Review of graininess measurements

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Graininess - Definitions

Granularity :

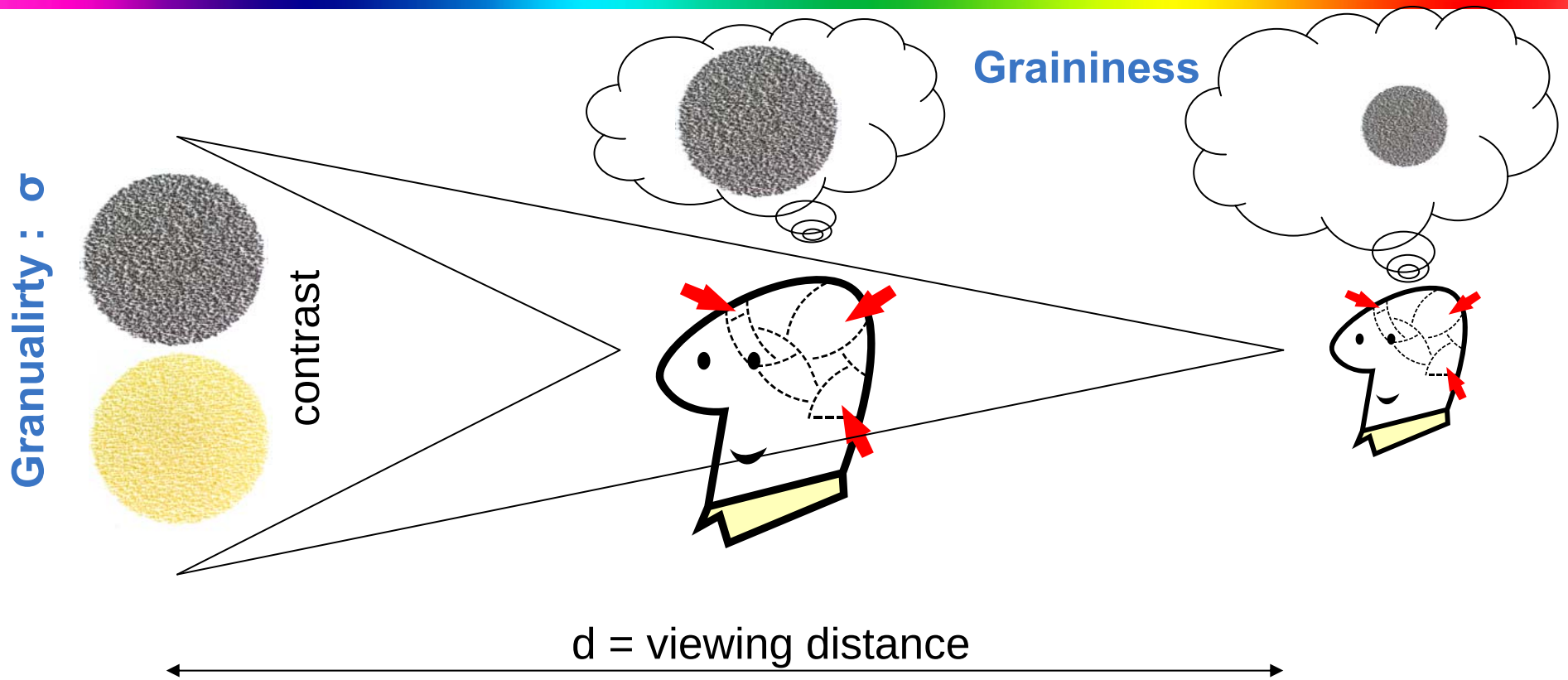
objective measurement of the local-density variations in an area of overall uniform density.

Graininess :

subjective perception of a mottled random pattern apparent to a viewer who sees small local-density variations in an area of overall uniform density.

Reference **Kodak Print Grain Index.**

Graininess - Concept



Graininess = f(σ, d, C)

Graininess - Cause and effect

Cause : Inkjet printers are binary.

