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# Automatic 3DTV Quality Assessment Based On Depth Perception Analysis



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**Nantes, 30th October 2013**

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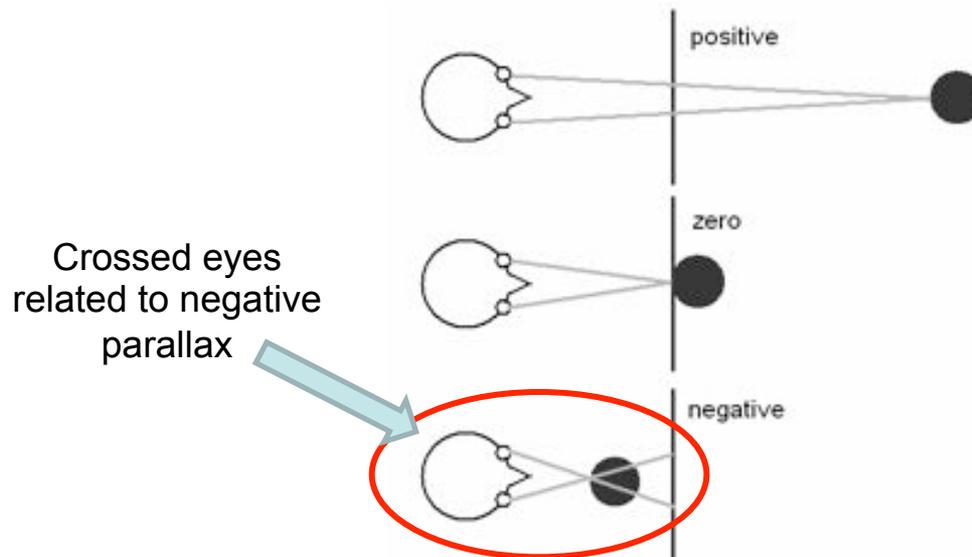
- Introduction
- Environment: Parallax and Visual Discomfort
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# Introduction

- The success of new 3D services is a reality due to the improvement in technology, but visual comfort analysis is demanded.
- Although there are some impact factors and initial measurement methods in this field, there is still no common way and procedure to compare 3D video content and integrated solutions and obtain an evaluation of quality.
- In natural viewing, the eyes focus (accommodate) and converge to the same distance, but when looking at a 3D object displayed on a screen, a viewer's eyes must focus on the screen while vergence is determined by disparity. This effect generates **vergence-acommodation conflict**

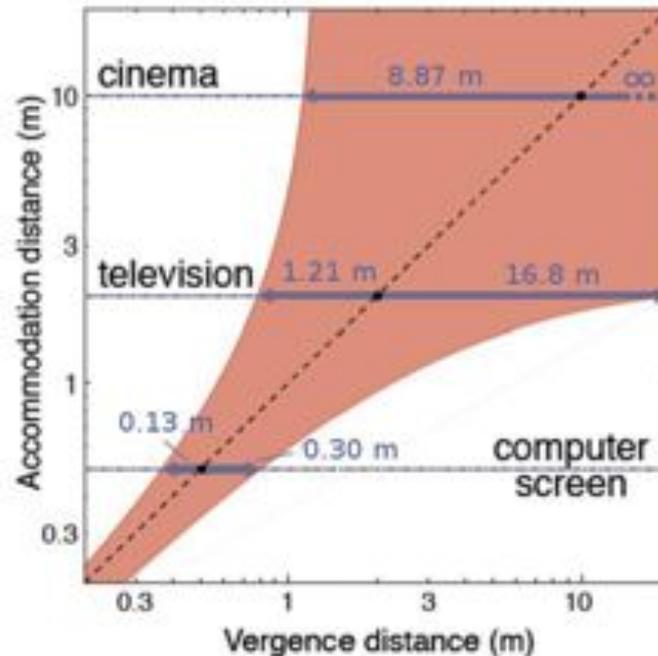
# Parallax and visual discomfort

- Parallax created by disparity is determined by the virtual perceived location of the objects in a scene.
- Negative parallax cross the eyes generating the highest vergence-acommodation conflict, basis of our studies, because it is one of the main reasons of **visual discomfort**.



