

A Beat Tracking System for Acoustic Signals of Music

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Outline

1. Introduction
2. Issues and Overview
3. Implementation and Results
4. Applications
5. Conclusion

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1. Introduction

□ What is Beat Tracking?

- track quarter notes
- just as people keep time to music by foot-tapping



□ Multimedia Applications

- Video editing systems
- Audio editing systems
- Stage lighting control
- Real-time computer graphics

No.3

□ Previous Systems

- MIDI-input systems
- Non-real-time audio-input systems
- Classical repertoire



MIDI



Audio

□ Our System

- Real-time audio-input system
- Complex sonic environment
- Popular music

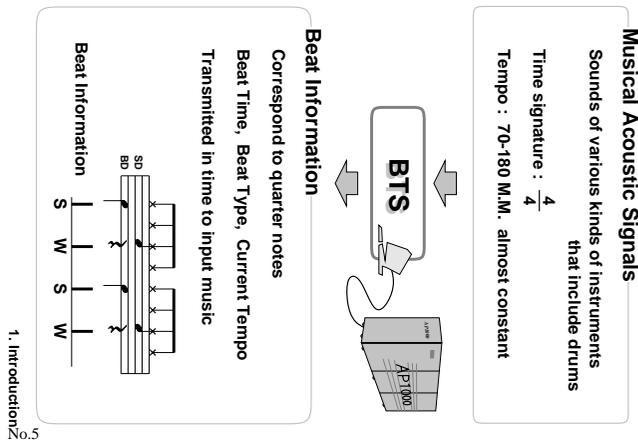


Audio

No.4

1. Introduction

□ BTS



No.5

2. Acoustic Beat-Tracking Issues

- Issues of Signal Processing
- Issues of Real-time Processing
- Issues of Musical Judgement

2. Acoustic Beat-Tracking Issues

No.6

□ Issues of Signal Processing

1. No specific sound directly indicates the position of beats

→ Manage Multiple Evidence

- Use onset times in several different frequency ranges
- Use onset times of two different instruments (Bass drum and Snare drum)
- Use onset loudness in addition to time



2. Acoustic Beat-Tracking Issues

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□ Issues of Signal Processing

2. Difficult to obtain precise onset times from complicated acoustic signals

→ Sophisticated Means of Estimating Onset Time

- Multiple interpretations of onset times
- Each assigned reliability

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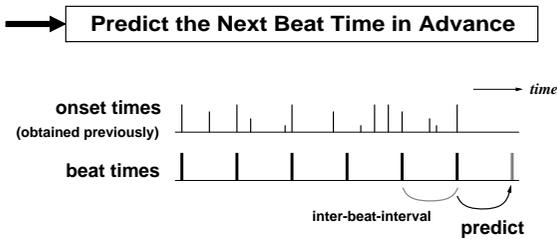
1. Introduction

No.8

2. Acoustic Beat-Tracking Issues

□ Issues of Real-time Processing

- 3. Only acoustic signals obtained previously are available to track beats in real time



2. Acoustic Beat-Tracking Issues

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□ Issues of Real-time Processing

- 4. BTS should be able to recover from tracking errors



- Manage multiple agents that track beats according to different strategies
- Each agent interprets onset times and makes hypothesis
- Generate BI on the basis of the most reliable hypothesis

2. Acoustic Beat-Tracking Issues

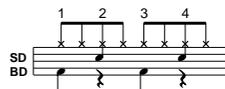
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□ Issues of Musical Judgement

- 5. Difficult to determine whether a beat is strong or weak



- Bass Drum (BD) on Strong beat
Snare Drum (SD) on Weak beat
- Particular BD or SD may be missing (e.g., Syncopation)
- Automatically acquire characteristic frequencies



