Stereoscopic 3D video monitoring and correction: from lab to air

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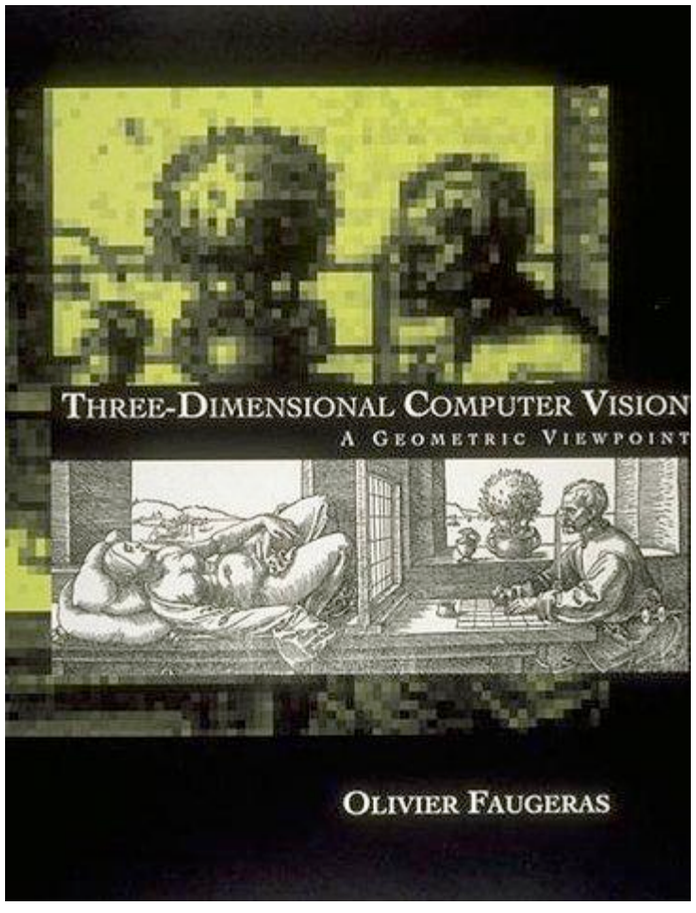
