Image Enhancement of Biomedical Images by Paired Transform

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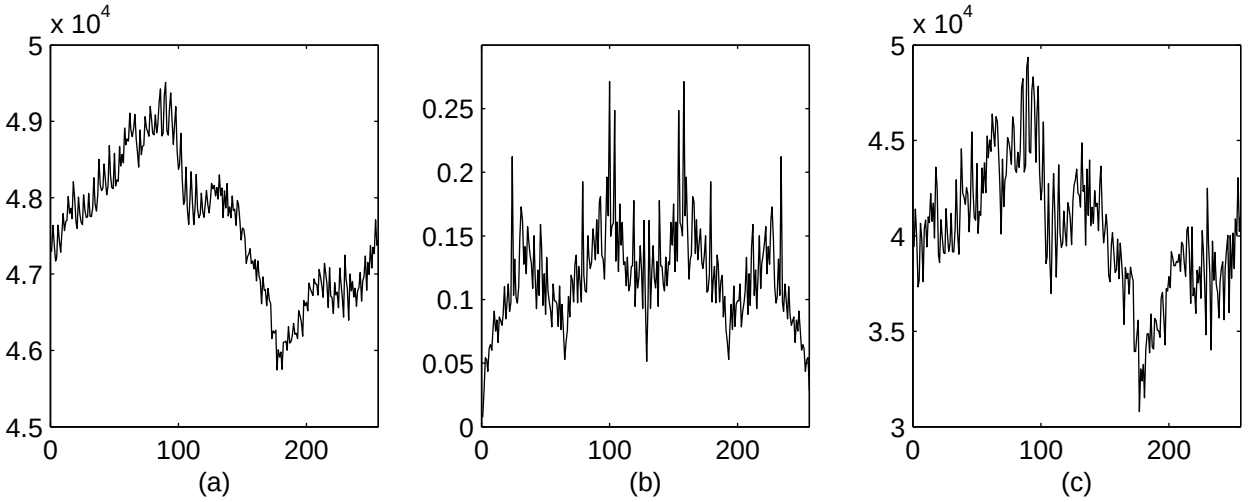
Enhancement in Frequency Domain

The Fourier transform-based method of image enhancement consists in computing the 2-D DFT of the image, manipulating the transform coefficients by a specific operator $\mathbf{M}$, and performing then the inverse 2-D transform.

$$\{f_{n,m}\} \rightarrow \{F_{p,s}\} \rightarrow \{G_{p,s} = M\left[|F_{p,s}|\right] e^{-j\vartheta_{p,s}}\} \rightarrow \{g_{n,m}\} \quad (1)$$

1-D α-Rooting

$$F_k^* = |F_k|^{(\alpha-1)}.F_k$$



(a) Original signal f_n of length 256. (b)Coefficients C_k of length 256 (c) Enhanced signal $f_n^{'}$ of length 256.

Quantative Measure of Enhancement

The image $g_{n,m}$ is divided by M^2 blocks $(L \times L)$, and the measure is calculated as

$$QME_{[r]}(g) = \frac{1}{M^2} \sum_{k=1}^{M} \sum_{l=1}^{M} 20 \log_{10} \left[\frac{OR_{[r],(k,l)}(g)}{OR_{[L^2-r+1],(k,l)}(g)} \right]$$

where $OR_{[n]}(g)$ is the nth order statistic of the enhanced image g inside the (k,l)th block, when $n = r$ or $L^2 - r + 1$.

Paired Representation

$$F_{\overline{p},\overline{s}} = \sum_{t=0}^{N-1} f'_{p,s,t} W^t, \tag{2}$$

where $f'_{p,s,t} = f_{p,s,t} - f_{p,s,t+N/2}, \quad t = 0 : (N/2 - 1)$

$$F_{\overline{(2m+1)p},\overline{(2m+1)s}} = \sum_{t=0}^{N/2-1} \left(f'_{p,s,t} W^t \right) W_{N/2}^{mt} \tag{3}$$

for $m = 0 : (N/2 - 1)$.

