



# Strain Variation for B-Mode Image

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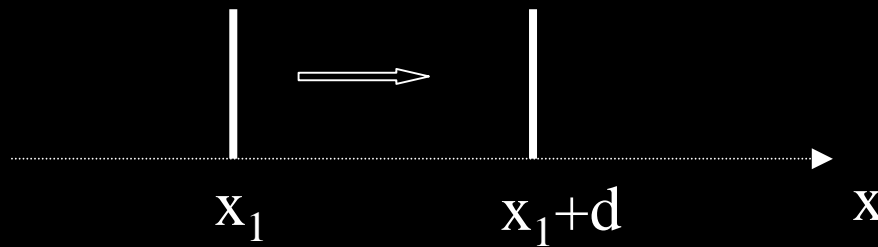
# Previous Work

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- Improve Speckle Tracking Correction
  - Block Size
  - Multi-Level Speckle Tracking Correction
- Improve Elastic Image Resolution
  - Strain
  - Shorten、Elongation
  - Direction

# Displacement and Strain

- Strain



$$S = \frac{\partial d}{\partial x}$$

- Our approach

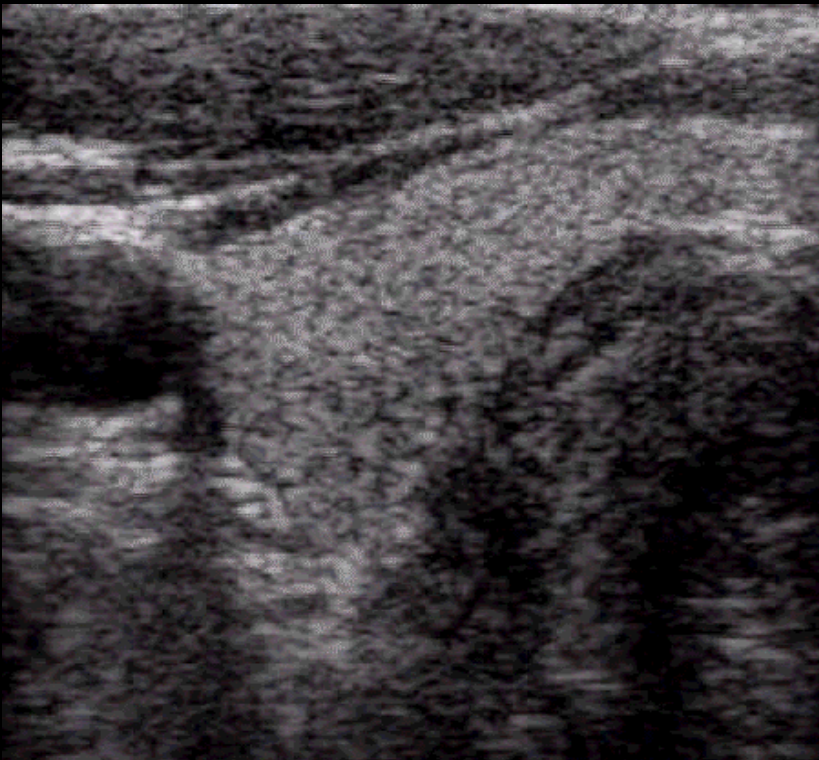


$$S = \frac{|d_1 - d_2|}{d_1}$$

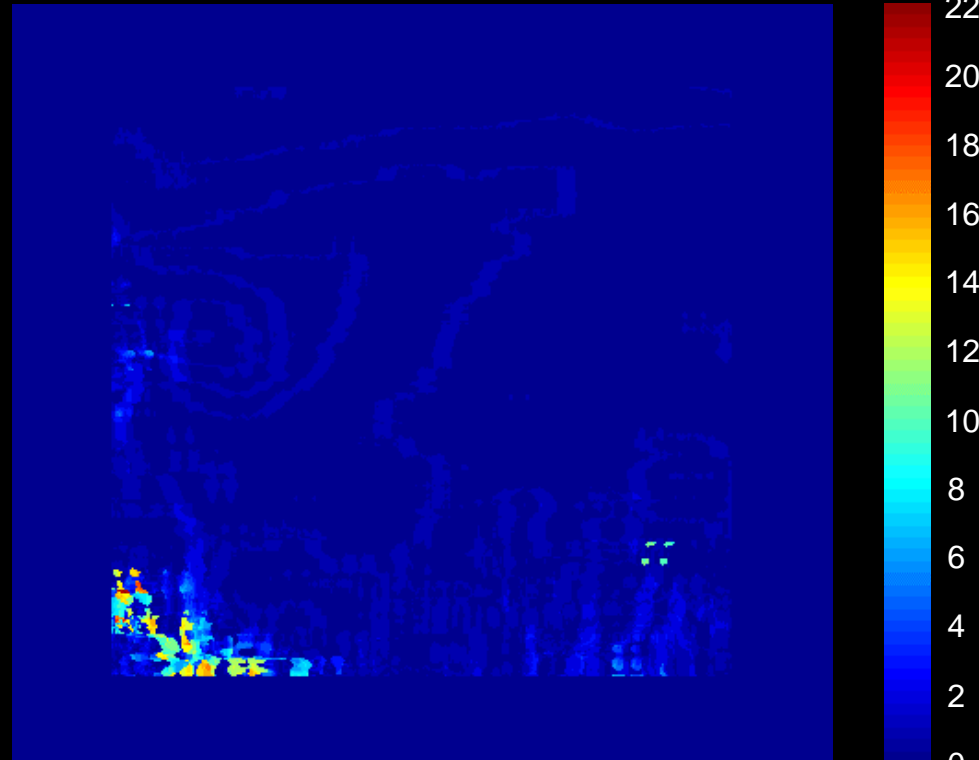
# Result

- Image Size : 450 X 450 pixels  
Block Size : 50 X 50 pixels

Thyroid Image



Strain Image