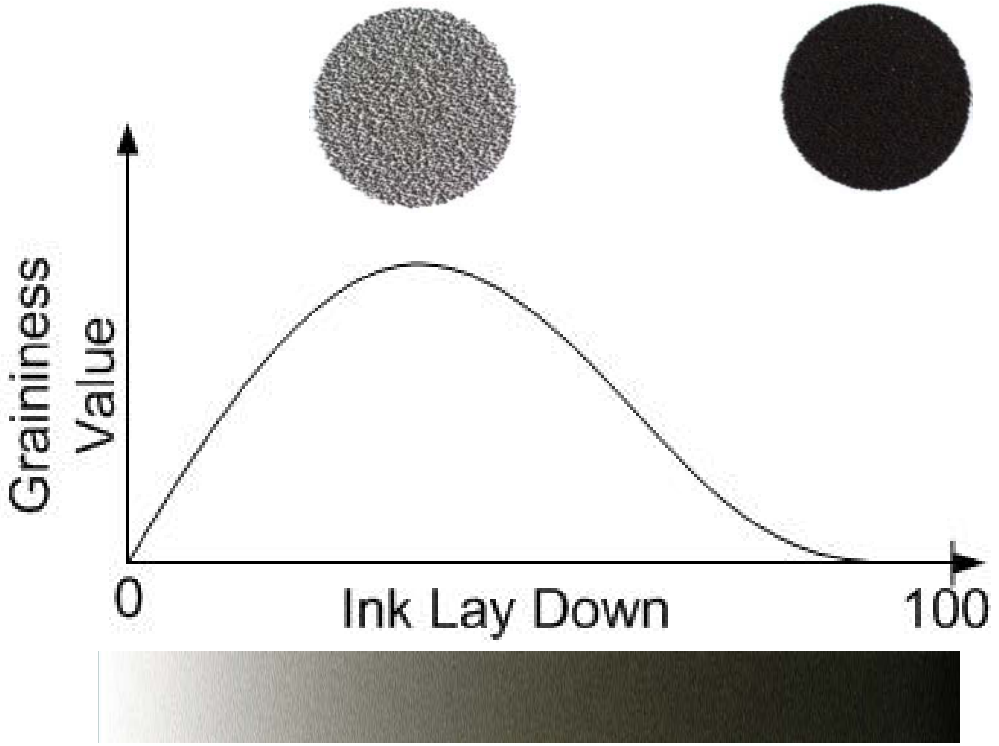
Halftone : pattern of black (dots) and white (not dots) generated by inkjet printer to create a grey appearance.

If the dots are small or overlap, the eye can not resolve the pattern and see grey.

Effect :

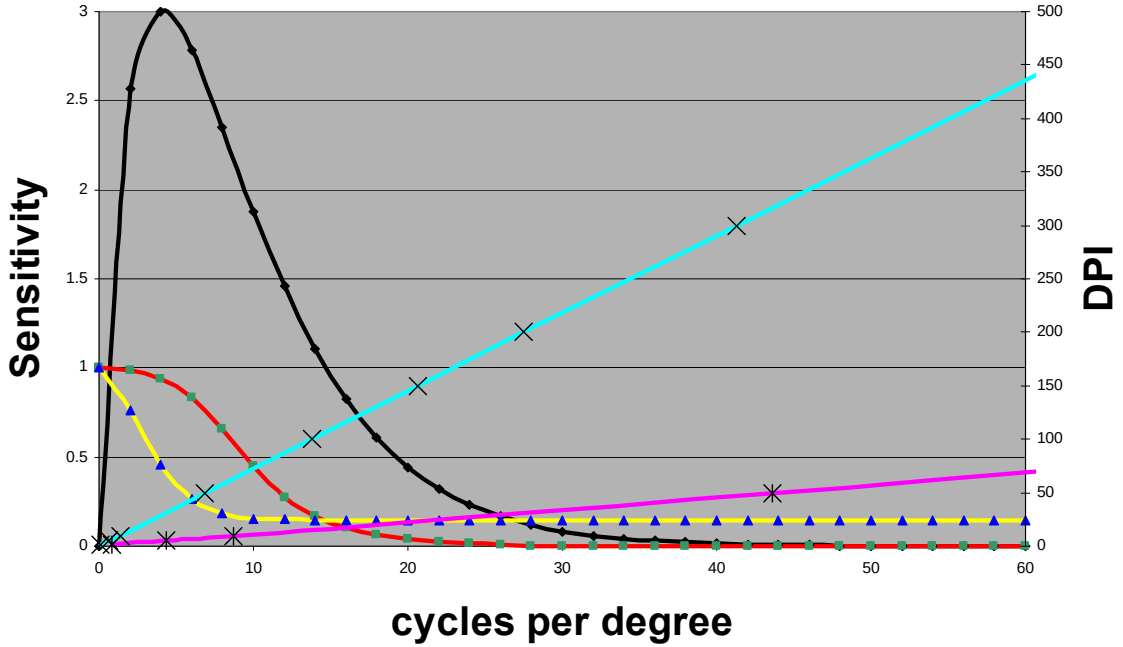
If the dots are just visible by the eye, the halftone pattern will be visible and appear grainy.