Paired Representation

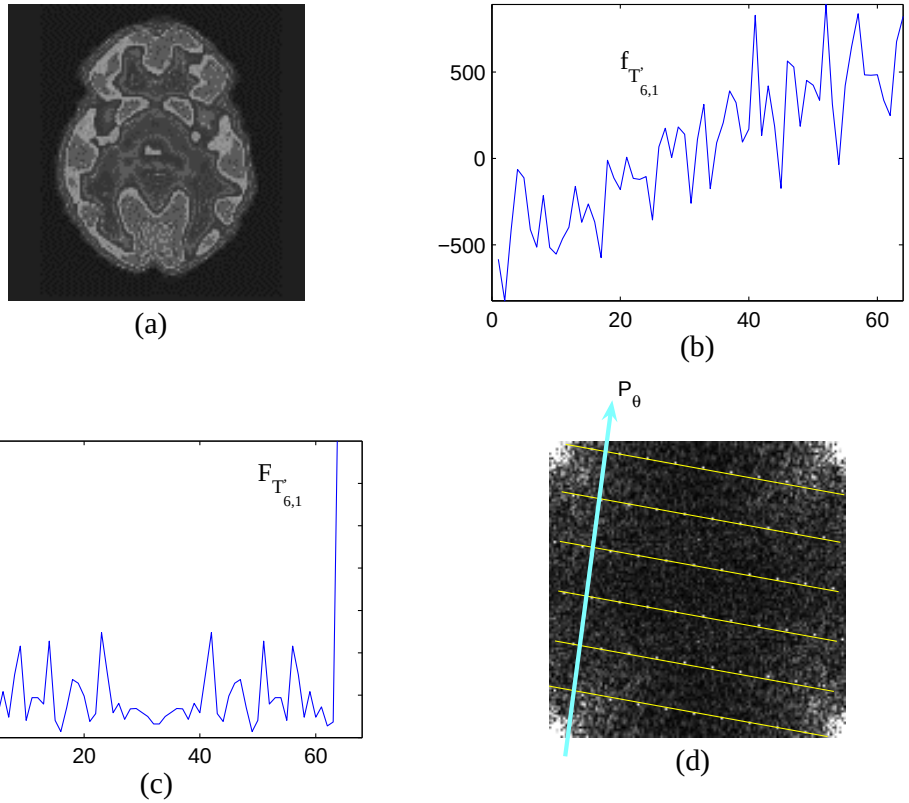
Thus the 2-D DFT of f at points of the following subset of the group $T_{p,s}$

$$T'_{p,s} = \left\{(p,s), (\overline{3p}, \overline{3s}), (\overline{5p}, \overline{5s}) \ldots, (\overline{\overline{(N-1)p}, \overline{(N-1)s}})\right\} \tag{4}$$

is defined by the splitting-signal of length $\leq N/2$

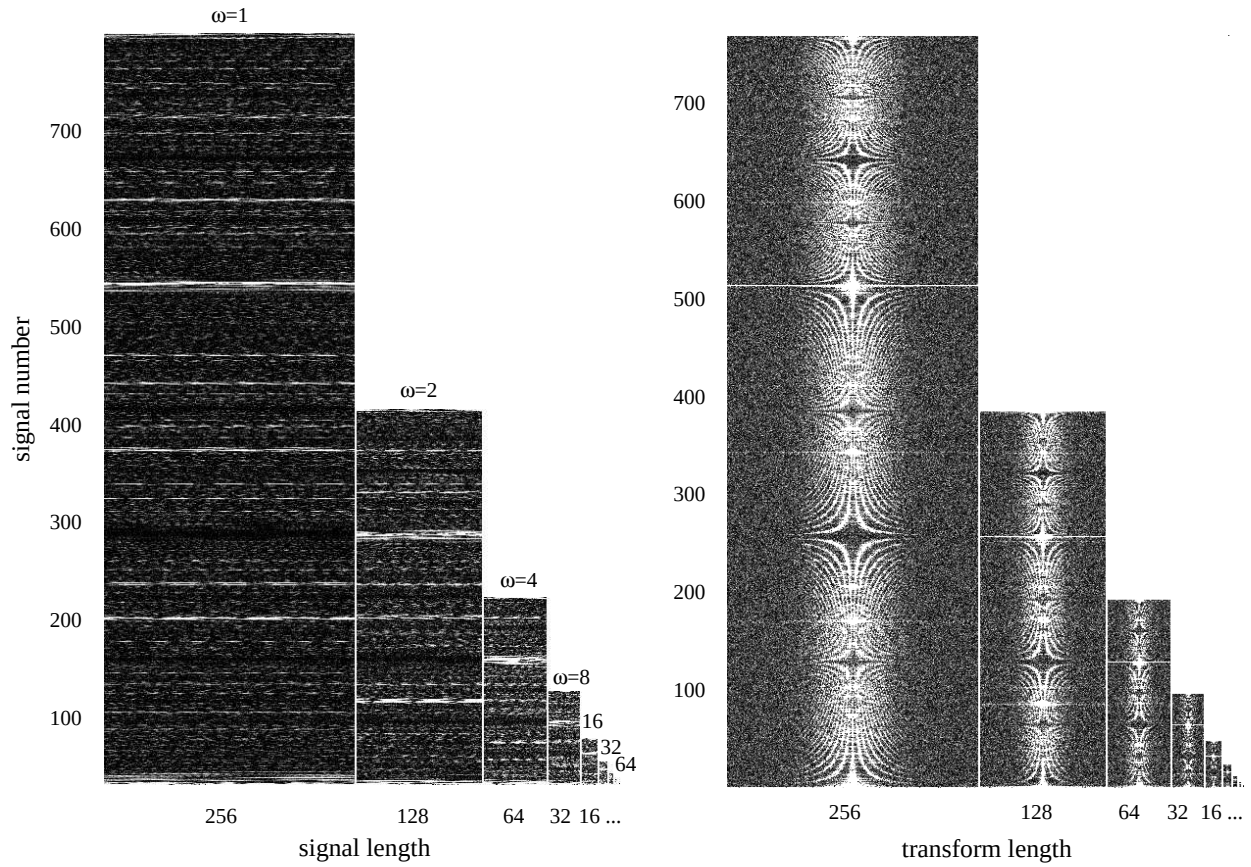
$$f_{T'_{p,s}} = \{f'_{p,s,0}, f'_{p,s,1}, f'_{p,s,2}, \ldots, f'_{p,s,N/2-1}\}.$$