# Trade-Off

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- If **strain variation** between images is increased, speckle correlation is decreased and **speckle tracking correction** is decreased.
- If **strain variation** between images is decreased, speckle correlation is increased and **speckle tracking correction** is increased.

# Method

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- $nst_{13}$  (new speckle tracking between 1st and 3rd images) =  $st_{12} + st_{23}$
- $ost_{13}$  (original speckle tracking between 1st and 3rd images) =  $st_{13}$

1st



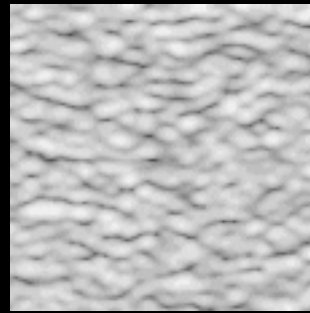
2nd



3rd

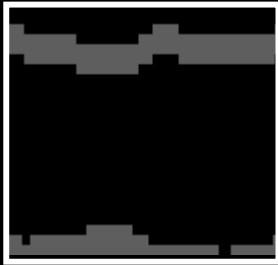


# Result

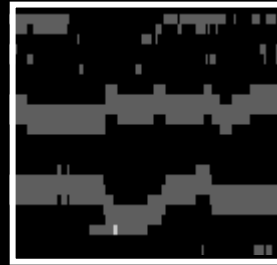


- Summation of strain with the 1% strain variation between 2 images.

