Noise in 3D video sequences

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3D video systems

- 3D video systems
  - Free-viewpoint television (FTV)
  - Three-dimensional television (3DTV)
  - Light-field
- Algorithms
  - Stereoscopic depth estimation
  - Virtual view synthesis
  - Light-field rendering
  - Advance refocussing

Noise 3D video systems

- Operation of algorithms conditioned by noise
  - Typically in literature
    - The presence of noise is omitted
    - Assumptions about the characteristics of noise are made only implicitly
      - A guess: Laplace or Gaussian
    - Solely Gaussian noise is considered
      - Without experimental verification
  - Algorithms work with very various video sequences, acquired with different cameras

Multiview video sequences

- Used by MPEG group

Sequence Name	Camera	Width x Height	Frame rate [frames/s]	Total number of frames	Views numbers	Depth data available for views
Poznan Carpark	Canon XH-G1, 3-CCD camera	1920 x 1088	25	250	0…8	3,4,5
Poznan Street						
Poznan Hall				200	0…8	5,6,7
Lovebird1	Point Grey Flea camera (CCD), Moritex ML-0813 lenses	1024 x 768	30	240	0..8	3,5,7
Newspaper	Point Grey Research Flea camera (CCD) with 1/3-inch Sony lenses			300	0…8	2,4,6
Balloons	XGA CMOS, 8-bit RGB-Bayer Camera			300	0…6	1,3,5

What is shown

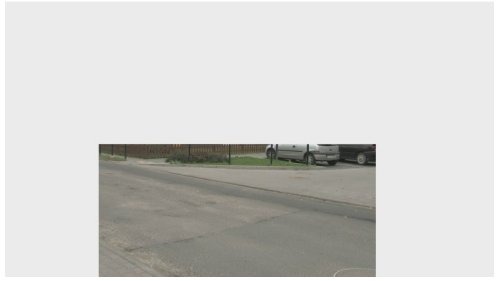
- Noise in context of 3D video systems
  - Noise analysis by noise extraction
  - Test for noise time-independency
  - Noise value distributions
    - Is Laplace?
    - Is Gaussian?

Noise extraction

- Denoising by averaging

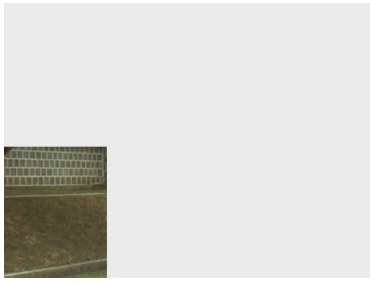
$$Denoised(x,y) = \frac{1}{N}\sum_{i=0}^{N-1} Frame_i(x,y)$$

- Performed over still regions
  - Selected manually
  - As good representation of the whole sequence as possible

