Temporal Sampling and Interpolation

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http://scanline.ca/deinterlacing/

Software

- **tvtime**: A realtime video deinterlacer.
  http://tvtime.sourceforge.net/

- **movietime**: A DVD deinterlacer.
  http://www.sourceforge.net/projects/movietime/

- **reetpvr**: An off-line 2-3 pulldown inverter.
  http://www.sourceforge.net/projects/reetpvr/

Overview

- Motion and the eye
- Film
- Video
- Converting film to video
- Converting video to progressive
- Problems, problems, problems

Motion and the eye

- In 1824, Peter Mark Roget wrote "Persistance of Vision with Regard to Moving Objects", used a rotating device with vertical slits to make still images appear as if they are in motion.

- Sparked alot of inventions, including the **Thaumascope**, a card with a picture on each side. If rotated fast enough, the two pictures merged into one.

- Eventually lead to film: early silent films used anything between 16 and 24 frames per second.

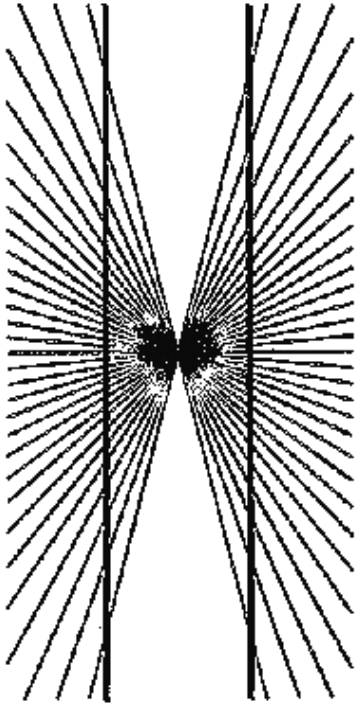
Motion and the eye: Observations

- Stroboscopic motion: still frames shown fast enough appear as motion
- Filter effects of the eye: The **Thaumascope** uses the "motion blur" effects of the eye: persistance can cause images shown rapidly in sequence to appear as one.
- Dithering is an example of how the eye acts as a low pass filter.
- Temporal aliasing: Spinning wheels that appear still or go backwards

Edges and perception

- The eye is sensitive to sharp changes in contrast.
- As well, the brain is able to use edge information
- Edges contain much of the information in the scene.

Some cool eye tricks related to edges, perception, and contrast sensitivity



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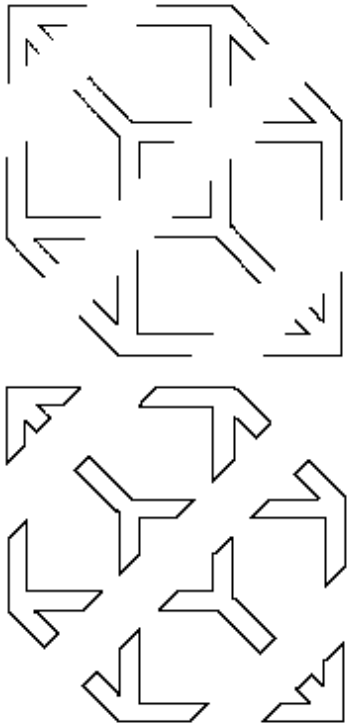

