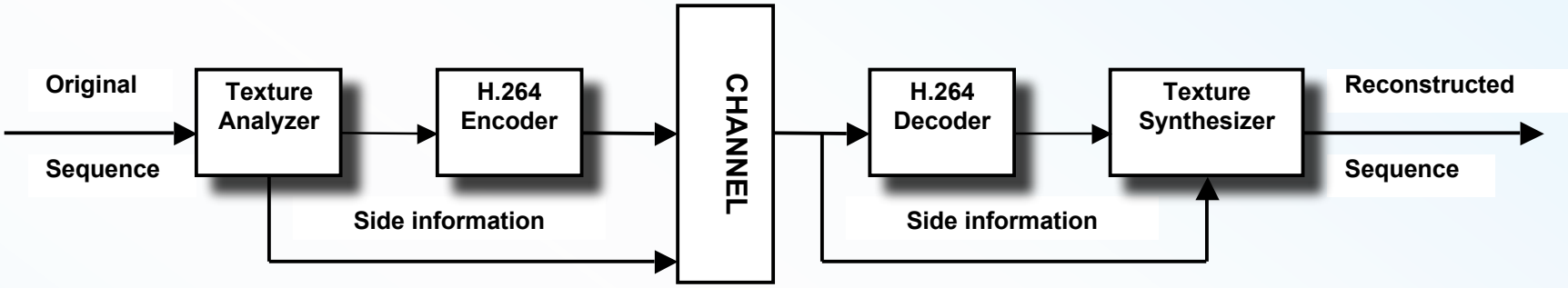


Segmentation Based Compression: Basic Concept

"Reference" Frame **Current Frame**



System Overview



- **Texture Analyzer**
  - **Identifies homogenous regions in a frame and labels the regions as textures**
  - **Use global motion models to ensure temporal consistency**
- **Encoder and Decoder: Conventionally codes the sequence with synthesizable regions labeled as skipped macroblocks**
- **Texture Synthesizer: Inserts synthesizable parts using the side information**

Flowergarden Frame 58

(a)

(b)

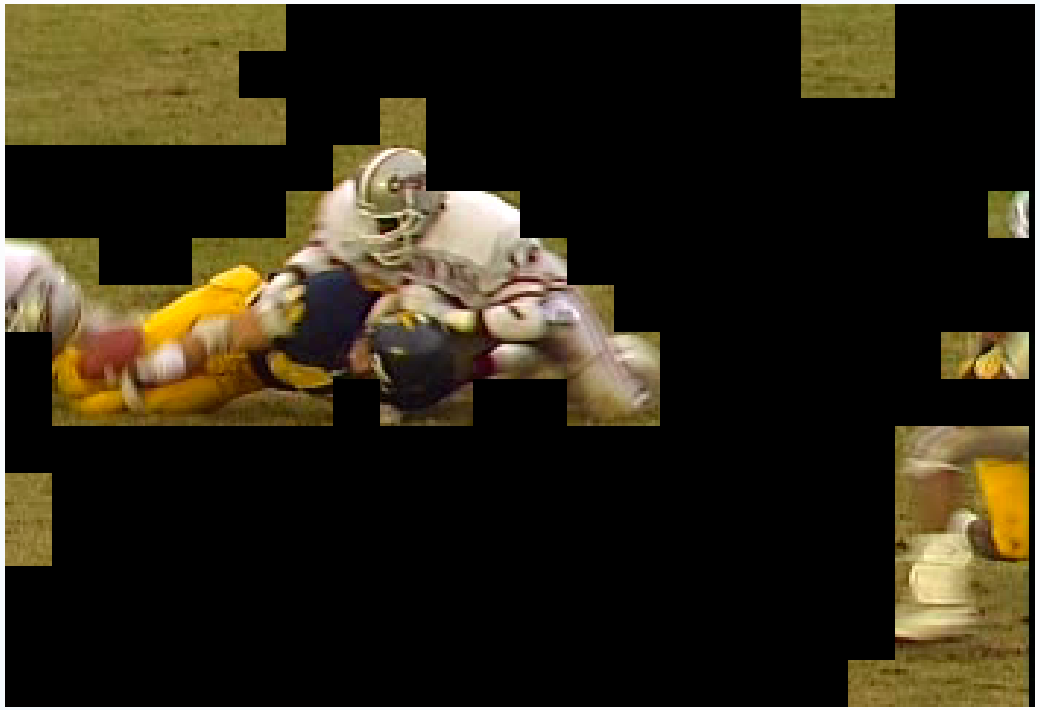
(c)

(a) original frame

(b) reconstructed frame

(c) synthesizable texture mask

Texture Analysis



Football Sequence

Original

Reconstructed

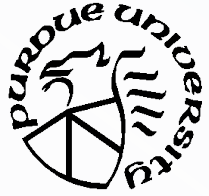
Mobile Video Content

Personal Content or Unstructured Video

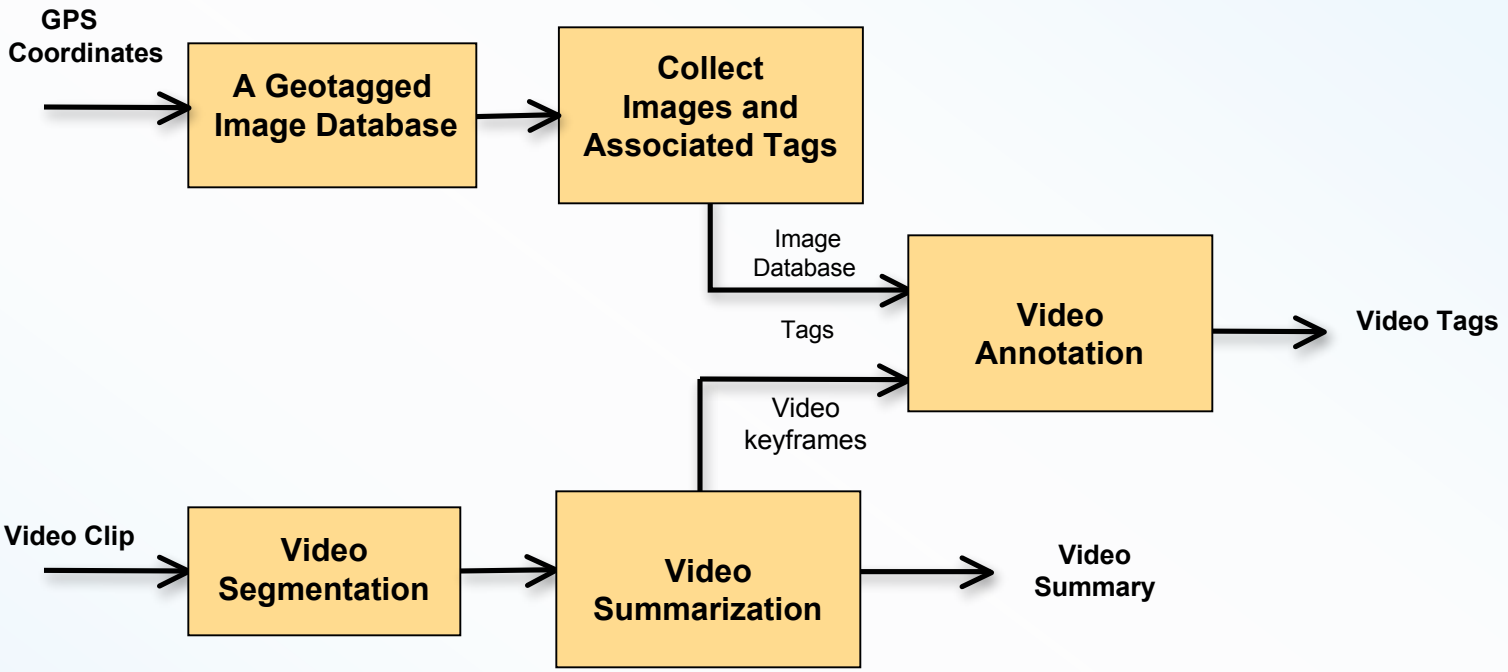
- captured by the user using the camera on the device