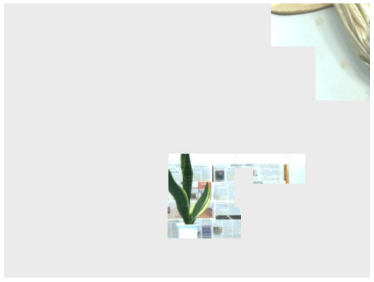

”Poznan Street” sequence


”Poznan Carpark” sequence


”Poznan Hall” sequence

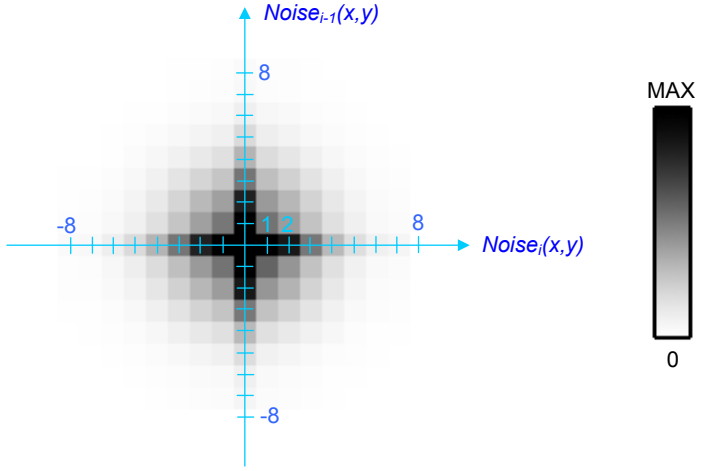

”Lovebird1” sequence


”Balloons” sequence


”Newspaper” sequence

Independency in time

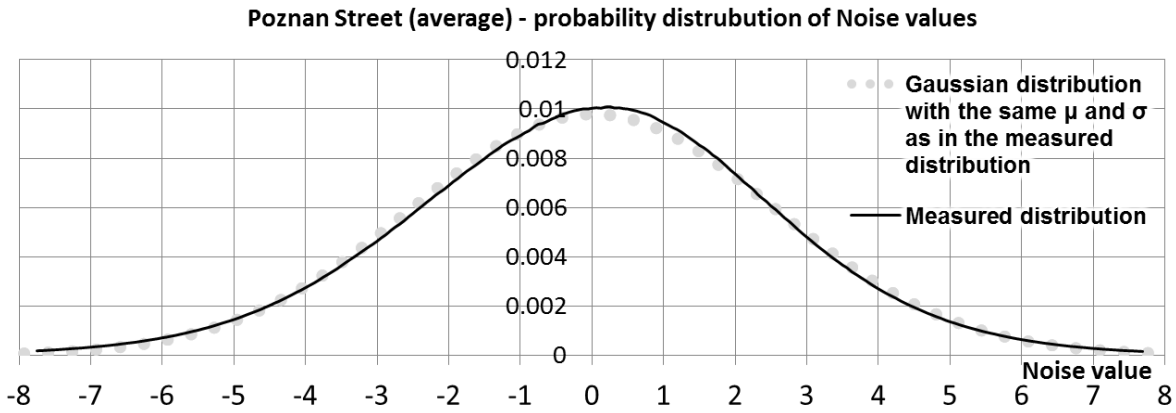
- Two-dimensional histograms of successive frames
- Chi-square test for independency
- The noise in subsequeı frames is indeper

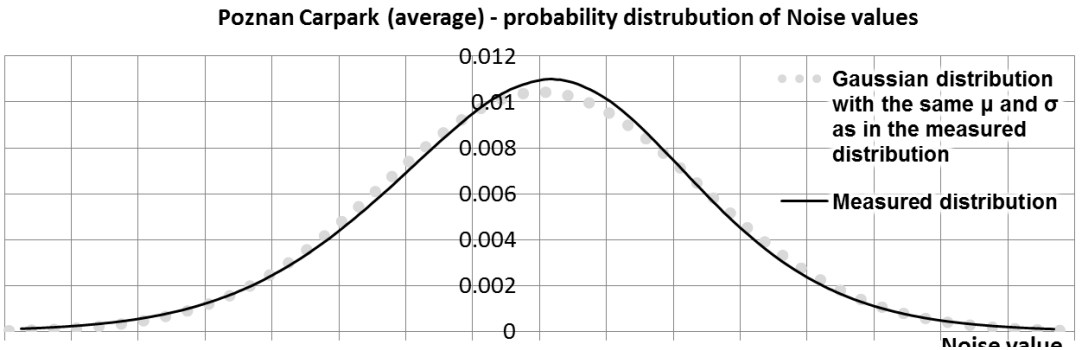


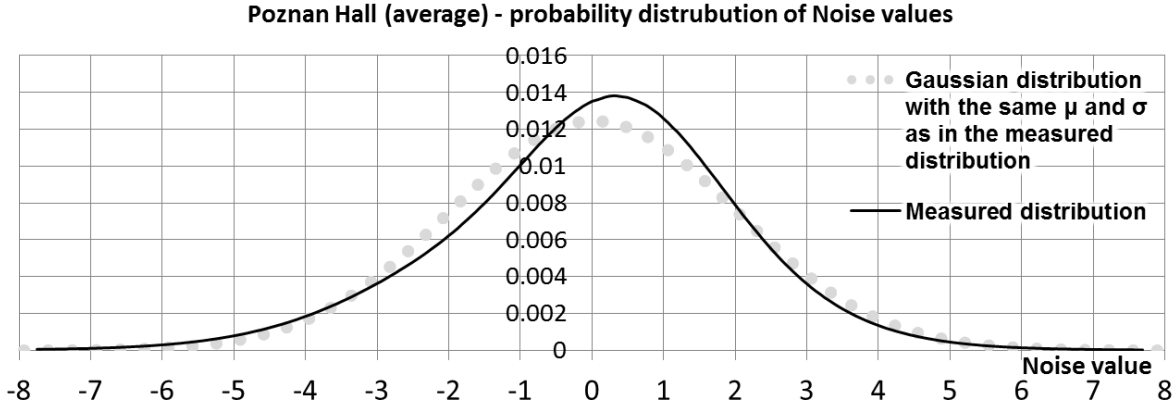
Sequence name	$\chi^2_{ind.\ ratio}$
Poznan Street	0.0145
Poznan Carpark	0.0249
Poznan Hall	0.0194
Lovebird1	0.0387
Newspaper	0.0269
Balloons	0.0307