# Zone of Comfort (ZoC)

- The Zone of Comfort (ZoC) was first introduced by Percival. He suggested the limits to vergence-accommodation postures that could be achieved without causing discomfort.



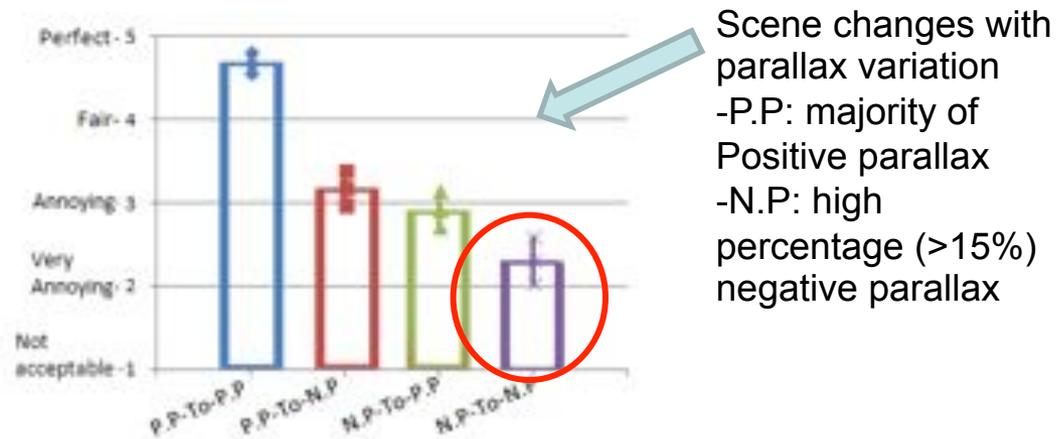
# Subjective assessment

- Tests have been run over a set of 3D video sequences to understand and analyze different features which generate visual discomfort or quality reduction.
- Results were compared to the objective data obtained through our developed tools to decide which features would be a possible cause of visual discomfort and how to modify them to obtain good 3D experiences



# Subjective assessment developed (I)

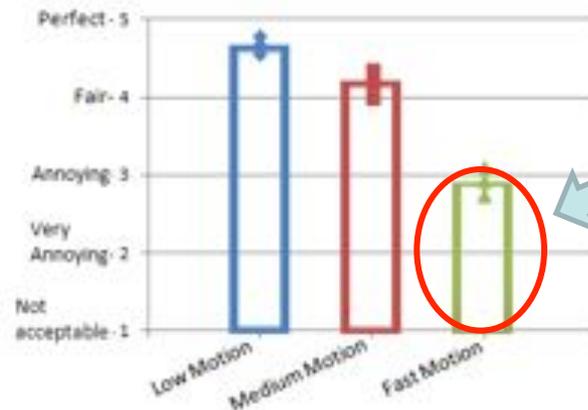
- Different experiments were developed in subjective tests:
  - Pairs of sequences with transitions from **different types of parallax**, negative and positive



- Users manifest visual discomfort when changes occur on a negative parallax environment, rather than in positive.

# Subjective assessment developed (II)

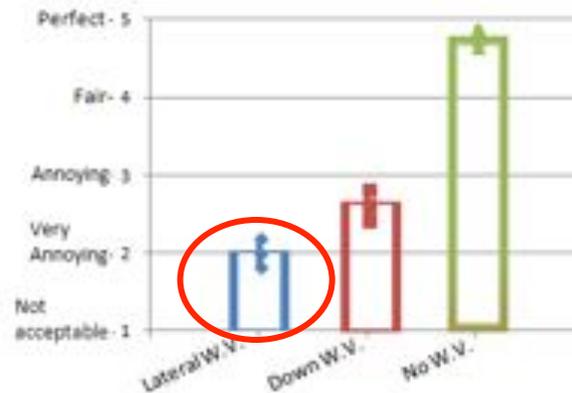
- Negative parallax sequence with different levels of motion: low, medium and high.
  - If motion is not significantly fast, users do not manifest visual discomfort, and the attractive experience related to negative parallax is considered.



