Data-driven methods: Video
Weather Forecasting for Dummies™

Let’s predict weather:
• Given today’s weather only, we want to know tomorrow’s
• Suppose weather can only be {Sunny, Cloudy, Raining}

The “Weather Channel” algorithm:
• Over a long period of time, record:
  – How often S followed by R
  – How often S followed by S
  – Etc.
• Compute percentages for each state:
  – $P(R|S)$, $P(S|S)$, etc.
• Predict the state with highest probability!
• It’s a Markov Chain
Markov Chain

What if we know today and yesterday’s weather?

\[
\begin{pmatrix}
0.3 & 0.6 & 0.1 \\
0.4 & 0.3 & 0.3 \\
0.2 & 0.4 & 0.4
\end{pmatrix}
\]
Text Synthesis

[Shannon,’48] proposed a way to generate English-looking text using N-grams:

• Assume a generalized Markov model
• Use a large text to compute prob. distributions of each letter given N-1 previous letters
• Starting from a seed repeatedly sample this Markov chain to generate new letters
• Also works for whole words

WE NEED TO EAT CAKE
Results (using *alt.singles* corpus):

- “As I've commented before, really relating to someone involves standing next to impossible.”
- “One morning I shot an elephant in my arms and kissed him.”
- “I spent an interesting evening recently with a grain of salt”
Video Textures

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Still photos
Video clips
Video textures
Problem statement

video clip

→

video texture
Our approach

- How do we find good transitions?
Finding good transitions

• Compute $L_2$ distance $D_{i,j}$ between all frames $i$ vs. $j$.

Similar frames make good transitions
Markov chain representation

Similar frames make good transitions
Transition costs

- Transition from $i$ to $j$ if successor of $i$ is similar to $j$

  - Cost function: $C_{i\rightarrow j} = D_{i+1, j}$
Transition probabilities

- Probability for transition $P_{i \rightarrow j}$ inversely related to cost:
  
  $$P_{i \rightarrow j} \sim \exp \left( - \frac{C_{i \rightarrow j}}{\sigma^2} \right)$$

- High $\sigma$ vs low $\sigma$
Preserving dynamics
Preserving dynamics
Preserving dynamics

- Cost for transition $i \rightarrow j$
  - $C_{i \rightarrow j} = \sum_{k = -N}^{N-1} w_k D_{i+k+1, j+k}$
Preserving dynamics – effect

- Cost for transition $i \rightarrow j$
  
  $$C_{i \rightarrow j} = \sum_{k = -N}^{N-1} w_k D_{i+k+1, j+k}$$
Dead ends

• No good transition at the end of sequence
Future cost

- Propagate future transition costs backward
- Iteratively compute new cost

\[ F_{i \rightarrow j} = C_{i \rightarrow j} + \alpha \min_k F_{j \rightarrow k} \]
Future cost

- Propagate future transition costs backward
- Iteratively compute new cost

\[ F_{i\rightarrow j} = C_{i\rightarrow j} + \alpha \min_k F_{j\rightarrow k} \]
Future cost

- Propagate future transition costs backward
- Iteratively compute new cost

\[ F_{i \rightarrow j} = C_{i \rightarrow j} + \alpha \min_k F_{j \rightarrow k} \]
Future cost

- Propagate future transition costs backward
- Iteratively compute new cost

\[ F_{i \rightarrow j} = C_{i \rightarrow j} + \alpha \min_k F_{j \rightarrow k} \]
Future cost

- Propagate future transition costs backward
- Iteratively compute new cost
  - \( F_{i\rightarrow j} = C_{i\rightarrow j} + \alpha \min_k F_{j\rightarrow k} \)
- Q-learning
Future cost – effect
Finding good loops

- Alternative to random transitions
- Precompute set of loops up front
Visual discontinuities

• Problem: Visible “Jumps”
Crossfading

• Solution: Crossfade from one sequence to the other.
Morphing

• Interpolation task:

\[
\frac{2}{5} \quad \boxed{A} \quad + \quad \frac{2}{5} \quad \boxed{B} \quad + \quad \frac{1}{5} \quad \boxed{C}
\]
Morphing

• Interpolation task:
  \[ \frac{2}{5} \text{A} + \frac{2}{5} \text{B} + \frac{1}{5} \text{C} \]

• Compute correspondence between pixels of all frames
Morphing

- Interpolation task:
  \[ \frac{2}{5} \text{A} + \frac{2}{5} \text{B} + \frac{1}{5} \text{C} \]

- Compute correspondence between pixels of all frames
- Interpolate pixel position and color in morphed frame
- based on [Shum 2000]
Results – crossfading/morphing
Results – crossfading/morphing

Jump Cut       Crossfade       Morph
Frequent jump & crossfading
Video portrait

- Useful for web pages
Video portrait – 3D

- Combine with IBR techniques
Region-based analysis

- Divide video up into regions

- Generate a video texture for each region
Automatic region analysis
User-controlled video textures

User selects target frame range
Video-based animation

• Like sprites computer games
• Extract sprites from real video
• Interactively control desired motion

©1985 Nintendo of America Inc.
Video sprite extraction

blue screen matting
and velocity estimation
Video sprite control

- Augmented transition cost:

\[ C_{i \rightarrow j} = \alpha C_{i \rightarrow j} + \beta \text{ angle} \]

Animation

Similarity term \hspace{2cm} Control term

vector to mouse pointer

velocity vector
Video sprite control

• Need future cost computation
• Precompute future costs for a few angles.
• Switch between precomputed angles according to user input
• [GIT-GVU-00-11]
Interactive fish
Summary

- Video clips → video textures
  - define Markov process
  - preserve dynamics
  - avoid dead-ends
  - disguise visual discontinuities
Discussion

- Some things are relatively easy
Discussion

- Some are hard
A final example
Michel Gondry train video

http://youtube.com/watch?v=qUEs1BwVXGA