A paper for 24th Symposium of ICTM Study Group on Ethnochoreology 2006
in Theme 1., From Field to Text: Translations and Representations

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Formal methods in form analysis of Transylvanian male solo dances

This paper is a brief version of the work that won the first prize on the competition held by György Martin Foundation in 2006.

Introduction

In analyzing Transylvanian improvised male solo dances (usually called *legényes*), the Hungarian dance structural analytical school introduced and applied several concepts and methods. György Martin, Ernő Pesovár, Mária Szentpál and Olga Szentpál made dance form analysis a scientific discipline in Hungary since they used Kinetography Laban as a tool.
From a computational point of view, some of their theoretical definitions still contain inaccuracies, resist formalization, and therefore cannot be applied in practice without relying on intuition. Some problems will be discussed below in seven points in connection with specific areas of analysis – some of them are related to *legényes* only and some are more general.

1. Dance segmentation
György Martin and Ernő Pesovár used the concept of motif for segmentation. A motif is a recurring unit and the smallest organic one. Examining this definition, the meaning of organic ("relatively closed" [Martin–Pesovár 1961 p.5.]) is not clear enough formally. Nevertheless, in practice Martin and Pesovár constituted segments in another way, with music measures; and therefore their method produces too many motif variants. Another method that was introduced by Mária Szentpál [Szentpál, M. 1981] highlights small units based on movement analysis. This generates fewer variants but unfortunately ignores the relationship between music and dance.
This paper proposes a method that takes music into account and produces few variants.

2. Connections between structural units
According to both methods mentioned above (Martin's and M. Szentpál's), structural units connect themselves to each other, that is the connections are part of the units. On the other hand, in Olga Szentpál's view there are separate linking elements between motifs, which may consist of only one movement phase [Szentpál, O. 1958].
It will be worth separating short dance parts as linkers in *legényes* also.

3. Unit classification
György Martin and Ernő Pesovár defined a support index as the primary attribute for the classification of motifs. In the article where it was introduced [Martin–Pesovár 1963], the support index is not well defined in the case of a jump from two legs to one leg (Robert Henry Leibman also noted this [Leibman 1992]). Later Martin described it exactly [Martin 1964] but it became too complicated. Additionally, it does not work so well with dances containing many gestures like *legényes*.
The classification attribute should rather be some kind of a motif-core similar to what György Martin and Ernő Pesovár introduced with the concept of the nucleus of a motif. But this concept ("the least variable component part displaying a relative steadiness" [Martin–Pesovár 1963] p.305.) is formally imprecise. In practice their classification is rather intuitive and difficult to understand in some cases.
In his last works Martin added two new attributes to the classification: fusion and function of motifs. In the end, fusion is also a function, since it describes functional connections of adjacent little units.
According to this paper function should not be dealt with during classification (only at the time of dance representation, see point 6.) Classification must be performed on the basis of the form of dance units only, and dance notation should be capable of extracting the common part of units.

4. Representative unit
For the typical form of a motif, Olga Szentpál or György Martin suggests to choose an instance of the motif class according to quantitative and qualitative features ([Szentpál, O. 1958], [Martin 1964]). (Obviously quantity cannot mean simple motif frequency, since each instance is different; it means the frequency of the qualitative components.) Martin argued against creating a schema from the instances but he also applied templates when he used the support index or the nucleus of motif.
This paper uses schemas to represent a dance unit class and these schemas will be formulated with dance notation.

5. Unit naming
In research papers a unit name sometimes refers to an instance of a motif class and sometimes to its representative form. The instances and the representative form should be distinguished by notation and also by name to remain formally correct. Additionally, unit names should be more uniform than before so that several papers can refer to each other.

6. Written dance representation
For dance representation, a) structural formulas [Martin–Pesovár 1961], b) charts [Martin 1977] and c) analytical tables [Karsai–Martin 1989] are in use. The first two description types are too general and in fact, the scaled drawings of the second may be too subjective. The third form, i.e. the analytical tables properly show a detailed 'how-to-dance' prescription but it is not too easy to follow the cross-links of the tables.
William C. Reynolds suggested a reader-friendly generative graph where motifs are placed in graph vertices, edges show the connections and numbers can indicate frequencies of motifs and their connections [Reynolds 1994]. Reynolds described a dance that was analyzed by someone else. According to the description, in the case of compound motifs the dancer's choice points are always located at the end. This is not necessarily true: they can also be inside these motifs, so there is a problem here, which relates to segmentation.

