#### High Quality Deinterlacing Using Inpainting and Shutter-Model Directed Temporal Interpolation

by

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#### **Overview**

Description of a High Quality (HQ) de-interlacing process.

Main application : Tape to film blow-up

#### **Applied research :**

 Chaining and Adaptation of well known methods (inpainting, motion estimation, warp filters)

#### Contents of the talk :

- Film and video image capture, an overview
- What is de-interlacing
- Process description
- Results, Conclusion, Future Works

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 $0.670 \times 10^{-3}$ 



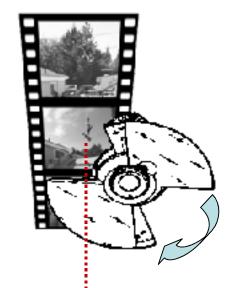
#### **Overview : film camera exposition**

## Image capture is progressive for film cameras

- Exposition is full frame
- A rotating shutter covers the film during transport and uncover the film during exposure time
- Variable exposure = variable angle for the open sector
- if motion ⇒ motion blur (integration over time)

ARRI 35mm





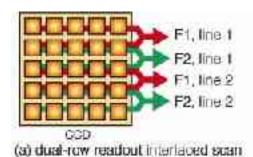
Optical axis

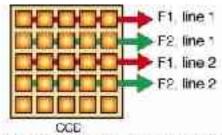
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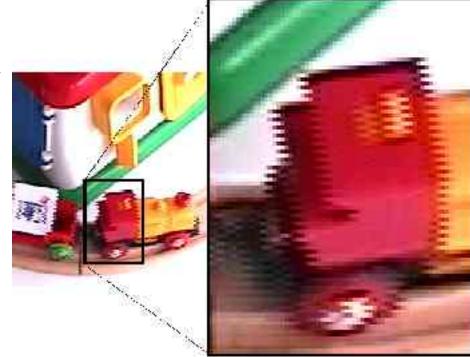
#### **Overview : video camera integration**

- Video (PAL/SECAM, NTSC) is interlaced
- For most of the CCD arrays used, image integration is interlaced
- Integration time is short
- If motion :
  - the playback is smooth, because rendering device (TV set) is also interlaced
  - But if looking at a still image, the "comb" effect become visible





(b) single-row readout interlaced scan



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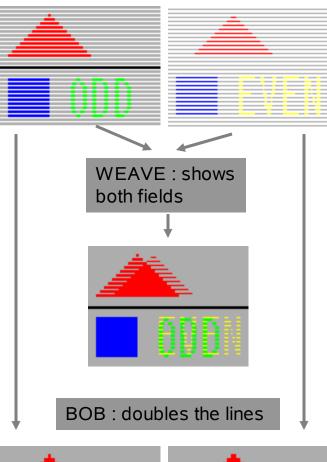
#### **De-interlacing**

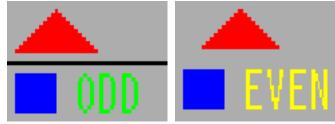


- BOB / WEAVE
- Motion adaptive deinterlacing : switch between BOB and Weave according to motion

#### Other approaches use :

- Fourier analysis
- T-shaped spatio-temporal filters





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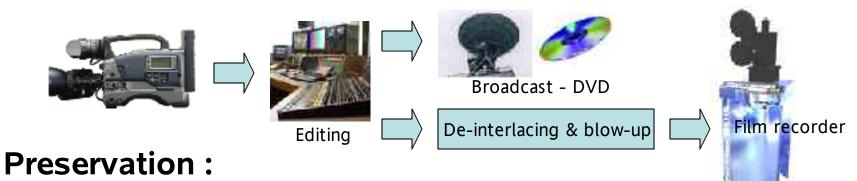
### HQ de-interlacing : Why ?

### D-cinema rush (digital from camera to projection) :

 few theatres are equipped - in which countries ?. What is the standard ? (16mm and 35mm reels are standard worldwide)

### Producing on video is inexpensive :

- for low budget feature films, documentaries, commercials,...
- but film distribution goes trough the (35mm equipped) film theatres



- Polyester film is very stable (estimated > 500 years)
- while digital media is evanescent (remember, the 5<sup>1/4</sup> floppies, used only a decade ago, with 720 Ko data on it)

