Medical Image Processing for Diagnostic Applications

Defect Pixel Interpolation

Online Course – Unit 16

Andreas Maier, Joachim Hornegger, Markus Kowarschik, Frank Schebesch
Pattern Recognition Lab (CS 5)

virtuelle hochschule bayern

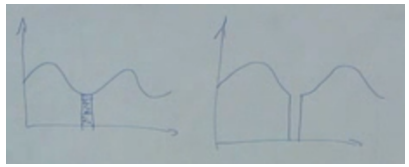
FRIEDRICH-ALEXANDER UNIVERSITÄT ERLANGEN-NÜRNBERG
TECHNISCHE FAKULTÄT

Topics

Defect Interpolation by Bandlimitation

Summary

- Take Home Messages
- Further Readings



Defect Interpolation by Bandlimitation

assume the underlying signal has a bandlimitation

dead pixel -> edge -> high frequ.

The initial idea for defect pixel interpolation using frequency domain methods is based on a fundamental result of signal theory:

- According to the sampling theorem, the ideal signal $f(n)$ is required to be bandlimited regarding to a certain band frequency ξ.
- Defect detector elements bring intensities of corresponding pixels down to zero.
- Defect pixels cause high differences in intensities of neighboring pixels and thus imply higher frequencies in the 2-D image function. These higher frequencies cause a violation of the required bandlimitation.

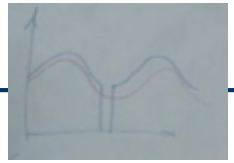
Idea for defect interpolation: Replace defect pixels iteratively by enforcing bandlimitation.

Remark: Discrete signals are inherently bandlimited, consider this as a conceptual approach in the first place.

we see a spike in f-Domain

Bandlimitation-f L is independent from sampling theorem frequency B

a change in the frequency domain affects the entire image
new signal ->



we know where the image is ok -> only use red line at position of dead pixel

Defect Interpolation by Bandlimitation

the other areas were measured - we know they are good

now the jump is not as steep -> repeate the process until all frequencys are in ok bandwidth
or for x times. if there are still corners left -> smooth them

compute FT of input signal $g(n)$
set $G(\xi) = 0$ for $\xi < B_{\text{lower}}$ or $\xi > B_{\text{upper}}$ (here B is the L we mentioned earlyer :?)
compute inverse FT of corrected $G(\xi)$
replace defect samples in $g(n)$ with values of the bandlimited signal
UNTIL changes are below a threshold

Figure 1: Interpolation by enforcing a bandlimited signal in a frequency range of $[B_{\text{lower}}, B_{\text{upper}}]$

Drawbacks of Bandlimitation

The proposed method is quite simple and intuitive, but there exist a few serious practical issues:

- The bandlimitation $B_{\text{lower}}, B_{\text{upper}}$ must be known. again this is L in the images
- The interpolation scheme is computationally expensive, because each iteration requires the Fourier transform of the signal twice. This prohibits its straightforward practical use.
- The proposed interpolation algorithm is not optimal w. r. t. the minimum number of non-zero frequencies.
- Extrapolations decay outside the observation interval. bad for extrapolation
- The application of adaptive thresholding during interpolation is advantageous. Start with low L and make it bigger over time

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Take Home Messages

- Bandlimitation can iteratively be applied to a defect pixel image.
- Be careful when applying defect pixel interpolation.

changing stuff in FD causes change everywhere

Further Readings

- The method presented for defect pixel interpolation in the frequency domain was published by Til Aach and Volker Metzler in 2001:

  Til Aach and Volker Metzler. "Defect Interpolation in Digital Radiography: How Object-Oriented Transform Coding Helps". In: *Proc. SPIE 4322, Medical Imaging 2001: Image Processing*. Vol. 4322. San Diego, CA: SPIE, Feb. 2001, pp. 824–835. DOI: 10.1117/12.431161

- A recent article about defect pixel interpolation with respect to image quality issues can be found here:

  Jan Kuttig et al. "Effects of Defect Pixel Correction Algorithms for X-ray Detectors on Image Quality in Planar Projection and Volumetric CT Data Sets". In: *Measurement Science and Technology* 26.9 (Aug. 2015), 095406 (14pp). DOI: 10.1088/0957-0233/26/9/095406