Cartesian Product Label-Based Hierarchical Bottom-up Clustering for Game Rules Induction

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Agenda

- Introduction
- Methodology
- Dataset
- Experimental Setup
- Results
- ACASVA Link
- Future Work

Introduction

- Tennis and badminton games have a specific event structure based on labels
    - Game rules
        - Event Location (Left/Right, Near/Far)
        - Event Type (Serve/Hit/Bounce)
    - Events are combined in the form of Cartesian combinations
    - For Example
        - Game-play described like: SNL>BIF>HF>BIN>HN>BOF can be represented with minimal information as S>B>H>B>H>B or N>F>F>N>N>F based on whichever Cartesian combination chosen
- This in-turn forms levels for label-based delineations and are represented in the figure (1) showing an example topological structure
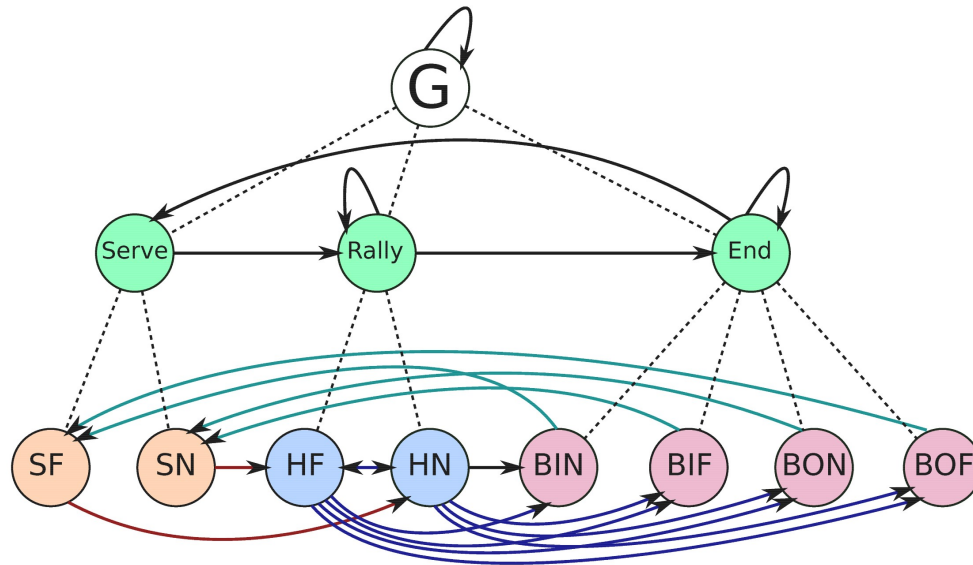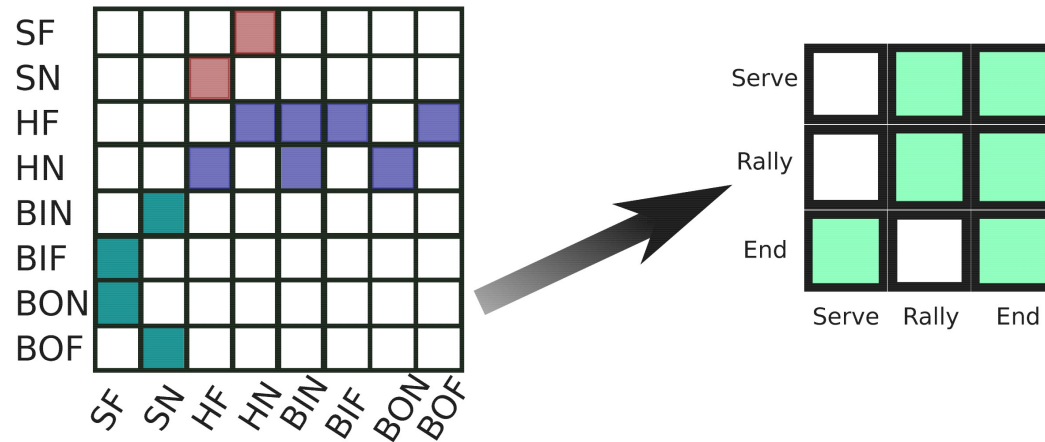
Introduction(2)

