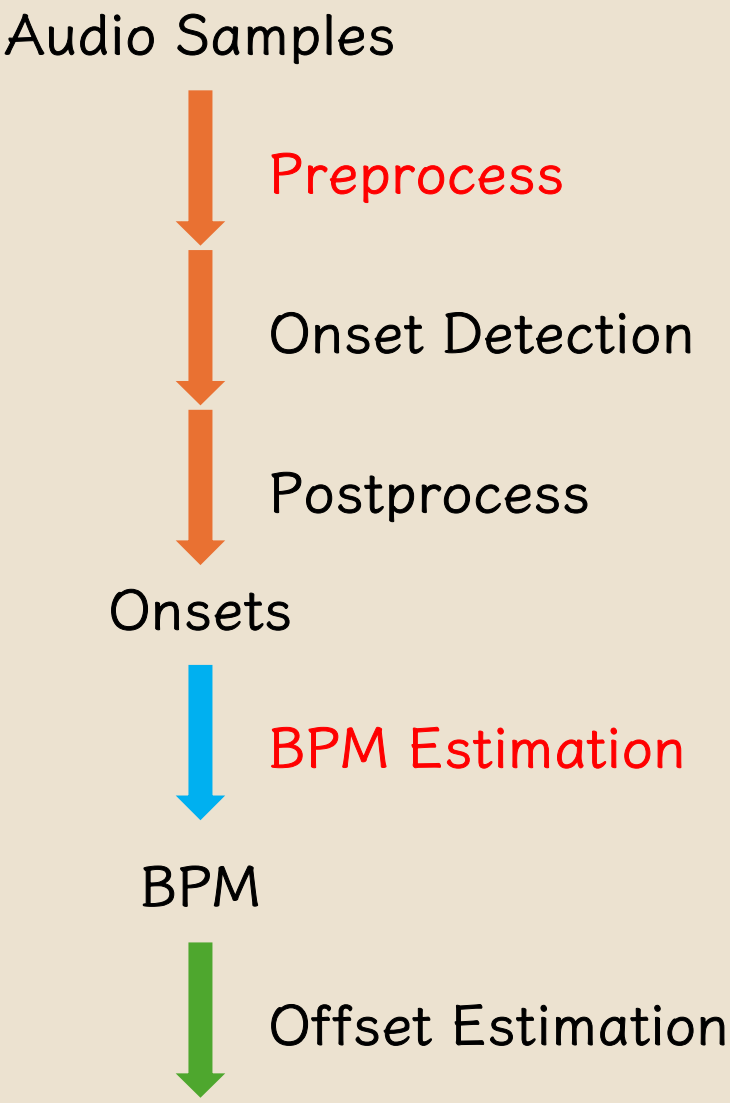
- CS Project Progress Report -

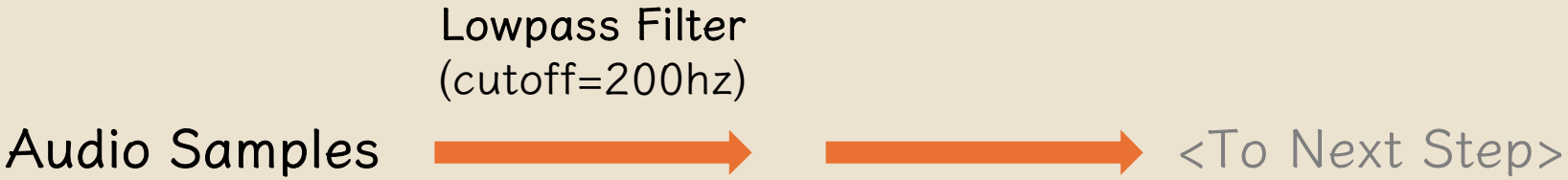
111550037 嚴偉哲

Process


Audio Samples
Preprocess
Onset Detection
Postprocess
Onsets
BPM Estimation
BPM
Offset Estimation

