

# SCORE-PERFORMANCE MATCHING

JOHN ASHLEY BURGoyNE  
MUMT 611 · 1 MARCH 2007



# SCORE-PERFORMANCE MATCHING

---

- Goal is to perform accompaniment for a musical soloist automatically using MIDI or other synthesised instruments.
- Work began in 1984.
- In many ways – but not all! – is a solved problem now.



# OUTLINE

---

- challenges and applications
- early presentations
- recent work
- C. Raphael, 'Music Plus One'
- audio examples



# CHALLENGES AND APPLICATIONS

---

- two big challenges:
  - latency
  - real-time performance
- applications:
  - rehearsal opportunities for soloists
  - electro-acoustic performances
  - digital music stands



# CONNECTION TO TRANSCRIPTION

---

- (polyphonic) pitch detection
- onset detection
- metre and tempo detection
- expressive gestures



**SINFONIA  
CANTATA 12  
J.S. BACH**



# THE BEGINNING

---

- Barry Vercoe, ICMC 1984
  - listen – perform – learn
  - not implementable from paper
- Roger Dannenberg, ICMC 1984
  - string-matching approach
  - not implementable from paper



# MORE RECENT WORK

---

- Grubb & Dannenberg (ICMC '97 & '98)
  - estimate continuous PDF over time
- Cano, Locos, & Bonada (ICMC '99 & '00)
  - HMM-based system
- Schwarz (ICMC '05)
  - HMM that does not model signal



# MUSIC PLUS ONE

---

- Christopher Raphael (1999; 2001)
- inspired by Music Minus One
- mature, but still being developed
- prior knowledge:
  - complete score of both solo and accompaniment
  - real-time onset estimates from soloist



# SOLO MODEL

---

$$\begin{pmatrix} t_{n+1} \\ s_{n+1} \end{pmatrix} = \begin{pmatrix} 1 & l_n \\ 0 & 1 \end{pmatrix} \begin{pmatrix} t_n \\ s_n \end{pmatrix} + \begin{pmatrix} \tau_n \\ \sigma_n \end{pmatrix}$$

$$x_{n+1}^{\text{solo}} = A_n x_n^{\text{solo}} + \xi_n^{\text{solo}}$$



oboe

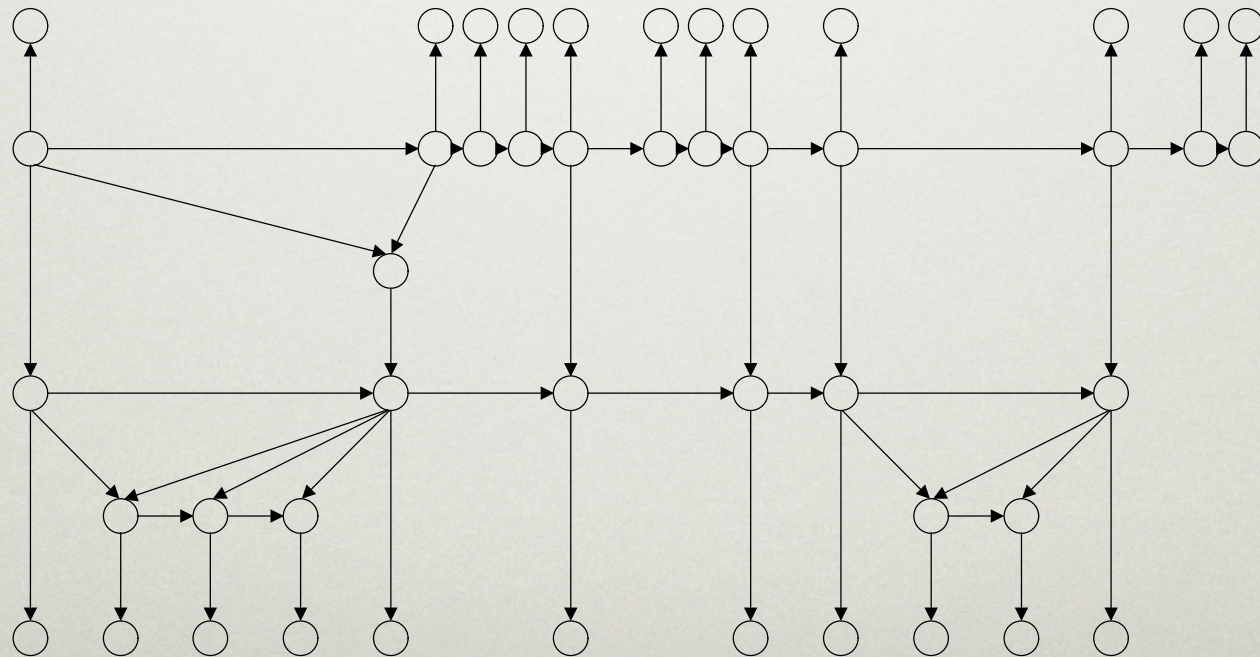
vln. 1

vln. 2

vla. 1

vla. 2

cont.





