#### Real-time UP-Converter from HDTV to 4K with Super High Resolution -HDTV Expansion to 4K Super Resolution-

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## Question What is the Super Resolution(SR)? What is your idea of the SR?

# Super Resolution (SR)



If it works, we do not need digital HDTV broadcasting





What is the difference between convectional image enhance methods and SR?

There are several SR proposals. What are the difference?

2 dimensional FFT results



#### Difference between Enhancer and SR



#### **Conventional Enhancer**



### The limitation of video

- SR for video MUST work in real time
- Super resolution image reconstruction (SRR) was the eligible and practical algorithm
- HDTV sets with SRR is available in the market

Does it really improve resolution?



Gather the highest resolution pixels from each frame











Limitations of Super resolution image reconstruction (SRR)

### SRR reduces only aliasing

#### Is this what we want for SR?

#### Scheffe's paired comparison







Evaluation	Score
B is excellent compared with A	2
B is good compared with A	1
B and A are Fair	0
B is bad compared with A	-1
B is poor compared with A	-2

#### A is evaluated from -2 to2.









Evaluation	Score
A is excellent compared with B	2
A is good compared with B	1
A and B are Fair	0
A is bad compared with B	-1
A is poor compared with B	-2





Fig. 6 Waveform of (a), (b),(c),(d) in Fig.5

(a) 
$$f(z) = \sum_{i=-N}^{N} a_i \cos(i\omega_0) + \sum_{i=-N}^{N} b_i \sin(i\omega_0)$$
$$= \sum_{i=-N}^{-1} a_i \cos(i\omega_0) + a_0 + \sum_{i=1}^{N} a_i \cos(i\omega_0) + \sum_{i=-N}^{N} b_0 \sin(i\omega_0)$$
$$\underset{\text{Image}}{\overset{\text{(a)}}{\overset{\text{HPF}}{\overset{\text{(b)}}{\overset{\text{(c)}}{\overset{\text{(c)}}{\overset{\text{LMT}}{\overset{\text{(c)}}{\overset{\text{(c)}}{\overset{\text{LMT}}{\overset{\text{(c)}}{\overset{\text{(c)}}{\overset{\text{(c)}}{\overset{\text{LMT}}{\overset{\text{(c)}}{\overset{(c)}{\overset{(c)}{\overset{(c)}}{\overset{(c)}{\overset{(c)}{\overset{(c)}}{\overset{(c)}{\overset{(c)}{\overset{(c)}{\overset{(c)}}{\overset{(c)}{\overset{(c)}}{\overset{(c)}{\overset{(c)}{\overset{(c)}{\overset{(c)}{\overset{(c)}{\overset{(c)}}{\overset{(c)}}{\overset{(c)}{\overset{(c)}{\overset{(c)}{\overset{(c)}{\overset{(c)}{\overset{(c)}}{\overset{(c)}{\overset{(c)}}{\overset{(c)}{\overset{(c)}{\overset{(c)}}{\overset{(c)}{\overset{(c)}}{\overset{(c)}{\overset{(c)}{\overset{(c)}{\overset{(c)}{\overset{(c)}}{\overset{(c)}{\overset{(c)}{\overset{(c)}}{\overset{(c)}{\overset{(c)}}{\overset{(c)}{\overset{(c)}}{\overset{(c)}{\overset{(c)}{\overset{(c)}}{\overset{(c)}}{\overset{(c)}}{\overset{(c)}{\overset{(c)}}{\overset{(c)}{\overset{(c)}}}{\overset{(c)}}{\overset{(c)}}{\overset{(c)}}{\overset{(c)}}}{\overset{(c)}}{\overset{(c)}}}{\overset{(c)}}{\overset{(c)}}{\overset{(c)}}}{\overset{(c)}}{\overset{(c)}}{\overset{(c)}}}{\overset{(c)}}{\overset{(c)}}}{\overset{(c)}}{\overset{(c)}}}{\overset{(c)}}{\overset{(c)}}}{\overset{(c)}}{\overset{(c)}}}{\overset{(c)}}{\overset{(c)}}{\overset{(c)}}{\overset{(c)}}}{\overset{(c)}}{\overset{(c)}}{\overset{(c)}}{\overset{(c)}}$$

(b) 
$$\sum_{i=-N}^{-1} a_i \cos(i\omega_0) + \sum_{i=}^{N} a_i \cos(i\omega_0) + \sum_{i=-N}^{N} b_0 \sin(i\omega_0)$$

b) 
$$\sum_{i=-N}^{-1} a_i \cos(i\omega_0) + \sum_{i=}^{N} a_i \cos(i\omega_0) + \sum_{i=-N}^{N} b_0 \sin(i\omega_0)$$

$$\lim_{\substack{\text{Image}\\\text{Input}}} \bigoplus_{\substack{\text{HPF}\\\text{UB}\\\text{UB}\\\text{UB}\\\text{UB}\\\text{UB}\\\text{UB}\\\text{UB}\\\text{UIput}}} (c) \left( \sum_{i=-N}^{-1} a_i \cos(i\omega_0) + \sum_{i=1}^{N} a_i \cos(i\omega_0) + \sum_{i=-N}^{N} b_0 \sin(i\omega_0) \right)^3$$

$$= \sum_{i=-3N}^{-1} \alpha_i \cos(i\omega_0) + a_0 + \sum_{i=}^{3N} a_i \cos(i\omega_0) + \sum_{i=3N}^{3N} b_0 \sin(i\omega_0)$$

$$\sin^3 \theta = \frac{3}{4} \sin \theta - \frac{1}{4} \sin 3\theta \qquad \cos^3 \theta = \frac{3}{4} \cos \theta + \frac{1}{4} \cos 3\theta$$

#### The Nyquist Frequency



#### Two dimensional FFT result



Fig.10 The Enlarged and eliminated Image



Fig 12 The Image Processed with SC



Fig.11 Two Dimensional FFT Result of Fig.10



Fig.13 Two Dimensional FFT Result of Fig.12



Fig. 14 The Image Processed with The Proposed Method



Fig.15 Two Dimensional FFT Result of Fig.14



#### Real time HDTV-4K converter with SR



#### Parameter screen and the remote controller

### Conclusion

- Limitations of SRR for video was discussed
- The new signal processing method was proposed
- It can create higher frequency elements than the Nyquist frequency
- It is a simple algorithm and does not need frame memories and iterations
- It works in real time

# Thank You !

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