Preprocess – Lowpass Filtering

The feeling of beats is mainly made by drum sounds (Low Frequency)



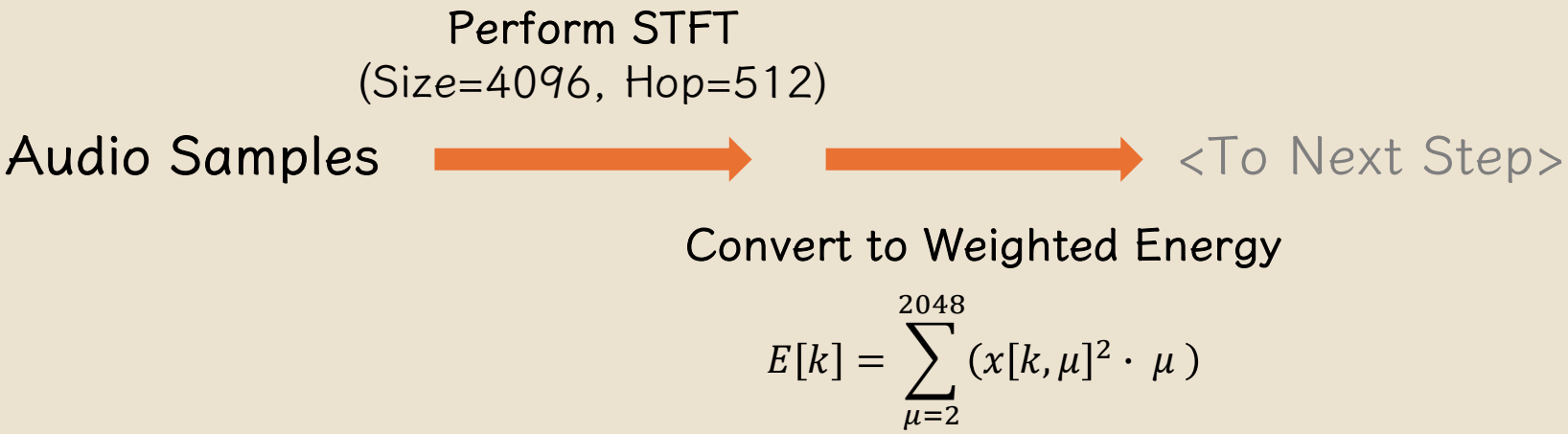
Convert to Instant Energy

$$E[i] = \frac{1}{512} \sum_{k=512i}^{512(i+1)-1} (x_L[k]^2 + x_R[k]^2)$$

https://archive.gamedev.net/archive/reference/programming/features/beatdetection/index.html

Preprocess – Weighted Energy

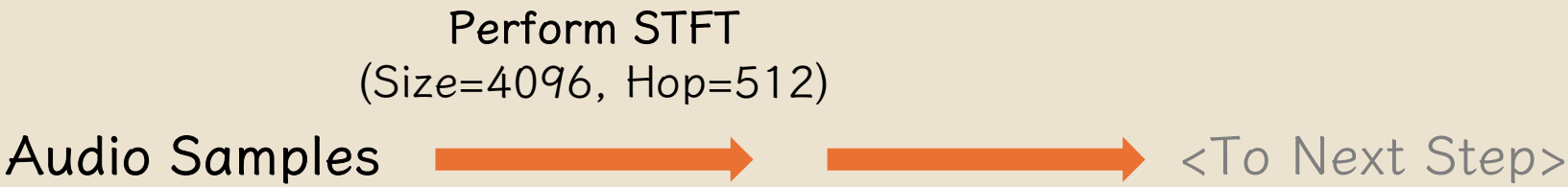
Make the energy biased towards the high frequency content



Masri & Bateman, Improved Modelling of Attack Transients in Music Analysis-Resynthesis, 1996

