## **Multimedia Search**



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## What is Multimedia?

### Definition from the ACM Special Interest Group on Multimedia Retreat in 2003

- More than one media (text, images, audio, video) that are correlated
- Examples:

*Time correlated: Video with text transcript of the audio* 

Spatially correlated: Images on a page with associated text

### A less strict definition:

### Not "Just" Text

- Images
- Audio
- Video





### **Multimedia Search Outline**

### **Text Search**

• Keywords

### **Image Search**

- Search based on tags (FlickR, FaceBook)
- Search based on surrounding text (Google)
- Content based search Using image features Using faces

### **Audio Search**

- Search based on metadata (iTunes)
- Content based search (MuscleFish, Foote)

### **Video Search**

- Search based on text (Google/UTube)
- Search based on associated media (Lectures with slides)
- Search based on content (TrecVid News Search)



Select all

MediaMagic

house



### **Text Search**



Documents (Web pages) represented by words

Inverted index links keywords to the documents that contain them

Keyword query retrieves documents containing that word

### Inverted Index Example

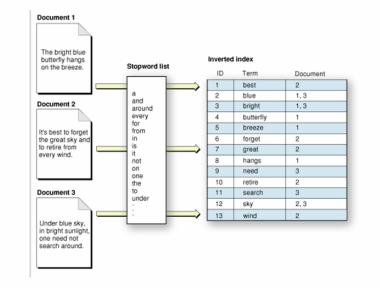


Image from http://developer.apple.com /documentation/UserExperience/Conceptual/SearchKitConcepts/searchKit\_basics/chapter\_2\_section\_2.html **Image Search - Tags** 



# Search over tags associated with images

- Users manually add Tags to images
   FlickR
  - FaceBook
- Find images with tags that match the query keyword

### Limitations

- Tags require human effort to create
- Tags may be wrong



### **Image Search - Text**

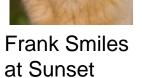
## Use text associated with images for search

- Search web for images
- Use surrounding text *Text in URL for image filename Text in HTML on page*
- Same as text search

#### Example: Google Image Search for "Sunset" gives

- Sunset at Rocky Point in Australia
- Sunset Beach, Oahu
- Frank Smiles at Sunset

## Because the keyword "Sunset" was in the title of all these images





#### Sunset at Rocky Point



Sunset Beach

Slide 6



### **Image Similarity Search**

### Query is an image

Search finds similar images

# Similarity is defined by features of the image

- Color Content
   *Color Histogram Color Corellogram*
- Image descriptors Gradients at image keypoints Quantize for "Visual words"
- Faces

Detection Recognition



Query Image



Search Results



### Image Search – Similar Color Content

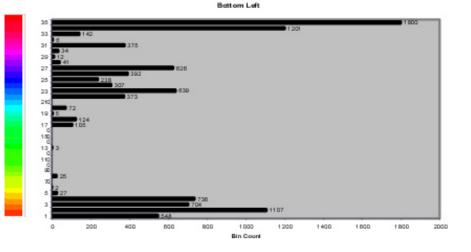
### **Color Histogram**

- Distribution of pixel colors in image
- No spatial information
- Similarity based on histogram distance

### **Color Correlogram**

- Color histogram as a function of distance between pixels *Multiple color histograms - one for each distance*
- Distribution of pixel color plus spatial information
- Similarity based on correlogram difference





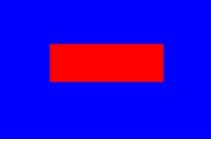




#### **Comparison of Image Retrieval**

- Color Histogram
- Color Correlogram

## Correlograms are better for image retrieval

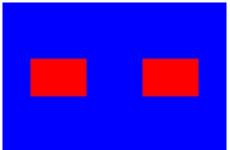


Images with identical color histograms but different correlograms



Images with different color histograms but similar correlograms





### Image Search – Image Descriptors



- (Scale Invariant Feature Transform) Features
- (2004: David Lowe, UBC)

# Select keypoints regions in image from extrema in scale space

 Different images have different numbers of keypoints

# Compute feature vectors X for each keypoint region

- Feature vectors from histogram of gradient directions near the keypoint
- SIFT features X are 128-dimensional vectors

### Image described by N SIFT features

- Features are  $X_1, \dots, X_N$
- N is different for different images





Quantize SIFT features to create "visual words" to represent images

Image Search – Visual Words

 (2006: Lienhart, University of Augsburg & Slaney, Yahoo!)