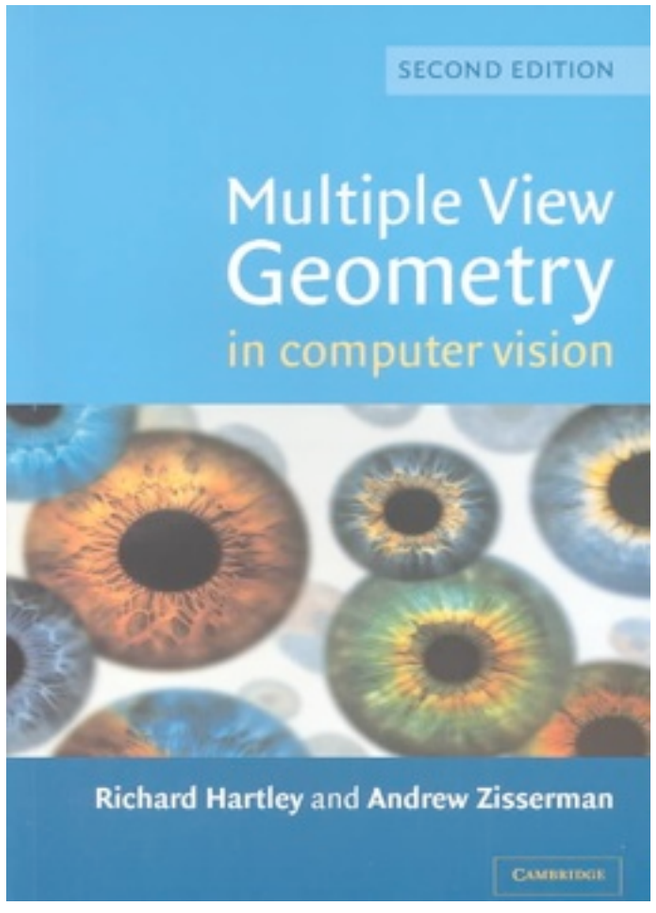
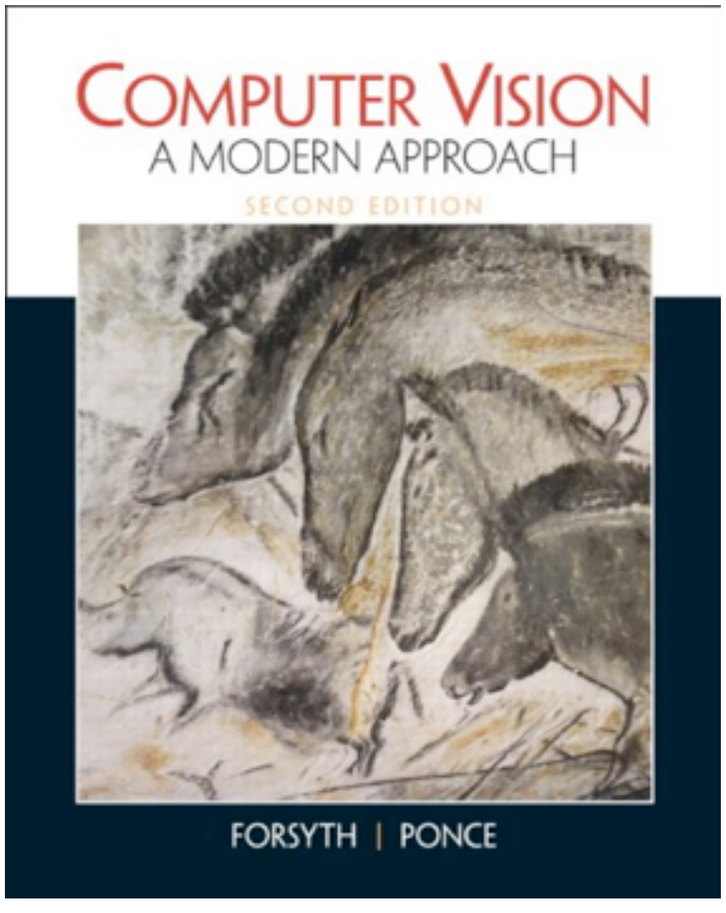
Can computer vision help making better 3D movies?