The higher the graininess value, the grainier the solid area appears.

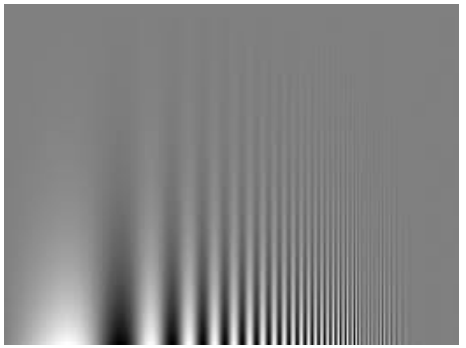


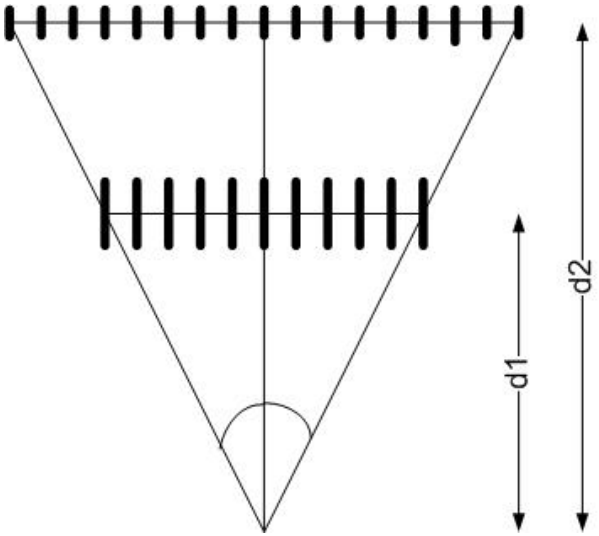
Contrast Sensitivity Function

Reference : Johnson and Fairchild (2003)



Picture Reference : http://w3.ualg.pt/~ubobing/movide/movide_csf.html





Contrast Sensitivity Function : threshold response to contrast as a function of spatial frequency.

Sensitivity : inverse of threshold.

$$cy/\deg = \frac{\frac{res}{2}}{\frac{180}{\pi} \cdot \arctan(\frac{1}{d})}$$

Objectives of a graininess model :

- **Process agnostic**
- **Output a single value**
- **Correlate with visual perception**
  - comparing two samples, if one sample is perceived twice as grainy as the other, this should be reflected in the graininess index.
  - Comparing two samples, if two samples look the same, they should get the same value.
- **Easy to measure**
- **Not an iterative process**

ISO 13660 – Information technology – Office equipment – Measurement of image quality attributes for hardcopy ouptut

