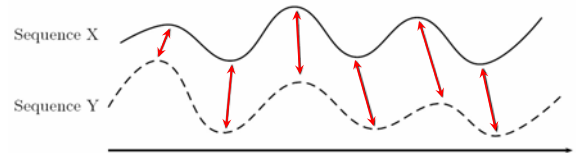


Lecture  
Music Processing

## Dynamic Time Warping

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## Alignment

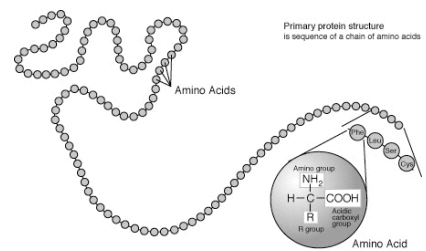


## Alignment



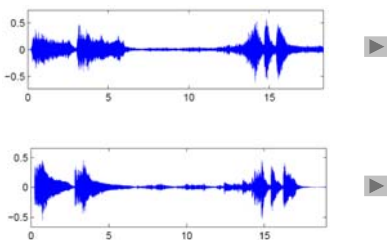
DNA = Sequence of Nucleotids

## Alignment



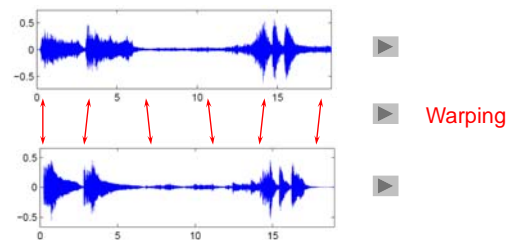
Protein = Sequence of Amino Acids

## Alignment



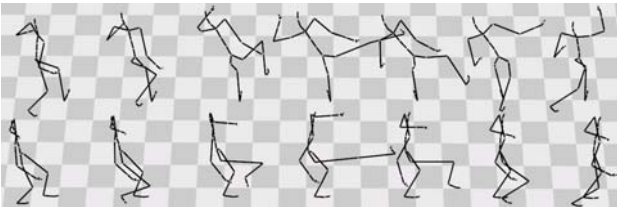
Music = Sequence of Audio Samples

## Alignment



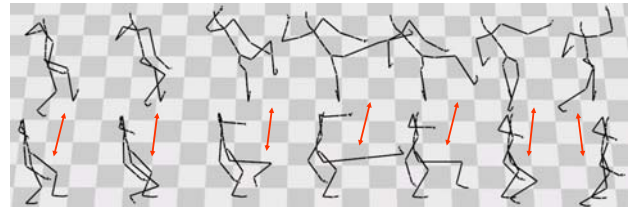
Music = Sequence of Audio Samples

## Alignment



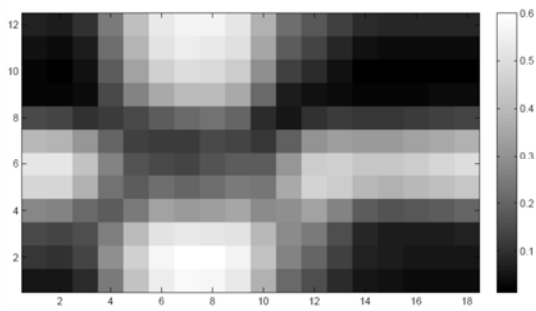
Motion = Sequence of Poses

## Alignment



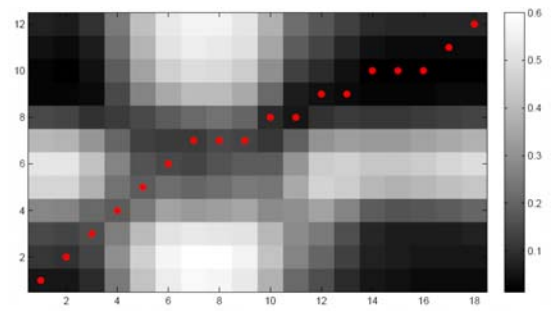
Motion = Sequence of Poses

## Cost Matrix

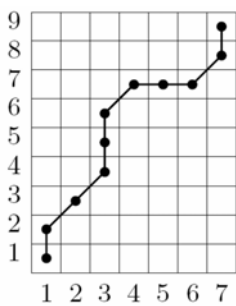


## Cost Matrix

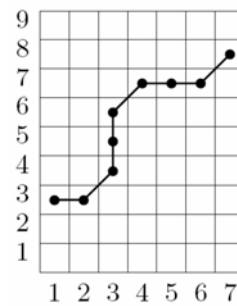
Cost-minimizing warping path



## Warping Path

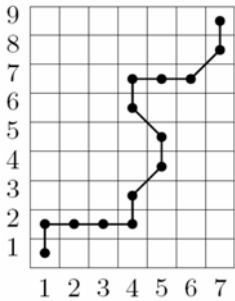


## Warping Path



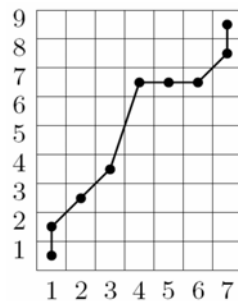
Violation of Boundary Condition

### Warping Path



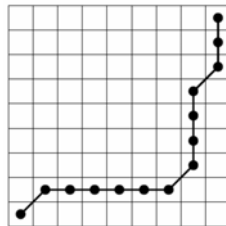
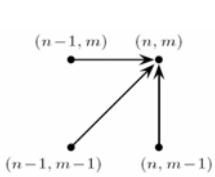
Violation of Monotonicity Condition