7. Mistakes of the dancer
A mistake is a special non-repeating part in dance. The dancer did not want to use that movement and will not want to reuse it. Publications in Hungary do not show mistakes in dances, as if they did not exist. Researchers corrected the mistakes during the notating phase or later, but it was not documented when, where or how – probably with intuition.
Evaluating a mistake as a motif can be misleading. Mistakes should be recognized so as not to insert them into the written dance representation. Mistake recognition should not be left to the intuition of the researcher watching film; rather, it should be based on the examination of dance notation in this case as well.

* * *

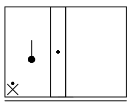
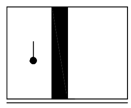
Csilla Könczei is aware of most of the problems mentioned above. She turns to semiotics to decrease the role of intuition in the case of the *borica* dance [Könczei 1990]. This paper takes another approach to ensure a <u>higher level of objectivity</u>: it applies formal concepts and methods.
A formal method means a method that works only with notation i.e. with written graphical signs without any meaning. Formal methods were used in mathematics first at the beginning of the 20th century but other sciences have also adopted them, including linguistics in the 50's, 60's.
Since formal methods will be dependent upon the quality of notation, i.e. how detailed and graphically standardized it is, notation conventions have to be complied with before performing an analysis.

The notation of the analyzed dance presented in this paper describes the movement in great detail without modifications (including mistakes), yet it is standardized. Synonyms are avoided, e.g. knee bending is always drawn with second-degree measurement sign and never with a low-level direction sign. Additional graphic standards are applied, e.g. the column usage is consistent: a rotation sign for turning is drawn in the support column (never beside the staff), or a given part of the trunk is always placed in the same auxiliary column.

Formal concepts

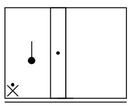
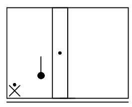
Definition: Two kinetograms are <u>semantically equal</u> if they describe the same movement.

Example:

 and  are equal semantically.

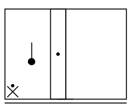
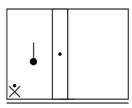
Definition: Two kinetograms are <u>syntactically equal</u> if they describe movements with the same signs, each with the same meaning.

Example:

 and  are equal syntactically.

Definition: Two kinetograms are <u>graphically equal</u> if they describe movements with the same signs, each in the same 2D position.

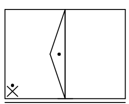
Example:

 and  are equal graphically.

Semantic equality is a consequence of syntactic equality and syntactic equality is a consequence of graphical equality. (These statements are not true conversely.) Although the semantic equality is the most general, further concepts will remain at the graphical level where they are the easiest to define and handle. Notation can be approached at the graphical level by applying the notation standards mentioned before.

Definition: Let a <u>Laban-pattern</u> be a two dimensional figure consisting of signs of Kinetography Laban where the position of each sign is set in a coordinate system determined by the support line and the first measure line.

Example:

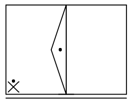
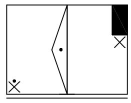


Remark: The staff lines are not part of a Laban-pattern; they are drawn to show the coordinate system.

A Laban-pattern can be defined as a mathematical structure: a set of ordered quadruple. The four elements of an ordered quadruple are: a unique identifier and three real numbers (two coordinates, and a length). Size, intersection and subtraction are defined for it as a set. A special intersection named sign-majority intersection can be defined concerning a certain percent majority of signs in given positions. Transformations on a Laban-pattern are definable: mirroring transformation (for each set element: id and x coordinate exchange) and lengthening transformation (for each set element: y coordinate and length multiplication).

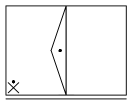
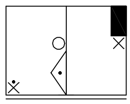
Definition: A Laban-pattern matches an other Laban-pattern sign-length-identically (strong match) if each sign of the Laban-pattern has a corresponding sign in the other Laban-pattern: with the same form on the same 2D position and with the same length.

Example:

 matches  sign-length-identically.

