Development and Evaluation of Indexed, Captioned, Searchable Videos for STEM Coursework

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Usage of video to deliver coursework online: commonplace

Evidence for video usage:
- MIT OpenCourseware
- Apple’s iTunes University
- YouTube Edu
- Classroom lecture videos widely used at University of Houston

- Tablet PC recordings
Surveys, focus groups:

- **Video lectures**: powerful and versatile resource

  ![Graph showing the importance of different resources](chart.png)

  - Professor's lecture notes: 80%
  - The lecture videos: 70%
  - Students' notes: 60%
  - Textbook reading sources: 40%

  - Is this resource “very important”? Yes.

- **The biggest weakness of the video format**: *Inability to quickly access the content of interest*
ICS Videos

- **Indexing**: Segmented videos
- **Search**: Keyword search in video
- **Captioning**: Scrolling text for audio

Integrated in **ICS Video Player**

**Project Goal**: *Quick access to video content*
Example

- One of the simplest types of linear convolutions is the operation (or averaging filter).
- Conceptually, each image pixel is replaced by the average of values within a square “window”.

This may be expressed, at most points (without proving it here) as the wraparound convolution of the image with another image of a square with intensity 1/M, where M = # pixels in the square.
INDEXING
Indexing: dividing video into segments; User can start playback from any index frame

Indexing Tasks:
- identify all transition points (TP)
- select subset of TPs as index points
**Transition points**: slide changes

- Detection:
  - comparison of frames in the video
  - minimum pixel RGB value difference

- Which frames to compare
  - sequential algorithm with jumping
  - binary search algorithm
sequential:

sequential (with jumping):

binary search:
Detection and Execution Performance

-Almost all Transition Points are detected by all alg.

Average time (mins) for indexing an hour of video
Transition points ➔ Index points

- Large number of transition points hard to manage: 10s-100s
- Automatically select
  - fixed number of index points (15)
  - roughly uniformly spaced
KEYWORD SEARCH
Example

- One of the simplest types of linear convolutions is the operation (or averaging filter).
- Conceptually, each image pixel is replaced by the average of values within a square "window":

  ![Diagram of linear convolution]

- This may be expressed, at most points (without proving it here) as the wraparound convolution of the image with another image of a square with intensity $1/M$, where $M =$ # pixels in the square:

  ![Diagram of wraparound convolution]
Keyword Search requires text detection in video frames
- Can be accomplished by OCR tools

Integration with ICS video framework?
- Accuracy on lecture video images?
**Introduction**

**ICS Video Project**

**Assessment**

**Conclusion**

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**Example images from lecture videos**

**Link Layer: Introduction**

*Some terminology:*
- hosts and routers are **nodes**
- communication channels that connect adjacent nodes along communication path are **links**
  - wired links
  - wireless links
  - LANs
- layer-2 packet is a **frame**, encapsulates datagram

**Data-link layer** has responsibility of transferring datagram from one node to adjacent node over a link

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**Testcross**

- How can you determine the genotype of a dominant phenotype?:
  - Purple-flowered pea plant is either **PP** or **Pp**; cross with a homozygous recessive (pp) white-flowered plant:

  ![Genetic Cross Diagram](image)

  - If **PP** Sperm
    - All purple
  - **Or** If **Pp** Sperm
    - ½ purple; ½ white

- By definition, the **testcross** is used to determine the genotype of an organism expressing a dominant phenotype by breeding with a recessive homozygote.
Outputs of OCR Tools

Question 3

Where did the story say that there was a statue raised in Mrs. Bethune’s honor?

- Washington, D.C.
- Miami, Florida
- Mayesville, South Carolina
Segmentation of Text Region

Image Example

Noisy, $\sigma=10$ (MSE=100)  denoised (T=3, MSE=56)
Segmentation of Text Region and Enlargement

# Inversions of Colors

<table>
<thead>
<tr>
<th>Original Image</th>
<th>R / G / B</th>
<th>Inversion1</th>
<th>255-R / G / B</th>
</tr>
</thead>
<tbody>
<tr>
<td><img src="image1.png" alt="Original Image" /></td>
<td><img src="image2.png" alt="R / G / B" /></td>
<td><img src="image3.png" alt="Inversion1" /></td>
<td><img src="image4.png" alt="255-R / G / B" /></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Inversion2</th>
<th>R / 255-G / B</th>
<th>Inversion3</th>
<th>R / G / 255-B</th>
</tr>
</thead>
<tbody>
<tr>
<td><img src="image5.png" alt="Inversion2" /></td>
<td><img src="image6.png" alt="R / 255-G / B" /></td>
<td><img src="image7.png" alt="Inversion3" /></td>
<td><img src="image8.png" alt="R / G / 255-B" /></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Inversion4</th>
<th>255-R / 255-G / B</th>
<th>Inversion5</th>
<th>R / 255-G / 255-B</th>
</tr>
</thead>
<tbody>
<tr>
<td><img src="image9.png" alt="Inversion4" /></td>
<td><img src="image10.png" alt="255-R / 255-G / B" /></td>
<td><img src="image11.png" alt="Inversion5" /></td>
<td><img src="image12.png" alt="R / 255-G / 255-B" /></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Inversion6</th>
<th>255-R / G / 255-B</th>
<th>Inversion7</th>
<th>255-R / 255-G / 255-B</th>
</tr>
</thead>
<tbody>
<tr>
<td><img src="image13.png" alt="Inversion6" /></td>
<td><img src="image14.png" alt="255-R / G / 255-B" /></td>
<td><img src="image15.png" alt="Inversion7" /></td>
<td><img src="image16.png" alt="255-R / 255-G / 255-B" /></td>
</tr>
</tbody>
</table>
Recognition accuracy with OCR Tools and Image Enhancement (IE)