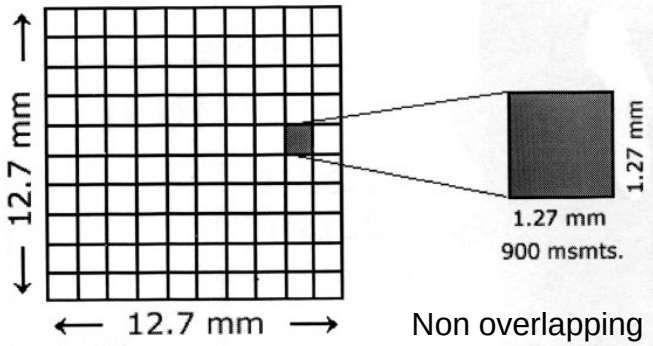
To be revised as ISO 24790 – Target publication 2012-05-11

ISO 13660 : measure of granularity at a fixed viewing distance of 40 cm

Graininess : aperiodic fluctuations of density at a spatial frequency greater than 0.4 cy/mm in all directions.

Mottle : aperiodic fluctuations of density at a spatial frequency less than 0.4 cy/mm in all directions.

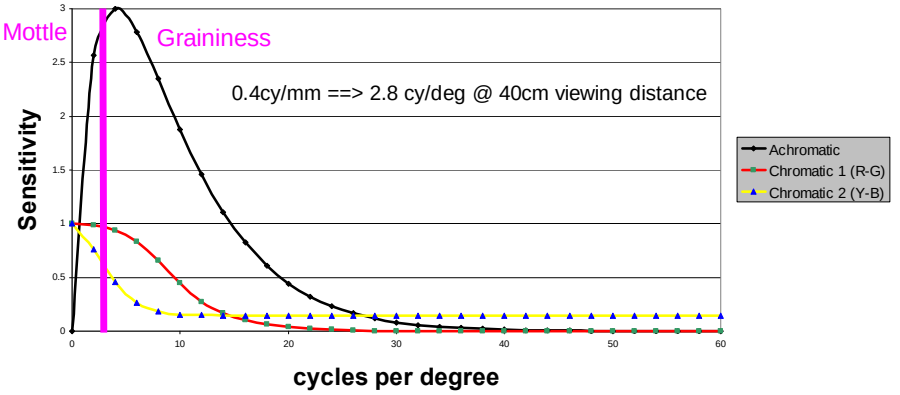
Reference ISO 13660.



Non overlapping measurement

Figure 5 — ROI divided into tiles; a tile (with dimensions)

$$GI = \frac{\sqrt{\sum_{i=1}^{n} \sigma_i^2}}{n}$$



- σi is the standard deviation of optical density measurements within tile i

-n is the total number of tiles.

Kodak Print Grain Index (photographic print)

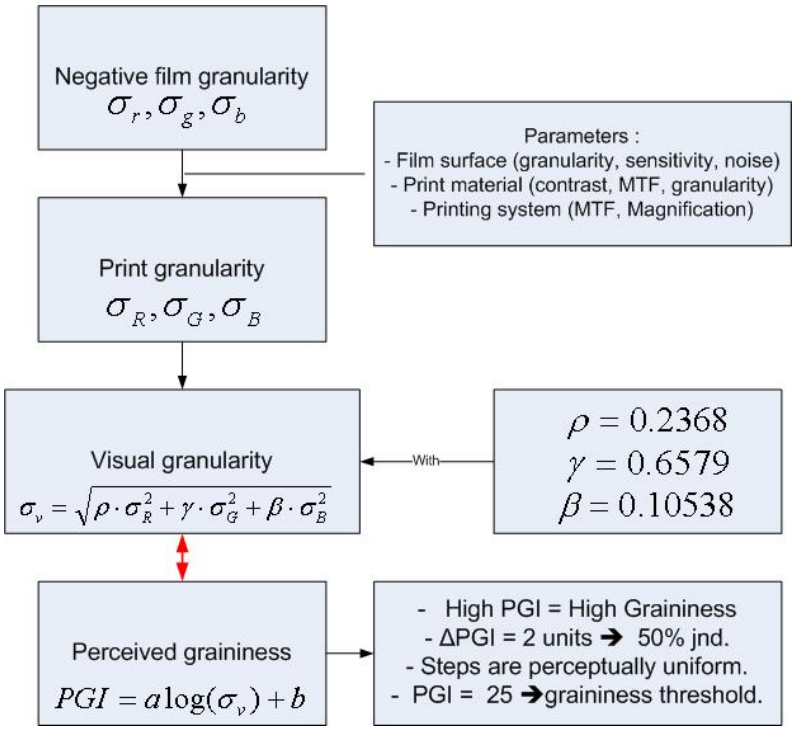
ISO 10505 rms-granularity (photographic film)