Commercial Content or Structured Video

- (e.g. news, sports, and music videos) streamed or downloaded into the device

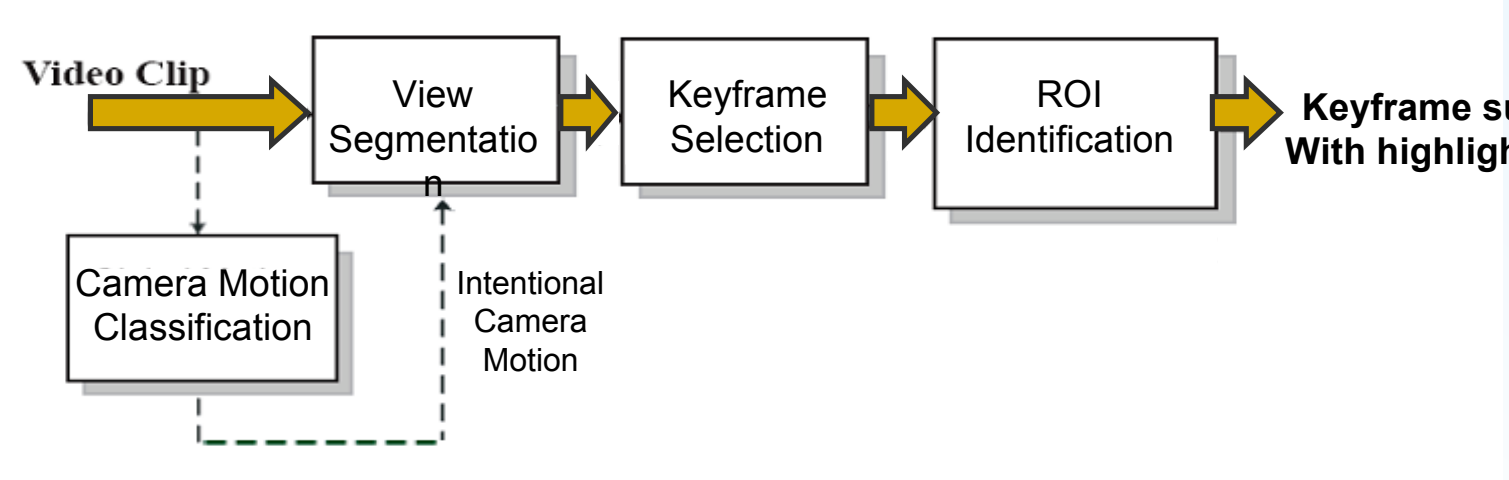


System Overview

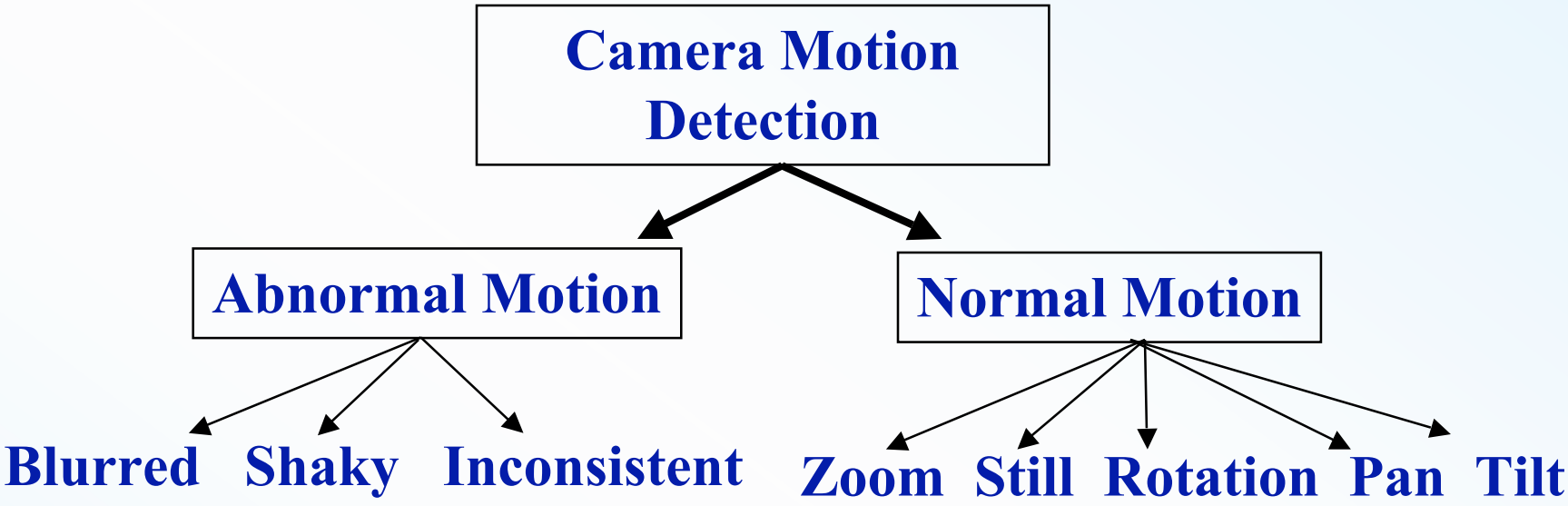


- **Goal - use camera motion and GPS metadata to find annotated pictures with the same coordinates in an image database and use them to automatically annotate (tag) user generated video**

Motion-Based Video Summarization



- **User Generated Video (UGV) often has a rich camera motion structure that generated by the camera person**
- **We use this structure in different steps of the analysis**
- **Camera motion in UGVs contain both intentional motion (pan, tilt and zoom) and unintentional (blurry and shaky) motion**



- ***Blurred*** segments are caused by fast camera motion
- ***Shaky*** segments are caused by frequent change of direction
- ***Inconsistent*** segments are caused by uneven acceleration of camera

Video Labeled By Type

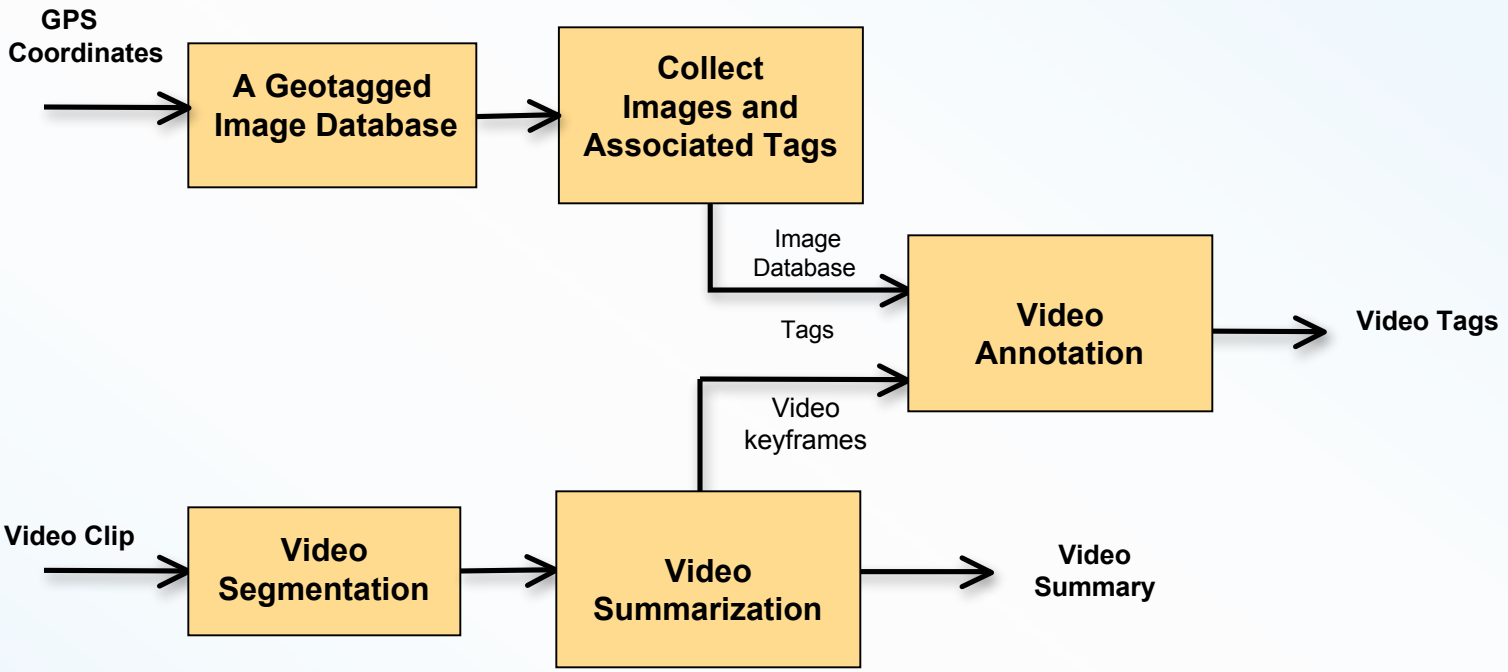
Color Contrast Saliency Maps

ROIs






System Overview



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Example-A Geotagged Image Database

Examples

Query Keyframe

The 8 most similar images in the dataset

g3

Rosetta Phone

System Overview

Image Acquisition

Segment

OCR

TTS

Display

رحیم یار خان

Transliteration: Rahim Yaar Khan
Translation: Rahim Yaar Khan
Context: Town Name

Audio Output

-Spoken Text in Original Language
-Spoken English Translation of Text

Rosetta Phone System

- **Natural scene image acquisition**
- **Text segmentation**
- **Optical character recognition**
- **Text interpretation**
- **Audio output**