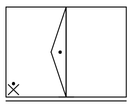
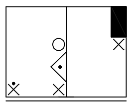
Definition: A Laban-pattern matches an other Laban-pattern in a sign-length-tolerant way (weak match) if each sign of the Laban-pattern has a corresponding sign in the other Laban-pattern: with the same form on the same 2D position.

Example:

 matches  in a sign-length-tolerant way.

Definition: A Laban-pattern matches an other Laban-pattern in a pre-sign-tolerant way (very weak match) if each sign of the Laban-pattern has a corresponding sign in the other Laban-pattern: with the same form inside a pre-sign-length 2D environment.

Example:

 matches  in a pre-sign-tolerant way.

Remark: The second and third equalities are defined for semantic reasons of course.

Additional matches can be defined: symmetric, augmented matching (with the aid of the mathematical transformations of Laban-patterns), logical expressions for matching (with logical OR, NOT operators) and wildcard matches (introducing wildcard signs).
A Laban-pattern occurs in another Laban-pattern if it matches the other one with a shift in placement.
A Laban-pattern repeats in another Laban-pattern if it occurs in at least two places in the other. At a certain place of an occurrence, the identified part of the Laban-pattern produces an isolated, new Laban-pattern.
The distance and similarity of Laban-patterns can be calculated from several occurrences (using size, intersection and subtraction of Laban-patterns).

It is important to note that the above definitions are based on notation, and not explained in terms of movements.

These concepts can be applied to formal dance analysis: matching and repeating for segmentation, distance and similarity for classification, intersection and sign-majority intersection for creating representative forms.

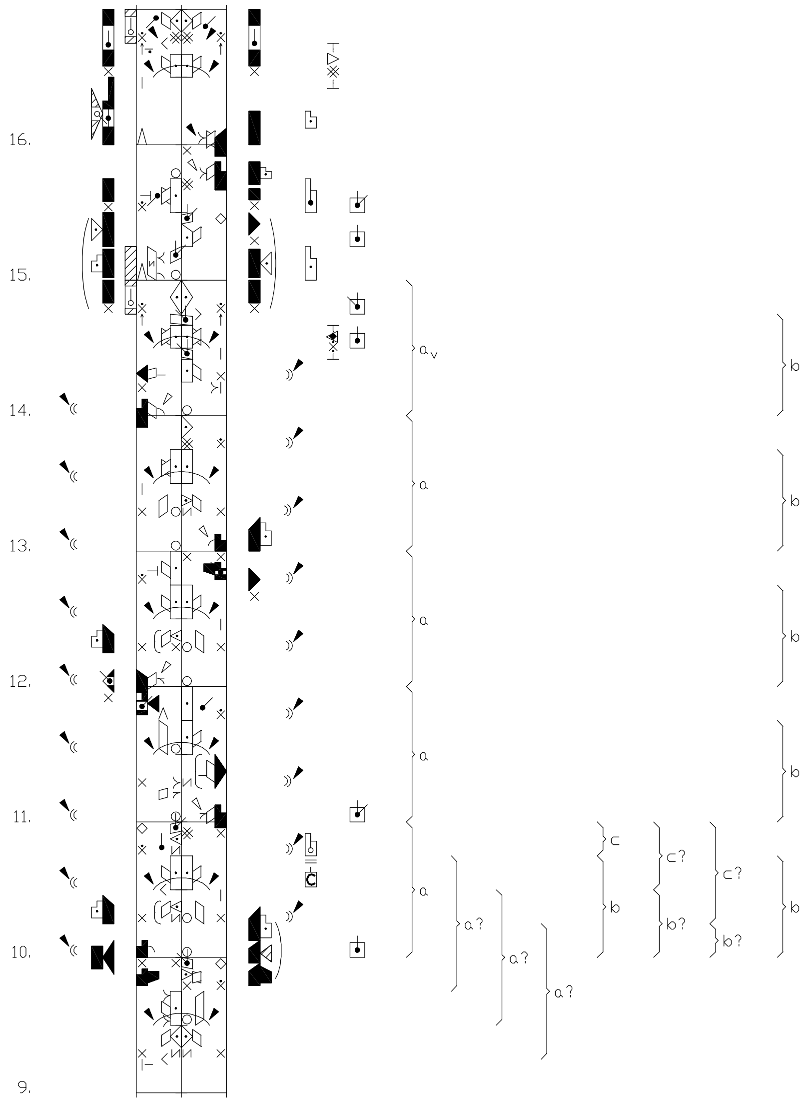
The occurrences produced as a result of the same query are similar; this is trivial if the mathematical concepts are properly defined. It is provable that the sign-majority intersection has some unfavorable properties compared to the simple intersection: it does not match each pattern that it was created from.