Noise value distributions

- Poznan Seqs.
  - Not Laplace
  - Distorted Gaussian?
  - EX=~0.4
  - Std=~2.2

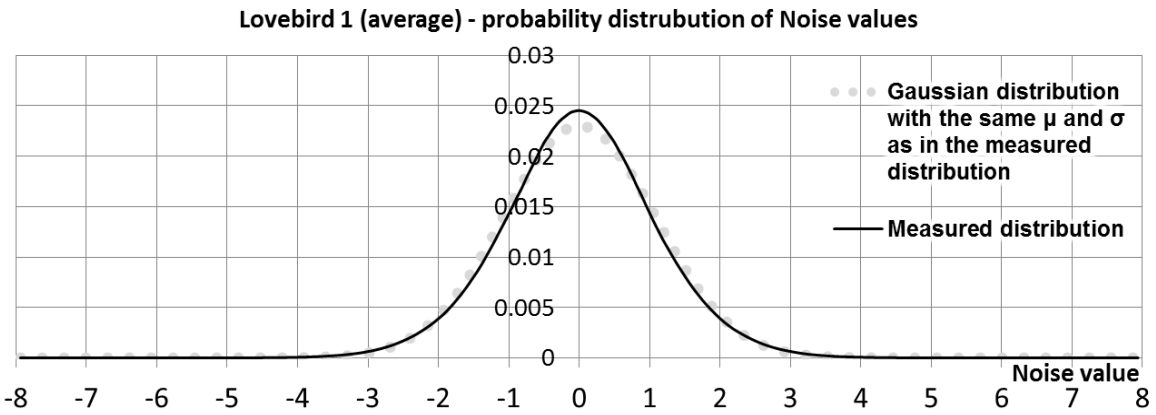


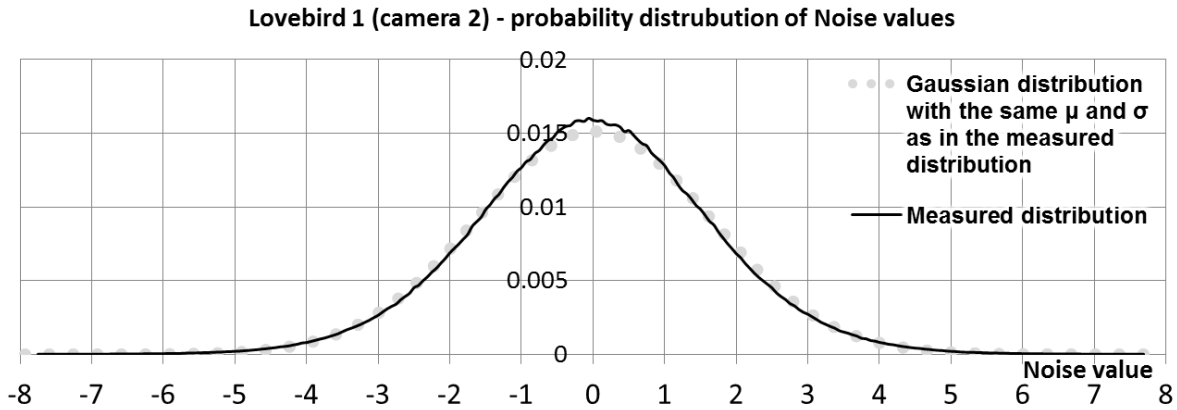




Noise value distributions

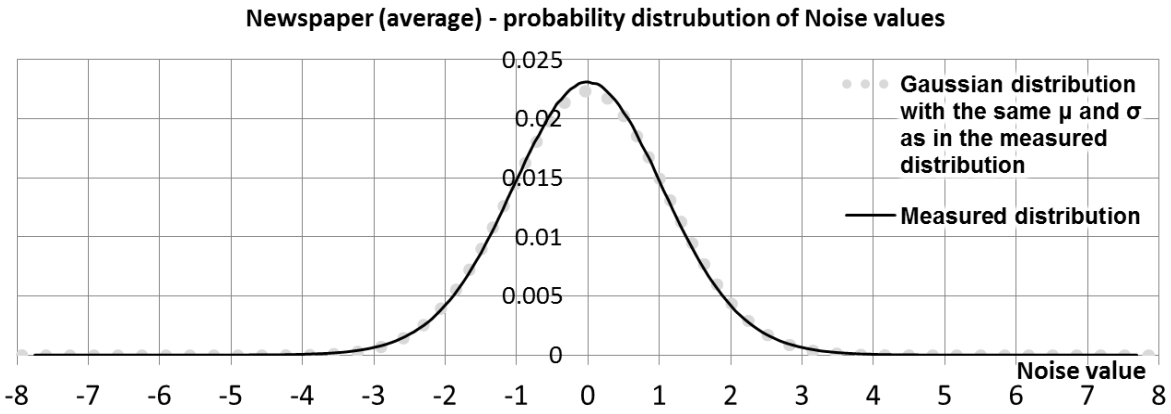
- Lovebird
  - Not Laplace
  - Gaussian?
  - EX=~0
  - Std=~0.6
- Camera 2 is different!
  - Std=2.01