Preprocess – Percussivity

Percussion instruments have spectrum with rapid broadband onset

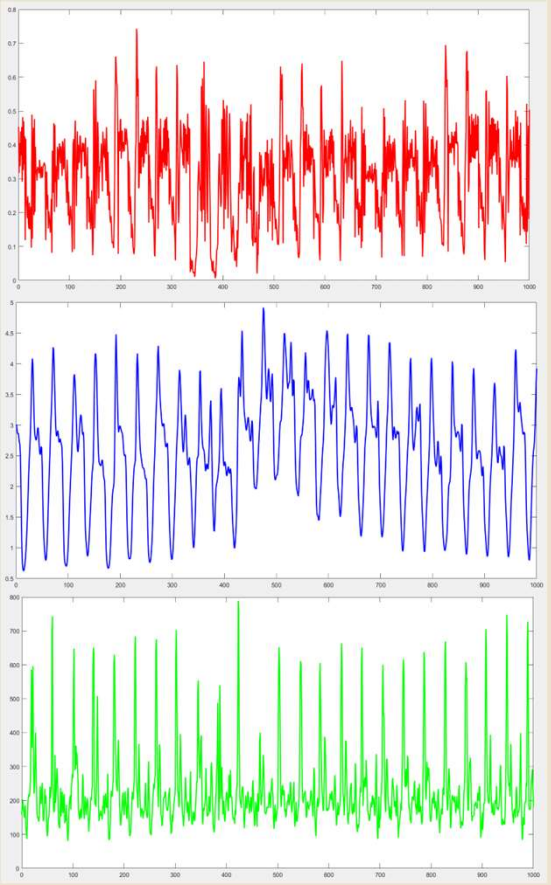


Compute Percussivity

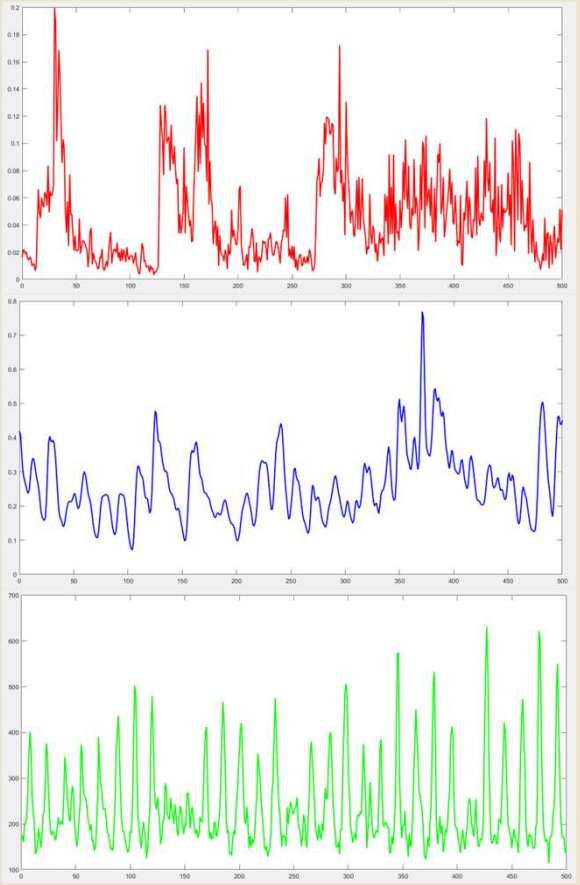
$$P[k] = \sum_{\mu=20}^{2048} \begin{cases} 1, & if \ \dfrac{|x[k,\mu]|}{|x[k-1,\mu]|} > 5 \\ 0, & otherwise \end{cases}$$

Barry et al., Drum Source Separation using Percussive Feature Detection and Spectral Modulation, 2005