Although all of these concepts were defined in a rudimentary (not sign or column weighted) manner, they were used in the analysis of three Transylvanian male solo dances.

Applying formal methods

The analyzed three dances: "magyar", "sűrű", "verbunk". Dancer: János Lőrincz, born 13/08/1916, Szépkenyerűszentmárton, Sânmărtin, Romania. Field work: László Füleki and Gábor Misi, 14/08/1994.

The figure below shows a dance period of "sűrű". Measures No. 9-14 contain repeating four-phase subsequences: 1. touching gesture + 2. side movement + 3. closing legs + 4. one leg support + etc.

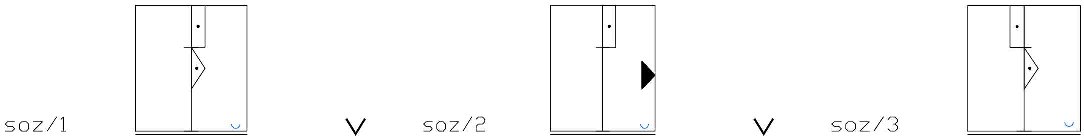


Because of the repeating subsequences, theoretically segments can be constituted in four possible ways with unit start shifting. (See 'a' and 'a?'-s. 'a' belongs to Martin's segmentation, the left-most 'a?' shows a Szentpál's unit).

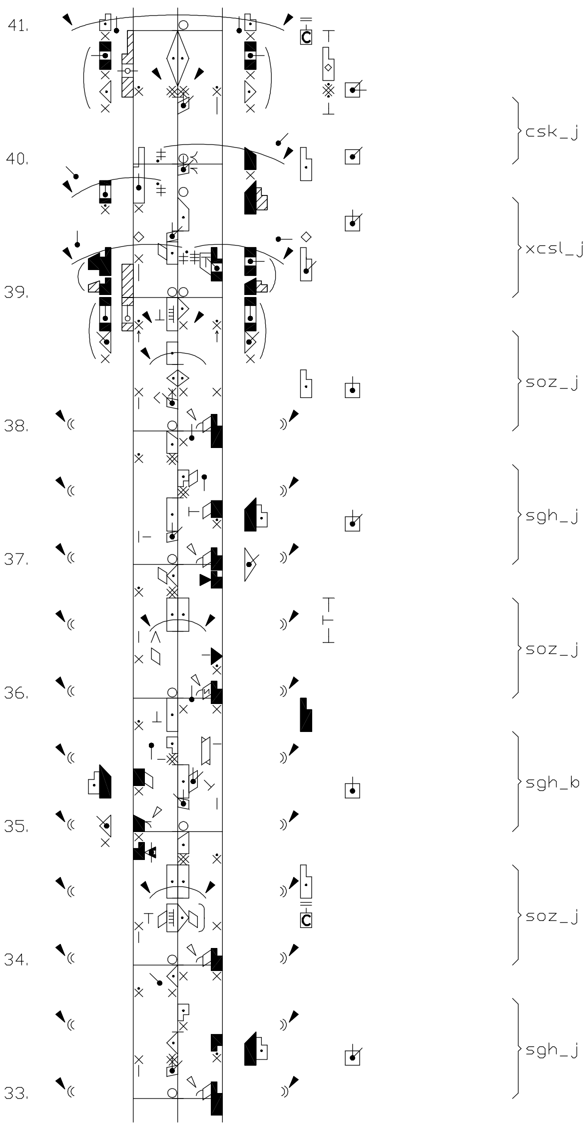
To avoid variants ('a_v'), connections ('c') can be made between dance units ('b', no 'b_v'). Such a unit ('b') is called "<u>dance element</u>" instead of "motif", and only the recurring criterion was used for it. What is the length of this dance element ('b?'='a'–'c?')? It is determined with an optimum calculation: 'b' is 3 phases long here (covering 5 measures), because a 4-phase unit would produce fewer occurrences (only 4 measures would be covered, the 14th measure has no "+4. one leg support"), but it makes no sense to build a model with 2-phase dance elements (no more than 5 measures would be covered).