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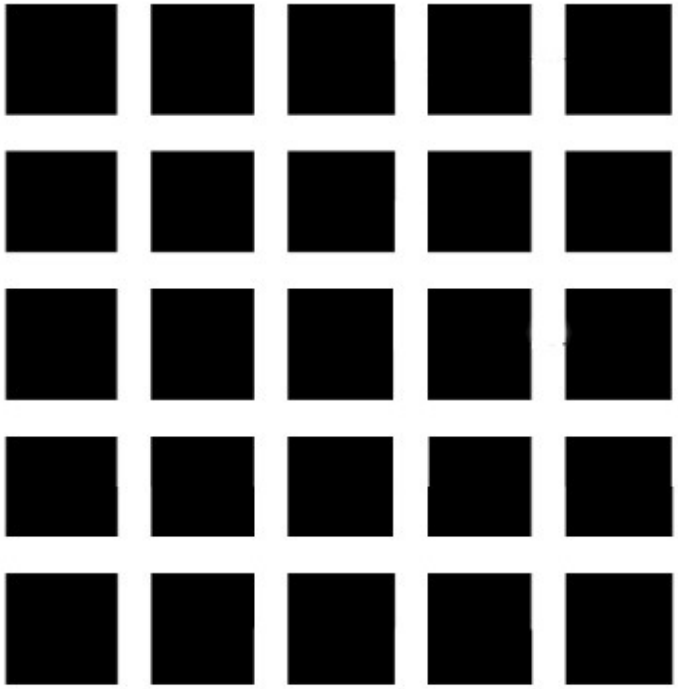


More eye stuff: Flicker

- The eye is sensitive to high frequencies, despite the blurring effect, and more sensitive in the peripheral vision.
- Most computers complain about flicker if their monitor is at 60hz or lower.
- Most TV viewers don't mind: TV is brighter than a monitor, and further away.

How many frames per second

- From 100fps.com:

  How many frames per second can the human eye see?
  is NOT the same as: *How many frames per second do I have to have to make motions look fluid?*
  And it's not the same as: *How many frames per second makes the movie stop flickering?*
  And it's not the same as: *What is the shortest frame a human eye would notice?*

Frameless rendering

- Neat idea: Importance sample in time.
- Zagier 97, Bergman et al 86, some others
- Idea is that updating individual pixels can also achieve high quality animation.
- Poynton shows some arguments against this (Poynton97): doesn't work for standards conversion, and leads to spacial inconsistencies that are noticable. (edges over filtering)

Film

- Film is shot at 24 frames per second.
- Film aperature times are usually high enough that you get some gratuituous motion blur.
- 'Refresh rate' in a theatre is 48hz, each frame is shown twice, not usually noticable strobing.
- Slow enough that pans can be stuttery.

Video

- Video uses the blurring effects of the eye to compress video: **interlaced video**.
- Idea: Like the **Thaumascope**, rapidly switching between two low quality images to appear like a single high quality image.
- Interlaced video is a sequence of fields instead of frames.
- Each field is half of the scanlines of a full image: even and odd fields.

Video

Video standards

- North america is "NTSC style": Frames are 486 scanlines tall (each field is 243 scanlines), 59.94 fields per second.
- Most other places are "PAL style": Frames are 576 scanlines tall (each field is 288 scanlines), 50 fields per second.
- People say that PAL TVs flicker horridly.

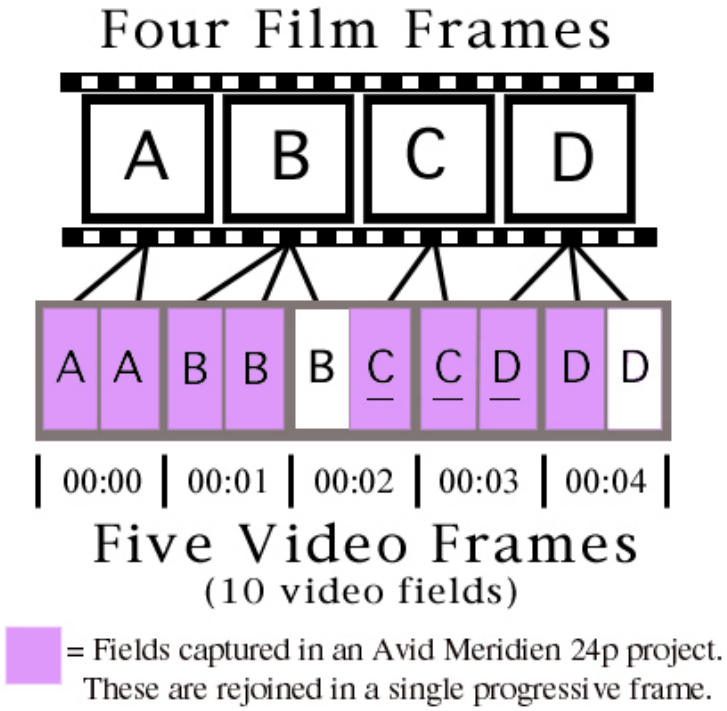
Converting film to video

- Process is called **pulldown**.
- Easier case: 24fps film to 50fps PAL, known as **2-2 pulldown**.
- Film is sped up to 25fps, each frame is shown for two fields.

