Skill Identification Using Time Series Data Mining

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Keywords: Time Series Data, Sports Skill, Data Mining, Motion Picture, Knowledge Acquisition

Abstract: This paper addresses sports skill identification using time series motion picture data, focused on volleyball. In this paper, volleyball play is analyzed with motion picture data recorded by hi-speed cam-coder, where we do not use physical information such as body skeleton model, and so on. Time series data are obtained from the motion picture data with marking points, and analyzed using data mining methods such as Naive Bayes, and other tree learning algorithm. We attempt to identify technical skill models of volleyball attacks.

1 Introduction

For not only engineering skills but also sports skills, many researchers treat body structure models and/or skeleton structure models obtained from physical information such as activity or biomechatronical data for sports skill researches [1].

Those might be because those researchers believe that internal models of technical skill are structured physically, with some skill levels which are human intention, environmental adjustment, and so on [2].

For instance, Matsumoto and others describes skilled workers skills which have actually internal models of structured skill architecture and they choose an action process from internal models adjusted with environment [3]. It is even though hard for skilled workers to represent internal models by themselves. They reflect involuntarily their own represented actions, and achieve highly technical skills with internal models.

We had, however, researched that fore-hand strokes of table tennis play exemplify sports action, and classify skill models using motion picture data analysis without body structure model nor skeleton structure model. We had evaluated those into three play levels as expert/intermediate/novice, and classify the models using data mining technologies [4, 5]. That means this research is a challenge to clarify internal models only from represented image data.

We hence have an attempt to apply our research framework to other sports skills, and then this paper addresses a personal sports skill identification using time series motion picture data, focused on volleyball.

2 Related Works

Wilkinson[6] describes that qualitative skill analysis is an essential analytic tool for physical educators and refers to a process in which a teacher identifies discrepancies between the actual response observed and the desired response. Providing instruction for preserving teachers regarding how to recognize errors has been largely neglected in teacher preparation. The purpose of this study was to evaluate an alternative approach for teaching qualitative skill analysis to undergraduates. The study evaluated the effectiveness of a visual-discrimination training program. The subjects were 18 undergraduate students. The visual-discrimination training program was introduced using a multiple-baseline design across three volleyball skills: the forearm pass, the overhead pass, and the overhead serve. After the introduction of each instructional component, subjects made abrupt improvements in correctly analyzing the volleyball skill. This approach for teaching qualitative skill analysis is one alternative to the conventional techniques currently being used in professional preparation.

Watanabe et al.[7] shows a method for the measurement of sports form. The data obtained can be used for quantitative sports-skill evaluation. Here, they focus on the golf-driver-swing form, which is difficult to measure and also difficult to improve. The measurement method presented was derived by kinematic human-body model analysis. The system was developed using three-dimensional (3-D) rate gyro sensors set of positions on the body that express the 3-D rotations and translations during the golf swing. The system accurately measures the golf-driver-swing form of golfers. Data obtained by this system can be related quantitatively to skill criteria as expressed in respected golf lesson textbooks. Quantitative data for criteria geared toward a novice golfer and a mid-level player are equally useful.

Barzouka et al.[8] examine the effect of feedback with simultaneous skilled model observation and self-modeling on volleyball skill acquisition. 53 pupils 12 to 15 years old formed two experimental groups and one control group who followed an intervention program with 12 practice sessions for acquisition and retention of how to receive a ball. Groups received different types of feedback before and in the middle of each practice session. Reception performance outcome (score) and technique in every group were assessed before and at the end of the intervention program and during the retention phase. A 3 (Group) $\times$ 3 (Measurement Period) multivariate analysis of variance with repeated measures was applied to investigate differences. Results showed equivalent improvement in all three groups at the end of the intervention program. In conclusion, types of augmented feedback from the physical education teacher are effective in acquisition and retention of the skill for reception in volleyball.

3 Experiments

Our research is to identify internal models from observed motion picture data and skill evaluation with represented actions, without measurement of the body structure or the skeleton structure.

We focus on volleyball attack among various sports, and analyze volleyball skills of stacks from observed motion picture data and skill evaluation with represented actions.

For the feasibility research, we have recorded motion pictures of 6 subjects who are 3 expert / 3 novice-level university students. As skill evaluation of representing action, We classify the levels as follows;

- Expert class: members of volleyball club at university,
- Novice class: inexperienced students.

Figure 1 shows positions of marking setting. Each player is marked at 4 points on the right arm as;

1. Left knee,
2. Right waist,
3. Right shoulder, and
4. Right elbow.

We have recorded swing traces of stacks using a high-speed cam-corder (resolution: 512 $\times$ 384 pixel and frame-rate: 300 frames per seconds) installed besides of the players. On playing in 5 minutes, several attack motions are recorded for each player.

4 Skill Identification

From the recorded motion pictures, 100 to 200 frames are retrieved from the beginning of take-back to the ball until the end of the attack. We have then distributed two dimensional axes positions (pixel values) of 4 marking points for each frame, where the starting point is set at the shoulder position of the first frame.

We then attempt an investigation using data mining technique. The skill evaluation of representing action consists of two classes such as Expert and Novice. Each marking position is represented two dimensional and so the observed data are reconstructed in 48-input / 2-class output.