- Live correction of geometric and photometric asymmetries
  - eliminate vertical disparities (rectification)
  - left-right color balance
- Live monitoring of stereoscopic footage quality
  - detect high/low horizontal disparities
  - detect lens mismatch (focus/zoom)

In 2005, the problem was already solved





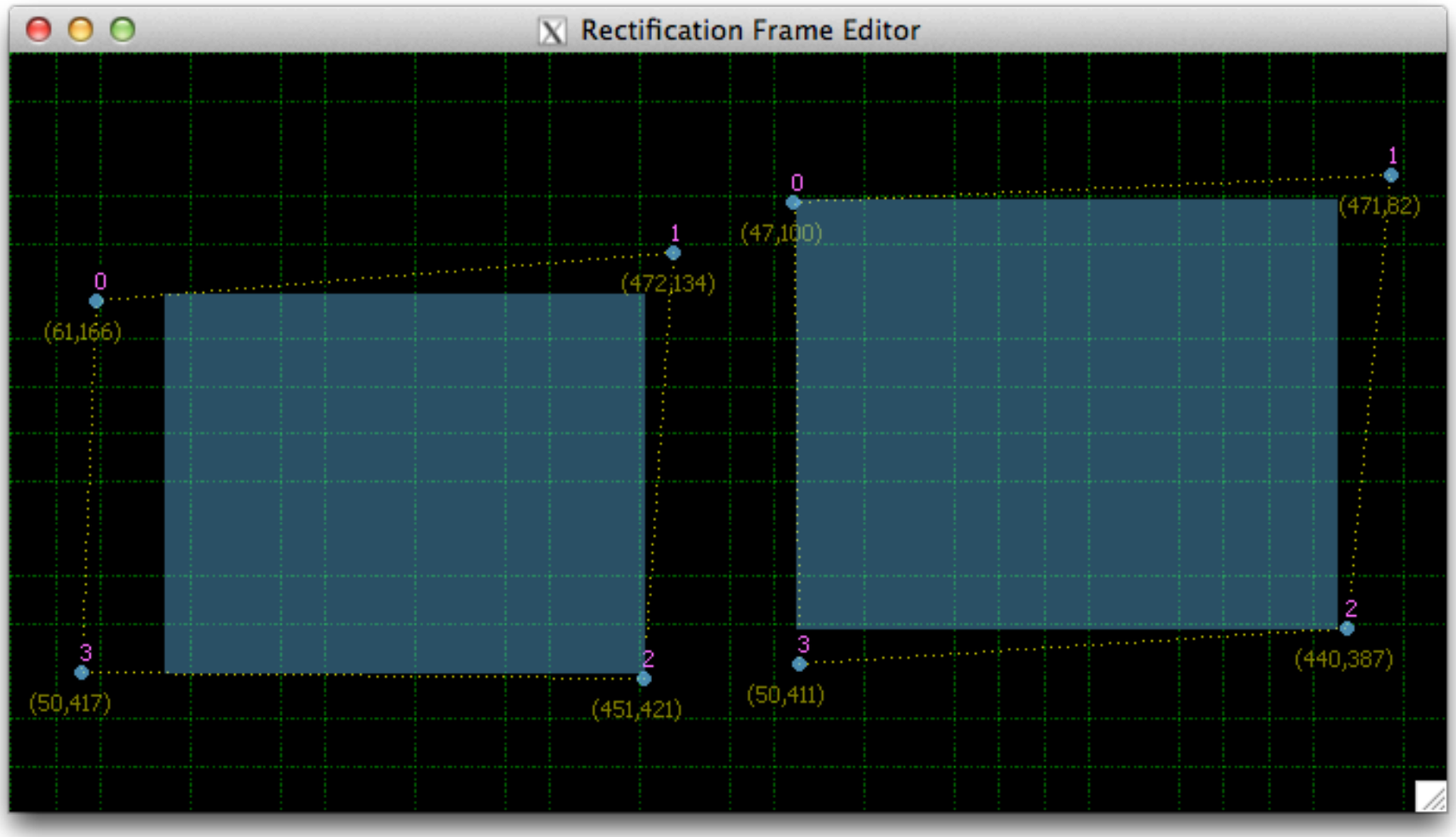


... really? How do you rectify a 3D movie?