Only fast motion in negative parallax environment generates discomfort.

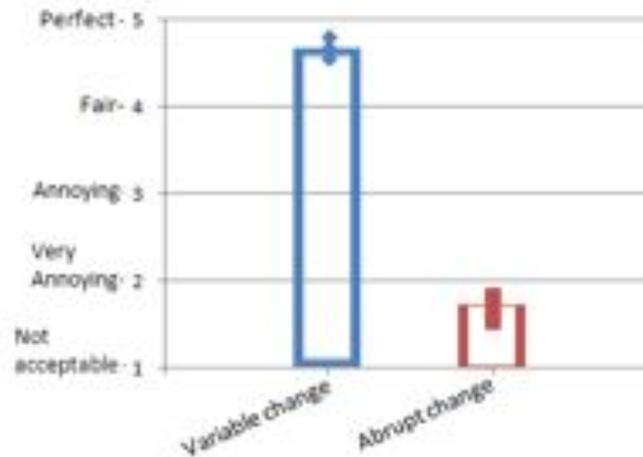
# Subjective assessment developed (III)

- Sequences with window violation (W.V) produced in different edges of the image, lateral or top/bottom regions:
  - Lateral window violations are more annoying than down (bottom) violation.



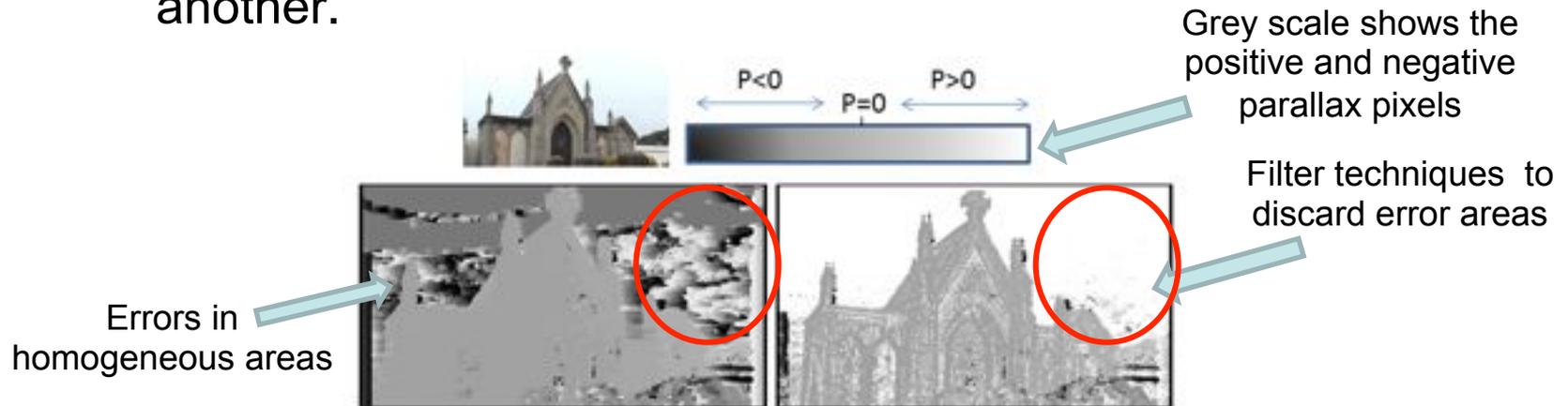
# Subjective assessment developed (IV)

- Long sequence with soft variation of parallax, at the end the sequence starts from the beginning producing an abrupt parallax change.
  - Users do not perceive the variance produced in parallax until the abrupt change occurs at the end, revealing a very annoying experience to most observers.



