Human motion classifier based on Laban Movement Analysis

Luís Santos* and Jorge Dias* {luis,jorge}@isr.uc.pt

*Institute of Systems and Robotics, University of Coimbra, Portugal

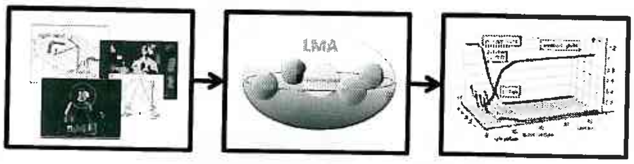
Introduction

- Human-Robot Interaction is a growing trend in scientific research in latter years. Machines and applications are developed to assist people in their working, living and entertainment enviroments.
- Most of these assisitive/social tasks have a performance dependency according to the interpretation capabilities of the machine;
- This work aims to explore visual interpretation capability of robots in the context of human motion analysis. In our daily life, we analyse and communicate with each other making use of the rich visual information aside from verbal. Most of people intuitively base their decisions according to the observed body motion language of others.
- Current work presents how we use a descriptive llanguage, **Laban Movement Analysis** (LMA), to model human motion.

Laban Movement Analysis

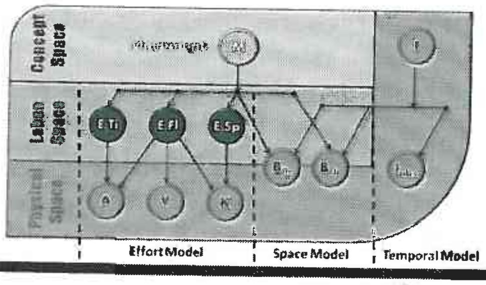
- LMA is a language invented by Rudolf Laban to describe dancing movements. Divided in 4 main components, each describing a particular aspect of human motion. ***Body*** specifies which body parts are moving, their relation to the body center; ***Space*** deals directly with the trajectory executed by the body parts while performing a movement. Within the Kinematic ones there are: ***Effort*** which deals with the dynamic qualities of the movement, and the inner attitude towards the use of energy; ***Shape*** (emerging from Body and Space) is focused on the body itself.
- Each of these components has inherent qualities which make LMA semantically rich, allowing movements to be characterized as *sudden, retreating, direct*, etc.
- We use LMA to create an intermediate state space in order to interpret low-level-features (LLF) into higher movement semantics (byebye, point, etc).

General Framework



1) The first step corresponds to data acquisition. Our approach is based on visual sensing, however to provide ground truth, data is acquired using 3-D Magnetic sensor. We intent to track specific body parts (head and hands), and to do so, we use visual tracking enhanced with Geometric Horopter. From the acquired trajectories LLF (mathematical characteristics) are extracted.
2) Our Bayesian models are developed hierarchically. In the lowest level is the feature space. In the second layer, LMA qualities depend directly on features. The third and highest level corresponds to movement space where movements are described/dependent on LMA characteristics.
3) The result of our framework are probabilistic distributions for the classified movements.

Bayesian Models



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BACS

Project: BACS - Bayesian Approach to Cognitive Systems

http://www.bacs.ethz.ch/

Author e-mails: {luis, jorge}@isr.uc.pt

➢ Space Model

- The acquired data results in discretized trajectories. Between each time frame we obtain a vector from which we discretize to original a space state of 8 directions.
- The resulting LMA space model is the probability of Movement *M* knowing direction *B* and time frame *I:*

$$P(M \mid B \wedge I)$$

➢ Effort Model

- Effort is divided in 4 qualities from which 3 are possible to modeled using mathematical characteristics of the trajectories (velocity *V*, acelleration *A* and curvature *K*).
- Hence we can define movement ***M*** depending on the observed *Effort Qualities*. The *Effort Weight* cannot be modeled as it is difficult to infer muscle tension through visually observable characteristics..

$$P(M \mid E_{Time} \wedge E_{Space} \wedge E_{Flow})$$

➢ Shape Model (to be implemented)

- To model shape, we will study the triangle whose vertex are the head and hands positions. We will study the bheavior of the triangles mathematical characteristics in order to find dependencies and build the models
- By probabilistical analysis we will identify patterns relating characteristics such as the area, normal vector, etc to descriptors like shrinking, rising, spreading, etc

$$P(Shape.feature \mid \Delta characteristics)$$

Implementation and Results

- Our experiments were conducted using a database of 10 movements (e.g. Bye-bye, punch, etc) with 100 trials/movement.
- The first table presents the results for the ***Effort Component*** based on observed features.
- Each of the movements was labeled *a priori* with *Effort Qualities.* Data was processed into features, which were feed into the Bayesian Network resulting in the most probable state for each of the ***Effort Qualities.***

	Effort Qualities					
	Space		Time		Flow	
	Direct	Indirect	Sudden	Sustained	Free	Bounded
C.R.	79.3%	90.2%	84.8%	97.1%	61.2%	58.7%

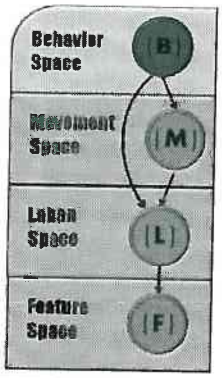
- The Effort and Space models were fused into one LMA "global" model.
- From the resulting Effort qualities results, the Bayesian Network was able to update the Movement Space Layer for movement classification.
- Following table presents **movement classification** of partial and global models.

	Laban Component			
	Space	Effort	Effort+Space	Space Multi-Ocular
C.R.	61.3%	86.4%	79.4%	81.0%

➢ C.R. Stands for classification positive results

Conclusions and Future Work

- We have 2 components developed so far, which indicate that the implementation of the remaining might improve classification results;
- Merging the two developed models improved results. The other components will be modeled to complete the LMA global Bayesian model.
- Results suggest that LMA is a viable tool for human motion modeling;
- Effort component allows to characterize human motion within its emotional content, and provides a good descriptor in terms of dynamic qualities of movements.
- Given that LMA has the ability to deal with emotional characteristics, we intent to expand our model with a new layer: Behavior Space. This new space will use movements and LMA characteristics as input to model basic behavior primitives such as *aggressive, focused*, etc.



Mobile Robotics Laboratory
Institute of Systems and Robotics
ISR – Coimbra