Rectification must not change the movie

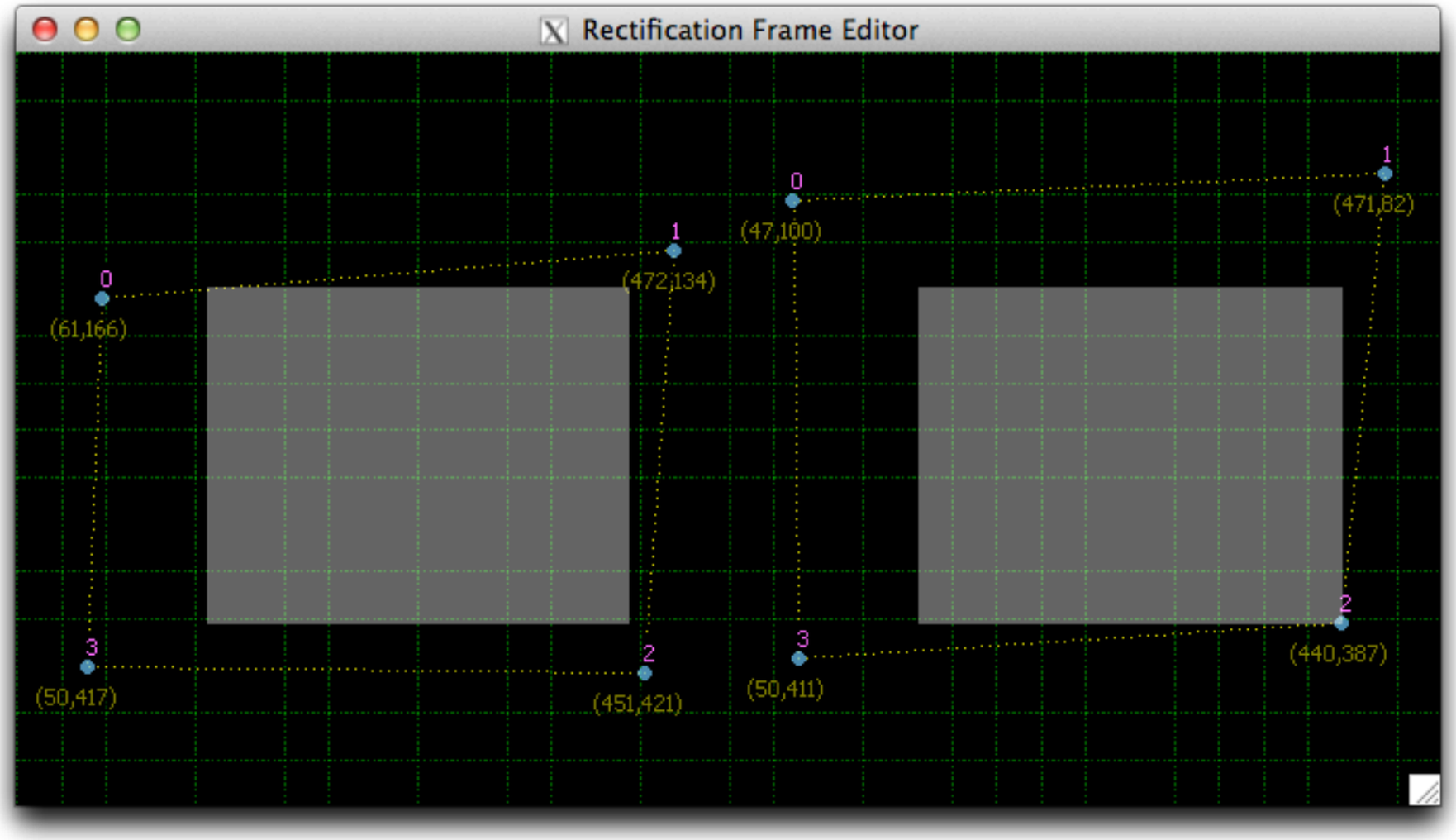
- As simple as applying a pair of homographies, but...
- The aspect ratio should not be affected
- No black borders, so images have to be cropped, but please not too much!
- The stereoscopic parameters (interocular & vergence) must remain unchanged

Given rectifications, largest fixed aspect ratio pair of rectangles? (1)