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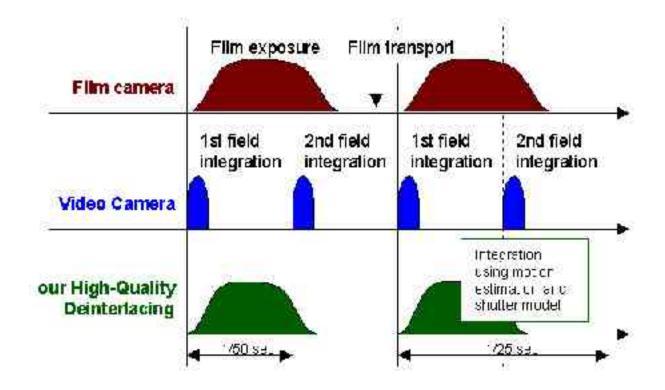
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#### **Our challenge**

# Achieve high quality de-interlacing for both moving and steady shots

- Simulate the progressive integration 
   create motion blur
- Maintain image quality even if resized to higher resolution

#### We have to estimate the motion between fields



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#### HQ de-interlacing : 1st step

#### Create an accurate "full frame" from a single field

 It's a spatial interpolation, but : These frames will be used for motion estimation (H&S method), so the edges should be well recovered

## Inpainting : PDE regularization of tensor images

 Each point of the image is an smoothed structure tensor : holds information about the local image structure (isophote direction)

 $\begin{aligned} G_{\sigma} &= G * \text{Causs}(\sigma) \quad \text{where} \quad \forall x, y \in [w, h], \qquad G(x, y) = \sum_{i=1}^{n} \nabla U_i \ \nabla U_i^T \\ & \cup : [w, h] \neq [0, 255]^3 \text{ (color image)} \end{aligned}$ 

 Filling the blank lines : average each set of two lines in the direction of the estimated color isophotes



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Check previous work of David Tschumperlé for more information

#### HQ de-interlacing : 2nd step

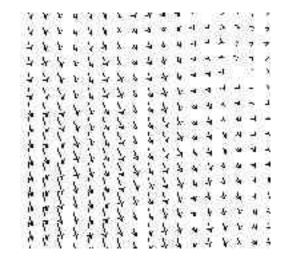
#### A motion estimation is needed :

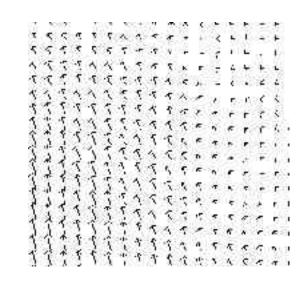
- for temporal decimation from 50 interpolated frames/sec to 25 frames/sec
- and for a temporal integration scheme

#### Well-known Horn & Schunck method

#### Forward and backward motion fields are computed

- forward motion (odd to even), backward motion (even to odd)
- not exactly opposed vector fields : occlusions, noise.





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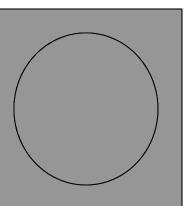
 $\sim 0.07 M_{\odot}$ 

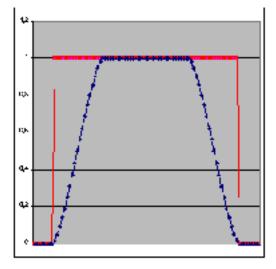
#### Integration to produce the output images

 $I_{desinterlaced}(x,y) = \int_{t=0}^{\frac{1}{2}} S(t) I'_{odd}(x - tm_f(x,y)_x, y - tm_f(x,y)_y) dt$ 

$$+\int_{t=\frac{1}{2}}^{t}S(1-t)I_{even}(x-tm_{b}(x,y)_{x},y-tm_{b}(x,y)_{y}) dt$$

 S(t) represents what we call the shutter characteristic function : surface uncovered and covered by the rotating shutter.





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#### HQ de-interlacing : last step

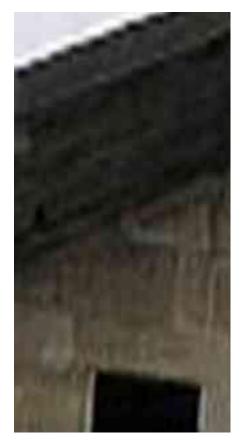
#### Resizing

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- Video resolution : 720 X 576
- Image recorder : 2K (2048 X 1536) or 4K (4096 X 3072)
- HDTV (1920 X 1080)