For applying observed data of fore-hand strokes of 6 subject players, we reconstruct time series data from the original data. One datum is a set of 48-tuple numbers such as 4 markings $\times$ 2 axis $(x, y) \times 6$ frames, and each datum is overlapped with 3 frames data (from fourth to sixth frame) of the next datum for presenting linkage of each datum (see Figure 2).

We use an integrated data mining environment “weka” [9] and analyze the data by analyzing methods of J48 (an implementation of C4.5) and NBT (Naive Bayes Tree).

4.1 Pre-examination

We have had a pre-examination for applying our research framework into volleyball skills. Table 1 shows the recognition rate of the data sets. As for expert players, two third of data on three players are used as learning data, and the rest for evaluation.

Table 1: Recognition rate of modified data sets.

	Recognition Rate(%)	
	Cross validation	Learning and test
J48	95.9	48.2
NBT	97.7	62.7

Table 2 shows the discrimination of classes of NBT classification.

In those results, the recognition rates for evaluation data are not so good, though NBT makes better results for evaluation data. On the contrary, the result of the number of class recognition for each method in Table 2 implies that NBT tend to recognize Expert as Novice. This implies that, even in Expert class, data

FIGURE 1: Measurement markings.

Table 2: Discrimination of classes for NBT classification.

	Classified as	
	Expert	Novice
Expert	66	58
Novice	14	55

may have some variation. We then focus on personal identification, as data variation may cause from personal skill variation e.g. an expert position in plays such as attacker, center player, and so on.

4.2 Personal Identification

As mentioned above, we here analyze for personal identification, where two subjects are compared for each test. One test is with an Expert and a Novice, and the other test is with two Experts. We here use NBT for these tests as NBT are better than J48 on above tests.

These results are fairly good and suggest this analysis process can identify each person, especially identification for two Experts, though we need further investigation.

Table 3: Recognition rate of personal data sets.

	Recognition Rate(%)	
	Cross validation	Learning and test
One Expert and one Novice	96.9	97.5
One Expert and another Expert	94.2	100.0

5 Conclusion

This paper addresses analysis and classification for internal models for technical skills as evaluation skillfulness for volleyball attack motion, and discuss skill identification. We had some experiments and

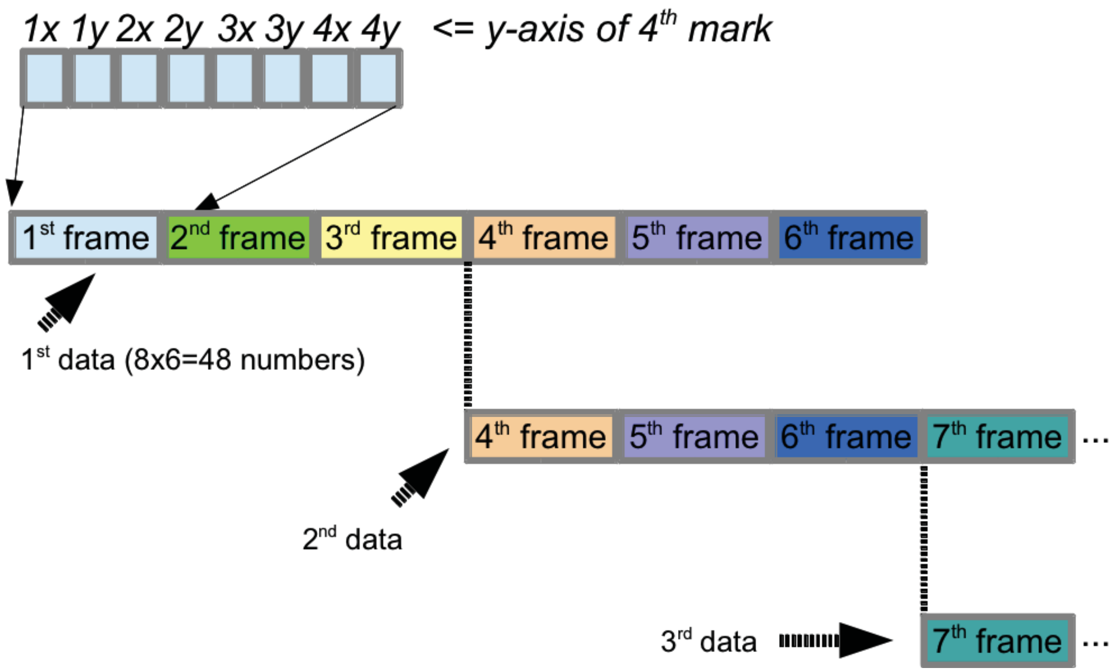

FIGURE 2: Data structure from isolated pictures.

some results imply that expert or intermediate players can make some categorical groups for technical skills, but there seems not to be a category for novice players because of various individual technical skills. Furthermore, for applying observed data of volleyball stacks of players, we reconstruct time series data from the original data and analyze the new data by data mining techniques such as J48, NBT, where the recognition rate for evaluation data is fairly good, and NBT makes better results for learning and evaluation data. Personal analysis furthermore may be better categorized. As future plans, we have to progress further experiments, and measure more precise data and then analyze if needed.

Acknowledgment

Part of this research was supported by JSPS KAKENHI Grant Number 15K02185 and 15K03802. This research was assisted, especially for data management, by Mr. Y. Tamari and Mr. Y. Tsujino at Hannan University. The authors greatly appreciate those.

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