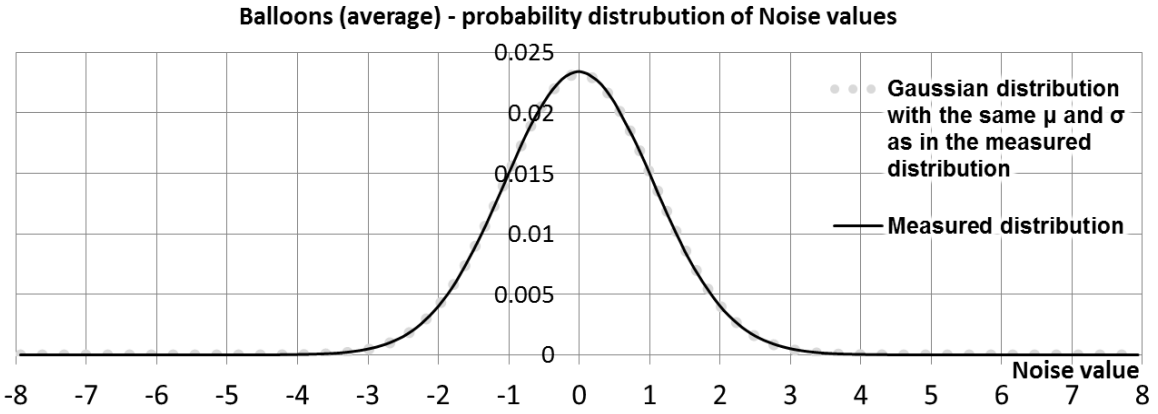




Noise value distributions

- Newspaper
- Balloons, Kendo
  - Not Laplace
  - Gaussian?
  - EX=~0
  - Std=~1





Value distributions

- Visual verification
  - Might be Gaussian
  - Not Laplace or any other

Sequence Name	Standard deviation	Maximum point of distribution, related to EX	Notes
Poznan Street	2.45	0.41	Measured distribution is skewed
Poznan Carpark	2.28	0.42	
Poznan Hall	2.01	0.51	
Lovebird1, w.o. cam.2	0.66	0.02	Camera 2 (renumbered index) of Lovebird1 sequence has vastly different noise profile
Lovebird1, camera 2	1.65	0.01	
Newspaper	1.11	-0.02	-
Kendo	1.01	0.01	Kendo is a moving sequence – values taken basing on Balloons sequence only
Balloons			

- Chi-square test
  - Almost none of sequences has Gaussian noise

Sequence \ Camera index		0	1	2	3	4	5	6	7	8
Name	**Multiplier**	**$\chi^2 ratio$, scaled by the multiplier**								
Poznan Street (cameras 0..8)	$10^1 \times$	7.93	7.65	6.71	6.82	7.00	4.90	5.54	5.51	5.11
Poznan Carpark (cameras 0..8)	$10^2 \times$	3.89	3.56	3.03	3.18	3.03	3.33	3.31	2.02	1.89
Poznan Hall (cameras 0..8)	$10^3 \times$	2.12	1.66	1.84	1.75	1.64	2.08	1.76	1.55	1.28
Lovebird1 (cameras 0..8)	$10^2 \times$	0.50	1.49	0.46	1.84	1.95	1.56	1.08	0.86	1.33
Newspaper (cameras 0..8)	$10^1 \times$	1.30	1.38	1.03	2.07	1.92	1.24	2.03	1.84	2.65
Balloons (cameras 0..6)	$10^0 \times$	1.03	1.42	1.16	0.88	0.94	1.90	0.69	-	

Conclussions 1/2

- Simple methods can lead to interesting and novel conclusions about presence of noise in multi-camera systems

- Noise samples are independent in time domain
  - Which justifies usage of most noise reduction techniques

Conclussions 2/2

- Assumptions about noise known from literature
  - Laplace noise
    - E.g. Sum of Absolute Differences matching
    - No such noise in the video sequence test set
  - Gaussian noise
    - E.g. Sum of Squared Differences matching
    - Noise is visually similar, but not statistically significant
    - DERS !

Thanks for your attention

- Questions?