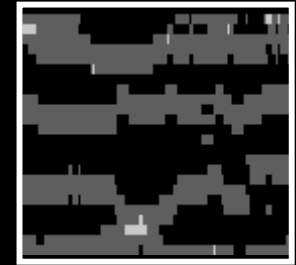
1-2



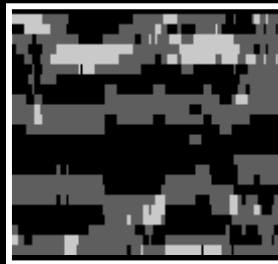
1-3=1-2+2-3



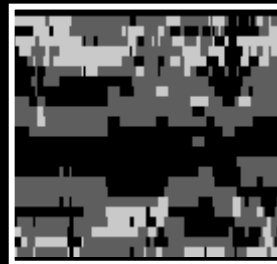
1-4=1-2+2-3+3-4



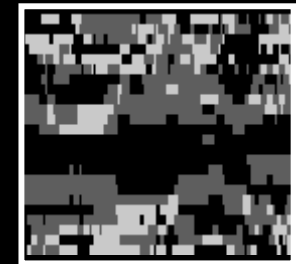
1-5=1-2+2-3+3-4+4-5



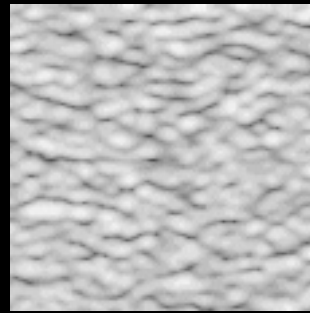
1-6=1-2+2-3+3-4+4-5+5-6



1-7=1-2+2-3+3-4+  
4-5+5-6+6-7



# Result



- Summation of strain with the 2% strain variation between 2 images.

1-3



1-5=1-3+3-5



1-7=1-3+3-5+5-7



- Summation of strain with the 3% strain variation between 2 images.

1-4



1-7=1-4+4-7

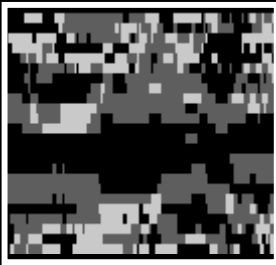




# Result

Summation of strain with the **1%** strain variation between 2 images.

$$1-7=1-2+2-3+3-4+4-5+5-6+6-7$$



Summation of strain with the **2%** strain variation between 2 images.

$$1-7=1-3+3-5+5-7$$



Summation of strain with the **3%** strain variation between 2 images.

$$1-7=1-4+4-7$$

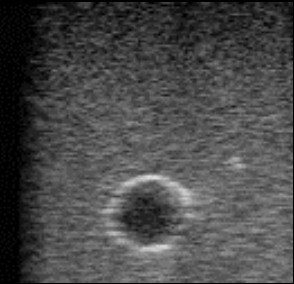


**No summation** of strain with the **6%** strain variation between 2 images.

$$1-7$$



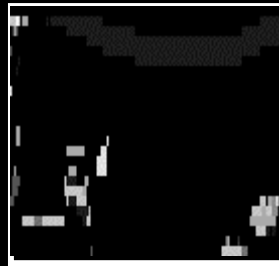
# Result (Breast Phantom)