Location-Aware Image Database (*LAID)*

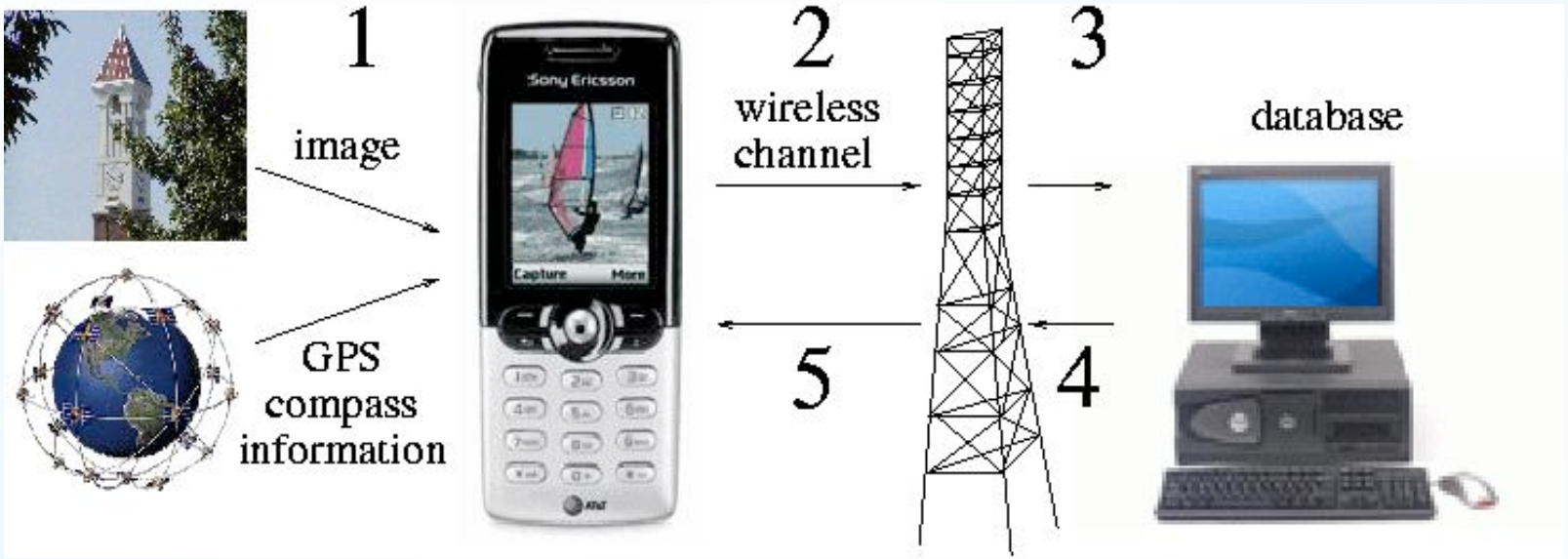


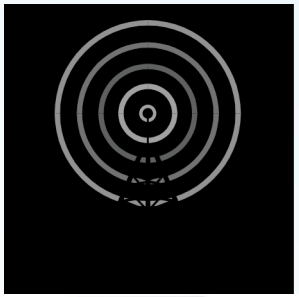
Image-Assisted Localization

+ Navigation

GPS and compass information

image

query through wireless network



thumbnail + description

information about the objects in the image

direction

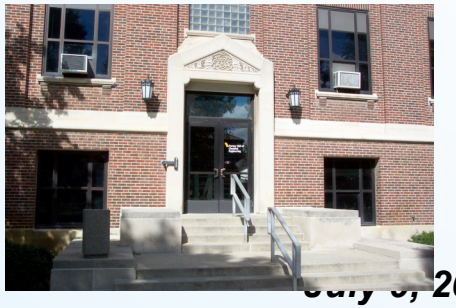
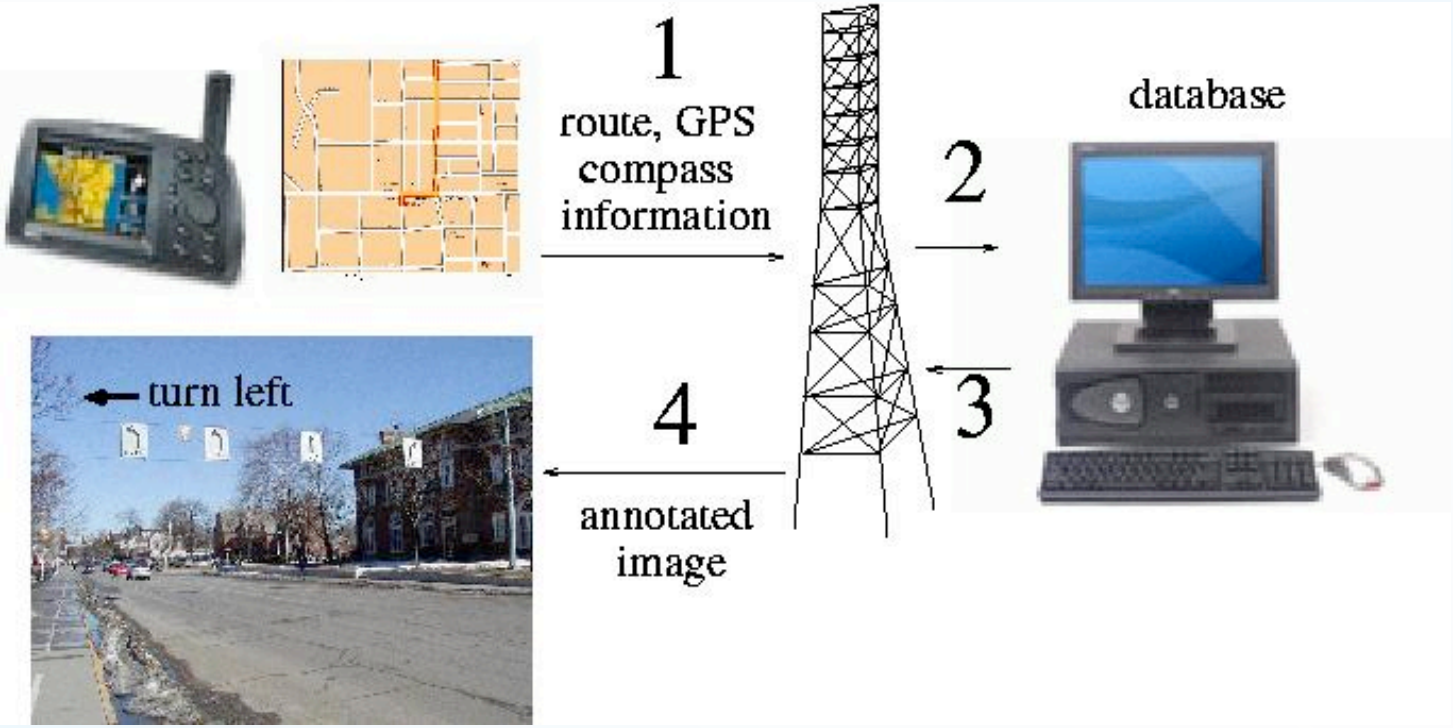
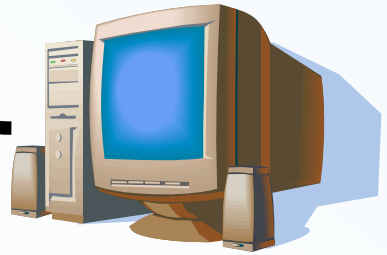


Image-Enhanced Navigation
(IEN)



Building and Using the Database



www.tadaproject.org

Extract

toast

Pork Rib

steak

Before Meal

Plate Waste

Food intake comparison

TADA System Overview

Client

Image + Metadata

1

4

Server

2

- Food Type (Label)
- Labeled Segmented Images (Area Estimates)