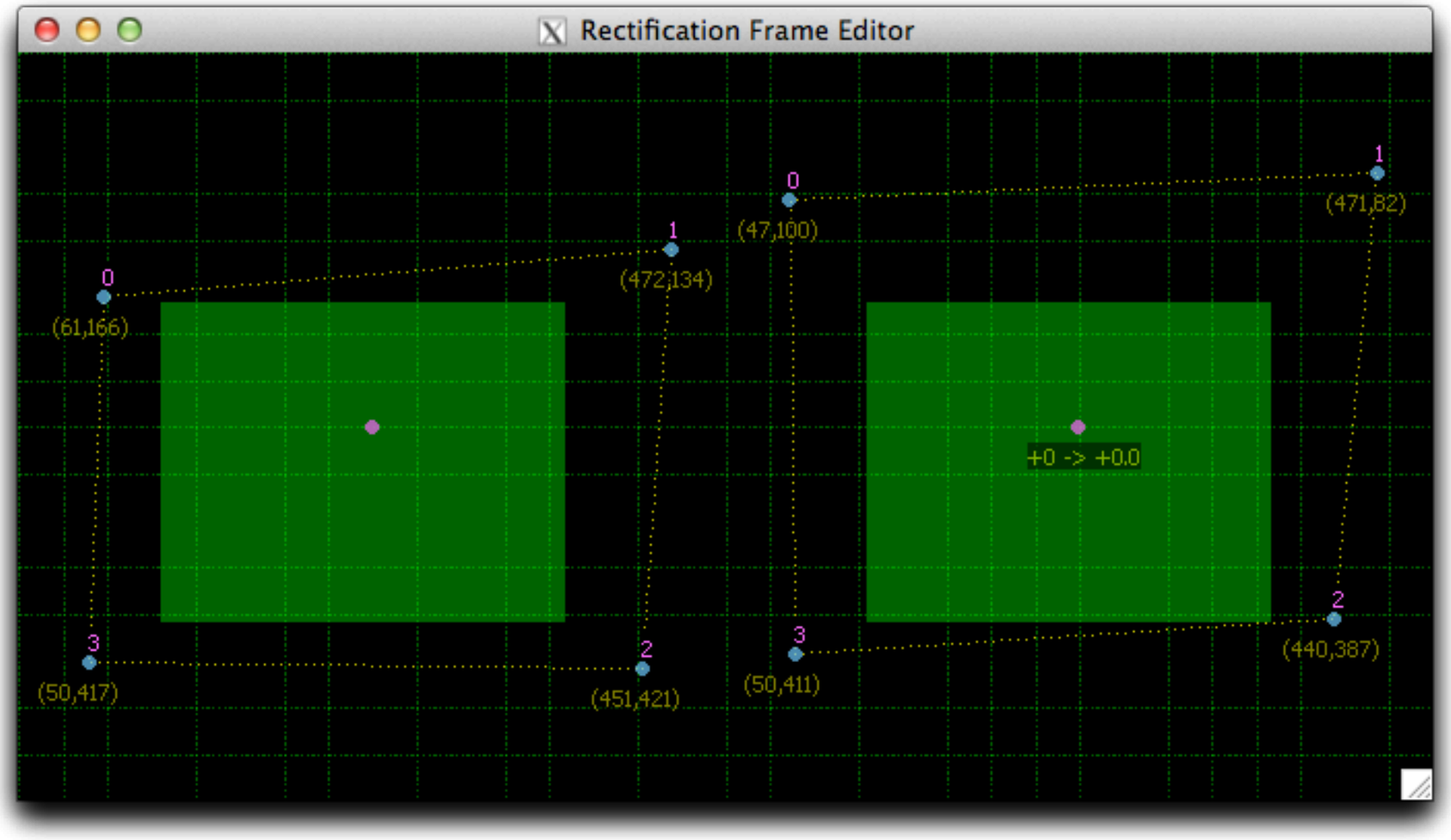
Solved by linear programming, but not a rectification, and vergence is modified

Given rectifications, largest fixed aspect ratio pair of rectangles? (2)



Solved by *linear programming*, vergence can be fixed, but unstable: may jump between close solutions (because of LP)

Given rectifications, largest fixed aspect ratio pair of rectangles? (3)



Given disparity at a fixed pointd, now a *scalar max* problem: much more stable though it crops more

What about other parts?

- Feature detection has to be multiscale because of reduced depth-of-field: upright SURF is OK
- Fundamental matrix by PROSAC (using detector's response for ranking) + LO-RANSAC (finds larger consensus sets by local optimization)
- Aspect-ratio-preserving rectification by nonlinear optimization using inliers of the F-matrix
- Rectifications fed into several parallel Kalman filters to capture fast changes
- Reframing is done last

2008: DisparityTagger

- A monitoring tool for 3D movie making, by Binocle (France)
- Captures two HD-SDI video streams, displays alerts (out-of-range features) and rectified images
- All the algorithms ran on thousands on images (sometimes unwanted...), many bugs were fixed
- But HD images cannot be processed at video rate, and no HD-SDI output
- Algorithms were here, but there was still room for improvements!