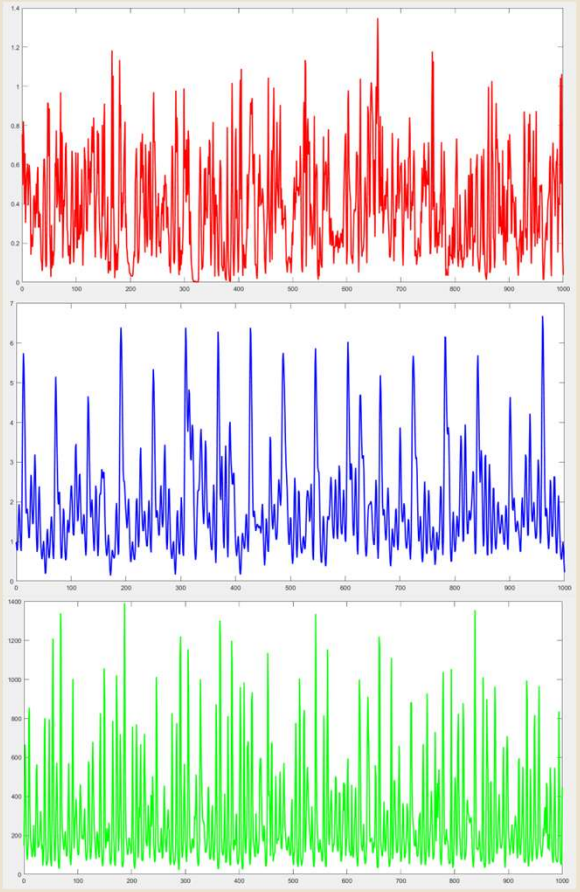
Preprocess – Comparison



Soda Sphere & PIKASONIC - Neverland



PYKAMIA - Fantasia Sonata Overdevil Concerto



Silentroom - Nhelv

Onset Detection

Use the 0.5 second samples' average (~43 instant blocks) as the reference

Simulate how we perceive sound intensity

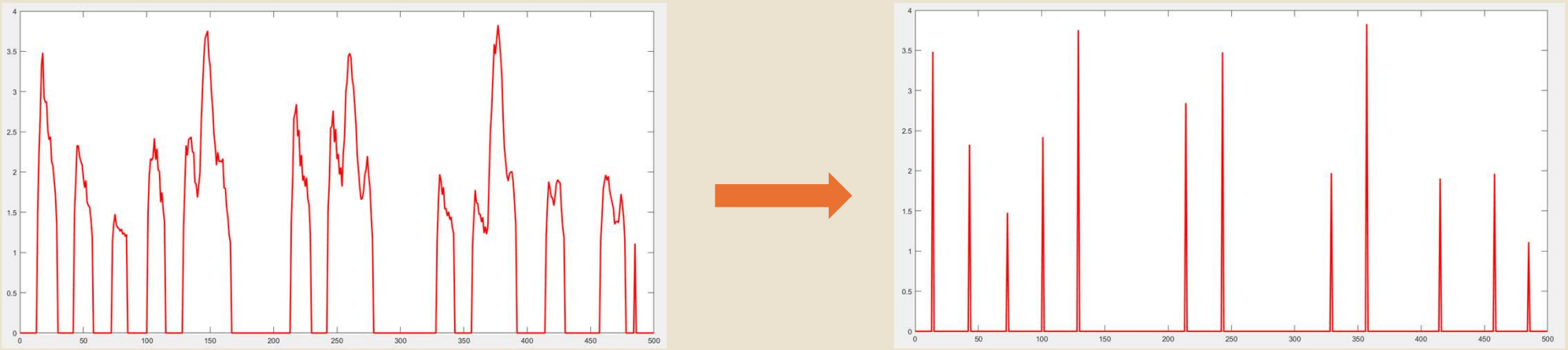
Compute Instant-to-Average Ratio

$$R[i] = \frac{E[i]}{\frac{1}{43}\sum_{k=i-4}^{i} E[k]}$$

Onset Detection – Cluster Removal

Slow / soft onsets (string / riser) or noise-like sound (cymbals / white noise) may trigger the detector multiple times and form clusters