This analytical method determines the <u>longest sequences</u> – or more precisely, the longest sequences starting on main beats – in an iterative way, with several tries to cover parts in Laban kinetograms. (Gaps between dance elements are allowed as linkers).

Measures are covered by constructing queries and performing the related searches to examine pattern match. The next figure shows such a query, which is constructed as a three-component OR expression (to cover sub-patterns where in the second phase a support or a gesture can occur, and in the third phase either leg can close). It contains a grey wildcard sign that means any hook (in the first movement phase the foot can touch the floor with various parts of the heel or sole). 'soz' is a made-up name that come from the first letters of Hungarian words.



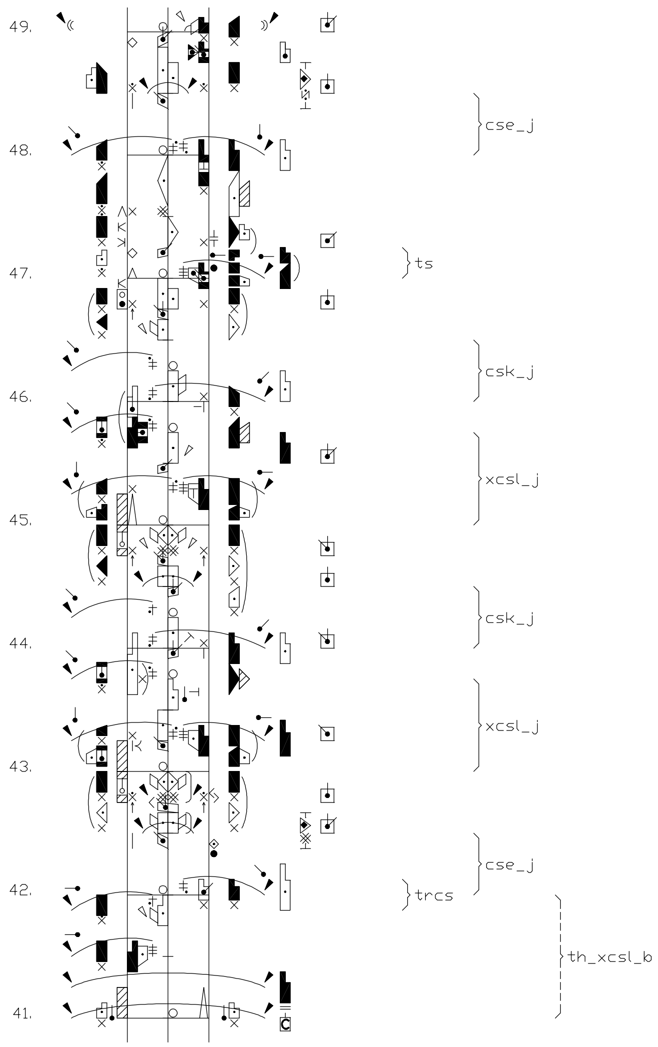
In searches for Laban-patterns very weak match is used. With the aid of search parameters, the found patterns can be distinguished: the '_j' postfix indicates the identical (right-leg), the '_b' postfix the symmetric (left-leg) instances. An '_aug' postfix means augmented patterns that can be found in the other two dances ("magyar" and "verbunk").



This period contains 3 instances of the 'soz' dance element. Measures between these elements were covered with a new query named 'sgh'. Constructing new queries and performing the related searches will gradually cover more and more measures.

As a result of 17 consecutive searches, all the measures of the three sample dances were successfully covered in following ratio: 29 out of 40 in "magyar", 47 out of 62 in sűrű", and 23 out of 33 in "verbunk". Of the 17 patterns 5 were found in all three dances, 4 in "magyar" and "sűrű", 2 in "sűrű" and "verbunk", 2 only in "magyar", and 4 only in "verbunk". Of the 17 patterns 7 occurred as symmetrical instances, and 5 as augmented patterns.