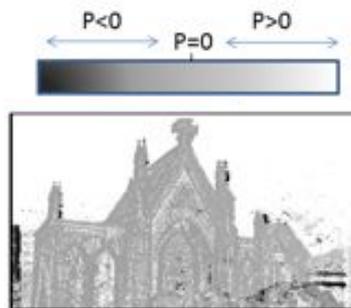
# Depth map and histogram (I)

- SAD algorithms were used to develop detection of stereoscopic parallax between left and right views.
- Errors occur in homogeneous zones:
  - For alleviating these probable errors, the system creates a difference between both views in order to calculate depths only over those pixels that will differ from one image to another.

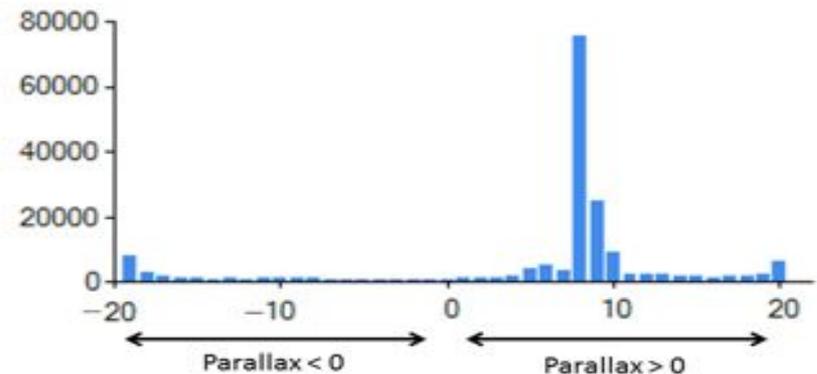


# Depth map and histogram (II)

- Through the SAD diagram, the histogram of parallax (both positive and negative areas) will be obtained.
- Analyzing behaviour and parallax trends through histograms of frames.
- First in static images, with motion in video sequences



SAD diagram with parallax in grey scale



Histogram Parallax

# Parallax histogram analysis in static images (I)

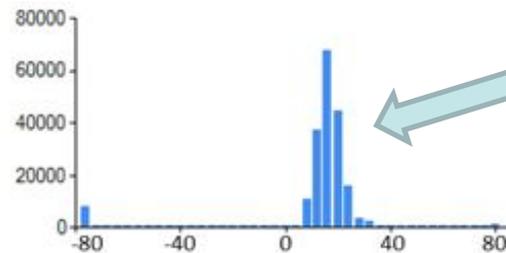
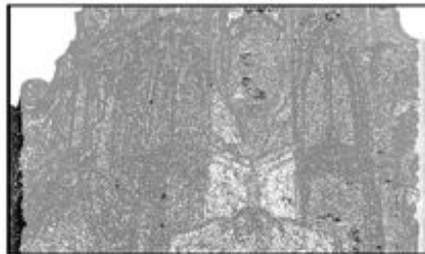
- Derived from the parallax histogram, the table with percentage of positive and negative parallax is generated to develop algorithms.
- Results from different frames are shown in next table.

Image	Name	Positive Variance (pix)	Negative Variance (pix)
1	Church	10%	-
2	Cemetery	19,6%	-
3	Library	12,8%	23,2%
4	Table	15,6%	16,4%

# Parallax histogram analysis in static images (II)

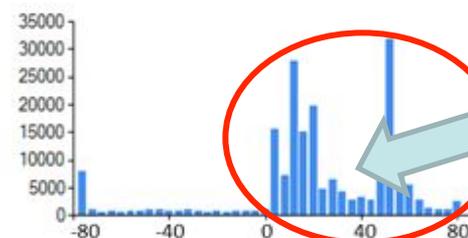
- The 3D perception between the “Church” and the “Cemetery” scenes: observers usually prefer the second image because there’s a wider range of depth. This is statistically measured as a bigger positive parallax variance.