### Warping Path

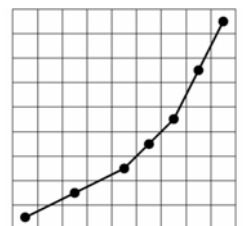
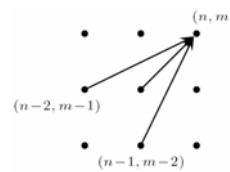


Violation of Step Size Condition

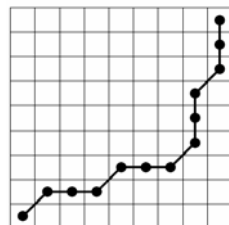
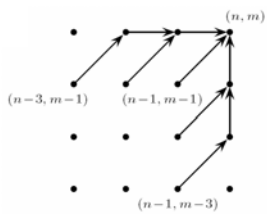
### Variation of Step Size Condition



### Variation of Step Size Condition

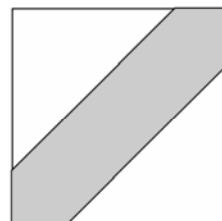


### Variation of Step Size Condition

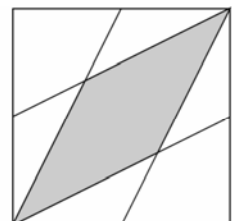


### Strategy: Global Constraints

Sakoe-Chiba band



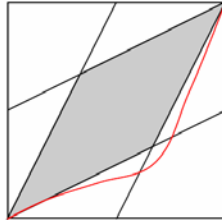
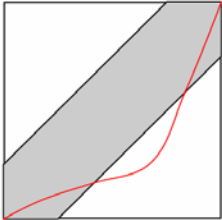
Itakura parallelogram



### Strategy: Global Constraints

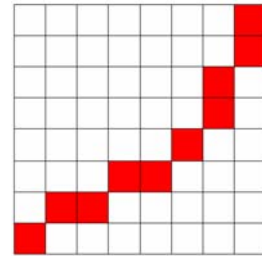
Sakoe-Chiba band

Itakura parallelogram



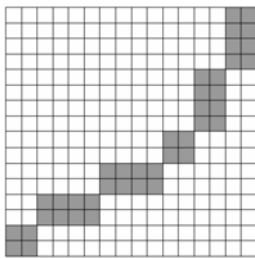
Problem: Optimal warping path not in constraint region

### Strategy: Multiscale Approach



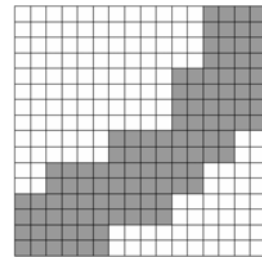
Compute optimal warping path on coarse level

### Strategy: Multiscale Approach



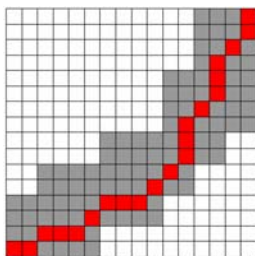
Project on fine level

### Strategy: Multiscale Approach



Specify constraint region

### Strategy: Multiscale Approach



Compute *constrained* optimal warping path

### Subsequence DTW