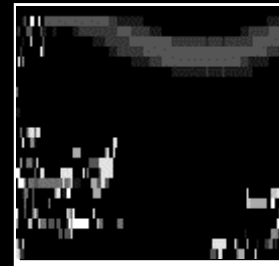
- Shorten  
1-2



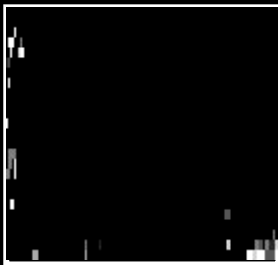
1-3



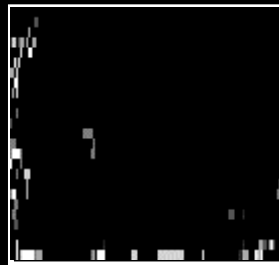
1-4



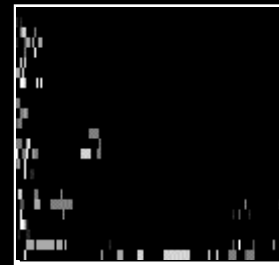
- Elongation  
1-2



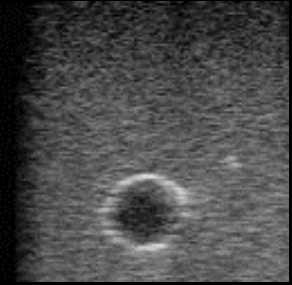
1-3



1-4

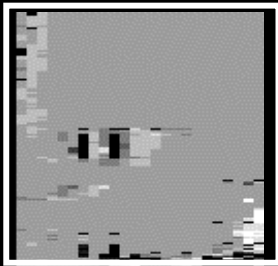


# Result (Breast Phantom)

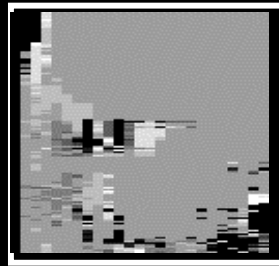


- X Direction

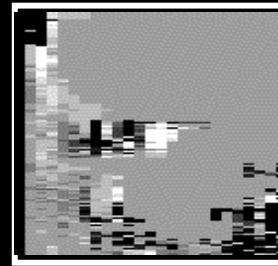
1-2



1-3



1-4



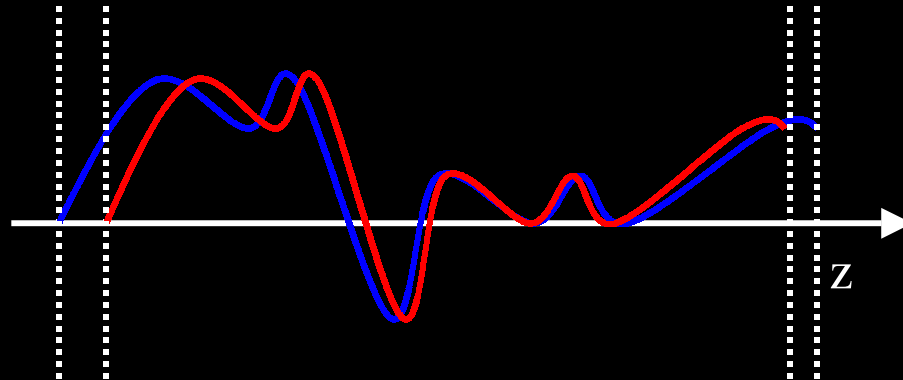
# FFT-based Speckle Analysis

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- 為了解決Speckle tracking所遭遇的問題：
  - Block size v.s. Resolution
  - Motion 量化誤差 v.s. 內插
  - Speckle移動距離 v.s. Speckle變形