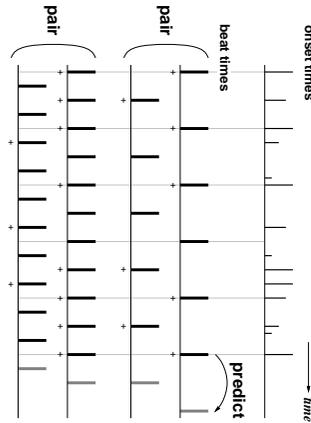
2. Acoustic Beat-Tracking Issues

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□ Beat Prediction

- 30 Agents predict the Next Beat in Parallel

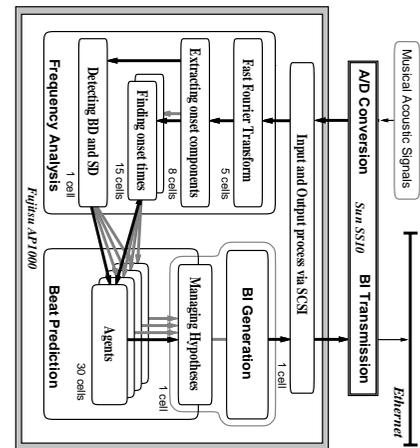
- Maintain hypotheses according to different strategies
- Evaluate reliability
- Select the most reliable hypothesis



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- Grouped into 15 pairs
- 2 agents in same pair predict cooperatively

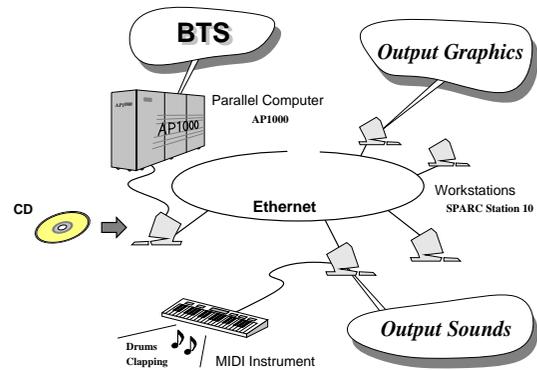
4. Implementation



- Distributed memory parallel computer AP1000
- 64 cells are divided into 8 groups
- Multiple parallelizing techniques

4. Implementation

□ System Configuration



4. Implementation

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5. Test Results

□ Conditions

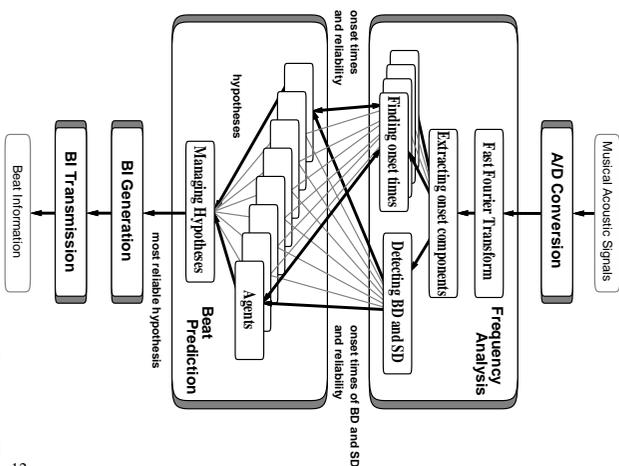
- 30 popular songs
- Monaural acoustic signal sampled from CD
- BD and SD usually on the strong and weak beats

□ Results

- Correctly tracked beats in 27 out of 30 songs in real time
- Efficacy of examining multiple hypotheses was confirmed

5. Experiments and Results

3. Overview of BTS

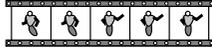


3. Overview of BTS

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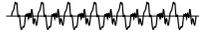
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6. Applications of BTS



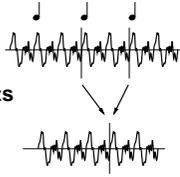
□ Video editing

- Synchronize visual track with musical beats
- Useful for creating MTV-style video

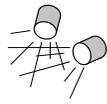


□ Audio editing

- Handle acoustic signals as a set of beats



□ Stage lighting control

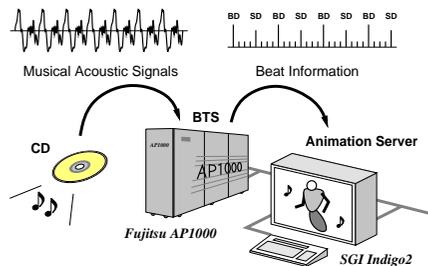


6. Applications of BTS

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□ Real-time computer graphics

- Create real-time CG synchronized with music
- Display a virtual dancer whose motion is changed with beats in real time



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7. Conclusion

- Track beats in acoustic signals
- Manage multiple beat-tracking agents
- Automatically learn characteristics of BD and SD
- Useful for various multimedia applications

7. Conclusion

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□ Future Work

- Reduce limitations on the input
- Recognize higher level musical events
- Apply to multimedia systems

7. Conclusion

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