Is the standard deviation of the specimen's diffuse microdensity fluctuations (corrected for instrument noise and instrument variability).

$$\sigma = \sqrt{\frac{\Sigma(D_i - \overline{D})^2}{(N-1)}}$$

Kodak Print Grain Index (photographic print)

Reference ISO 1050
Reference Kodak Print Index



- Set viewing distance of 36 cm.
- Steps correspond to 2 JND changes in print graininess :
  - 1 step = 4 units = 2 jnds

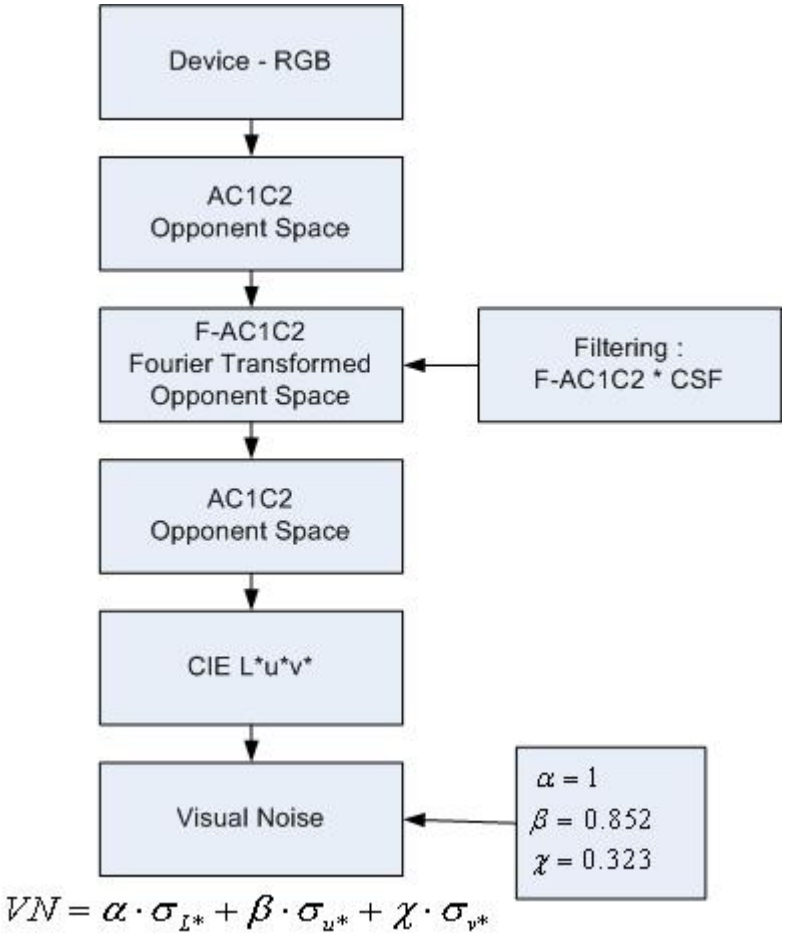
12	16	20	24	28	32	36	40	44	48	52
96	92	88	84	80	76	72	68	64	60	56

Same average density with increasing amouts of graininess.

Figure 4. Schematic of the KODAK Color Grain Ruler

ISO 15739 – Photography – Electronic still-picture imaging – Noise measurements

Visual Noise Algorithm



Noise : unwanted variations in the response of an imaging system.

Reference ISO 15739.

Picture Reference : Image Engineering.