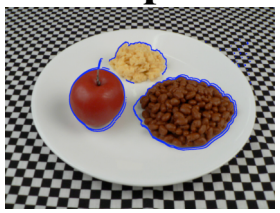
3

Volume Estimation

Output

- Labeled Images With Food Type (e.g. Apple, Beans, Eggs)
- Volume

+



5

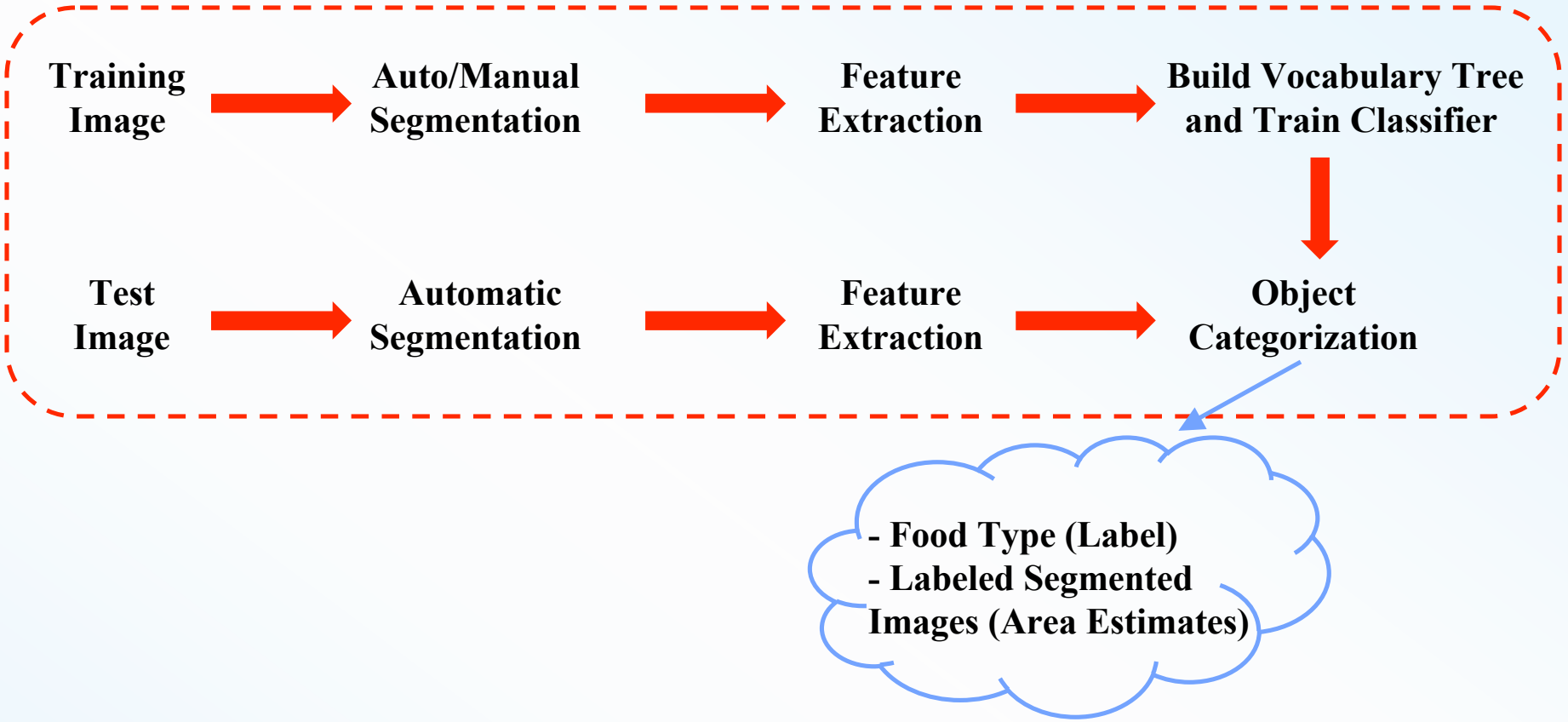
User Confirmation and Adjustment

6

- FNDDS Indexing
- Nutrient Information

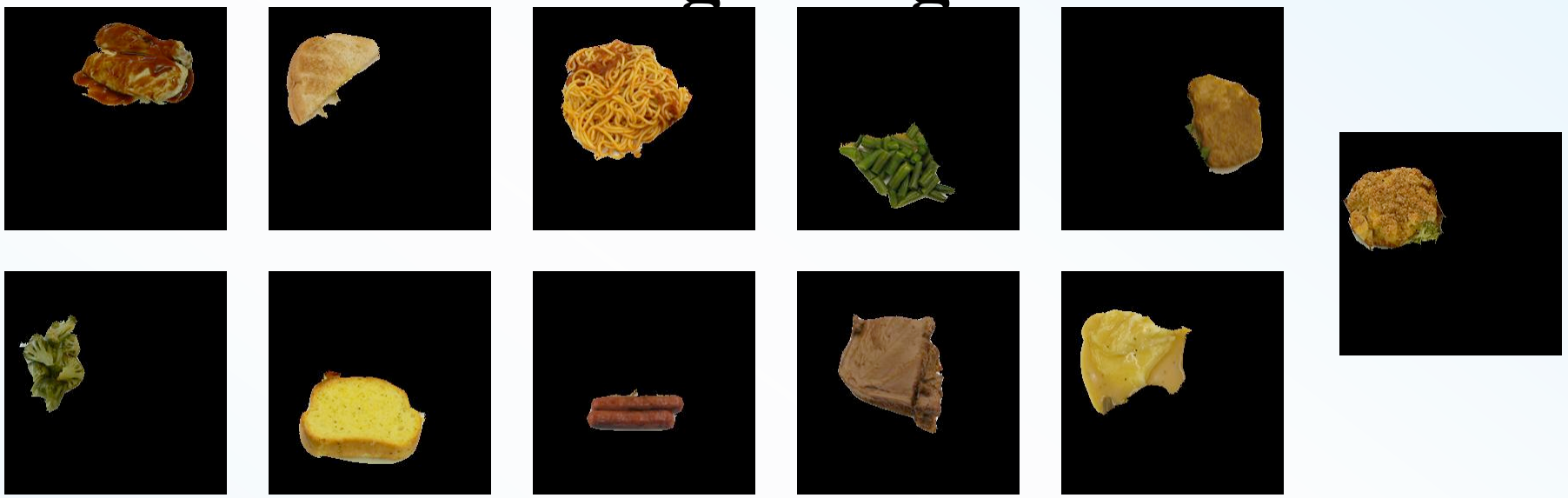
7

Research Community



- **Training images – categorized database containing single object images**
- **Segmentation – Normalized Cut, Connected Components**
- **Features – color, texture, SIFT**
- **Categorization – Bag of Features object recognition**

Building Categories

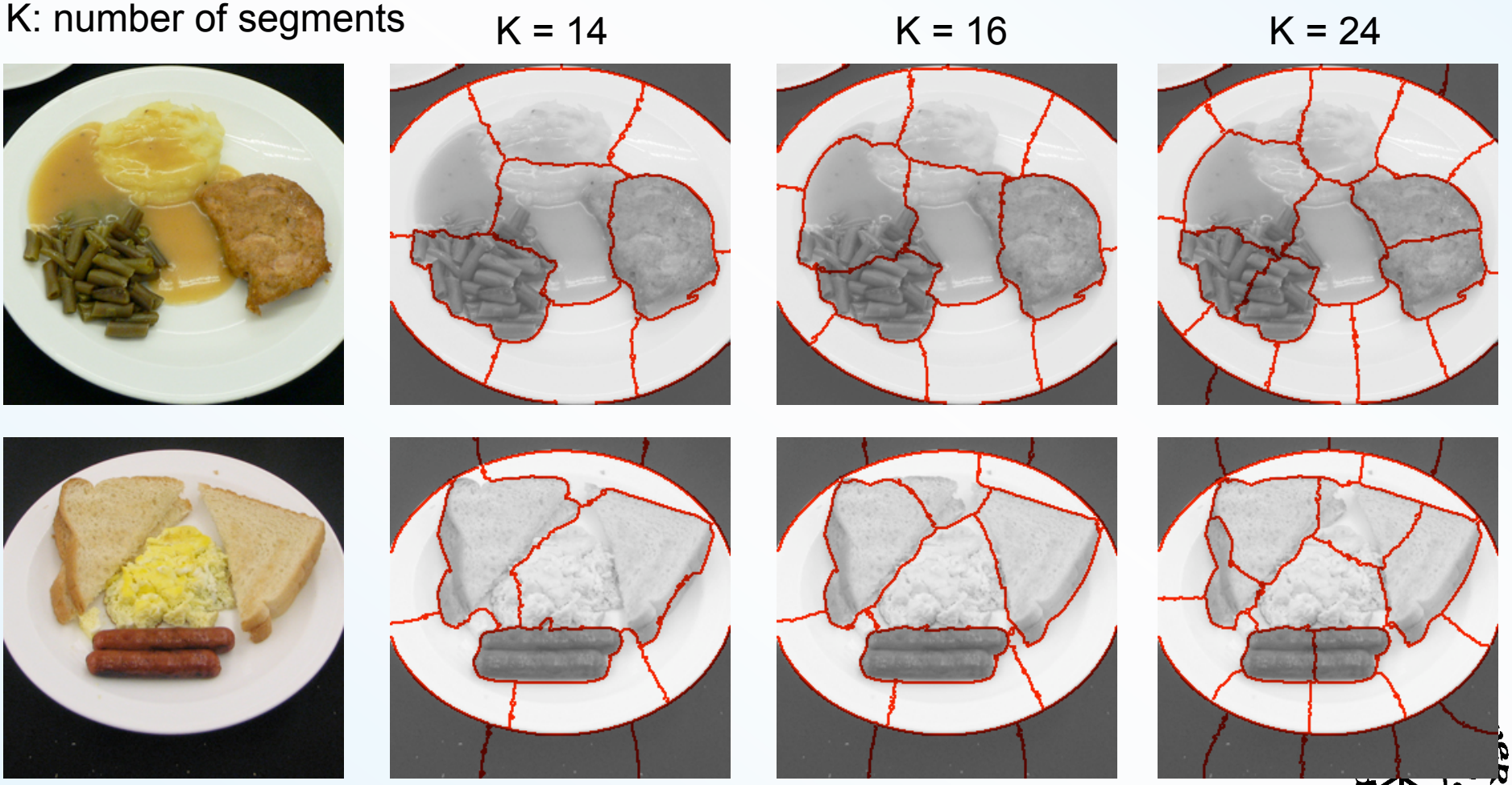


- **Normalized Cut to extract segments from the image**
- **Brightness as cue, image size 256x256**
- **Each category contains different images of the item**

Issue with Normalized Cut

- **Difficulty with some images**

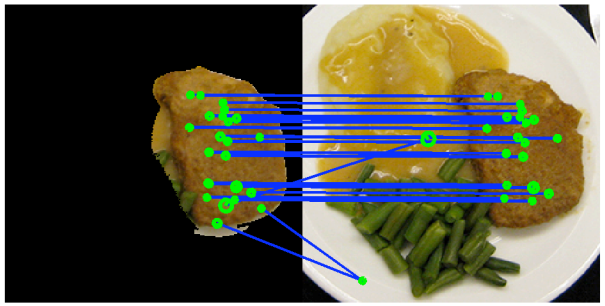
K: number of segments



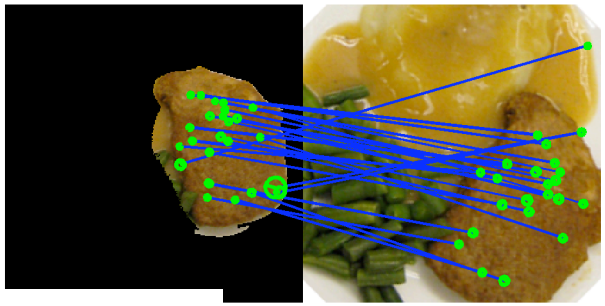
Extract Feature

- **SIFT descriptor for matching**

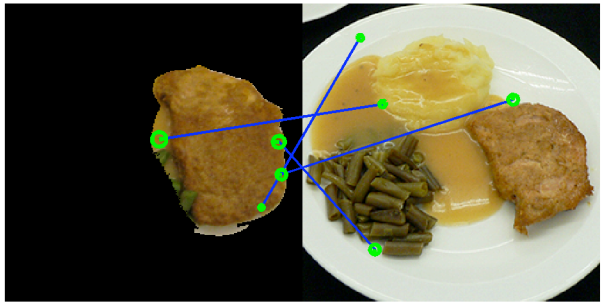
Same item



Same item, image scaled and rotated



Different item of same category



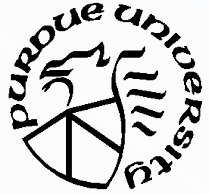
Multimedia Security: Yuck!

Overview

- **"Securing" multimedia content is a hard and undefined problem**
- **Problem started with "cute" applications and evolved into the "monster" of content protection**
  - **World-wide losses from piracy is estimated at more than $30 billion**

Content Protection Objectives

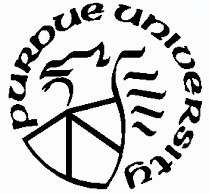
- **"Keeping Honest People Honest!"**
- **Prevent unauthorized access and use of digital content**
- **Prevent creation of illegal copies**
- **Audit usage of digital content**
- **Tamper detection, forgery detection, authentication**
- **Maintain rights and privileges expected by users, including "First Sale" and "Fair Use"**
- **Maintain user privacy**



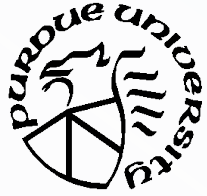
What Do Content Owners Want?