Figure 1

Methodology

- Hierarchical Hidden Markov Models are formed using different Cartesian combined event labels

- Count statistics are used for each level to compute transition probabilities for each state at each level

- Concept of Probability injection is introduced that takes in probabilities from the upper levels of the hierarchical structure to enrich the final transition probability matrix

$$Events = \left\{ \begin{array}{c} Serve \\ Hit \\ Bounce \\ Net \end{array} \right\}$$

$$Location_1 = \left\{ \begin{array}{c} Near \\ Far \end{array} \right\}$$

$$Location_2 = \left\{ \begin{array}{c} Left \\ Right \end{array} \right\}$$

$$Point = \left\{ \begin{array}{c} In \\ Out \end{array} \right\}$$

Methodology(2)

Tennis Events

Event	Description
SFR	Serve by Far player, Right side
SFL	Serve by Far player, Left side
SNR	Serve by Near player, Right side
SNL	Serve by Near player, Left side
BIF	Bounce Inside Far player's half court
BOF	Bounce Outside Far player's half court
BIN	Bounce Inside Near player's half court
BON	Bounce Outside Near player's half court
HF	Hit by Far player
HN	Hit by Near player
BIFSR	Bounce Inside Far player's Serve area on the Right
BIFSL	Bounce Inside Far player's Serve area on the Left
BOFS	Bounce Out of Far player's Serve area
BINSR	Bounce Inside Near player's Serve area on the Right
BINSL	Bounce Inside Near player's Serve area on the Left
BONS	Bounce Out of Near player's Serve area
NET	Bounce on NET

Badminton Events

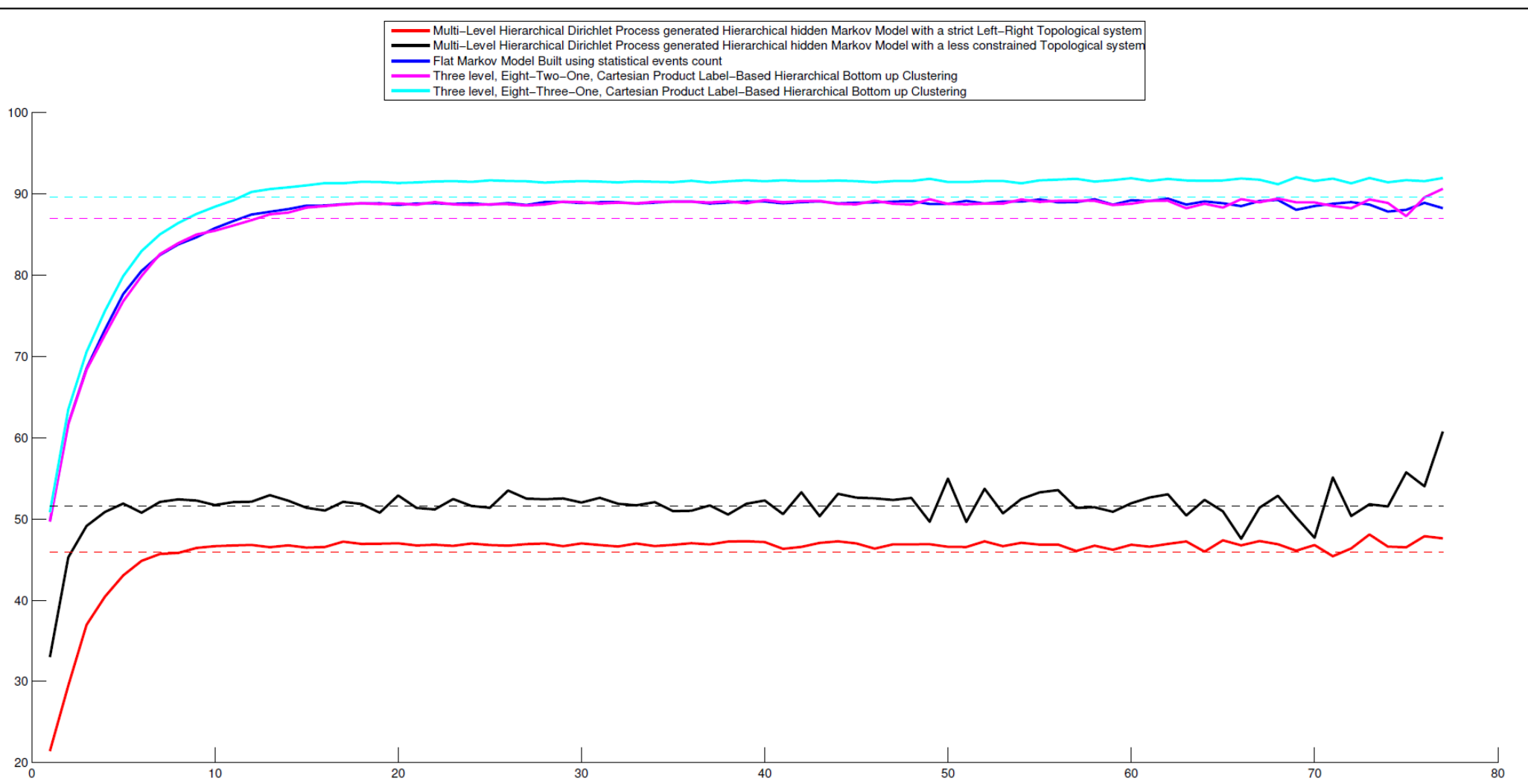| Event	Description
SF	Serve by Far player
SN	Serve by Near player
BIF	Bounce Inside Far player's half court
BOF	Bounce Outside Far player's half court
BIN	Bounce Inside Near player's half court
BON	Bounce Outside Near player's half court
HF	Hit by Far player
HN	Hit by Near player