Church



Only positive parallax

Cemetery

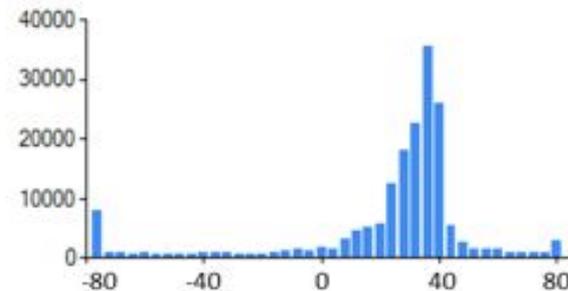


Wider range of parallax (only positive)

# Parallax histogram analysis in static images (III)

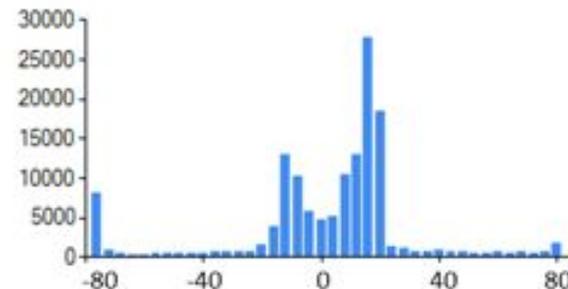
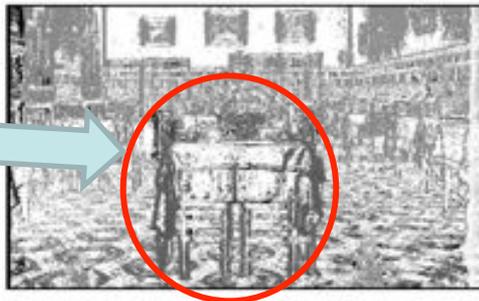
- The “Library” and the “Table” scenes were found to be the preferred scenes due to its variety of depths, from positive to negative parallax