- **Access Control**
- **Copy Control** $\Rightarrow$ Playback Control, Record Control, Generation Control

- **Auditing (fingerprinting)**
  - **Who did what and when?**



Media protected		Secure delivery of content	Device authentication	Association of digital rights	Licensed technology	System renewability
Prerecorded media	Video on DVD-ROM	encryption	Mutual between DVD drive and PC	metadata	CSS [8]	Device revocation
	Audio on DVD-ROM	encryption	Mutual between DVD drive and PC	metadata	CPPM [36]	Device revocation
		watermarking	n/a	watermark	4C/Verance Watermark [37]	n/a
	Video or audio on DVD-R/RW/RAM	encryption	Mutual between DVD drive and PC	metadata	CPRM [38]	Device revocation
	Video on digital tape	encryption	n/a	metadata	High Definition Copy Protection [39]	Device revocation
Digital interface	IEEE 1394	encryption	Mutual between source and sink	metadata	DTCP [40]	Device revocation
	Digital Visual Interface (DVI)	encryption	Mutual between source and sink	metadata	HDCP [41]	Device revocation
	NRSS interface	encryption	Mutual between host and removable security device	metadata	Open standards [42]–[44]	Service revocation
Broadcasting	Satellite	encryption	None	metadata	Conditional access system [45], [46]	Smartcard revocation
	Terrestrial	encryption	None	metadata	Conditional access system [46]	Smartcard revocation
Cable transmission		encryption	None	metadata	Conditional access system [47]	Smartcard revocation
Internet	Unicast	encryption	Receiver	metadata	DRM [48], [49]	Software update
	Multicast (A few watermarking schemes have been proposed for multicast data [50])	encryption	Sender and receiver (depends on the authentication type)	metadata	Group key management [50]	tbd



What Do Users Want?

- **Leave me alone!**
- **Make it easy to use and interoperate with other things I own!!**
- **Content Protection is not a "feature"**

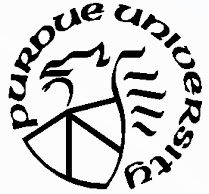
- **Time-shifting (Tivo)**
- **Format-shifting (iPod)**
- **Location Shifting (Slingbox)**
- **Single copy (back ups?)**

Re-distribute - Copies to your 10,000 closest friends?

How to Fix the Problem?

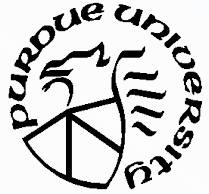
- **Technology - crypto, watermarking?**
- **Legal - DMCA?**
- **Moral Issues - is stealing good for you?**
- **Education - should stealing be good for?**

Should "bits" be free?

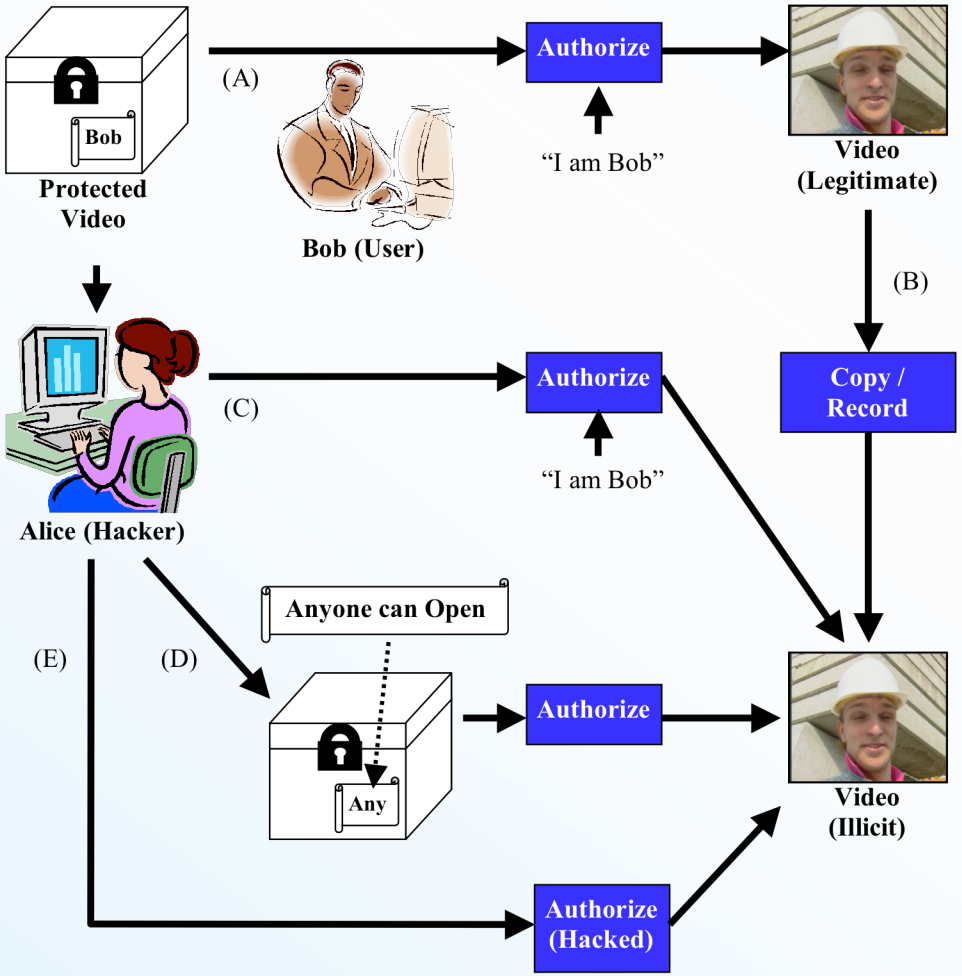


Legal Efforts

- Legal efforts
  - Digital Millennium Copyright Act (DMCA)
    - Anti-circumvention provisions
  - European Copyright Directive (EUCD)
    - Anti-circumvention provisions
    - Adoption has been slow
  - Consumer Broadband and Digital Television Promotion Act (CBDTPA)
  - Consumers, Schools, and Libraries Digital Rights Management Awareness Act of 2003



A Content Protection System



(A) Standard Use

(B) Illicit copying or "analog hole"

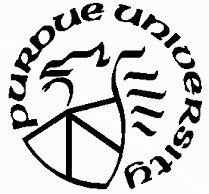
(C) False credentials

(D) Alteration of access conditions

(E) Use of "hacked" devices

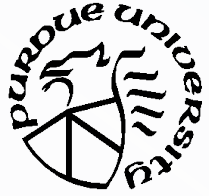
Users Concerns

- Users concerned that content protection systems may…
  - Unilaterally enforce usage rules that contravene the rights and privileges granted to the public
  - Violate expectations of privacy
  - Reduce competition amongst video / device vendors
  - Force users to pay increased costs to obtain content and devices that provide them with less control
    - Devices more complicated
    - Less compatibility or interoperability
  - Damage their devices (Sony's rootkit)



Multimedia Security - Tools Set

- **Encryption**
- **Authentication**
- **Hashing**
- **Time-stamping**
- **Watermarking**

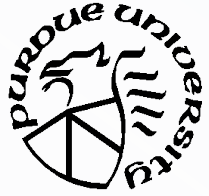


The New Battlefield!!

- **Books!**

DRM

- Stop working on this!!!
  - DRM systems face innovation of many attackers
  - Content protection system must remain secure for a long time -BUT attackers only need to succeed once
- A "technology" fix will not solve the mess we are in today
- The protection of intellectual property rights is perhaps one of the last major barriers in the "digital world"



What is THE important problem moving forward?

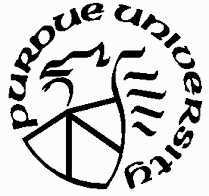
TRUST

Who and What I do trust?

- **People, Data, and Physical Things**
- **Done is plain sight!**
- **This is not just a technical problem**

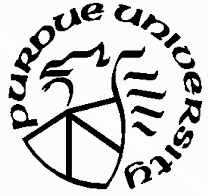
Important Application Domains

- **Authentication**
  - **People, data, and physical objects**
  - **Surveillance**
  - **Biometrics**
  - **“things” (rfid)**
- **Forensics**
  - **Data, e.g. Medical Imaging**
  - **Forgery of “events”**
  - **Content tracking**



Application Domains

- **Privacy**
  - **Remote Sensing**
  - **Databases (degradable content)**
  - **Mobile Systems and Sensor Networks**
    - **Sensors are everywhere**



What Are My Neighbors Doing?