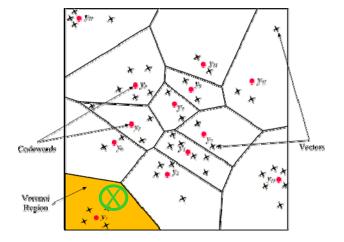
## **Cluster SIFT features of representative images**

- Features X are in 128-dimensional space
- Generate W clusters
- Clusters define "visual words"
- All features in same cluster are the same "visual word"

## To compute visual words describing an image

- Compute N SIFT X<sub>1</sub>,...,X<sub>N</sub> features for the image
- Find nearest cluster center (codeword) to each features X<sub>i</sub>
- These clusters define the visual words for the image







### Image Retrieval – Visual Words



## Image is described by it's visual words

• Just like a document is described by the text words

### **Create image index**

- Compute visual words for all images
- Create a visual word index into the images

### Compute visual words for query image

• Use query words for retrieval

### Just like text!

• Except the visual words aren't quite as meaningful



### **Image Search – Faces**

#### **Face Detection**

- Find faces in images
- Search for all images with faces
- Ex: Google advance search for images with faces
- Good results!

#### **Example:**

• FXPAL Photo Application (2004: Girgensohn et al.)



**Photo Collection** 



Faces in Photo Collection



**Face Detection** 

### **Image Search – Faces**



### **Face Recognition**

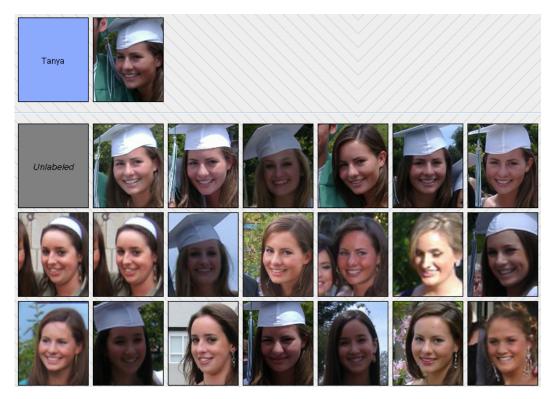
- Search for all images of a particular person
- Bad results!

### **Face Similarity**

- Similarity search based on face features
- Use face similarity to help manually label faces
- Good results!