#### Edge enhancement : traditional high-pass methods raise noise...

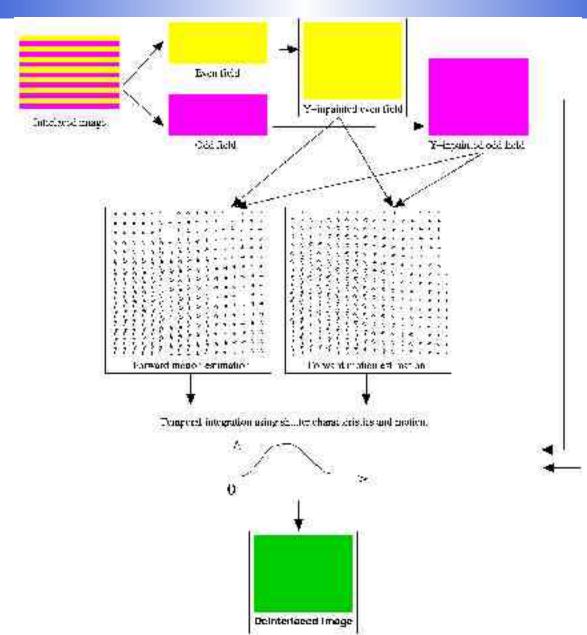
- Warp filter : moving information according to image gradient.
- Related to tensor images and regularisation



From video to 2K : bilinear interpolation

From video to 2K : our de-interlacing scheme + warp filter

#### **Overall workflow**



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a possible.

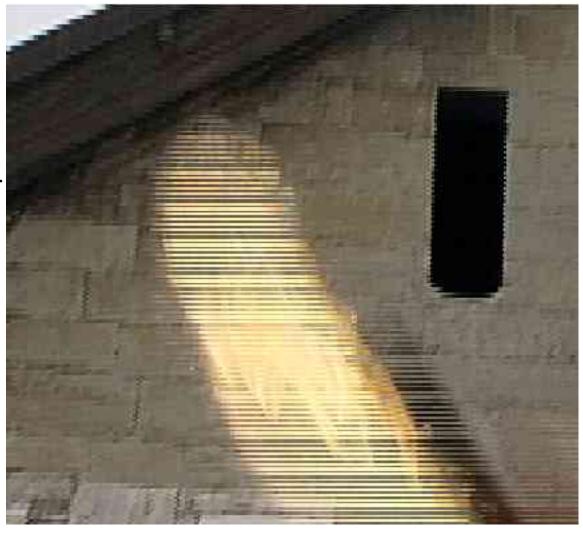


#### **Results**



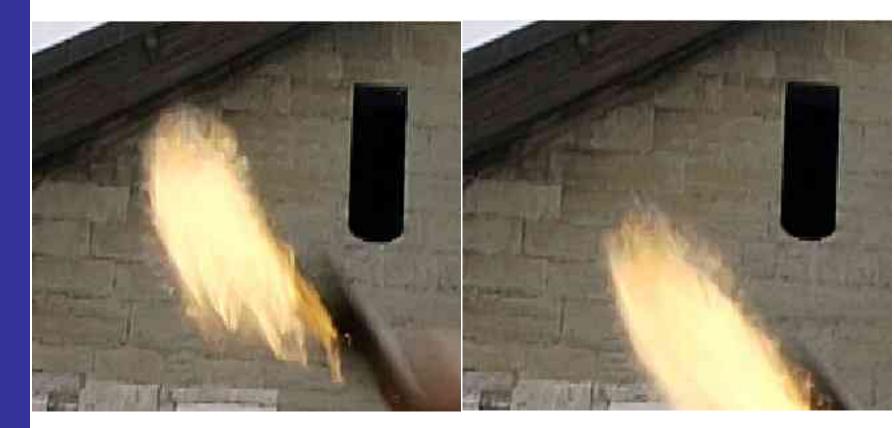
The torch juggler...

Interlaced original image









Odd field

Even field



## Forward motion vectors

## Backward motion vectors

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「ちちゃ・それはなるのでのがなりましたとしょうかんたかがかったりとしゃやからりというになったが、 (人)((なん))」 (1555)
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· "你你们,我们我们就是这些事情,你们就是我们就能能能能够没有这些事情,我们就是这些,你们们们们们们的,你们就是这些我们的,我们就是不是你们的,你们们不能能能能
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- 「ア・・・・・・」「アメッション」」」」「「「」」を発展したものできません。そう、「「」」」」「「」」」」「「」」」」」」」」」」」」」」」」」」」」」」」
「「キャー・チャール・・・・」「「」」ことであるためがなかないなどものなどです。 「「「」」として「「「」」こここではなくならなくなられていた」をうたせいか。
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**Results** 

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#### Deinterlaced image

De-interlaced image after warp filter (no resizing)

#### **Conclusion / Future works**

#### Very good results

## Slow, requires a lot of computational power

- Fortunately, image recorder are also slow (several seconds / image)
- Improvement in speed and user feedback while adjusting parameters

#### **Future works**

Complete retiming (from 25 to 24 frames/sec)

Thank you for your attention

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