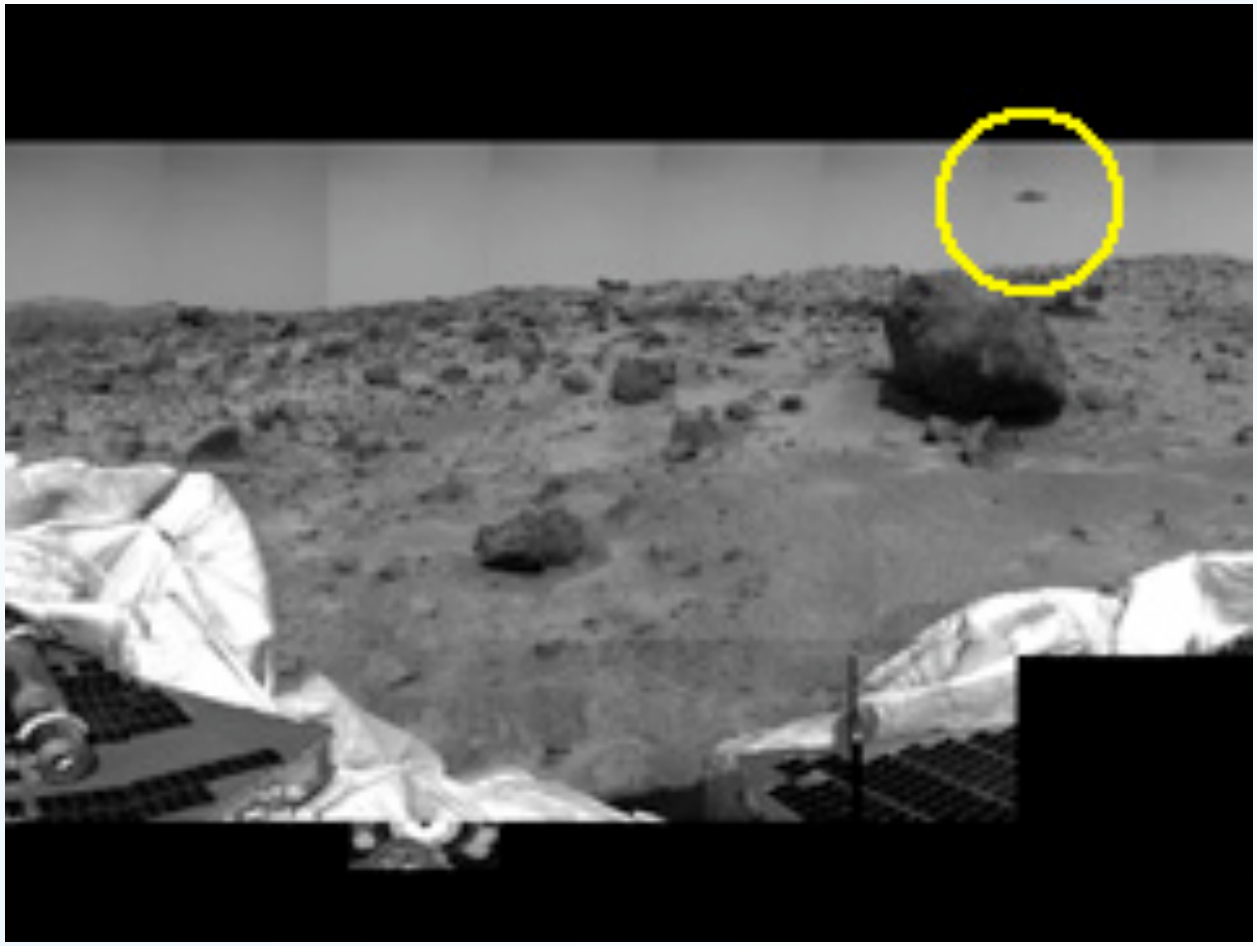
Where?

When?

Forensics


SPY
WHITE-HOT POLITICS ISSUE
KENNEDY
The Torch Passes
PLUS:
THOSE SURPRISING GORE GIRLS!

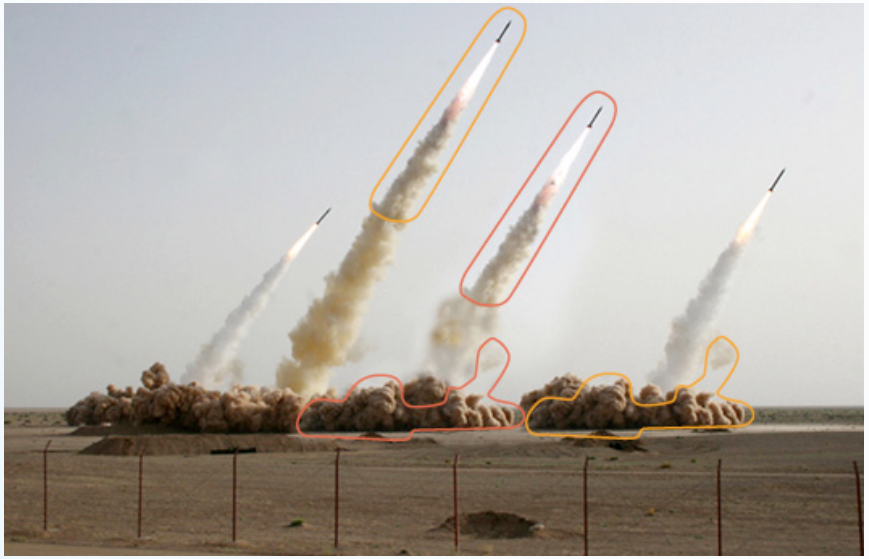
Forensics



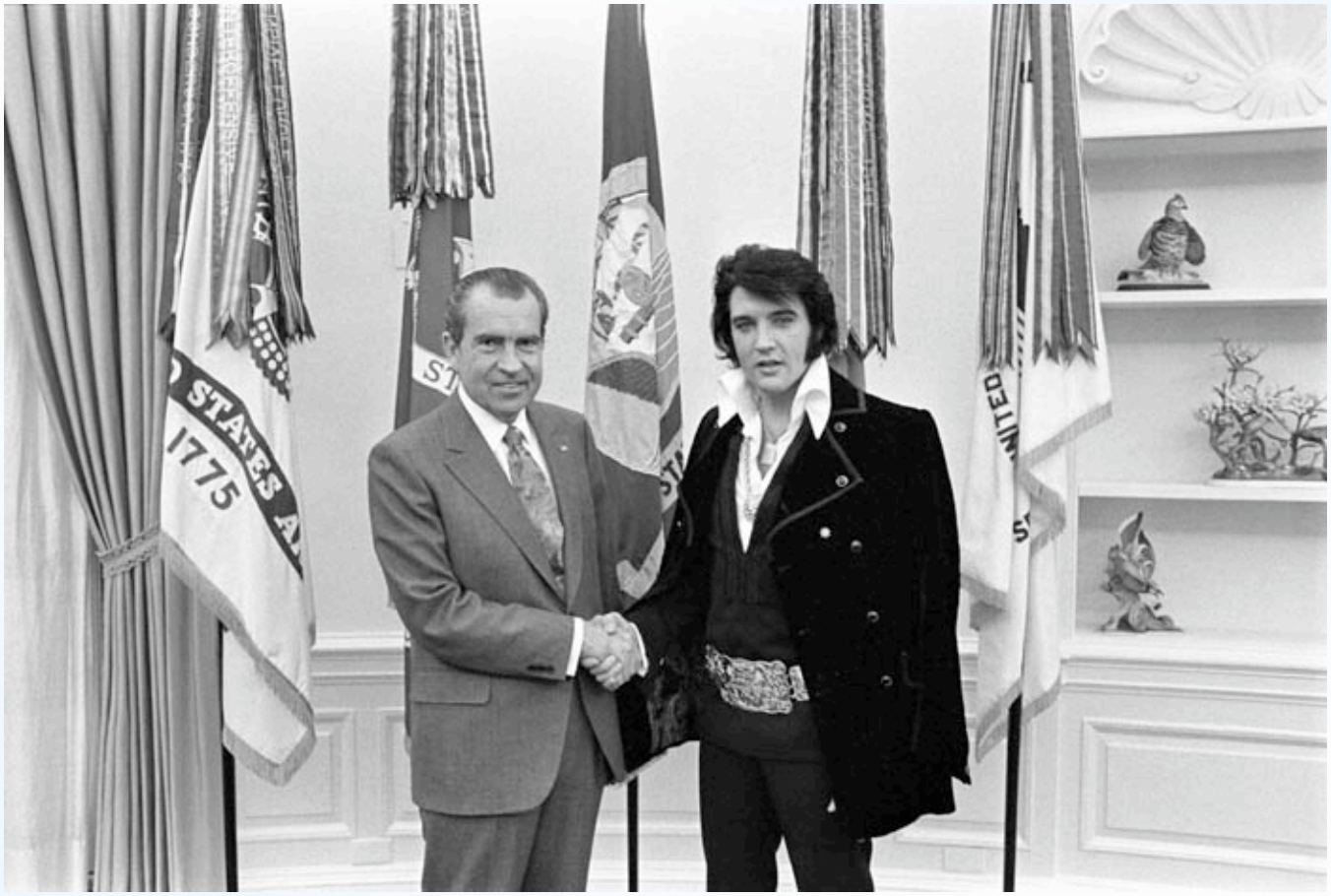
True or False?

July 10, 2008: Iranian Missiles Test

Well….well….well



Really!