Not all measures have to be covered: a dance part is not regarded as a dance element if it is non-recurring (e.g. the 41st or the 47th measure in the next figure). For the time being, such a part is understood as a long connecting part.

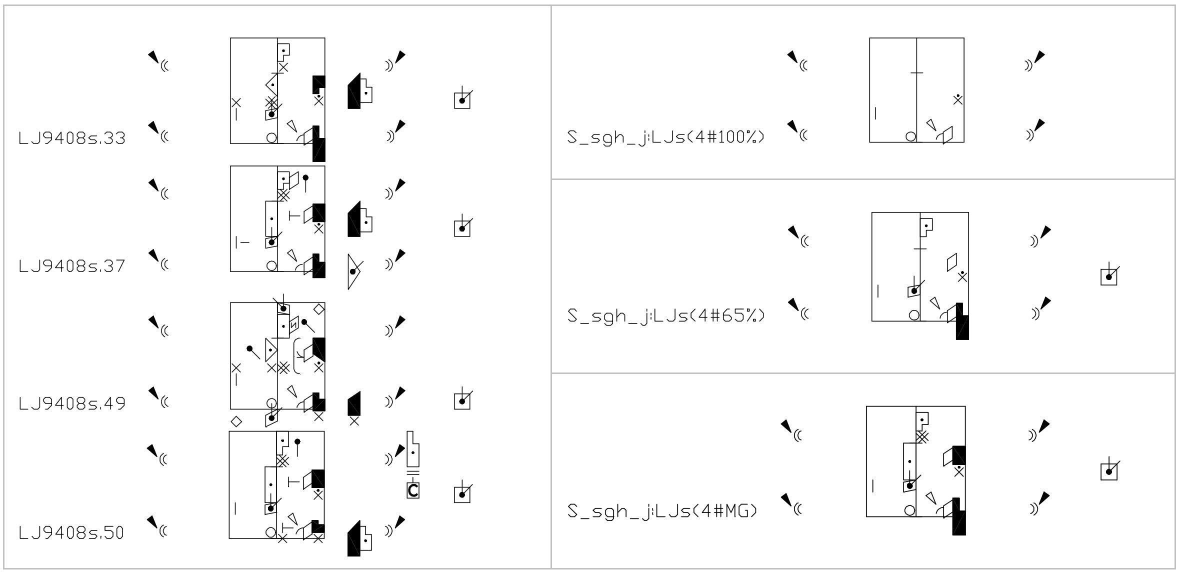


Obviously, a non-covered part can be repeated in a larger sample of notated dances. However, it can also be a mistake of the dancer. In the sample analysis mistakes were recognized. To diagnose them, pre-queries were performed for mistake-suspicious patterns: loss of balance ('ts' in the figure above) and unusual rhythm (an sixteenth among the general eighths) ('trcs'), which are actually indicated in the notation.

In the 41st measure there is an example for a mistake (namely 'th_xcsl_b' part is a faulty version of 'xcsl_j', see the 45th measure): the dancer clapped twice rather than once, and therefore his usual movement fell behind the music until he corrected it at the end of the measure with 'trcs'.

During the analysis three mistake types were identified: 1. "vestigial", 2. "shifted in music" 3. "length-changed" (extended or compressed) forms or a combination of the three. It was found that the mistakes appeared close to each other in clusters and at a late phase of the analysis it was realized that a dance element instance was imported from another dance type (from "verbunk" to "sűrű") – this is identified as mistake type 4. "local non-repeating" element (probably it is part of a dancer's attempt to make a correction).

The dance element instances were gathered in a number of classes based on the queries. One such class is shown on the left side of the next figure, where 4 isolated occurrences are displayed as a result of the 'sgh' query (with IDENTICAL search-parameter). About the naming conventions: e.g. LJ9408s.33 means the segment that started at the 33rd main beat of the "sűrű" danced Lőrincz, J. in 08/1994.

