GENERATION OF SCALABLE SUMMARIES BASED ON ITERATIVE GOP RANKING

ICIP 2008
San Diego, California

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OBJECTIVES

- Develop a scalable representation of the bitstream useful for video summarization.
- Efficient generation of the bitstreams.
- Develop a flexible method able to generate summaries from short summaries (few frames) to medium-large summaries in a gradual manner and with reasonable results.

APPROACH

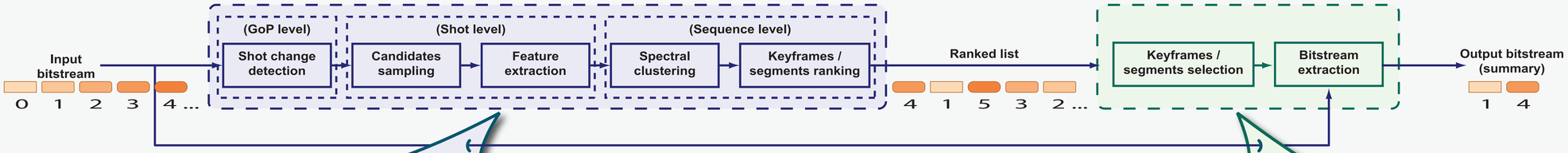
- Analysis and generation are decoupled (lightweight generation using bitstream extraction).
- Two criteria for satisfactory summary:
  - **Semantic coverage:** contains most of the information in the content.
  - **Visual smoothness:** without annoying visual artifacts if possible.
- Use Group of Pictures (GoP) as basic unit for both analysis and generation.
- Method: order GoPs in importance for summarization (iterative ranking).
- Both video skims and storyboards.

Why iterative ranking?

The appropriate summarization technique depends on the target size of the summary:

- Short: mainly semantic ***coverage***.
- Longer: balance both ***coverage*** and ***smoothness***.

We tackle both cases separately, but in a gadual manner. Ranking allows to balance both criteria and adapt them as required. The iterative scheme allows to improve progressively the summary,



ANALYSIS

1. GoP level

- Shot change detection (compressed domain)

2. Shot level

- Rejection of unsuitable GoPs: those belonging to shot changes and very short shots.
- Candidate sampling: for each shot, from 1 to 3 representative keyframes are selected
- Feature extraction of the representative keyframes.

3. Sequence level

- Clustering (spectral) of the representative keyframes into clusters (group similar shots).

After clustering, the sequence is structured in shots and clusters.

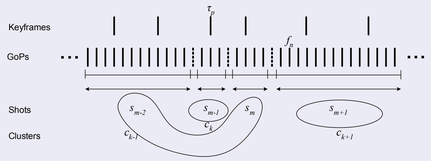
- GoP ranking: ranks the GoPs iteratively trying to find the best GoP that improves previous summary.

GoP ranking

1. Cluster level ranking

- Mark every cluster as unselected
- Compute the score for every unselected cluster

$$score(c_k) = (1-\alpha_{cluster}) \cdot \frac{score_{distance}(c_k)}{\max_j score_{distance}(c_j)} + \alpha_{cluster} \cdot \frac{score_{duration}(c_k)}{\max_j score_{duration}(c_j)}$$



- Select cluster with maximum score, mark as selected and add it to the ranked list (one GoP for storyboards and a segment of GoPs for skims).
- Repeat until all clusters are selected

2. Shot level ranking

- Compute the score for every shot, except those completely selected

$$score(s_m) = (1-\alpha_{shot}) \cdot \frac{score_{dist}(s_m)}{\max_j score_{dist}(s_j)} + \alpha_{shot} \cdot \frac{score_{duration}(s_m)}{\max_j score_{duration}(s_j)}$$

- Select shot with maximum score
  - If the shot was not selected before, add a segment of GoPs to the list.
  - If it was already selected, add a new GoP at its boundary (excerpt growing)
- Repeat until all shots are selected

3. Ranking of discarded GoPs

Begin including the GoPs of discarded shots, and then GoPs with shot changes.

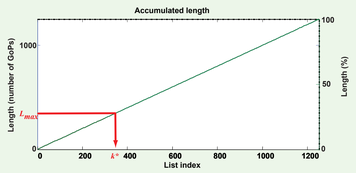
GENERATION

- Keyframe selection

Given a constraint (e.g. length) find the cut-off index k^*

$$k^* = \max k,\ L_{skim}(k) < L_{max},\ 1 \le k \le N$$

Select the first k* GoPs and sort them in coding order.



- Bitstream extraction

Simply keep those packets corresponding to the selected GoPs

- Storyboards: only I frames (slices)
- Video skims: whole GoPs

RESULTS

Example: storyboard.

news12 (from MPEG-7 content set)

H.264/AVC, GoP length = 8 frames

1. Analysis

Keyframes in temporal order (clusters)

Keyframes in ranked order (ranking)

2. Generation

3 keyframes

6 keyframes

10 keyframes

CONCLUSIONS

- Flexible algorithm for both storyboard and skim summaries.
- Formulation of video summarization as excerpt growing (with a novel ranking algorithm).
- Scalable representation ⇒ *"analyze once, generate many"*
- Efficient analysis and generation.