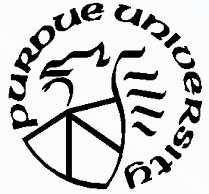


New Challenges

- **Authentication -**
  - **identity theft**
  - **mobile connected sensors**
- **Security, Surveillance, and Forensics**
  - **how do I protect information about myself?**
    - **rfid-like devices**
    - **tracking - e.g. who is in the parking lot?**
- **Scalable data conditional access - databases**
- **Use of context from the application**

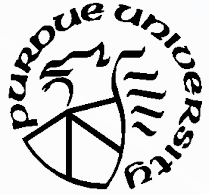
Sensor Forensics

- Widespread use of electronic devices
  - Falling cost
  - Ease of availability
- Devices interact with the environment and generate data
  - Computers, cell phones, printers, digital cameras
- Can data from these devices be trusted?
  - Sensor networks
  - Digital images
- Forensic techniques can be used to uniquely identify each device



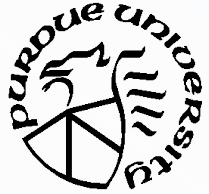
Sensor Forensics

- Forensic characterization
  - Observe device output ➔ which device produced it?
  - Exploit how the device "makes" its output
- Device authentication
  - Performed using forensic characterization
  - Identify device type, make, model, configuration
  - Can the sensor be trusted?
- Detection of data forgery or alteration
- Fingerprint and trace



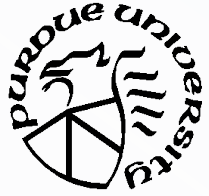
Signatures

- ***intrinsic signature*** **- identity as much information as possible from output of the device**
- **Embed auxiliary information in output via *extrinsic signature***
- **Intrinsic and extrinsic signatures are based on the basics of how the device operates**



Sensor Forensics Research

- **Printers**
- **Cameras**
- **Scanners**
- **Sensors Nodes**
- **RF Devices**

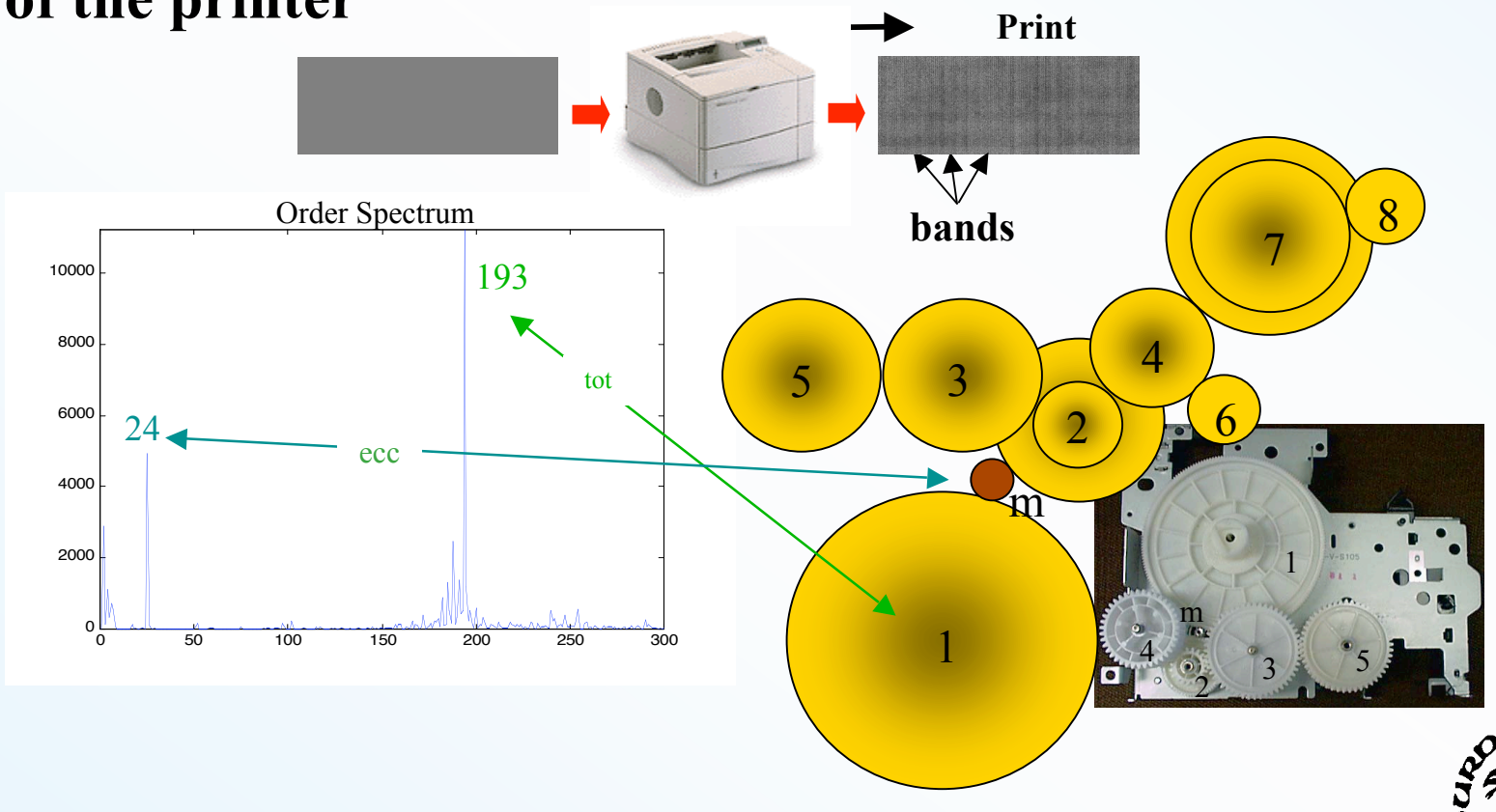


Sensor Forensics

www.sensor-forensics.org

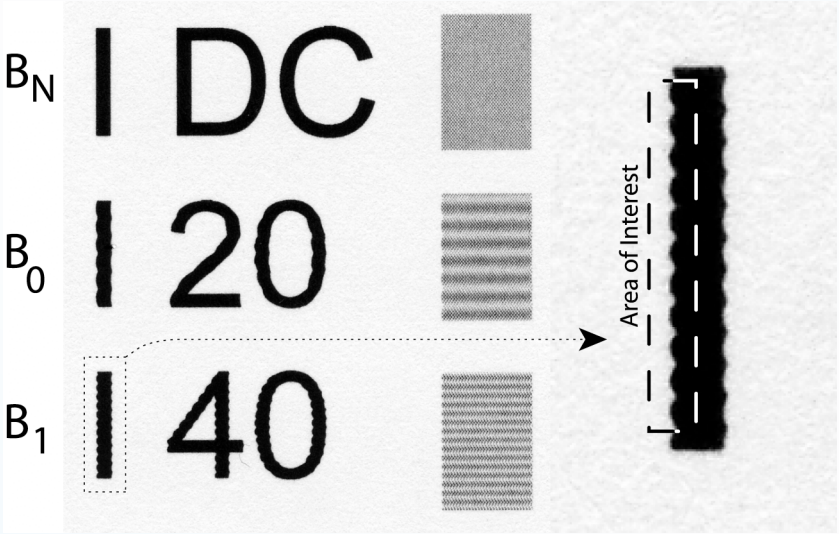
Printers

- **Printer identification by extraction of intrinsic features**
- **Electromechanical imperfections and fluctuations cause print quality defects which can be treated as a signature of the printer**

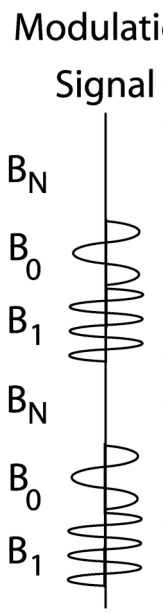


Effects of Laser Modulation

- *Artificial banding* in midtone regions
  - Can be minimized by designing the modulation signal to lie below the human contrast sensitivity curve
- Edge raggedness visible on vertical edges
  - Can be minimized by limiting embedding amplitude
  - Can also be used to detect the signals! Use ISO-13660 raggedness measure



Embedding Framework



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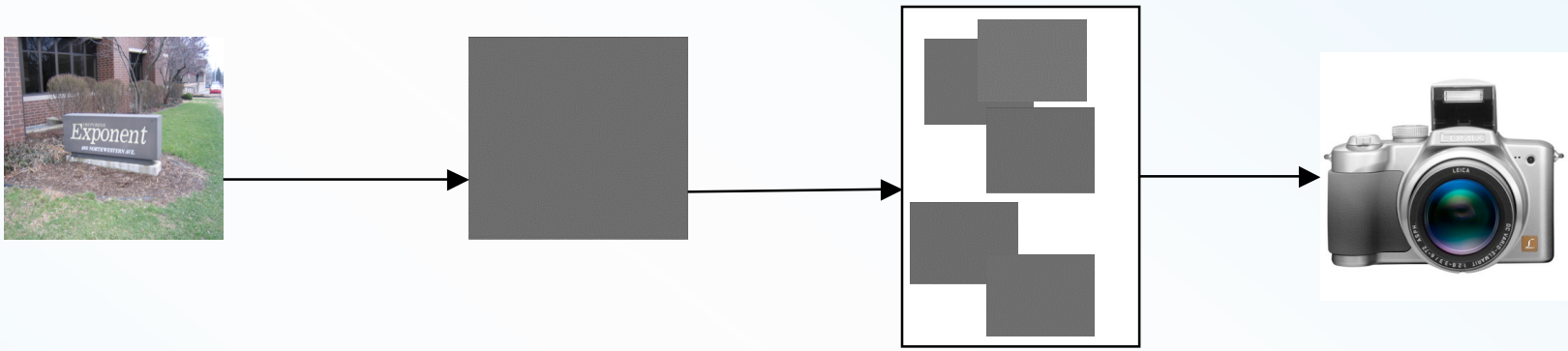
Sensor Based Characterization