Possible candidate – TC130 Activities

Objectives \ Methods	ISO 13660 (ISO 24790)	Kodak Grain Index	ISO 15739
Process agnostic	?	X	?
Single Value	✓	✓	✓
Correlate with visual perception	R2=0.899* (ISO 24790) Grain Score (Lexmark) R2=0.561* (ISO 13660)	✓	Current model developed by Fogra based on S-CIELAB
Easy to measure	✓	✓	✓
Not iterative process	✓	✓	✓

*Anchor method (with removal of some part of image)

Conclusion

Graininess is a psychophysical phenomen as it is the human visual answer to physical spatial stimulus of local density variations.

Existing measurement methodologies have been reviewed, and TC130 is currently working on improving the models so it correlates with visual perception.

Requirements for measurement procedure :

Test Chart Design :

- Uniform patch
- Patch dimension for measurement : to sample enough of the population of the density variations (10 mm).
- Colours : wedge of CMYK + Secondaries + Grey + Skin

Measuring instrument :

- Sampling resolution ➔ just about higher than human visual system
- Standard flatbed scanner should be ok : 600 dpi
- Further specs to be defined, such as illumination uniformity, focus, MTF.
- To characterise : instrument noise, instrument variability, colour calibration.

Psychometric test requirements for graininess model evaluation :

- Pair comparison to determined a scale of JNDs to determine a ruler.
- Patch dimension for visual assessment : A4.
- Determine a quality ruler valid for a viewing distance of 40 cm.
- Evaluate the correlation between ruler and graininess models.

References

[1] ISO Database Concept : http://www.iso.org/iso/concept_database_cdb.htm

[2] ISO 10505 : 2009 – Photography – Root mean square granularity of photographic films – Method of measurement

[3] ISO 13660 :2001 – Information technology – Office equipment – Measurement of image quality attributes for hardcopy ouptut – Binary monochrome text and graphic

[4] ISO 15739:2003 Photography – Electronic still-picture imaging – Noise measurements

[5] ISO 20462-3:2003 Photography – Psychophysical experimental methods for estimating image quality – Part 3 : Quality ruler method

[6] Briggs. J. C., (2002), Application Note : Graininess Measurements of Halftones [Online 6th of June 2011]

http://www.qea.com/upload/files/products/AppNote%20QEA%20Graininess.pdf

[7] Kodak Print Grain Index [Online 7th of June 2011] http://www.kodak.com/global/en/professional/support/techPubs/e58/e58.pdf

[8] Kane, P.J., Cookingham, R.E., (1998), A Color Grain Ruler for the Measurement of Print Graininess, IS&T's 1998 PICS Conference

[9] Engeldrum, P.G. (1998), Absolute Graininess Threshold and Linear Probability Models, IS&T 1998 PICS Conference

[10] Johnson, G.M., Fairchild, M.D., (2003), A Top Down Description of S-CIELAB and CIEDE2000 [Online 6th of June 2011] *www.cis.rit.edu/people/faculty/johnson/pub/ciede_scielab.pdf*

[11] Fairchild, M.D., (2005), Color Appearance Models, 2nd Edition, Wiley IS&T Series in Imaging Science and Technology

[12] Urabe, H., (2009 - FujiFilm Corporation), Japanese Proposal on ISO/PWI 15311) to ISO/TC130/JWG9

: TC130WG3_NXXX_ISO15311_JNB_proposal2 - CR.ppt

[13] Kraushaar, Fogra Digital Printing Activities : [Online 13th of June 2011] http://www.fogra.org/en/fogra-research/wc-digital-printing/imagequality-35003/research-topics/graininess/

Thank you

Acknowledgment : Will Eve, Phil Smith, Laurie Pate

Measuring instrument Requirement

- **sampling resolution ➔ higher than human visual system**
- **ISO 13660 : camera of 600 spi (corresponds to a region of 90.000 pixels divided into tiles of 900 pixels) ➔ 82 cy/deg @ 40 cm or 23 samples/mm**
- **ISO 10505 : micro-densitometer (optical low pass filter of not less than 50 cycles/mm).**
- **ISO 15739 : pixels basis of captured image (dependent on monitor resolution).**