Bayesian Approaches to Human motion Analysis and Synthesis based on Laban Movement Analysis

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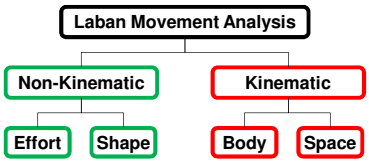
Overview

- This work explores the abstraction of a theoretical human motion descriptive language to develop a Bayesian model for motion analysis and synthesis beyond a pure mathematical representation.
- Explore the concepts of hierarchy and reversibility of Bayesian theory to develop a highly flexible, adaptive and scalable model.
- This study is divided in 3 major research blocks:
  - Bayesian formulation of the forward and reverse model

  - Explore different research scenarios emerging from the development of the core model (Laban Motion Analysis Model)
  - Probabilistic trajectory generalization characterized by special dynamic characteristics according to a "common" understanding of Laban syntax.

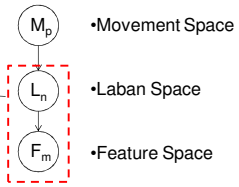
Laban Movement Analysis



- Divided in 2 main groups spreading into 4 different components, each describing a particular aspect of human motion.
- Laban component space emerges from *Labannotation* and is represented by a rich and intuitive syntax (e.g. *sudden* or *retreating)*

1. Bayesian Model Formulation

✓ **Hierarchic Structure**
✓ **Scalable**
✓ **Flexible**



- **Core Model**

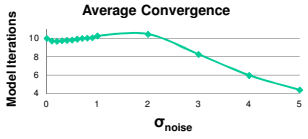
$$P(L_n \mid F_0 \bigcap ... \bigcap F_m) \propto P(L_n) \sum_{i=0:m} P(F_i \mid L_n)$$

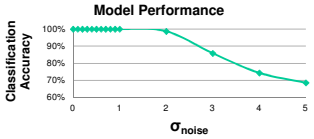
- **Gesture Sub-model (Scalability)**

$$P(M_t = q_i, M_{t+1} = q_j \mid \sigma AB\pi)$$

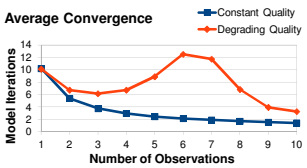
Model Performance

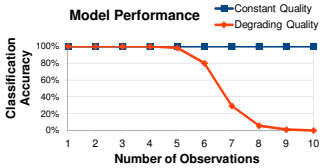
- Performance measured in convergence time and classification accuracy.
- Tested the model subject to the following conditions (**most relevant results**):
  - Input Noise (Signal subject to Gaussian noise of different variances)



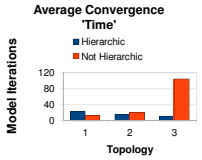


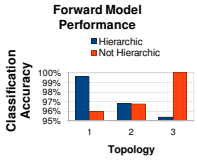
  - Feature cardinality and quality (Features are represented by Gaussian distributions and assume quality degrading with increasing variance)





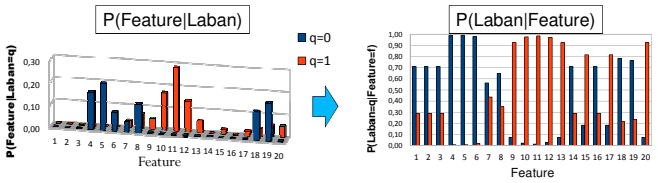
  - Topological Changes (Different hierarchies and node connectivity)





Reversibility

- Exploring Bayes symmetry property, we have inverted the learned occurrence matrices (Trained Analysis Probability Distributions) to reverse causality without the need to train a new synthesis model.



Experimental Results

- The database has currently 5 different actions, ranging from 20 to 25 performances each, divided between 3 to 5 different actors. Actions average performance is 11s, annotated by the second. The model update rate is 36Hz

	Laban Space sub-model (CORE) results P(L|F)									
	Effort						Shape			
	Space		Time		Flow		Space		Flow	
	Dir	Ind	Sudd	Sust	Free	Bnd	Rise	Sink	Spr	Encl
C.R.	94.1%	90.2%	69.0%	93.2%	94.3%	90.2%	50.0%	74.6%	77.3%	73.7%

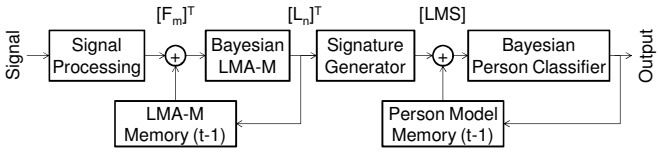
	Movement Space sub-model results P(M|L)				
	Point	Lift	Write	Punch	Bye-bye
C.R.	89.0%	92.2%	83.7%	81.5%	78.8%

Conclusions summary and Future Work

- The core model provides a reliable and robust abstract motion classifier, providing a scalable hierarchic taxonomy, applicable to a wide scope of areas.
- The selected features (PCA component) are not ideal to components depending on direction rather than orientation.
- We explore Bayes Symmetry property, allowing to reverse learning distributions, to synthesize feature from desired Laban component states.
- We are now using the developed models into the remaining research stages:

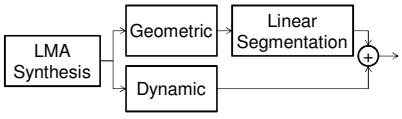
2. Laban Motion Signatures

- Human motion is influenced by a person's unique physical and psychological characteristics, hence we propose a model to identify different persons based on **HOW** they move, developing a **highly abstract** Motion Signature based on Laban Movement Analysis descriptors.



2. Trajectory Generalization

- Style machines are special processing models geometrically adapting a motion trajectory to fit a person style.
- We aim to develop a probabilistic adaptive 3 phase process that will shape trajectories geometrically and dynamically according to the comprehensive abstract syntax of LMA, in order to be performed as described by Labannotation.



(1) Geometric: Based on Body, Shape and Space synthesized Features.
(2) Dynamic: Probabilistic adapt trajectories with Effort and Shape.
(3) Fusion: Fuse both partial trajectories

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