**SINFONIA  
CANTATA 12  
J.S. BACH**



REVERIE  
C. DEBUSSY



**FIRST MOVEMENT  
VIOLIN CONCERTO  
P. TCHAIKOVSKY**



# CONCLUSION

---

- In some situations – e.g., monophonic common-practice music – score-performance matching is solved.
- Challenges remain when polyphonic music must be tracked.
- Existing systems handle tempo only; what about dynamics and other expressive gestures?

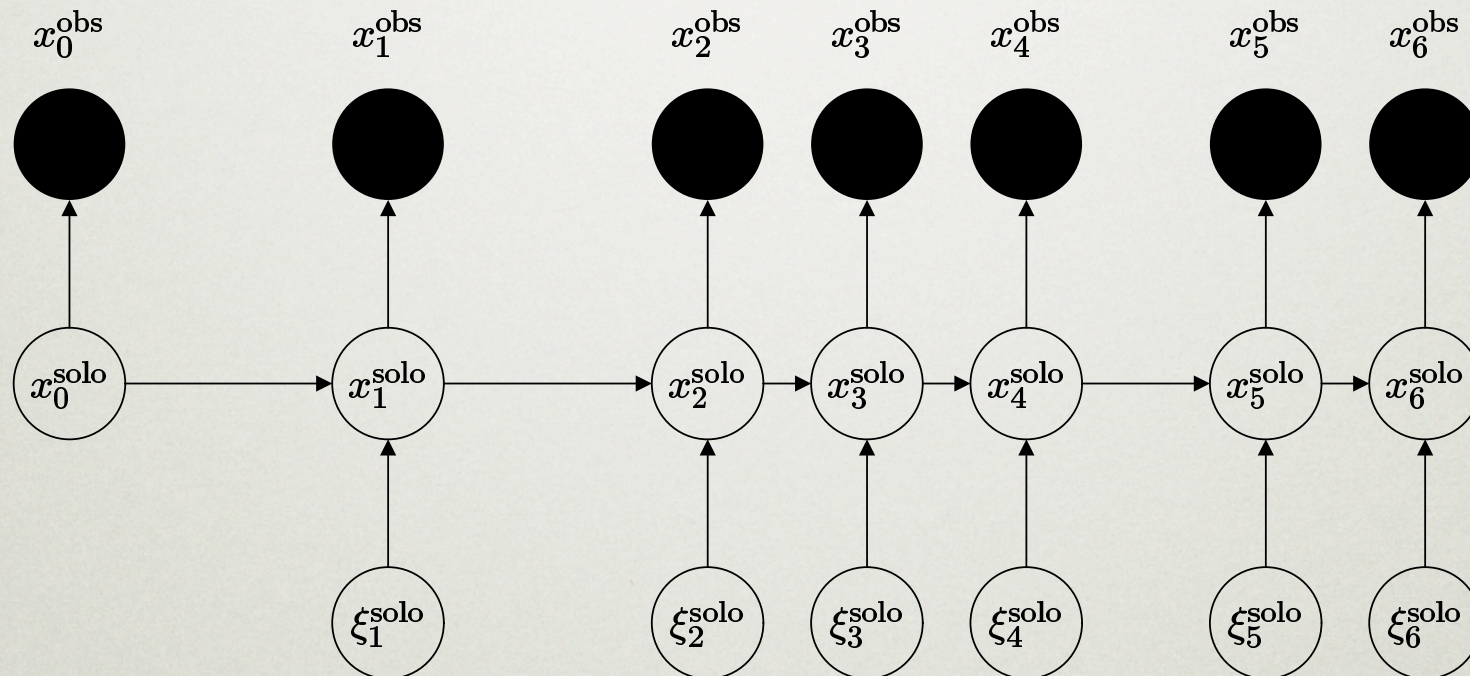


**EXTRA SLIDES**



# COMPLETE SOLO MODEL

---





# “PRACTICE ROOM” MODEL

---

$$x_{m+1}^{\text{accom}} = C_m x_m^{\text{accom}} + \xi_m^{\text{accom}}$$



# SANDWICHES

---