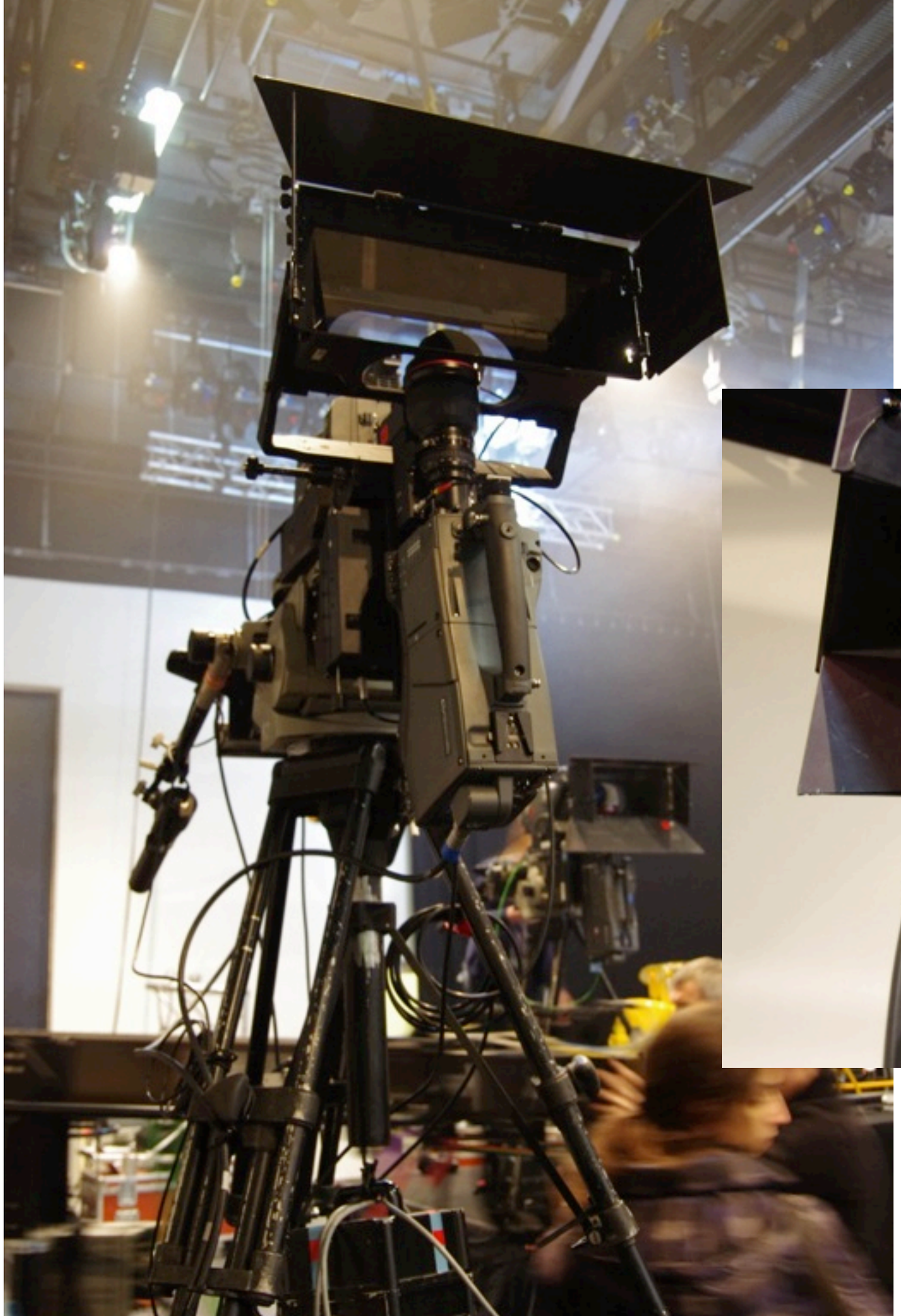
2009-2012: 3DLive

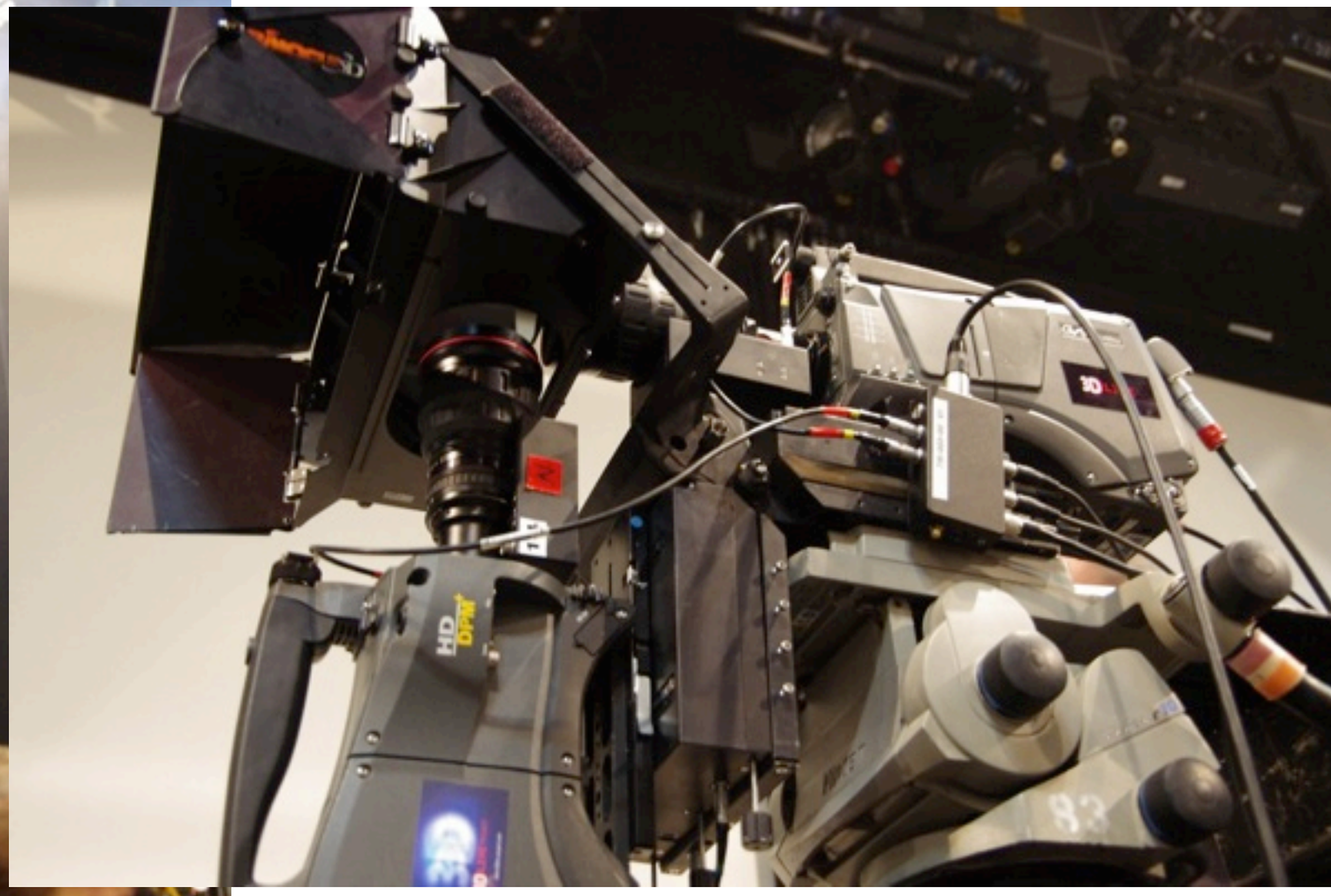
- French government-funded consortium:
  8 partners, industrial & academic
- Objective: Develop tools and know-how for the production and broadcasting of live 3D events
- Validate the technology on live 3D broadcasts: sports (2 events) and performing arts (3 events)
- Experiment! (resulting 3D sequences are being submitted to MPEG)

How DisparityTagger became a correction tool

- 100% GPU (OpenGL + CUDA) image pipeline, using NVIDIA Quadro DVP
- Upright SURF ported to CUDA to avoid transfering the images to RAM (only transfer matched features without descriptors)
- New issues appeared (color restitution, deinterlacing/reinterlacing, output delay, physical integration in the OB van)

Stereo rigs (by Binocle)






DISPATCH

First corrected live 3D broadcast: 2010 (Balé de rua, in Lyon)

In the OB van: the master console

... and the DisparityTaggers

Tuning the rig parameters with the DisparityTagger

Live demo!

Fruits of the experience for a research lab

- *Artists*, *industrials* and *scientists* working hand in hand
- Full technology transfer (not just proof-of concept) requires a lot of work
- Making the algorithms robust requires in-depth knowledge: the researchers must be involved
- Not very helpful in terms of H-index, but really worth it, for the thrill of seing it run live!

Thank you!

Further information and publications :

- http://devernay.free.fr/vision/3dcine/
- http://3dlive-project.com/