### User Interface for Labeling Faces

• Drag face to label





### **Search text fields**

- Title
- Artist
- Album
- Genre

### Example

• iTunes

View     Search       Visic     Name     Time     Artist     Album by Year     Genre     My Rating     Play Count     Last P       Movies     Image: Prolude To The End Of The Game     0:20     Sting     Brand New Day     Rock     2     7/7/200       Image: Prolude To The End Of The Game     0:20     Sting     Brand New Day     Rock     2     7/7/200       Image: Prolude To The End Of The Game     0:20     Sting     Brand New Day     Rock     2     7/7/200       Image: Prolude To The End Of The Game     0:20     Sting     Brand New Day     Rock     2     7/7/200       Image: Prolude To The End Of The Game     0:20     Sting     Brand New Day     Rock     2     7/7/200       Image: Producats     Image: Producats     Image: Producats     Sting     Brand New Day     Rock     2     7/7/200       Image: Producats     Image: Producate To The End Of Gold     Rock     2     7/7/200     7/7/200       Image: Producate To The End Of Gold     Sting     The Pream Of The Bl     Rock Light     1     7/7/200       Image: Producate To The End Of Gold     Gold     3:39     Sting     Fields Of Gold     Rock Light     1     7/7/200       Image: Producate To The End Of Your Heart	jile Edit ⊆ontrols ⊻iew Store A	dvanced Help	_	iTunes	_					
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Top 25 Most Played       If I Ever Lose My Faith In You       3:47       Sting       Nothing Like The Sun       Rock Light       1       7/7/20         If I Ever Lose My Faith In You       4:30       Sting       Ten Summoner's Tales       Rock       Image: Constraint of the Sun Sting       Rock Light       1       7/7/20         If I Ever Lose My Faith In You       4:30       Sting       Ten Summoner's Tales       Rock       Image: Constraint of the Sun Sting       Rock       Image: Consun Sting	Recently Played	🖬 Fragile	4:21	Sting		Grammy Nominees 2003	Pop			
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Image: Seven Days       4:39       Sting       Ten Summoner's Tales       Rock         Image: CD1       Image: Seven Days       3:47       Sting       Ten Summoner's Tales       Rock       1       6/18/20         Image: CD2       Image: Seven Days       4:39       Sting       Ten Summoner's Tales       Rock       1       6/18/20         Image: CD3       Image: Seven Days       4:39       Sting       Ten Summoner's Tales       Rock         Image: CD4       Image: Seven Days       4:39       Sting       Ten Summoner's Tales       Rock         Image: CD4       Image: Seven Days       4:39       Sting       Ten Summoner's Tales       Rock         Image: DD4       Image: Seven Days       4:39       Sting       Ten Summoner's Tales       Rock         Image: DD4       Image: Seven Days       4:39       Sting       Ten Summoner's Tales       Rock         Image: DD4       Image: Seven Days       5:17       Sting       Ten Summoner's Tales       Rock         Image: DD4       Image: Seven Days       5:10       Sting       Ten Summoner's Tales       Rock         Image: DD4       Image: Seven Days       5:10       Sting       Ten Summoner's Tales       Rock         Image: DD4       Image: Sev		📓 If I Ever Lose My Faith In You	4:30	Sting		Ten Summoner's Tales	Rock			
CD1     If Helds Or Gold     33:47     Sting     Ten Summoner's Tales     Rock       If CD2     If She's Too Good For Me     2:30     Sting     Ten Summoner's Tales     Rock     1     6/18/20       If CD3     If Se's Too Good For Me     2:30     Sting     Ten Summoner's Tales     Rock     1     6/18/20       If CD3     If Se's Too Good For Me     2:30     Sting     Ten Summoner's Tales     Rock       If CD4     If Saint Augustine In Hell     5:17     Sting     Ten Summoner's Tales     Rock       If Dod1     If De Deabable Me     Evon Sting     Ten Summoner's Tales     Rock		Love Is Stronger Than Justice (Th	5:11	Sting		Ten Summoner's Tales	Rock			
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CD4     Saint Augustine In Hell     5:17     Sting     Ten Summoner's Tales     Rock       Dad1     Image: Saint Augustine In Hell     5:00     Sting     Ten Summoner's Tales     Rock	🕞 CD2	🖉 She's Too Good For Me	2:30	Sting		Ten Summoner's Tales	Rock			
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The iTunes MiniStore helps you discover new music and video right from your iTunes Library. As     you select tracks or videos in your Library, information about your selections are sent to Apple	🚺 Dad4				Apple d	oes not keep any		Gonillaz	Got	Raz
Dad3 you select tracks or videos in your Library, information about your selections are sent to Apple     and the MiniStore will display related songs, artists, or videos. Apple does not keep any	Dad5	information related to the contents of y	your iTun	es Library.				****		*** 1/2
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<ul> <li>Dad3</li> <li>you select tracks or videos in your Library, information about your selections are sent to Apple and the MiniStore wild display related songs, artists, or videos. Apple does not keep any information related to the contents of your iTunes Library.</li> <li>Dad5</li> <li>Dad6</li> <li>Would you like to turn on the MiniStore on now, click Hot How. You can always access this page again and turn the MiniStore on at any time by Not Now</li> </ul>		-0	101004244141	2008-000-000-000-000-000-000-000-000-000						

### Audio (Music) Search - Sound



#### Find similar sounding music

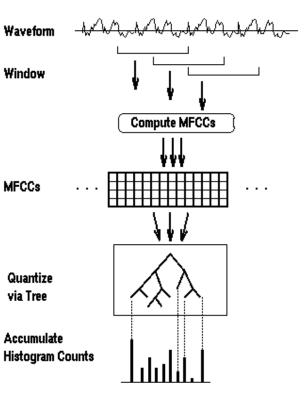
- Compute spectral feature vectors (MFCC)
- Quantize features to create audio histogram
   Audio histogram describes sounds
   Order of sounds is lost

