

Dynamic Range Extension in Flat Detector CT using a Compressed Sensing-Based Multi-Exposure Technique

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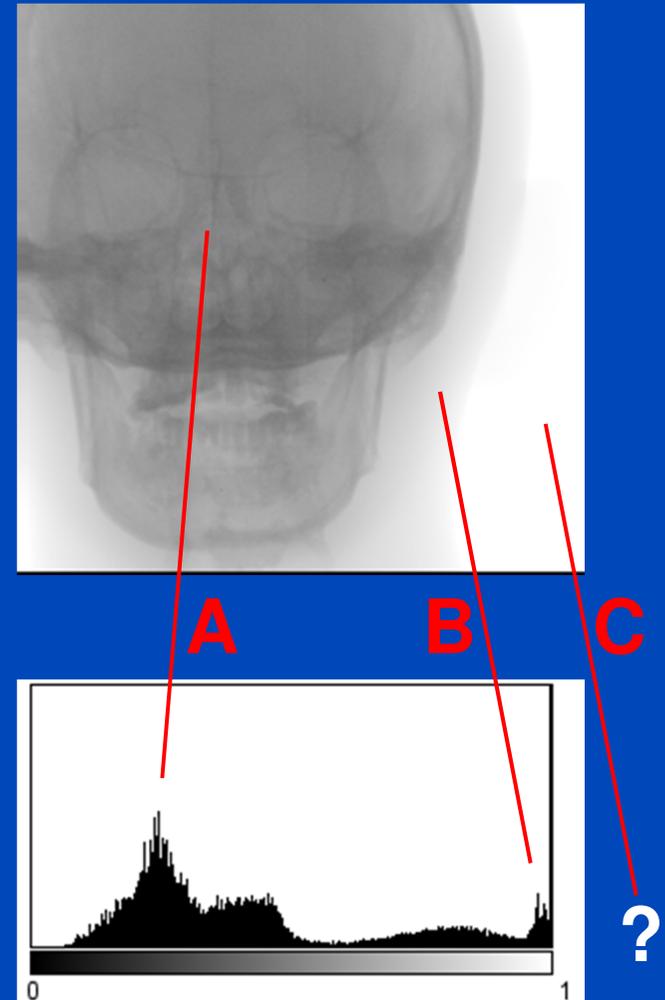
Aim

- Minimize the influence of readout electronic noise in flat detector CT.

Detectable Intensity Difference

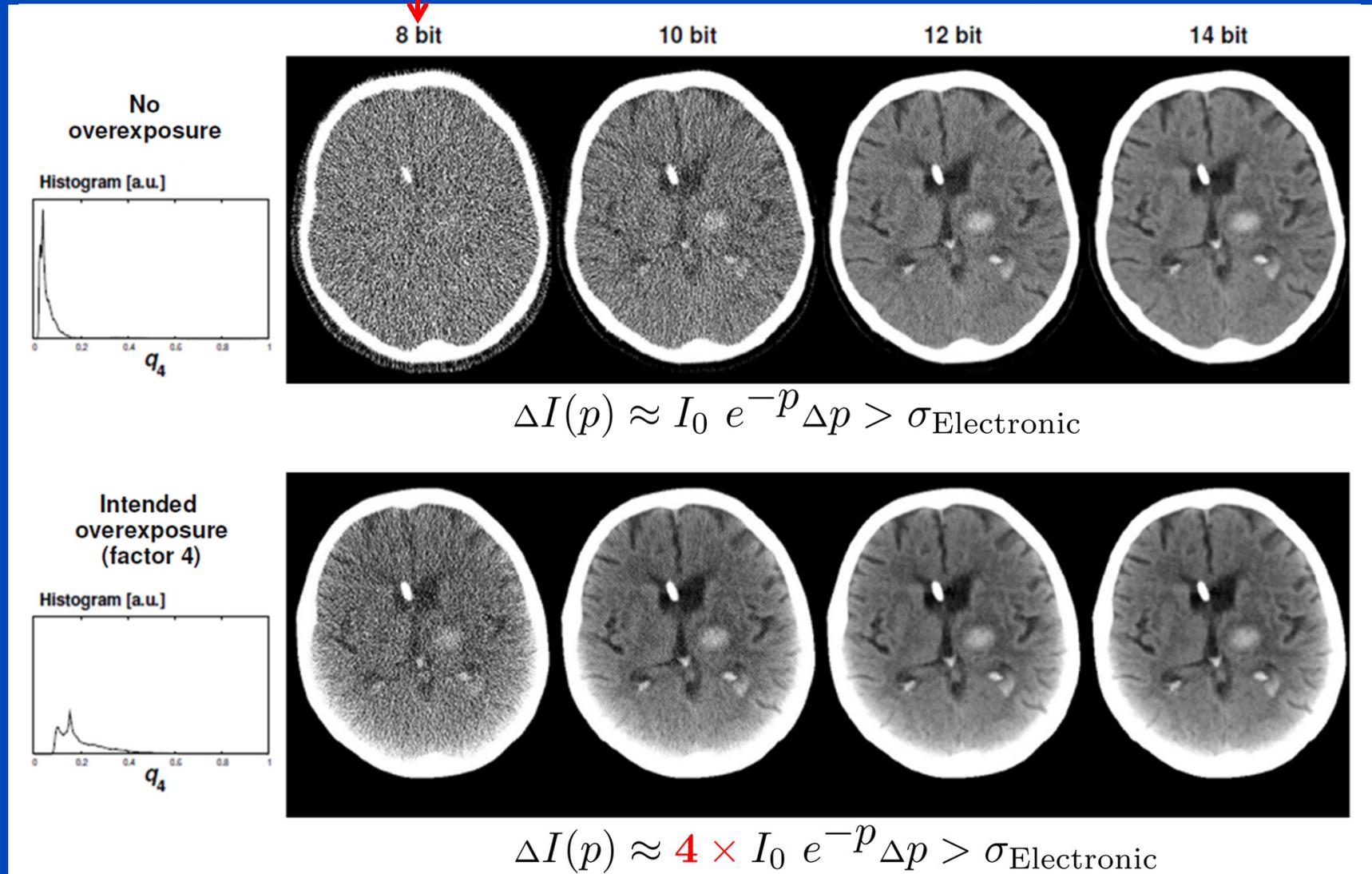
- Typically, the relevant information of the patient is in regions of strong attenuation (A).
- Regions of low attenuation (B) are needed to avoid truncation to obtain correct CT values.
- The detectable signal difference is limited by the detector electronic noise.
- Limitation of soft tissue visibility in reconstructed CBCT image.
Contrast Δp visible if