# FFT-based Speckle Analysis

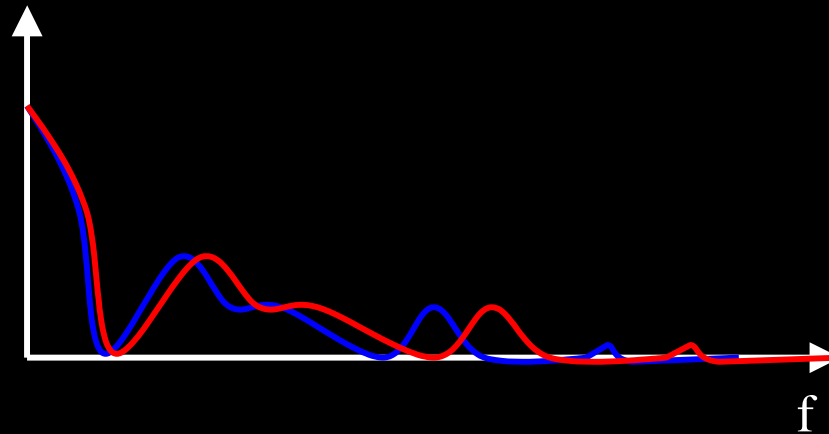
- 由頻域對B-mode影像進行分析
  - Z軸方向的一段組織反射信號



# FFT-based Speckle Analysis

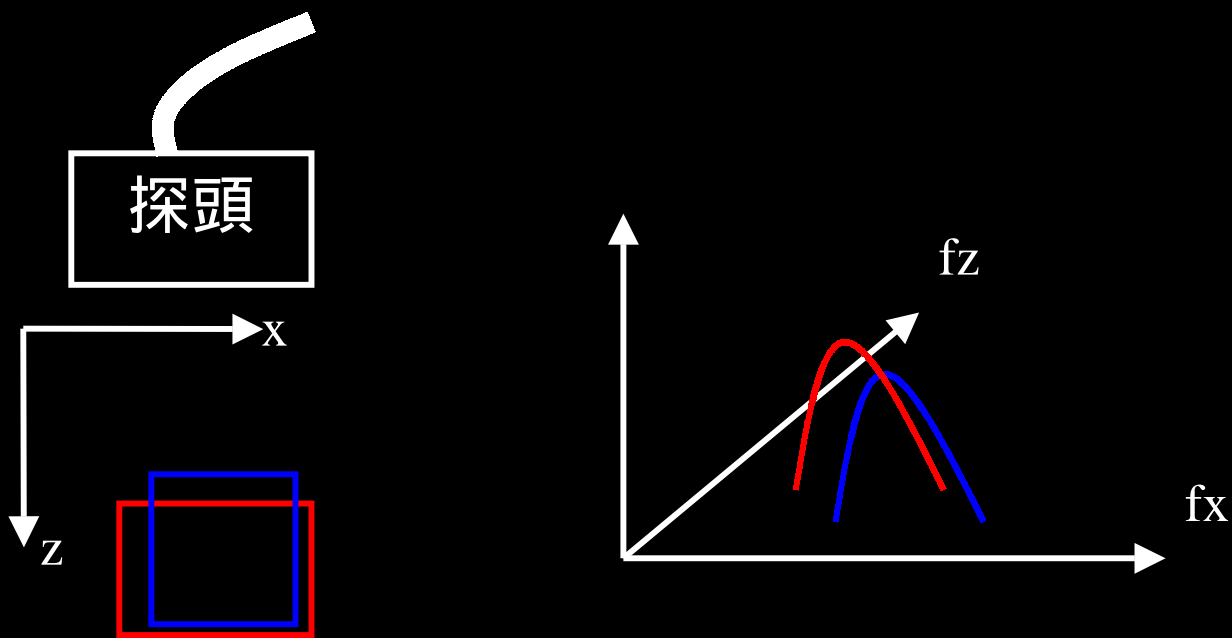
- 信號與系統理論：

- $a(z) \rightarrow A(\ )$   
 $a(kz) \rightarrow A(\ /k)$



# FFT-based Speckle Analysis

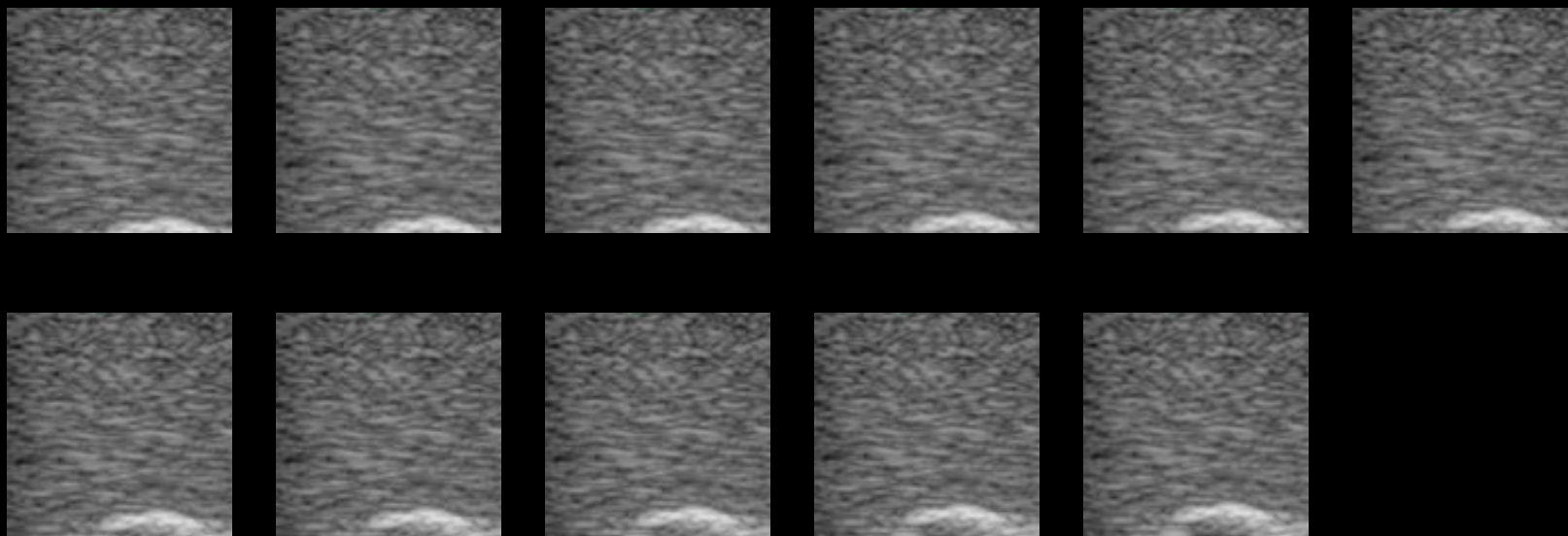
- 將此方法推廣至二維：