Converting film to video

- Harder case: 24fps film to 59.94fps NTSC, known as **3-2 pulldown**.
- 24 and 59.94 don't divide nicely, 24 and 60 are better.
- Pretend video is 60fps, show film as frames in a 2-3-2-3 pattern.
- Slow film down to 23.976fps and do this to get 59.94fps.

Pulldown


Four Film Frames
A
B
C
D
A A B B B C C D D D
00:00
00:01
00:02
00:03
00:04
Five Video Frames
(10 video fields)
= Fields captured in an Avid Meridien 24p project.
These are rejoined in a single progressive frame.

Converting film to video

- Other forms of pulldown used on older silent films (Metropolis).

Frame-based movies on a computer monitor

- Problem: computer monitors run at 60hz or 72hz or 85hz or whatever, have to design a more general algorithm.
- First solution: pulldown. Show frames multiple times, try and amortize.
- Some problems with 10ms scheduling: (3223233 instead of 232323).

Deinterlacing

- Deinterlacing is the process of converting fields to full frames.
- First method: Use linear interpolation for the 'missing' scanlines. This effectively emulates a television.

Temporal aliasing

- We're point sampling at a higher rate, should have no problems.
- First problem: Interlaced video. Uses the dithering effects of the eye.
- Without an even amortization, the effect is lost.
- Video fades between seeing more of the top fields/more of the bottom fields, looks like text is 'bouncing'.

Solutions for temporal aliasing

- First solution: Run at 59.94hz exactly, or 119.88hz. Requires triple buffering.

- Next solution: Try and make frames 'look complete', so if we favour top or bottom, we don't notice.

Motion detection in tvtime

- Compare pixel in next and previous fields to ones above and below, try and decide if there is motion.
- Motion? Interpolate pixel, No change? Copy pixel.
- Lots of artifacts, never perfect.
- Tom Barry: Motion compensation code, use pixel search to detect motion.

Reasons to deinterlace

- Display.
- Lower rate. Many computers can't deal with 60fps video. Better to drop to 30fps, and the easy way to do this is to deinterlace every second field.
- Encoding. Want to store a high quality but low bitrate version. Most encoders can only handle full frames, not keep fields distinct.

Film to Video to Computer

- These motion methods aren't optimal for film material. It would be better to detect pulldown, and construct the appropriate full frames.

My pulldown detection method

top	bot
-	-
diff	SAME
diff	diff
SAME	diff
diff	diff
diff	diff

Richard Felker's pulldown detection method

- Use blocks, look at four fields.
- Find block of largest difference, use that to make all decisions.

Problem cases: Mixed video and film content

- What to do if part of the frame is film and the rest is video?
- What to do if the video contains parts film, parts video, or crossfades between them?
- Problems: Many modern animated shows, documentaries about movies, or shows that composite logos.

Problem cases: Mixed video and film content

Problem cases: Film content edited as video

- Many, many shows go after the 'film look' by recording as film, but editing as video.
- Leads to pulldown that 'breaks' every scene change.
- Examples: Malcolm in the Middle, Buffy, Power Rangers, ...

More problem cases

- **single pixel lines**, intentional flicker, other hacks.
- 72hz or 59.94hz ?
- Low bitrate encoding, high quality encoding.
- Broadcast TV stations that speed-up shows.
- Standards converters that use linear interpolation.

More on this

- irc.freenode.net on #livid
- http://scanline.ca/deinterlacing/