<table>
<thead>
<tr>
<th>Without IE</th>
<th>IE improvement</th>
</tr>
</thead>
<tbody>
<tr>
<td>Modi-Gocr-Tesseract</td>
<td>94.8%</td>
</tr>
<tr>
<td>Tesseract</td>
<td>79.4%</td>
</tr>
<tr>
<td>Gocr</td>
<td>66.3%</td>
</tr>
<tr>
<td>Modi</td>
<td>91.1%</td>
</tr>
</tbody>
</table>

Maximum accuracy with all OCR engines with IE: 97.1%.
CAPTIONING
Captioning

- Motivation is to make video lectures available to the deaf students
- Improves the experience of hearing students
- Non-native English speakers
- ICS player supports captions; currently captions created manually
Introduction

ICS Video Project

Assessment

Conclusion

Video Indexer

Database

OCR

Video

Captions

Index Points

Image Transformations

ICS Video Player

JPG

JPG

JPG

JPG

JPG

JPG

JPG

JPG
ASSESSMENT OF STUDENT USE, EXPERIENCE, PERCEPTIONS
Assessment Questions

• What do students perceive as the value of ICS videos?
• What is the perceived value of the index?
• What is the perceived value of the search tool?
Survey Administration

• 1,167 student surveys
  – Spring 2010 (N=612) and Spring 2011 (N=555)

• 18 courses
  – Biology, computer science, chemistry, geology, and mathematics
  – Some courses have very high enrollments

• Last week of semester
  – Faculty sent out link, reminders
Sample Profile

60% female, 40 male%
Mean one-way commute time: 30-45 minutes
57% of students work to support themselves (7% >36 hours/week)
Strong commitment to education (class attendance, course grade, GPA)
### Reasons for Using Videos (n=1804)

<table>
<thead>
<tr>
<th>Reason</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>To hear a lecture that I had missed because I had not gone to class.</td>
<td>73%</td>
</tr>
<tr>
<td>To review before a test or quiz.</td>
<td>70%</td>
</tr>
<tr>
<td>To review concepts that were particularly difficulty for me.</td>
<td>64%</td>
</tr>
<tr>
<td>To review concepts I didn’t understand in the class-based lecture.</td>
<td>32%</td>
</tr>
<tr>
<td>To review concepts I could not hear in the class-based lecture.</td>
<td>64%</td>
</tr>
<tr>
<td>To preview a lecture before going to class.</td>
<td>7%</td>
</tr>
<tr>
<td>To review a lecture later on the same day that the lecture was presented in class.</td>
<td>17%</td>
</tr>
<tr>
<td>To review a lecture later in the same week that the lecture was presented in class.</td>
<td>32%</td>
</tr>
</tbody>
</table>
# ICS Videos Strongly Valued for Learning and Grades

<table>
<thead>
<tr>
<th>Survey Item</th>
<th>N</th>
<th>Mean (6-pt scale)</th>
<th>Std. Dev.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lecture videos help me to clarify material that was not clear in class.</td>
<td>825</td>
<td>5.45</td>
<td>.826</td>
</tr>
<tr>
<td>Lecture videos are useful for reviewing.</td>
<td>841</td>
<td>5.63</td>
<td>.693</td>
</tr>
<tr>
<td>Having access to lecture videos for this class is important to me.</td>
<td>837</td>
<td>5.61</td>
<td>.774</td>
</tr>
<tr>
<td>The lecture videos helped me to study for quizzes or tests.</td>
<td>829</td>
<td>5.51</td>
<td>.842</td>
</tr>
<tr>
<td>Importance of video lectures for this class for getting the grade you wanted.</td>
<td>885</td>
<td>3.51 / 4-pt scale</td>
<td>.751</td>
</tr>
</tbody>
</table>
Perceptions of Index

- 97%: index was helpful
- 89%: intuitive
- 96%: easy to use
- 90%: time intervals appropriate
“sometimes I would have to pause the lecture to take care of other responsibilities that I had to attend to, and when I was ready to come back to the lecture I'd pick up exactly where I was at, it was great!”
Index Use Correlated with Increased Perceived Value of Videos

• “Overall Attitude Toward Video” (scale of six items) (Cronbach’s α = .872)

• Index users valued videos more
  – (t(616) = -3.284, p < .001)
  – Small to moderate effect (d = 0.265)
Perceptions of Search Tool (N=50)

• 96%: easy to use
• 98%: results easy to use
• 95%: easier to navigate video
• 88%: helpful either most or all the time
• 82%: search results relevant to search most or all of the time
How Did Availability of ICS Videos Affect Class Attendance?

- 86% strongly agreed that it was important for them to go to class, whether or not the video lectures were available
- 67%: attended 75-100% of classes
- Class attendance positively and significantly correlated with video use ($r(1019) = .234, p < .000$)
CONCLUSION
Conclusion

➢ Reported: ICS videos and their usage for STEM coursework

➢ Indexing and search features: very helpful and easy to use

➢ New and innovative direction for effective use of videos in STEM coursework.
- Large scale usage and assessments
- Captioning with speech recognition tools
- Text and semantic based indexing and search
THANK YOU

http://icsvideos.cs.uh.edu/

The framework is freely available to educational institutions.