

A Real-time Beat Tracking System for Audio Signals

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1995/09/04 ICMC 95

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Outline

1. Introduction
2. Issues and Solutions
3. System Description
4. Experimental Results
5. Conclusion

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1. Introduction

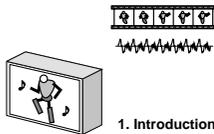
□ What is Beat Tracking?

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



□ Why is Acoustic Beat-Tracking Important?

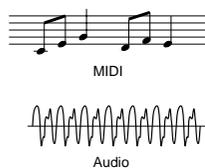
- Computational model of human music perception
- Multimedia applications
Video/Audio editing systems
Live performances
Real-time computer graphics



No.3

□ Previous Systems

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



□ Our System

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

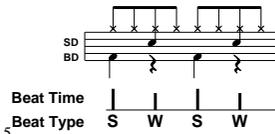
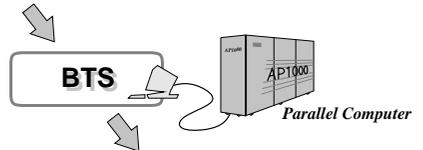


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□ BTS

Musical Acoustic Signals

Sounds of various kinds of instruments
that include drums
Time signature : $\frac{4}{4}$
Tempo : 65-185 M.M. almost constant



Beat Information

Correspond to quarter notes
Beat Time, Beat Type, Current Tempo
Transmitted in time to input music

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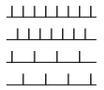
2. Issues and Solutions

- No specific sound directly indicates the position of beats
It is difficult to obtain precise onset times in audio

→ Multiple onset-time finders detect various cues

- Multiple interpretations of beats are possible
BTS should be able to recover from tracking errors

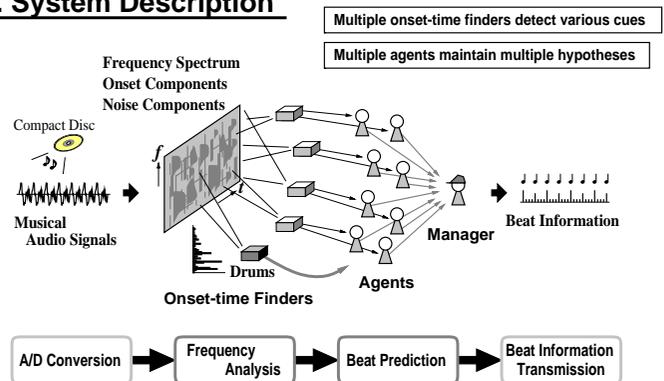
→ Multiple agents maintain multiple hypotheses



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2. Issues and Solutions

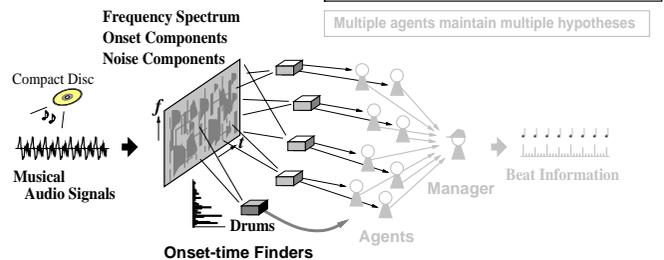
3. System Description



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3. System Description

□ Frequency Analysis



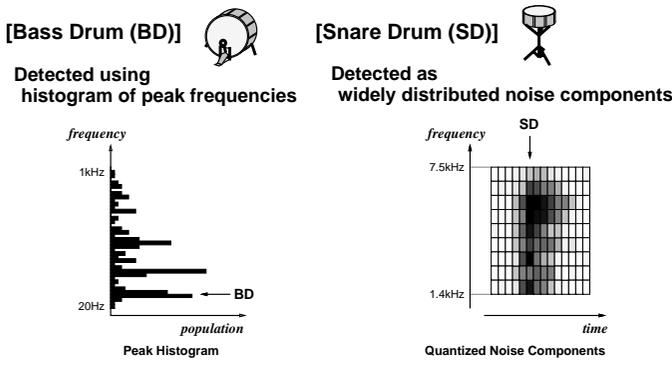
- Fourteen onset-time finders
detect onset times in different frequency ranges
with different levels of sensitivity
- One drum-sound finder
detects onset times of two drum instruments
(Bass drum and Snare drum)



