Rule-based Retrieval of Human Motion Data Using Inductive Logic Programming

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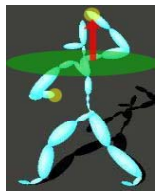
Abstract

We propose a novel method for automatically classifying and retrieving motions based on spatio-temporal features of motion appearance. Our method first converts a motion data into a form of clausal language that represents geometrical relations between human body parts and their temporal relations. A classification rule is then learned from the minimal set of manually classified examples using inductive logic programming. We introduce a two-step search algorithm to retrieve motion segments from the motion database, which uses two types of classification rules that are discovered by different learning models. Our method allows robust and efficient retrieval from complex motion sequences with a small number of training data.

Spatio-temporal Features of Human Motion

Geometric features [Muller et al. 2005] and their temporal relations.



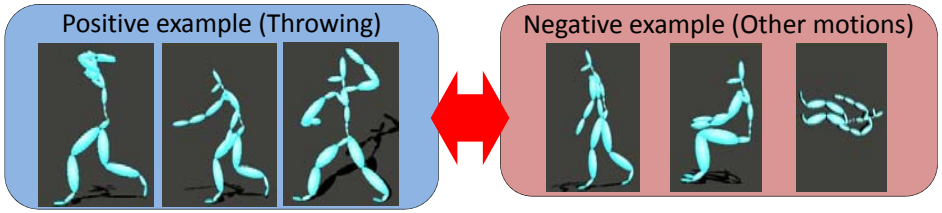



Our extension:
- Multi-valued geometric features
- Additional features (jump, twist, direction)
- Temporal relation and duration of GFs

Clausal representation of the features

```
havegf(M, r_foot_front, 2).
havegf(M, r_hand_bent, 3).
after(M, l_hand_up, 0, r_foot_bent, 2, short).
short(M, r_hand_up).  ...
```

Inductive Learning of Motion Classification Rules



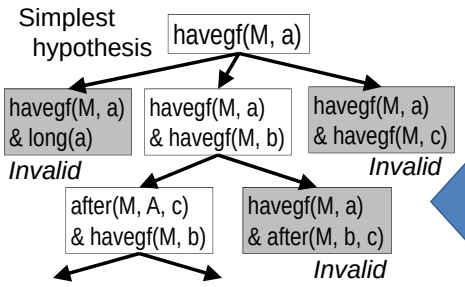

```
havegf(A, 3, l_foot_up).
long(A, r_hand_bent).
havegf(A, 0, hands_touch).
after(A, l_foot_front,1, r_hand_front,0,
middle).
after(A, r_hand_up,1, l_foot_up,3, short).  ...
```

Specific clauses

```
havegf(A, 3, l_foot_up).
long(A, r_hand_bent).
havegf(A, 0, gradient).
after(A, lying, gradient, short)
after(A, r_hand_up,1, l_foot_up,3,
short)...
```

Inductive Logic Programming

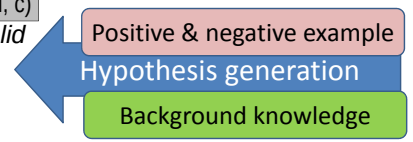
-Logical framework for discovering classification rules from pre-classified examples
-Using clausal representation for all data (examples, rules, background knowledge)
-No numerical function and heuristics



Hypothesis-testing procedure of Progol

Exclusive learning:
- Using both positive & negative examples

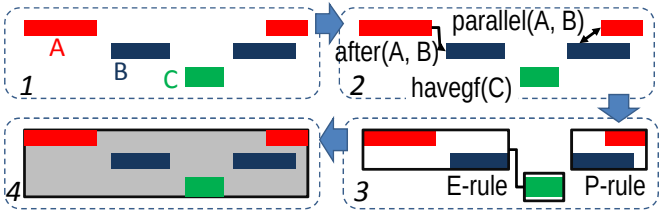
Positive learning:
- Generating pseudo-negative examples
- Based on Bayes theory



Known truth about examples and rules (subsumption relation, etc.)

Rule-based Motion Retrieval

Two-step matching check with exclusive (1st) and positive (2nd) rules



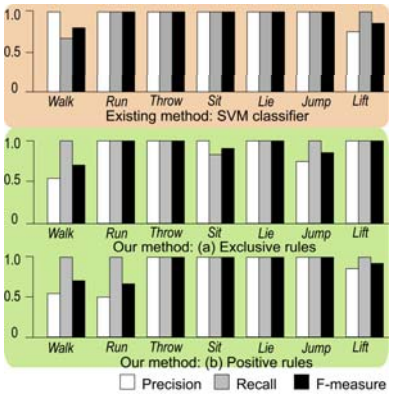
Example rules
- Exclusive rule: after(A, B) & havegf(C)
- Positive rules : parallel(A, B)

Feature learning & Retrieval procedures
1. Computing GFs of the target sequence
2. Segment matching with each clause
3. Labeling
4. Merging

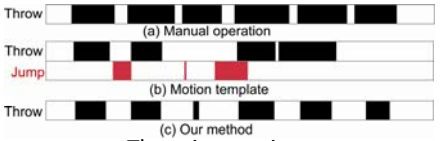
Experimental Result

Training examples: Walk (11), Run(13), Jump (6), Throw (6), Sit (6), Lift (6)

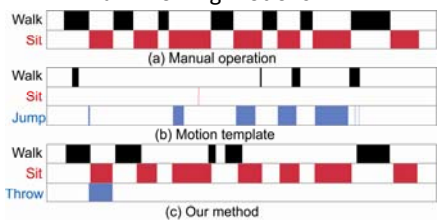
- Classification of the training examples



- Retrieval from complex motion sequence



a. Throwing motions



b. Walking & sitting motions

Future Work

-Probabilistic or fuzzy representation of spatial and temporal features
-Retrieval of appropriate unit movement
-Other background knowledge (kinematic/dynamic constraints)

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