# SIGGRAPH Content Formatting Instructions

**Figure 1:** *Spring Training 2009, Peoria, AZ.*


## Abstract



**Keywords:** Video summarization, Video navigation, Lecture videos, Blackboard-style lectures


## 1 Related Work

Navigation interface:

- [**?**] Lecture scape interface
- [**?**] Video Digest

Directly related to blackboard-style lectures:

- [**?**] Clickable visuals and panoramic frame
- [**?**] Panoramic frame

Other video summarization

- [**?**] Panopticon
- [**?**] Video Tapestry
- [**?**] soccer video summarization

Comic book style layout of keyframes

- [**?**]
- [**?**]
- [**?**]

Improving readability of video subtitles

- [**?**] optimizing subtitle placement by speaker recognition
- [**?**], [**?**] subtitle placement for sinle frame in cinema comics

## 2 Method

### 2.1 Time-stamped Transcript

Several on-line video lectures (e.g. Khan Academy) come with transcripts. In cases where transcripts were not provided, we used an on-line audio transcription service to acquire a verbatim text transcript. Then, we used a tool from [**?**] to compute an alignment between the video's audio file and the transcript. The final output is a time-stamped transcript, where each word is annotated with a start and end time.

### 2.2 Stroke Extraction

A *stroke* is defined as the set of foreground pixels that is drawn during one continuous drawing activity. The method used to extract strokes from video frames are similar to that used by [**?**] to extract visual objects in their NoteVideo interface. Figure **??** shows examples of extracted strokes from different videos. A typical stroke comprises several characters to several words, or it can also be a part of other drawings such as a graph (Figure **??**c).

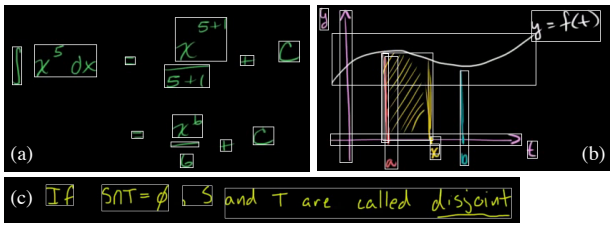


**Figure 2:** *Examples of strokes extracted from different videos.*

### 2.3 Hierarchical Grouping of Strokes

We group strokes into hierarchical units: lines and sentence-strokes. A line consists of a set of strokes that *belong together* semantically. For example, a line could be a single row of equations, or a graph including its labels. Figure **??** shows examples of lines. The problem of grouping strokes into lines is analogous to the problem of line breaking, also known as word wrapping [**?**]. An important difference is that in the traditional word wrapping problem, only a contiguous set of words can be put in the same line. In our case, strokes in a single line can be interspersed by strokes in a different line. This happens, for example, when the instructor goes back and

forth between two lines of equations, or between a graph and an equation (Figures **??**).

Scoring function description

Pseudo code figure

**Input** : list of strokes $S$
**Output**: list of optimal lines, $L_{|S|}$
$L_{-1} = -''$ // $L_i$ = optimal set of lines upto $i$-th stroke

**for** *each stroke* $s_i \in$ **S do**
  *minscore* = $+\infty$
  **for** $j \leftarrow -1$ ***to*** $i-1$ **do**
    **for** $n \leftarrow 0$ ***to*** $|L_j|+1$ **do**
      // score to merge $s_i$ to $n$-th line of $L_j$
      // If $n = |L_j|+1$, $s_i$ on a new line by itself.
      *score* $\leftarrow$ line_score($L_j$, $n$)
      **if** *score* $<$*minscore* **then**
        $optj = j$
        $optn = n$
      **end**
    **end**
  **end**
  $L_i =$ merge $s_i$ to $optn$-th line of $L_{optj}$
**end**

Sentence is a meaningful unit. So, we divide the strokes in a line to sentence-strokes.

In summary, we have the following hierarchical grouping of strokes: strokes, sentence-strokes, and lines.