# FFT-based Speckle Analysis

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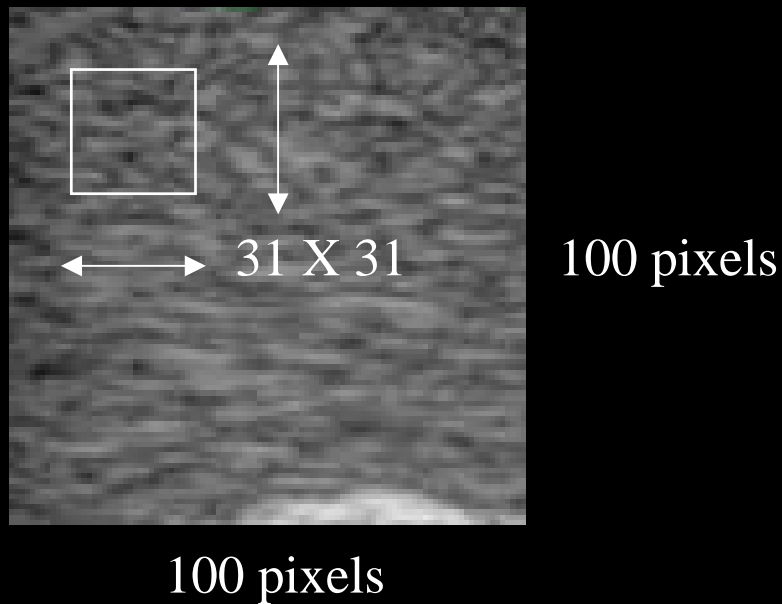
- 使用一系列以photoshop進行縮放調整之speckle影像進行模擬





# FFT-based Speckle Analysis

- 將每張影像取出31 X 31 pixels部分進行分析



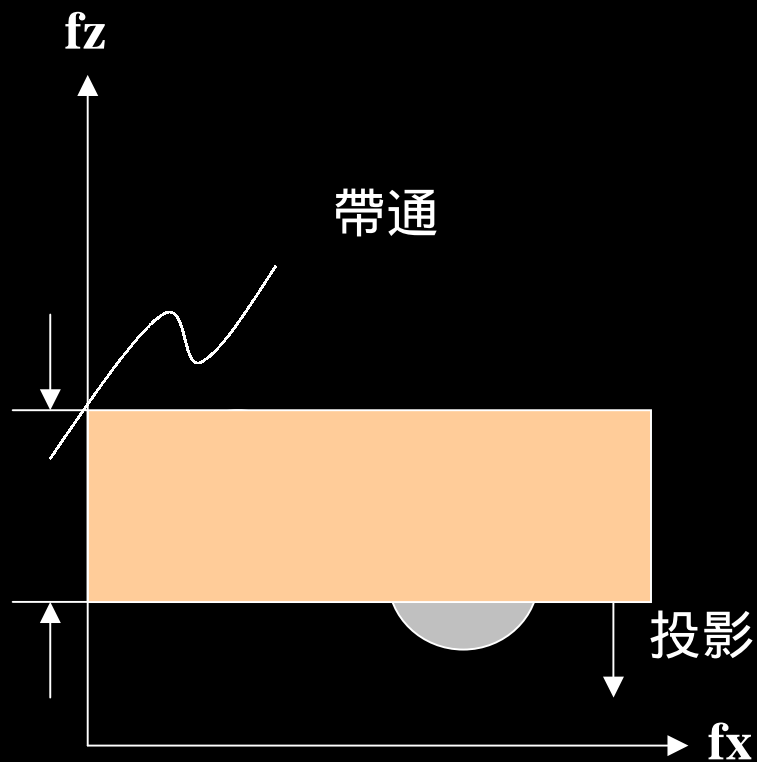
# FFT-based Speckle Analysis

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- 取hann window，進行128點二維富利葉轉換後，只保留正頻率之magnitude部分資訊。
- 將所得之頻域資訊，經過帶通、投影。