#### Example

- 1997: Jon Foote, FXPAL
- Similarity of Nat King Cole and Gregorian Chant

#### **Music Retrieval Demo**

1.000 NatKingCole+AintMisbehavin	~						
0.772 BelaFleck+ArkansasTraveler							
0.712 BelaFleck+UpAndRunning							
0.689 Monks+GlorialnExcelsisDeo							
0.675 BelaFleck+CircusOfRegrets							
0.659 TwilightInRio+DanzaParaguaya							
0.656 AmericanMusicClub+Hollywood4-5-92							
0.653 ShimaShoka+IdaLupino							
0.641 SoftSounds+AfterTheRain							
0.638 ShimaShoka+Timebends							
0.631 SoftSounds+YouTaughtMyHeartToSing							
0.605 Volume3+Countdown							
0.603 ShimaShoka+Meraviglioso							
0.600 Portishead+ItsAFire							
0.600 Volume3+JoySpring	~						
Search for similar files Play selected file	Reset						



#### http://www.rotorbrain.com/foote/musicr/

Slide 16

### Video Search – Whole Video

### Search for an entire video

• Search using surrounding text

### Example: Google/YouTube

• Search for sunset



#### Sunset - Nitin Sawhney



#### Sunset at Cafe Del Mar 2004

6 min - Oct 17, 2006 - **\*\*\*\*\*** (80 ratings) Mar 2004...A realy Cool **Sunset** at Cafe Del Mar Ibiza.I overlaid two songs on this video, the first is Water in Motion by sonic http://www.youtube.com/watch?v=vs1yzMNxhGk Watch video here - Related videos



#### The Kinks - Waterloo Sunset



### Video Search – Lecture Video

#### Search for a segment of a lecture

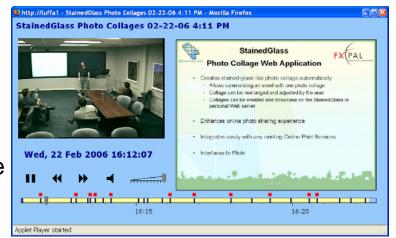
- Collection of lecture videos (maybe for a class)
- Find just that part of a lecture that you want to watch

#### **Indexing Method**

- Capture lecture audio and video
- Capture presentation material
- Extract text from presentation material
- Capture time correlations
- Segment the video based on slide change
- Create keyword index of segments of the video associated with each slide

#### **Search Method**

- Keyword search
- Play video starting at the relevant segment





### **Video and Audio Capture**



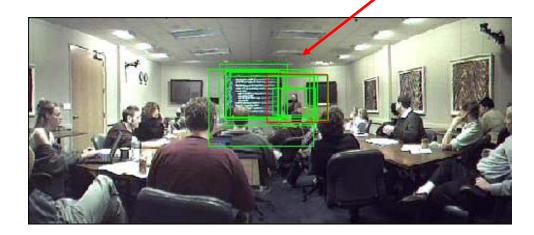
#### Automatic camera control

- Multiple cameras capture meetings from different angles
- Select camera with best view
- Pan and zoom to region of interest

#### **Region of interest determined using**

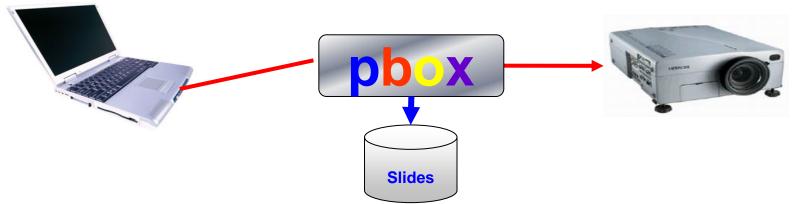
- Audio source
- Motion tracking
- Learning based on human operator







### **Presentation Capture**



#### **Capture Slide Images**

- ProjectorBox (PBox): Denoue and Hilbert FXPAL
- Insert PBox in RGB stream between PC and projector
- Capture slides images and time stamps *Capture slide images at a fixed rate Only keep distinct slide*

### **Capture Text from Slide Images**

• OCR slide images from PBox to get words *Optical Character Recognition (OCR) to convert text image to electronic text* 

#### Synchronize clocks of presentation and video capture devices

### Video Search – Segments of Lecture Video

#### **Video and Audio**

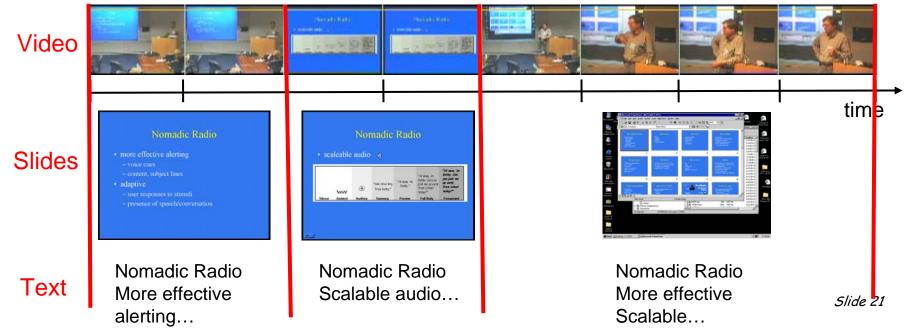
- Sequence of frames (images) with audio
- 30 frames/second