### 2.4 Layout

## 3 Results

## 4 User Study

### 4.1 Comprehension Task

[**?**]: 10-question pre-test and 10-question post-test. The two sets of questions test the same type of knowledge but were asked in a different ways (e.g. one question would be asked in identification form with a why question after, and the other question would be in essay form). Measured test scores and learning time.

### 4.2 Overview Task

### 4.3 Search Task

## Acknowledgements

## References


BARNES, C., GOLDMAN, D. B., SHECHTMAN, E., AND FINKELSTEIN, A. 2010. Video tapestries with continuous temporal zoom. *ACM Transactions on Graphics (TOG) 29*, 4, 89.

BORECZKY, J., GIRGENSOHN, A., GOLOVCHINSKY, G., AND UCHIHASHI, S. 2000. An interactive comic book presentation for exploring video. In *Proceedings of the SIGCHI conference on Human Factors in Computing Systems*, ACM, 185–192.

CHI, P.-Y., LIU, J., LINDER, J., DONTCHEVA, M., LI, W., AND HARTMANN, B. 2013. Democut: generating concise instructional videos for physical demonstrations. In *Proceedings of the 26th annual ACM symposium on User interface software and technology*, ACM, 141–150.

CHOUDARY, C., AND LIU, T. 2007. Summarization of visual content in instructional videos. *Multimedia, IEEE Transactions on 9*, 7, 1443–1455.

CHUN, B.-K., RYU, D.-S., HWANG, W.-I., AND CHO, H.-G. 2006. An automated procedure for word balloon placement in cinema comics. In *Advances in Visual Computing*. Springer, 576–585.

EKIN, A., TEKALP, A. M., AND MEHROTRA, R. 2003. Automatic soccer video analysis and summarization. *Image Processing, IEEE Transactions on 12*, 7, 796–807.

HU, Y., KAUTZ, J., YU, Y., AND WANG, W. 2015. Speaker-following video subtitles. *ACM Transactions on Multimedia Computing, Communications, and Applications (TOMM) 11*, 2, 32.

HWANG, W.-I., LEE, P.-J., CHUN, B.-K., RYU, D.-S., AND CHO, H.-G. 2006. Cinema comics: Cartoon generation from video stream. In *GRAPP*, 299–304.

JACKSON, D., NICHOLSON, J., STOECKIGT, G., WROBEL, R., THIEME, A., AND OLIVIER, P. 2013. Panopticon: A parallel video overview system. In *proceedings of the 26th annual ACM symposium on User interface software and technology*, ACM, 123–130.

KIM, J., GUO, P. J., CAI, C. J., LI, S.-W. D., GAJOS, K. Z., AND MILLER, R. C. 2014. Data-driven interaction techniques for improving navigation of educational videos. In *Proceedings of the 27th annual ACM symposium on User interface software and technology*, ACM, 563–572.

KIM, J., NGUYEN, P. T., WEIR, S., GUO, P. J., MILLER, R. C., AND GAJOS, K. Z. 2014. Crowdsourcing step-by-step information extraction to enhance existing how-to videos. In *Proceedings of the 32nd annual ACM conference on Human factors in computing systems*, ACM, 4017–4026.

KNUTH, D. E., AND PLASS, M. F. 1981. Breaking paragraphs into lines. *Software: Practice and Experience 11*, 11, 1119–1184.

KURLANDER, D., SKELLY, T., AND SALESIN, D. 1996. Comic chat. In *Proceedings of the 23rd annual conference on Computer graphics and interactive techniques*, ACM, 225–236.

MONSERRAT, T.-J. K. P., ZHAO, S., MCGEE, K., AND PANDEY, A. V. 2013. Notevideo: Facilitating navigation of blackboard-style lecture videos. In *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems*, ACM, 1139–1148.

MONSERRAT, T.-J. K. P., LI, Y., ZHAO, S., AND CAO, X. 2014. L. ive: an integrated interactive video-based learning environment. In *Proceedings of the 32nd annual ACM conference on Human factors in computing systems*, ACM, 3399–3402.

PAVEL, A., HARTMANN, B., AND AGRAWALA, M. 2014. Video digests: a browsable, skimmable format for informational lecture videos. In *Proceedings of the 27th annual ACM symposium on User interface software and technology*, ACM, 573–582.