Salient table



Library

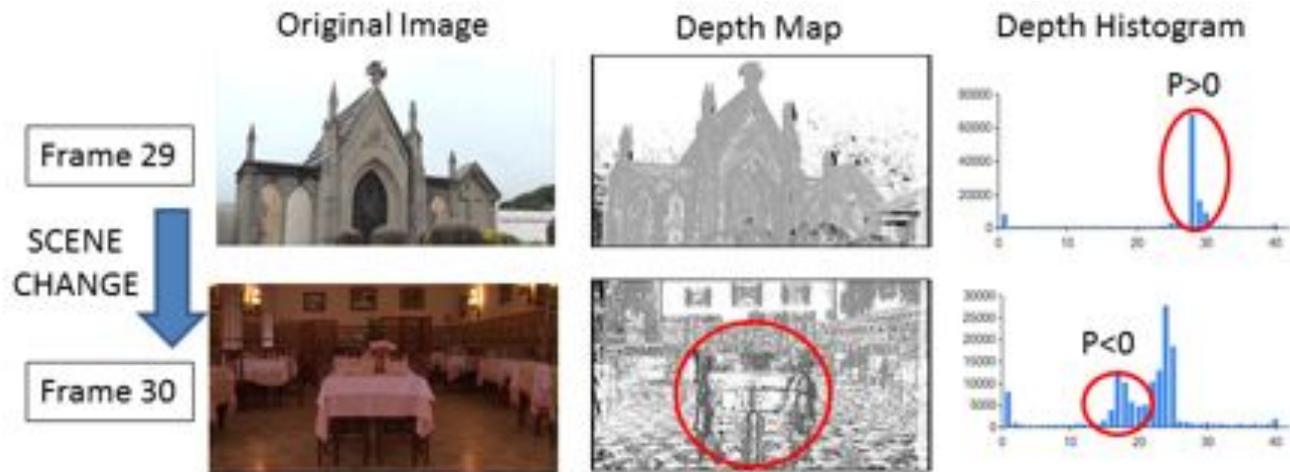
Salient dinning table



Table

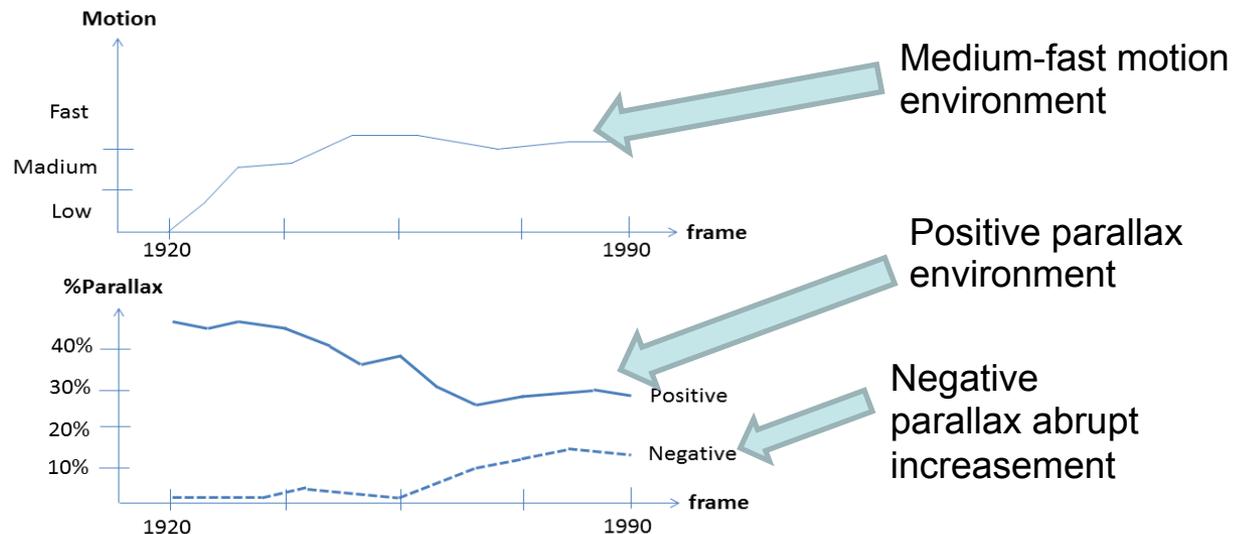
# Abrupt changes

- The variation of negative parallax from frame 29 to 30. Positive parallax is significant in both frames. This results in short time vergence adaptation.
- Users manifest discomfort in subjective tests when this phenomena occurs in a sequence.



# Algorithm for visual discomfort in motion environment

- Studies with both negative and positive parallax percentage, in parallel to motion description, are developed.



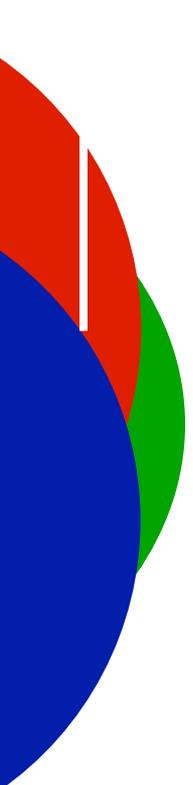
- An abrupt increase in negative parallax, combined with positive parallax raises the probability of discomfort.
- The probability of discomfort is higher with faster motion.

# Conclusions (I)

- Depth and motion are main factors in perceived quality of experience.
- Subjective assessment allowed us to isolate the main features to be detected
- The presence of objects with negative parallax on a static image, and especially when motion is detected in the video sequence, requires quantifying the probability of the observer's annoyance
- Information is obtained through depth maps, motion vectors and parallax histograms.

# Conclusions (II)

- Parallax getting near the ZoC edges (especially negative) has been proven to be undesirable when fast motion or high parallax variance appeared
- Results obtained offer guidelines for stereoscopic video creation, extracting probabilities of visual discomfort and fatigue and reaching consensus between 3D perception and annoyance to the observer's eye.
- Nevertheless, users have the final decision to accept or reject a determined content



Thanks for your attention!