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1. Introduction

• Drum-sound finder

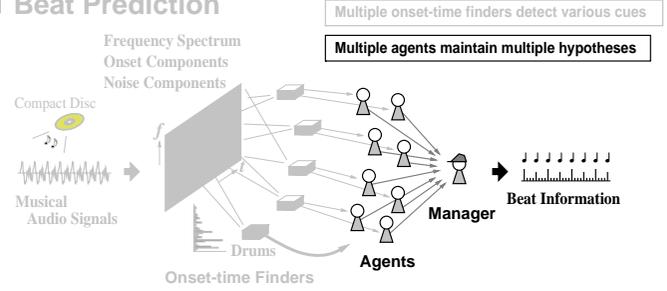


The detected drums are used only to label a beat time with its beat type

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3. System Description

□ Beat Prediction



- Twenty-eight agents track beats according to different strategies
- Manager generate beat information based on the most reliable hypothesis

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3. System Description

4. Experimental Results

□ Conditions

- 44 popular songs performed by 31 artists
- Tempo: 67 - 185 M.M. almost constant
- Eight pre-registered drum patterns

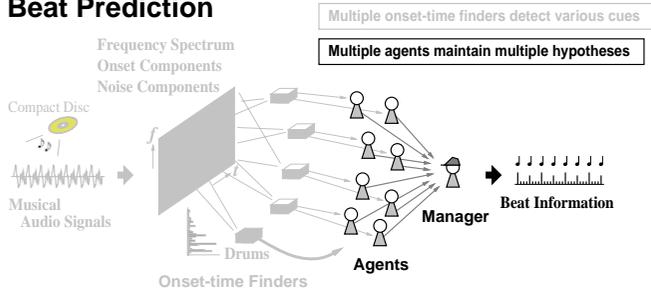
□ Results

- Correctly tracked beats in 42 out of 44 songs in real time
- Mistakes in two songs Half-tempo error Wrong beat type

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4. Experimental Results

□ Beat Prediction



- Twenty-eight agents track beats according to different strategies
- Manager generate beat information based on the most reliable hypothesis

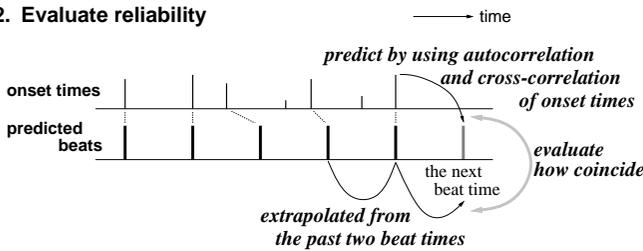
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3. System Description

□ Beat Prediction

• How to make a hypothesis

1. Predict beat time
2. Evaluate reliability



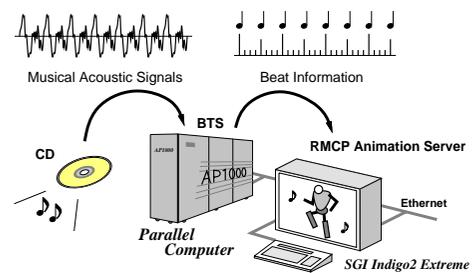
3. Infer beat type

3. System Description

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□ Digital Art Application with BTS

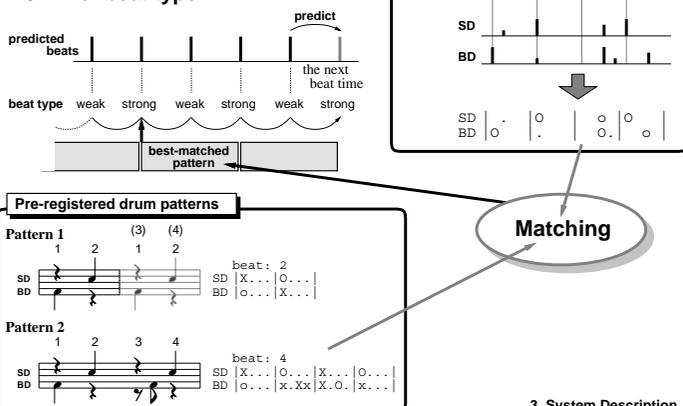
- Create real-time CG synchronized with music
- Display a virtual dancer "Cindy" whose motion is changed with beats in real time



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□ Beat Prediction

3. Infer beat type



3. System Description

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5. Conclusion

- Track beats in audio signals in real time
- Manage multiple beat-tracking agents
- Use drum patterns pre-registered as musical knowledge
- Robust enough to handle real-world audio signals

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5. Conclusion

□ **Future Work**

- **Upgrade our beat-tracking model**
to understand music at a higher level
to deal with other musical genres
- **Application to various multimedia systems**
for which beat tracking is useful