Methodology(3)

- Topological structures are trained using a particular game sequence and tested on another sequence

- Predictive power of the method is tested given a particular sequence

- Cartesian Product label-based Hierarchical bottom-up Clustering shows improved results against the previously used flat Markov model and Multi-level hierarchical Dirichlet process
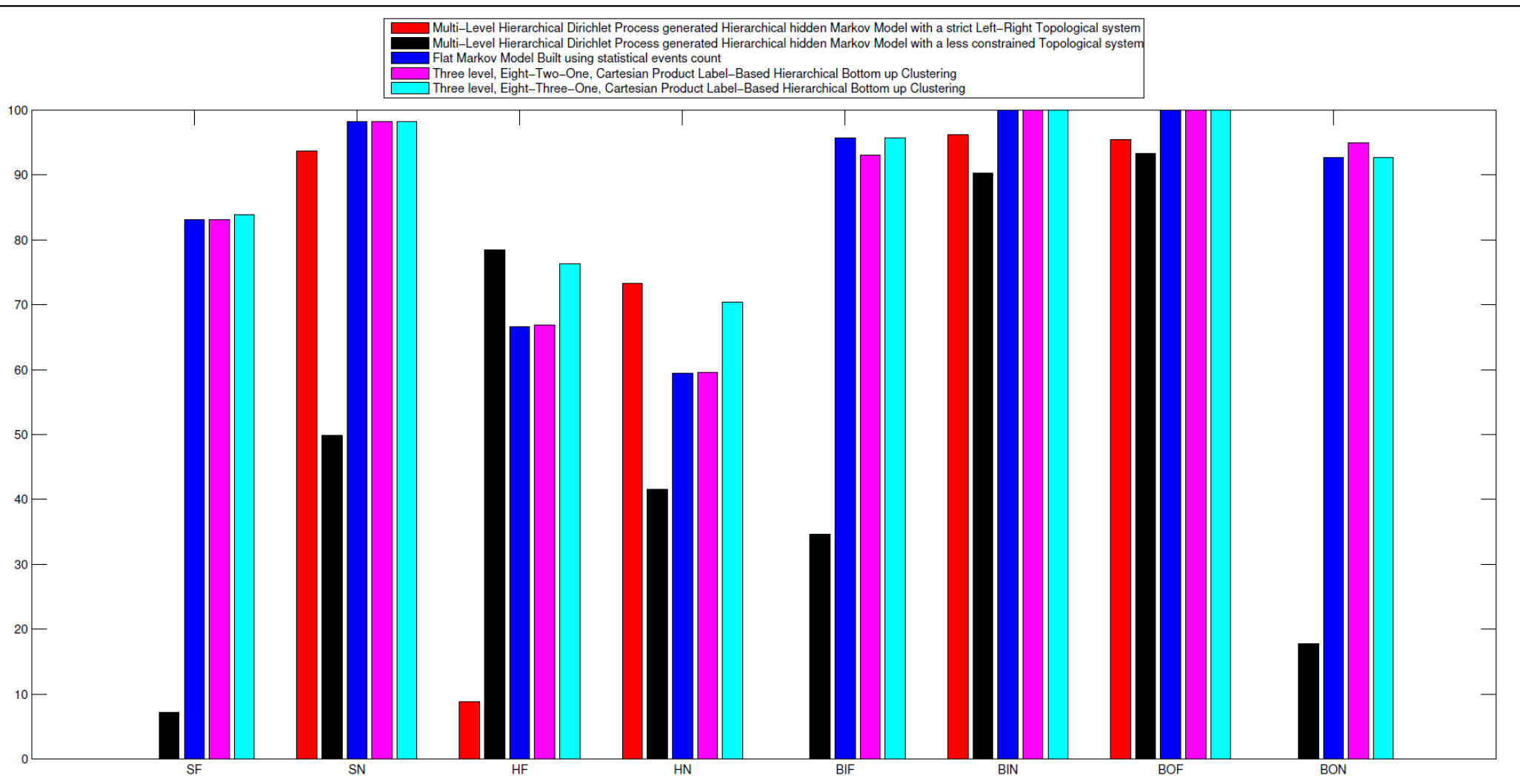
Datasets