#### **Presentation Slides**

- Slide images
- Time-correlated with video

#### Text from Presentation Slides Segment Video

- New segment when slide changes
- Video associated with a slide



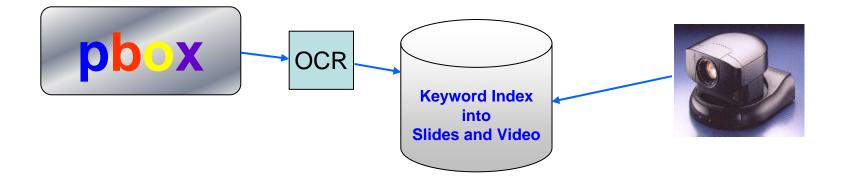


# Create index into video segments associated with each slide

• Index each slide in video based on text

### Search

- Keyword search locates relevant slide
- Play video at starting time for that segment



### **Example: Find Presentation**



### Find Presentation on Photo Organization

 FXPAL "Corporate Memory"

### Query

• FlickR, Organizing Photos, Photos

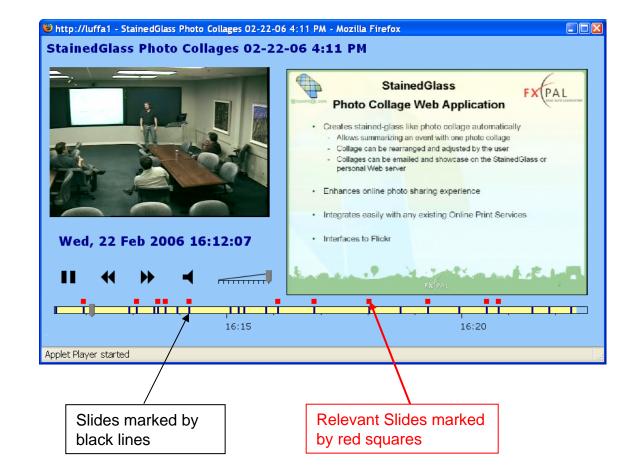
### Result

- Slides from presentation
- Click to play lecture video from current slide



### **Example: Find Segment of Presentation**





# Play video and view slides

- Skip to next slide
- Skip to next relevant slide

Slide 24

### Video Indexing for Stanford Med School



#### **Pathology Class**

- Presentation material was mainly images
- No PowerPoint

#### **Create Visual Index into Video**





#### **Timeline Slider**

- Move cursor along timeline to browse keyframes in video
- Click on keyframe to play
- Good for fast forward/reverse

#### **Manga Summaries**

- Visual summary of video
- · Click on image to play
- Good for study review

### **Usage Study**



#### **Student Focus Groups**

- Primary use of recorded video is to view missed class
- Video sometimes used for review
- Some note-taking while watching recorded lecture but it was too time consuming
- Students want links between video, slides, syllabus, TA handouts, book, other information on Web

### **Professor Interview**

- Manga and Timeline slider good index for professor since he knows material (slides)
- For students, text index is needed
- Students learn by note-taking and linking information from different sources
- Trial was too short



### Video Search – News Programs



#### Find segments of news on a topic of interest

- Find news story
- Find shots within story

#### TRECVID

- Sponsored by NIST (National Institute of Standards)
- Data base of 60 hours of news video (ABC, NBC) in 2004 – similar content other years
- Task user has 15 minutes to find shots relevant to a topic

### **Example Topics**

- "Find shots of a hockey rink with at least one of the nets fully visible from some point of view"
- "Find shots zooming in on the US Capitol dome"
- "Find shots of Saddam Hussein"