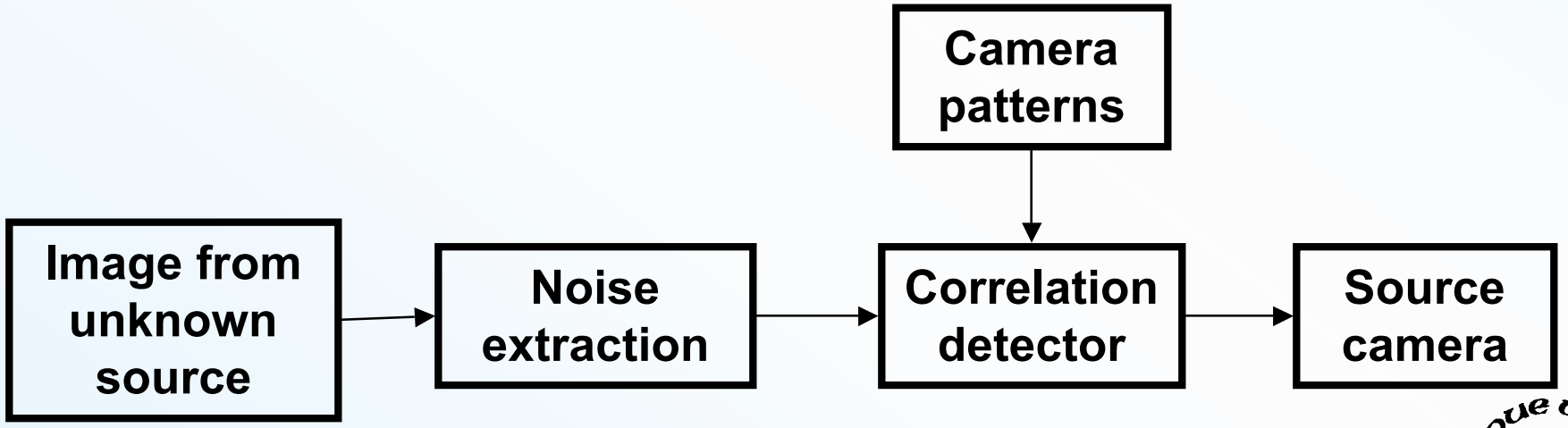
- **Two geometries of imaging sensors**
  - **Two dimensional (Cameras)**
  - **One dimensional (Flatbed Scanners)**
- **Noise pattern in imaging sensor is highly correlated to manufacturing defects**
  - **Fixed Pattern Noise (FPN) and Photo-Response Non-Uniformity (PRNU)**
  - **Noise modeled as the sum of random and fixed components**
- **Fixed component used for image source identification**

Sensor Based Characterization

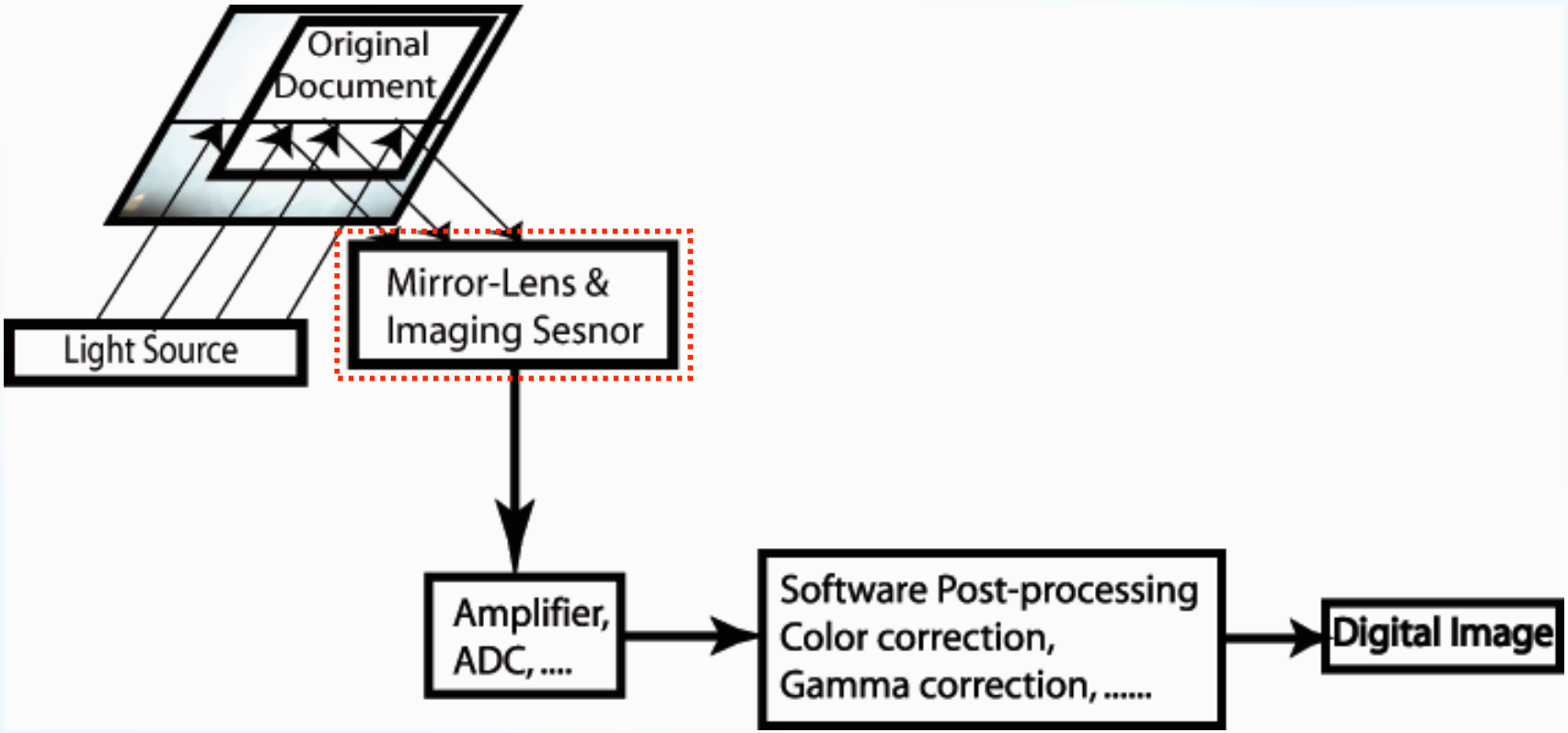
- **Pattern noise used as sensor reference pattern**
  - **Estimated using a denoising filter bank**
- **For scanners, the linear array is translated to generate the image ➔ periodicity in the fixed pattern noise corresponding to different rows of the scanned image**
- **No similar correlation between fixed pattern noise corresponding to different columns of the scanned image**

Source Camera Identification

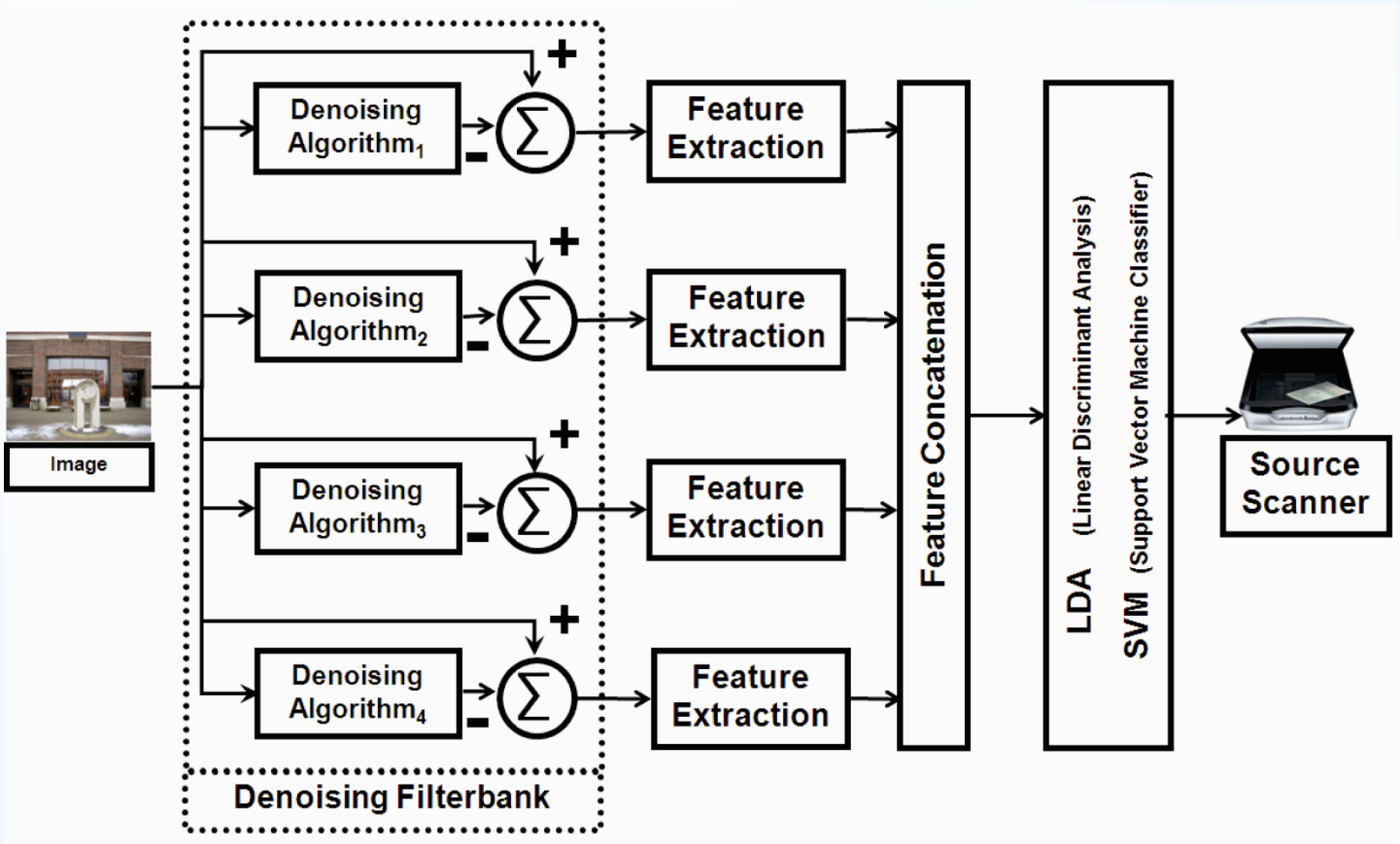




Flatbed Scanner Imaging Pipeline



Source Scanner Identification



Conclusion

We are having fun!

Multimedia Security: A Viewpoint From A Walking Wounded

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