- Badminton hand annotated events
  - BMSB08 (Train 80 Playshots, Test 20 Playshots)
- Tennis hand annotated events
  - TWSA03 (Train, 75)
  - TMSA03 (Test, 123)
- Tennis system generated events
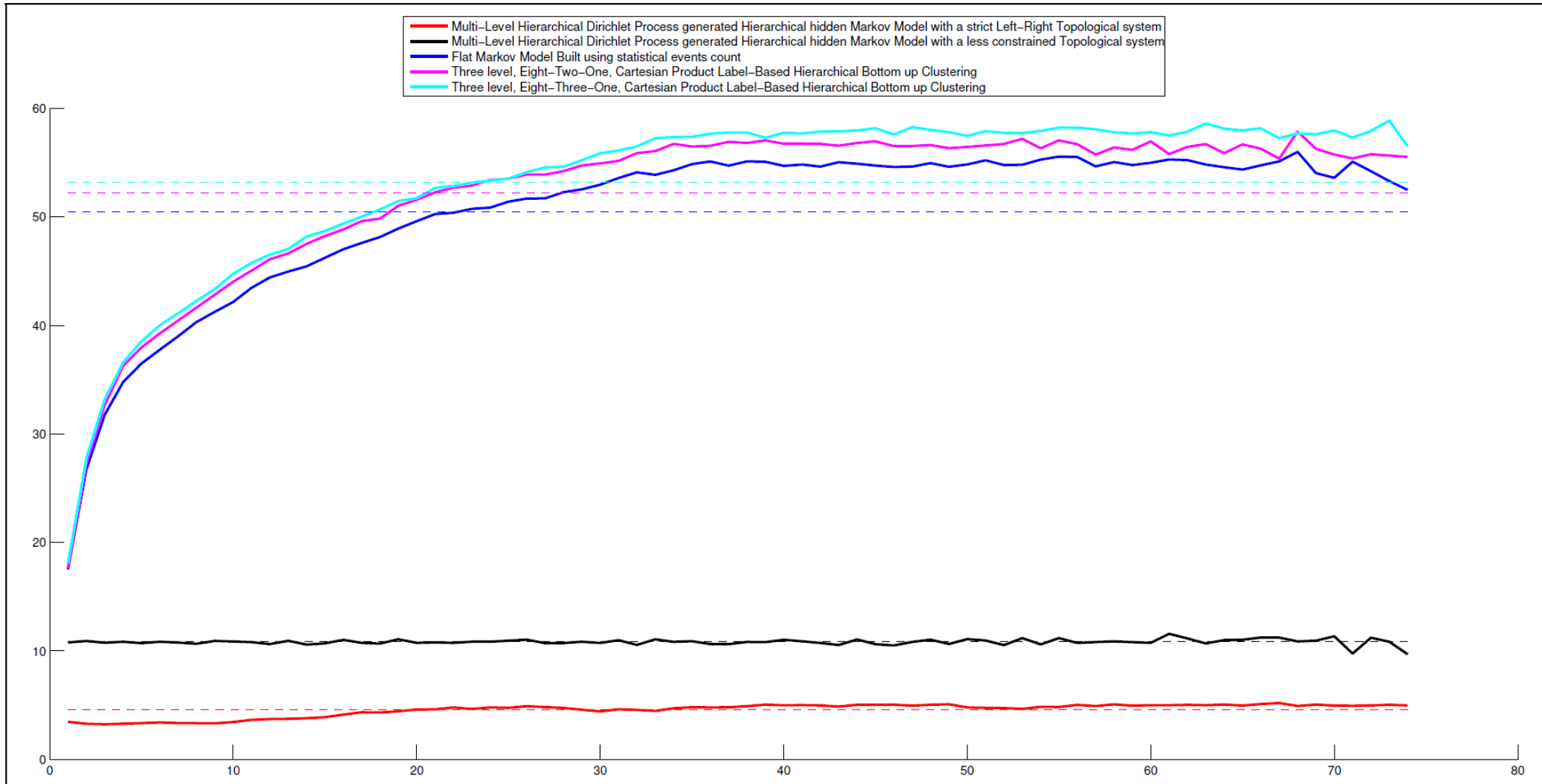 - Tennis Video Game (In progress)
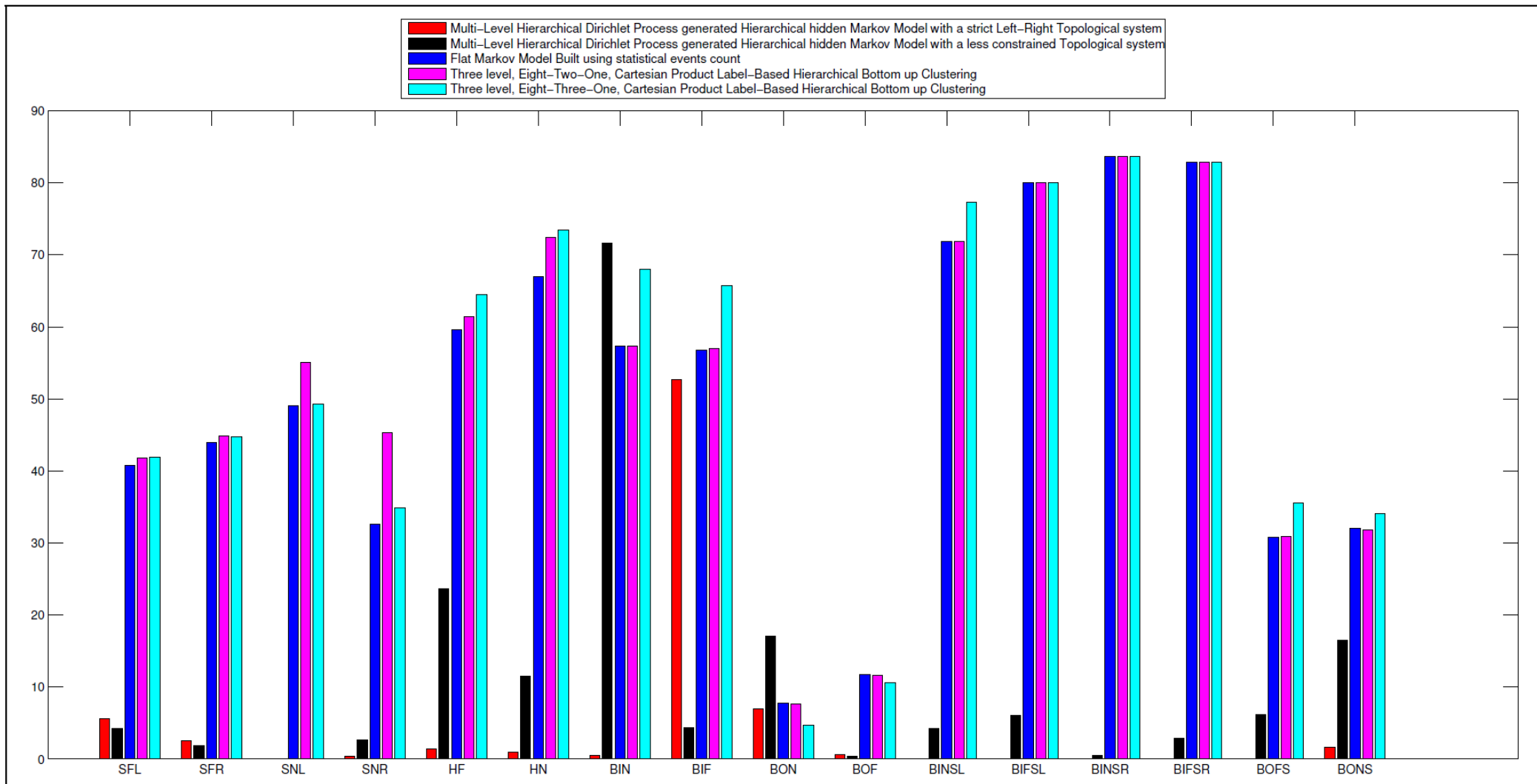
Results on Badminton Hand Annotated Data