Image Processing by Paired Transform



(a) Original image. (b) Splitting-signal $f_{T_{6,1}}$ (c) The 1-D DFT of the splitting-signal, (d) Arrangement of values of the 1-D DFT in the 2-D DFT of the image at frequency points of the subset $T'_{6,1}$.

Paired Transform of the Image and 2-D DFT



(a) Splitting-signals of lengths $N/2, N/4, ..., 2, 1, 1$.of the FISH image. (b) 1-D DFTs of the splitting-signals.

Experimental Results

Comparison of

- Traditional alpha rooting ,
- Tensor splitting signal (TSS)
- Paired splitting signal(PSS) with same α,
- Paired splitting signal(PSSD) with different α's.

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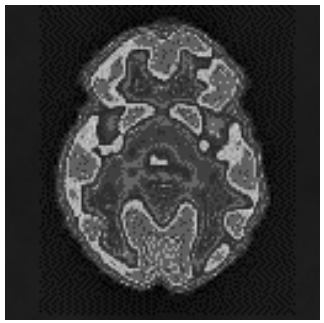
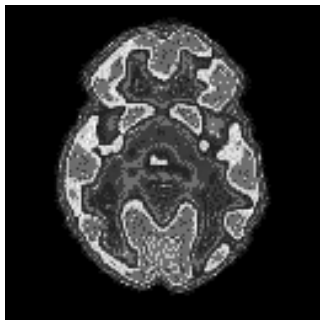
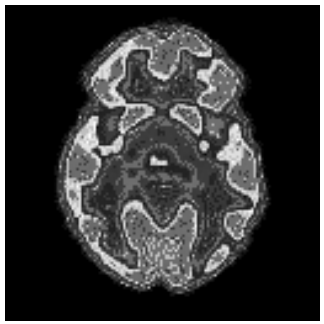
Experimental Results



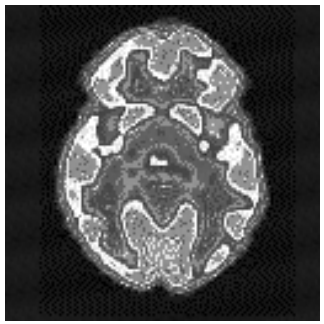
(b)



(c)



(a)

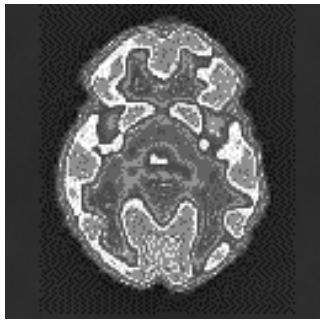


(d)

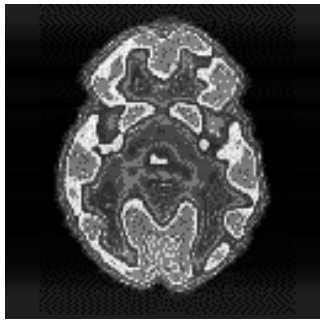
(a) Traditional QME=27.22(b)TSS. (1,6) QME=12.94 $\alpha = 0.92$

(c) PSS (1,6), $\alpha = 0.92$ QME=12.92 (d) PSSD (1,6) QME=27.68

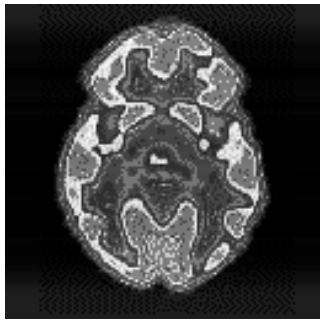
Experimental Results



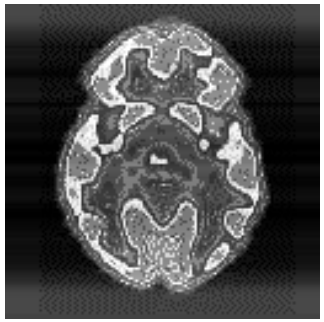
(b)