### **Video Search: Segments of Video**



#### Video

- Sequence of frames (images), typically with audio
- 30 frames/second

#### **Text Transcript of Audio**

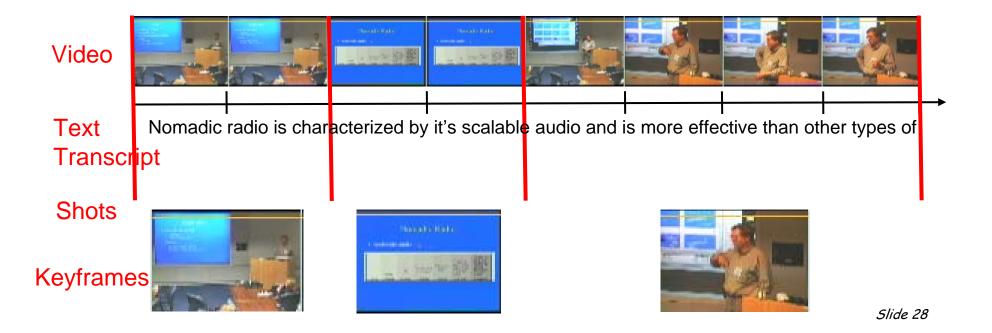
• Time-correlated with video

#### **Segments of Video**

- Shot: Unbroken segment of video from a single camera
- Story (news): Sequence of shots from the same news story

#### Keyframe

• Representative image from a video segment



### Video Search – News Index



#### Video Data

- Video sequence of frames (images)
- Time-aligned text from automatic speech transcription (text)

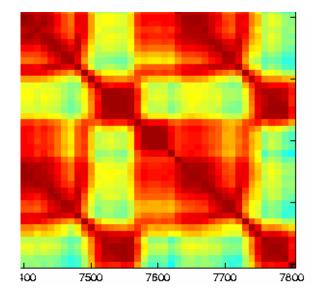
#### **Pre-processing**

 Segment video into shots using image features

Compute pairwise similarity between frames of video Similarity is based on image features

Segment when similarity is low

- Select a representative keyframe for each shot
- Segment video into stories using text *Compute pairwise similarity between shots of video Similarity is based on text associated with shot Segment when similarity is low*
- Each story will be composed of one or more shots



Self-similarity matrix for shot and story segmentation

### Video Search – News Retrieval



### **TRECVID** task is to find shots relevant to the query

• Use keyword search and image search

#### **Keyword Search**

• Retrieve stories relevant to keyword

#### **Image Search**

• Retrieve stories with shots relevant to keyword

#### Merge results of image and keyword search

• Examine shots within the retrieved stories

#### **TRECVID Search**

- User enters keywords and/or images for query
- System returns relevant stories
- User explores stories for relevant shots

### **Story Summary Quads**



#### **Query-dependent story summary**

- Use 4 highest scoring shots
- Allocate space proportional to score



#### Shot thumbnails

Story thumbnail

Slide 31

### **Query Area**





Find shots of Boris Yeltsin.



## Search entered as text and example images

• System returns relevant stories

## Results displayed in ranked list of story keyframe collages

• Keyframe collages adapt to query

## Shading reflects exploration history

### **Story Browsing Area**

# FX

## Selecting a story expands the video at that point

- Clickable video timeline with relevancy shading
- Clickable story quad timeline
- Overlay on shots marked (non)relevant
- Moused-over icon displays full-size media player area at top and tool-tip shows context of relevancy
- Double click to play video in the media player (if you really have to)







### **Evaluations based on "Mean Average Precision"**

- Recall is percent of relevant shots that are retrieved *Retrieving all shots give perfect recall*
- Precision is the percent of retrieved shots that are relevant *Retrieving only one relevant shot gives perfect precision*
- MAP is a measure of average precision at different recall levels

### **TRECVID** competition results are poor

• On average only 30% of the relevant shots are found correctly

### Why Results are Poor

- Keyword is not found in text associated with the video *Ex: Query is to find people riding bicycles, but no mention of bicycles is made in the text associated with the stories*
- Image search not good enough General image searches cannot find specific objects like people on bicycles

Slide 35

### **Multimedia Search Summary**

### **Text Search**

• Keywords

#### **Image Search**

- Search based on tags (FlickR, FaceBook)
- Search based on surrounding text (Google)
- Content based search Using image features Using faces

#### **Audio Search**

- Search based on metadata (iTunes)
- Content based search (MuscleFish, Foote)

### **Video Search**

- Search based on text (Google/UTube)
- Search based on associated media (Lectures with slides)
- Search based on content (TrecVid News Search)





0/13/1998 ABCa

#### MediaMagic