Results on Badminton Hand Annotated Data

Results on Tennis Hand Annotated Data

Legend:
- Multi–Level Hierarchical Dirichlet Process generated Hierarchical hidden Markov Model with a strict Left–Right Topological system
- Multi–Level Hierarchical Dirichlet Process generated Hierarchical hidden Markov Model with a less constrained Topological system
- Flat Markov Model Built using statistical events count
- Three level, Eight–Two–One, Cartesian Product Label–Based Hierarchical Bottom up Clustering
- Three level, Eight–Three–One, Cartesian Product Label–Based Hierarchical Bottom up Clustering

Results on Tennis Hand Annotated Data

Results Summary

	Badminton Annotated	Tennis Hand Annotated	Tennis System Annotated
Flat Markov Model	86.96%	50.49%	-
ML-HDP Left-Right Topological Model	45.94%	4.57%	-
ML-HDP Relaxed Topological Model	51.63%	10.84%	-
Cartesian Product Label based Hierarchical Bottom-up Clustering (Near-Far Model)	86.94%	52.21%	-
Cartesian Product Label based Hierarchical Bottom-up Clustering (Serve-Rally-End Model)	89.62%	53.19%	-

ACASVA Link

- Main motivation of this work is to replace the HighLevel module of the current system that gives out the final event sequence

- With higher accuracy achieved, this will improve the final annotations of the annotating system

Future Work

- Immediate plan is to link the new method to the existing system

- Assess the performance on real data generated from the system

Questions???