(c)



(a)

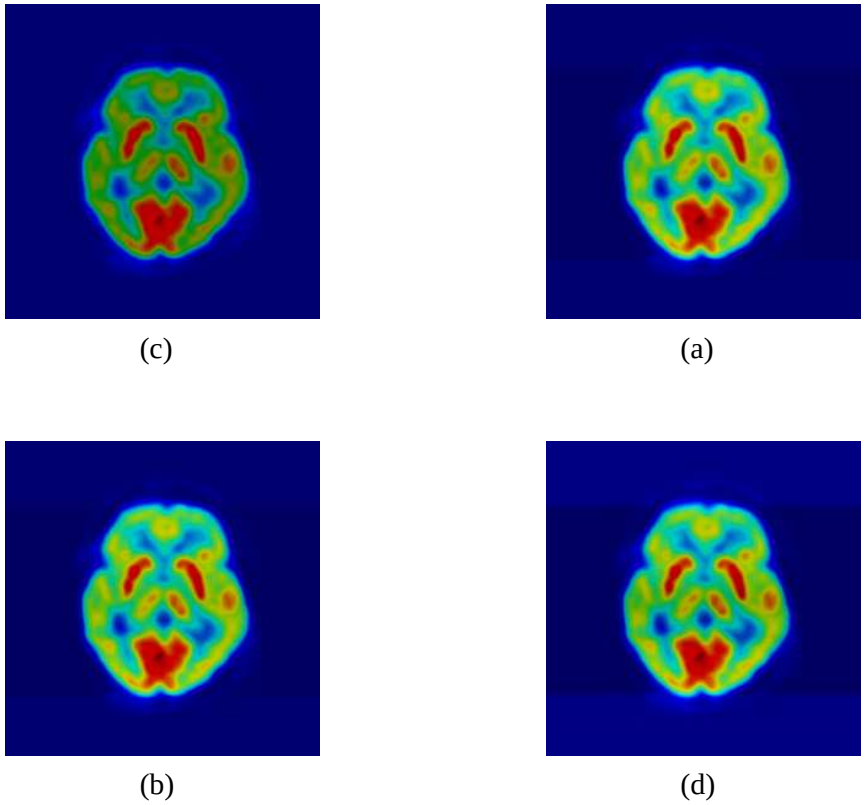


(d)

(a) Traditional QME=19.77 (b) TSS (0,1) QME=16.27 $\alpha = 0.95$

(c) PSS (0,1) $\alpha = 0.95$ QME=19.98 (d) PSSD (0,1) QME=15.29

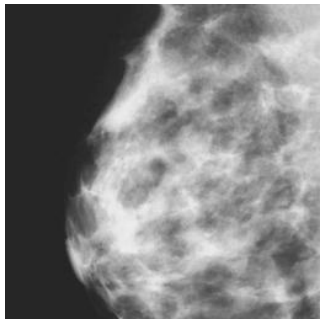
Experimental Results



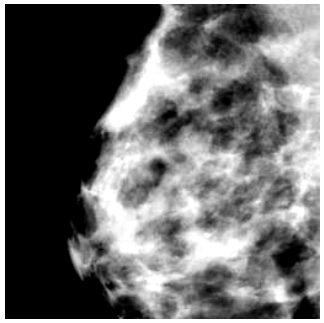
(c) (a) (b) (d)

(a) Traditional (b) TSS (1,1) $\alpha = 0.9$ (c) PSS (1,1) (d) PSSD (1,1)

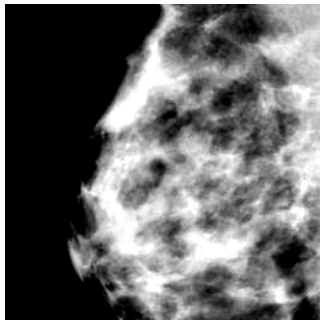
Experimental Results



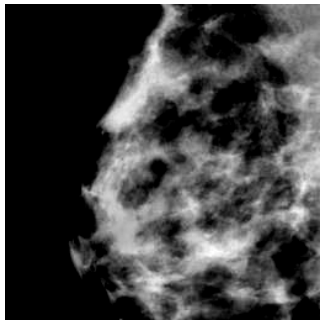
(a)



(b)



(c)



(d)

(a) Original QME=3.43 (b)Traditional QME=7.03 $\alpha = 0.92$

(c) PSS (1,1) $\alpha = 0.92$ QME=7.56 (d) PSSD (1,1) QME=8.00

Conclusions

Enhancement by paired splitting signal with same α for all decompositions of splitting-signal and with different α's for each decomposition of splitting-signal are proposed.
Each proposed method decreases the burden in two dimensional processing of images .