RUBIN, S., BERTHOUZOZ, F., MYSORE, G. J., LI, W., AND AGRAWALA, M. 2013. Content-based tools for editing audio stories. In *Proceedings of the 26th annual ACM symposium on User interface software and technology*, ACM, 113–122.

UCHIHASHI, S., FOOTE, J., GIRGENSOHN, A., AND BORECZKY, J. 1999. Video manga: generating semantically meaningful video summaries. In *Proceedings of the seventh ACM international conference on Multimedia (Part 1)*, ACM, 383–392.

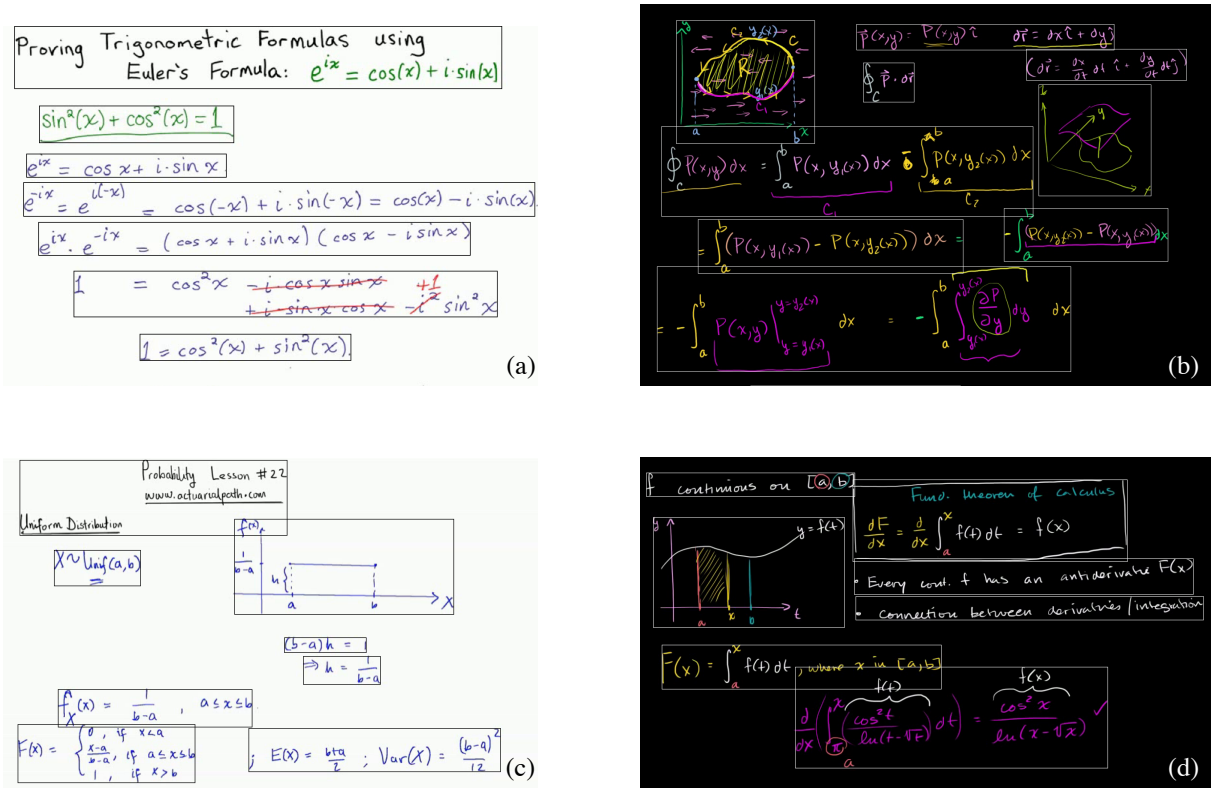


**Figure 3:** *Examples of lines (i.e. set of strokes that belong together semantically) output from our line-breaking algorithm. Our algorithm successfully identifies meaningful groups even from complex layouts with a mix of equations, figures and graphs.*