$$\Delta I(p) \approx I_0 e^{-p} \Delta p > \sigma_{\text{Electronic}}$$



Intended Overexposure

$$\text{DynamicRange} = \text{lb} \left(\frac{\text{SaturationExposure}}{\text{ElectronicNoiseLimitedExposure}} \right)$$



Requirements Specs

- **Fixed detector mode (high frame rate, high resolution)**
- **Single scan (short acquisition time)**
- **No additional radiation dose**
- **No additional hardware**

Prior Art

- **Shaped prefiltration (Bowtie)¹**
 - Requires object is centered in the rotation center
 - Not flexible enough for C-arm applications
- **Intended overexposure²**
 - Truncation of projection data
 - Use standard detruncation methods
 - Incorrect CT values
- **Multiple gain readout^{3,4}**
 - Reduces spatial or temporal resolution
 - Fixed amplification settings, not flexible
 - Complicated calibration
- **Multiple exposure technique⁵**
 - Longer acquisition time
 - Higher dose

¹Mail et al., “The influence of bowtie filtration on cone-beam CT image quality”, Med. Phys. , 36(22), 2009.

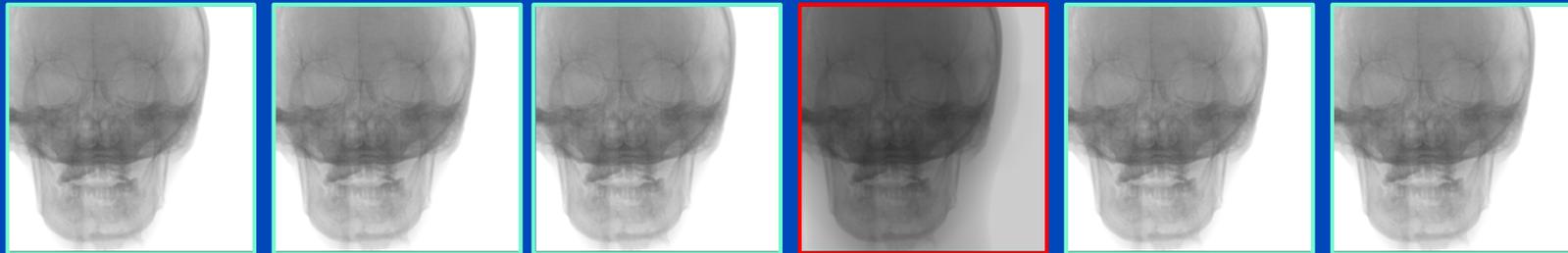
²Zellerhoff et al., “Low contrast 3D-reconstruction from C-arm data”, SPIE Medical Imaging Proc., 2005.

³Roos et al. , “Multiple gain ranging readout method to extend the dynamic range of amorphous silicon flat panel imagers”, SPIE Medical Imaging Proc., 2004.

⁴Schmidtgunst et al. , “Calibration model of a dual gain flat panel detector for 2D and 3D x-ray imaging”, Med. Phys., 34(9), 2007.

⁵Sukovic et al., “A Method for Extending the Dynamic Range of Flat Panel Imagers for Use in Cone Beam Computed Tomography”, IEEE NSS 2001.

Optimized Exposure Protocol



→ time,
rotation angle

- Acquire overexposed projections at required dose level using a high sensitivity mode.
- Perform interleaved low dose exposures which do not saturate the detector.
- Do this by varying the x-ray pulse length.

Thank You!

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