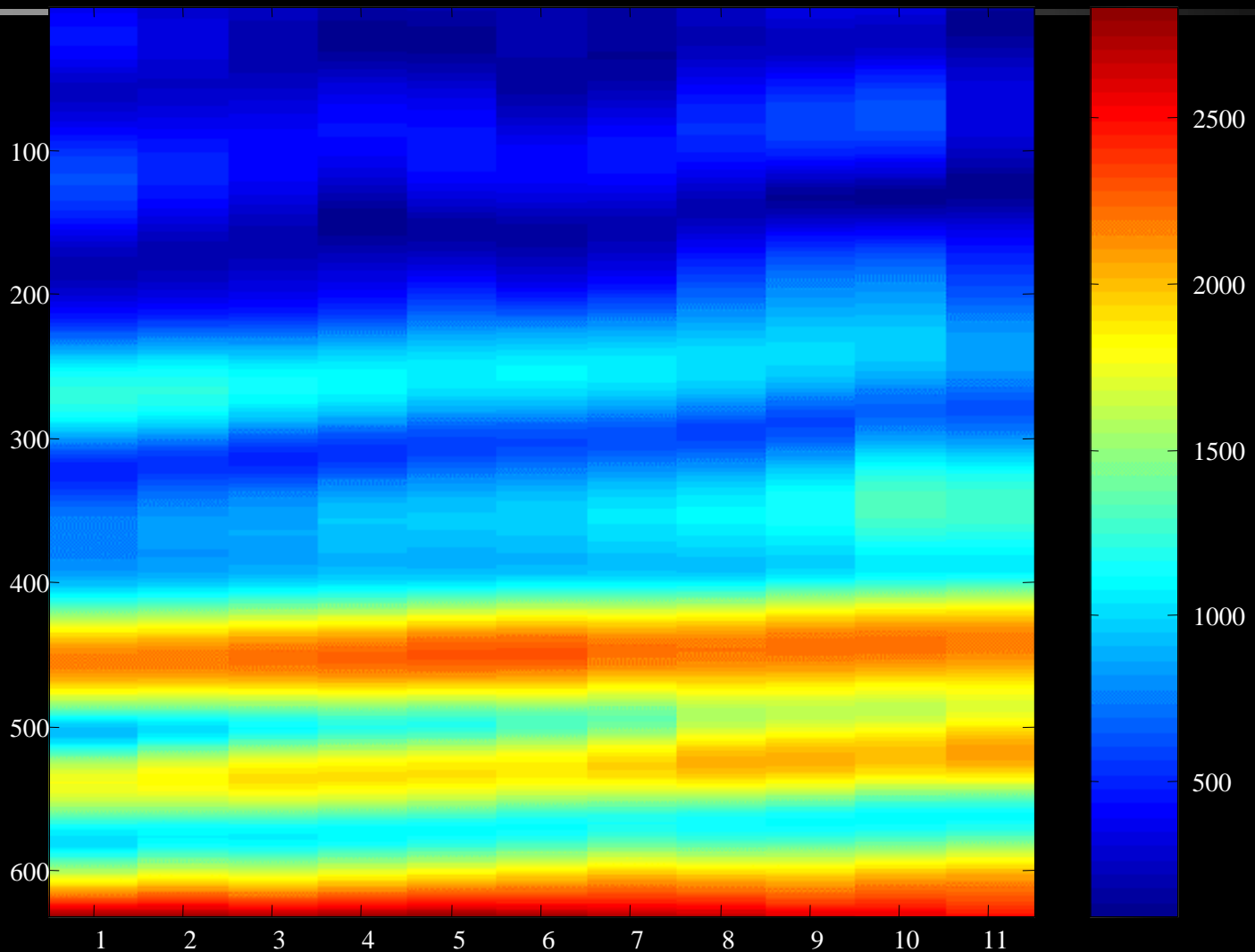
# FFT-based Speckle Analysis

- 用來分析相鄰frame之間，是否有頻率shift





# FFT-based Speckle Analysis



# FFT-based Speckle Analysis

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- 現階段模擬結果，印證最初之原理假設。
- 尚未考慮散射子重新分佈、雜訊。
- 需進一步設計定量分析的方法。
- 可配合既有之speckle tracking技術。