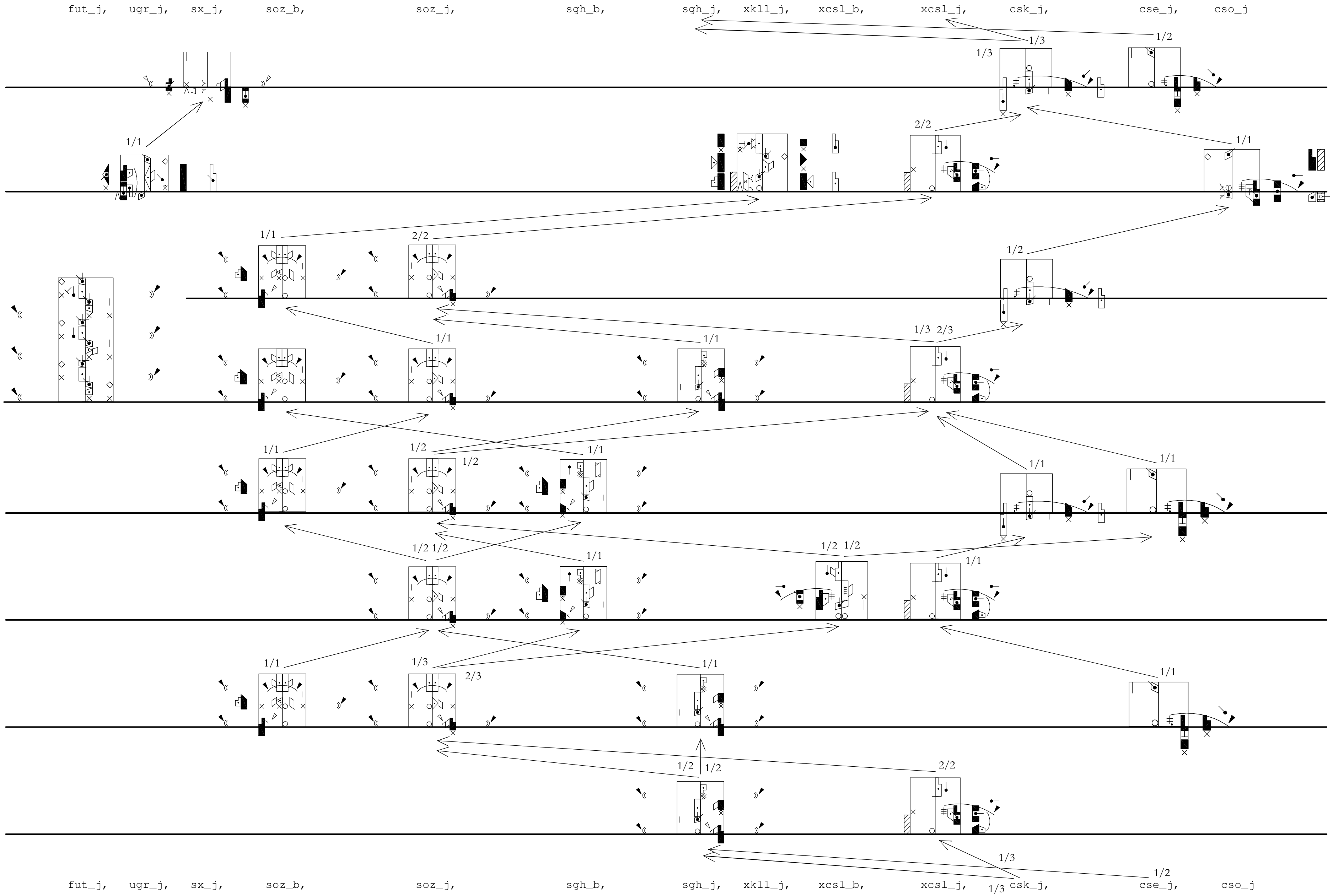


On the right, there are some attempts for composing the typical form of this dance element from 4 instances. Their names start with the letter 'S' (for 'schema'), in parentheses the number 4 means the number of instances, and the percentage figures of 100% or 65% means the percent used in creating the sign-majority pattern. The third kinetogram was created from the second by manually adding signs of Kinetography Laban that make it error-free and danceable. This completed form will be inserted into the written dance representation.

The first two kinetogram-schemas were not only drawn but generated with computer program named Labanatory.
The third completed kinetogram will appear in the 7th column of the representation as 'sgh_j' (right-leg) dance element.