Set a duration for closest two onsets possible and remove all except the first one



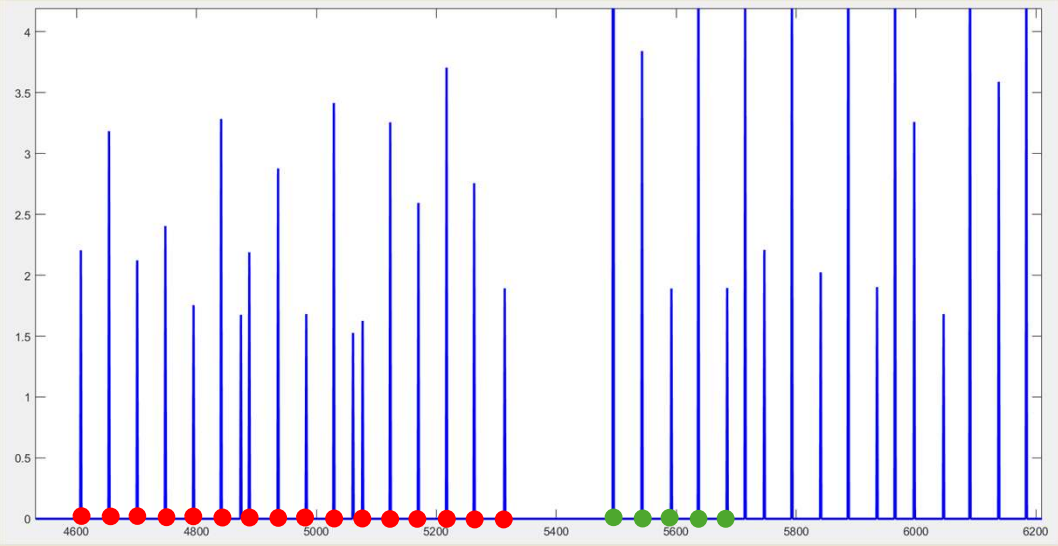
Rabbit House – Ad Astra Per Aspera
(Onset Resolution = 1/15 seconds)

BPM Detection

A comparison technique called pulse-train is used.

For every onsets, check the consecutive matched onsets with a target BPM (delay).

Longer onset chain would be rewarded with way higher score.

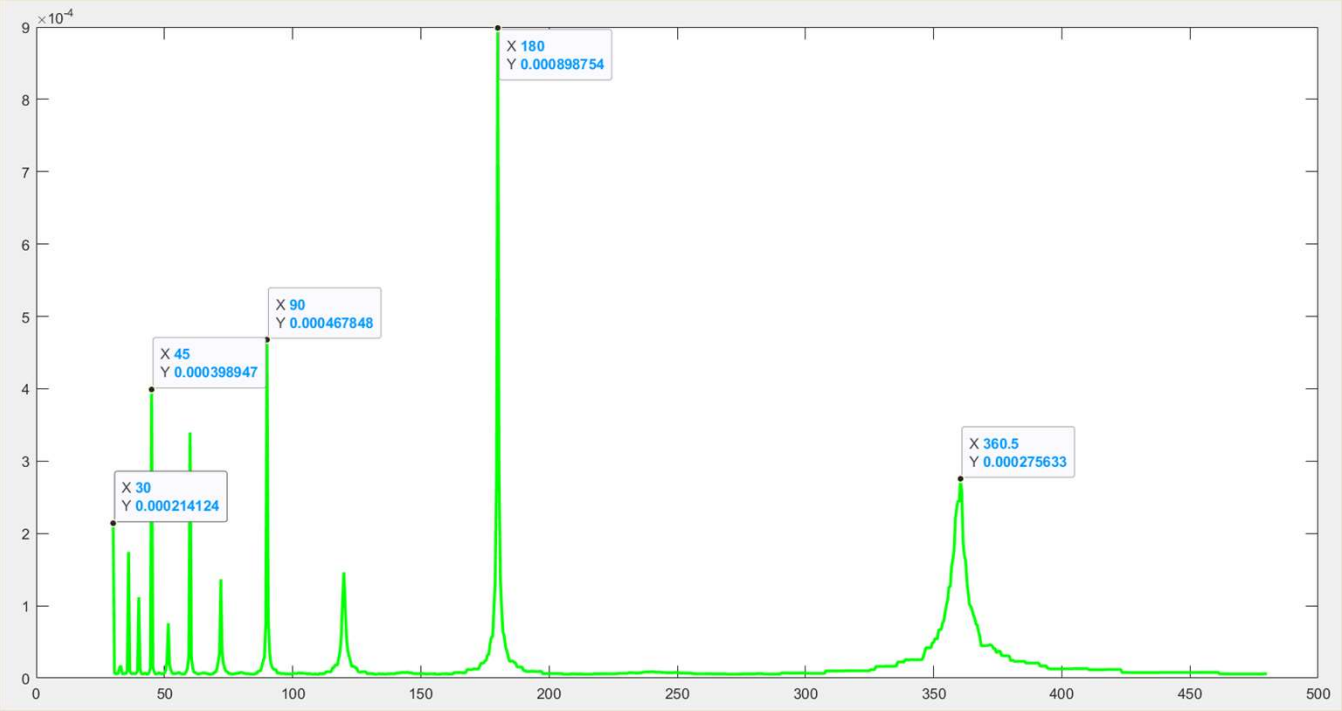


Creo - Shine

$$S(bpm) = \sum_{i=0}^{n} \left(\frac{Length\ of\ onset\ chain}{Total\ onsets} \right)^2$$

BPM Detection – Result

Once every BPM is tested, the one with the highest score is picked

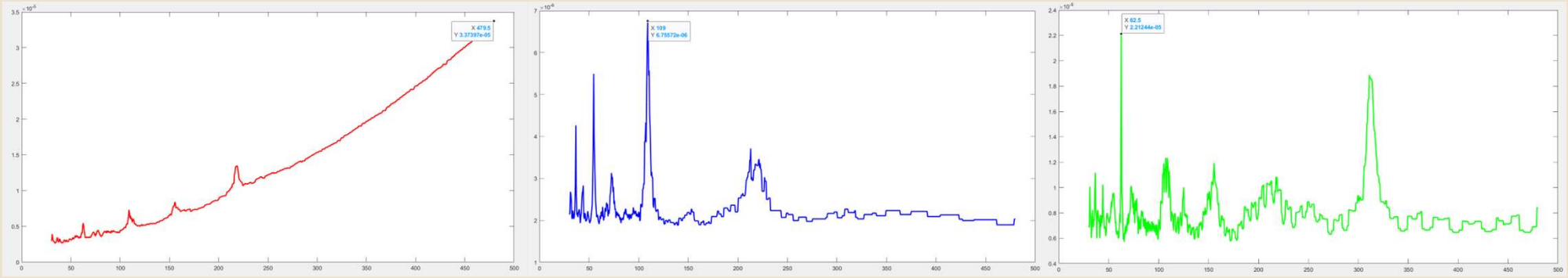


BPM estimation for **ARForest – Inverted World**

Notice that the BPM of the multiples of 180 are also spiked up

BPM Detection – Comparison

Three ways of preprocessing all have good performance, but using percussivity has the most accurate result overall.



BPM estimation for **LeaF – 弼** (125 BPM)

BPM Detection – Confidence

To know how sure the estimation is, I designed a formula to compute its confidence.

First, the peaks of the BPM estimation is extracted

Then, it use the harmonics of the **selected BPM**, and see the difference of the **harmonic BPM** and the closest **peak BPM**

Sum up the error and get the confidence score

Rocha et al., Segmentation and timbre- and rhythm-similarity in Electronic Dance Music , 2013