The next page shows the dance representation of "sűrű". (Similar graphs can be constructed for "magyar" and "verbunk" dances.) The kinetograms of the dance elements are placed in columns according to dance element types, and in rows according to placement in a music period. The succession of dance elements is indicated with arrows. At the beginning of each arrow a fraction appears, where the numerator is the frequency of the connection in question, and the denominator is the frequency of dance element at that place, so the fraction is the likelihood of how the dance will continue. In order to make the figure easily readable, horizontal lines represent measure lines. At the top of the page, the arrows do not loop back to the start of the periods but point to column labels, which are repeated at the bottom.

This 'measure-start graph' represents a model for improvisation of each analyzed dance. The dancer can compose a dance while 'reading' it. When he hears the music – cf. [Giurchescu 1983] –, he chooses the appropriate dance graph and then follows a path in the graph. He has to recall a movement schema from his memory at each main beat and decide on the next direction in the path while he has to connect the dance elements – the connecting movements are not drawn in the graph. (Evidently, the dancer's mistakes and all the non-recurring dance parts are not inserted into the graph.)
A measure-start graph contains the dance elements, their connections, frequencies of the dance elements and their connections. Researchers can study the construction of the dance in a graph and examine permanent connections that create the dance parts that György Martin called compound motifs.


fut_j, ugr_j, sx_j, soz_b, soz_j, sgh_b, sgh_j, xkll_j, xcsl_b, xcsl_j, csk_j, cse_j, cso_j
1/3
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fut_j, ugr_j, sx_j, soz_b, soz_j, sgh_b, sgh_j, xkll_j, xcsl_b, xcsl_j, csk_j, cse_j, cso_j

Summary

This paper offered some solutions for seven problem groups of folk dance form analysis.
1. For segmentation the longest sequences were considered.
2. The connections of segments were handled separately.
3. Classification was determined by similarity of notation.
4. Representative forms were composed with (sign-majority) intersection in notation.
5. The representative form and the instances were also distinguished by name.
6. The written dance representation was a measure-start graph excluding mistakes.
7. Dancer's mistakes were recognized during analyses at several process phases.

The essence of the methods was pattern search, based on notation. To put it simply, vertical search in Laban kinetograms was used to segment units and horizontal search to classify these units.
The method of the longest sequences decreases the number of variants, and thus enables simple dance representation. This method is capable of determining sequences regardless of their length, from the shortest to quite long units. Search queries can assist other methods like György Martin's or Mária Szentpál's, since pattern matching can also be used with them.
Searches are useful for checking the uniformity of a notation in a series of steps, where the user arrives at a standardized notation.
Searches and all formal methods can easily be supported by computer applications in dance analysis [Fügedi 1995], [Misi 2002]. Having formal concepts and methods a) is desirable to facilitate dialogue between researchers on a higher level of objectivity, and b) is necessary to describe algorithms for computer-aided dance analysis.

Dance notation was not simply a tool in this analysis but a fundamental device without which the operations would not have worked at certain parts of the analysis.
The analysis has not been able to eliminate intuition entirely, but all the steps where intuition was used have been noted. 1. The automatically generated notation schemas were not perfect as typical forms of dance elements (apparently, Kinetography Laban has limitations in this respect), and therefore they had to be complemented through human intervention. 2. Search queries were also constructed by human intellect. Even in the latter situation where intuition has to be relied on, mathematical statistics or data mining methods can serve as a useful aid for researchers.

In the words of the "father of the modern computers":

> "It is perfectly clear that we can assemble information which is more elaborate than ever before, and in larger quantities. In decision-making, the situation is somewhat different. There have been developed, especially in the last decade, theories of decision-making – the first step in its mechanization. However, the indications are that in this area, the best that mechanization will do for a long time is to supply mechanical aids for decision-making while the process itself must remain human. The human intellect has many qualities for which no automatic approximation exists. The kind of logic involved, usually described by the word »intuitive«, is such that we do not even have a decent description of it. The best we can do is to divide all processes into those things which can be better done by machines and those which can be better done by humans and then invent methods by which to pursue the two. We are still at the very beginning of this process."
>
> John von Neumann, 1955 [Neumann 1963]

We have to give formal description to more and more methods used in dance analysis. In this way we are able to move towards a partially automated dance analysis.

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