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CHARACTERISTIC ATTRIBUTES FOR RECOGNITION OF TRADITIONAL MACEDONIAN FOLK DANCES

Abstract: Macedonian folk dances are composed of fast-paced movements where the movement of legs is dominant compared to other parts of the body. In this paper we introduce several characteristic attributes, derived from the dancer's lower body position data, which are used for mathematical modeling of dances. Studying the values of these attributes for a given period facilitates the process or recognition of Macedonian dances.

Keywords: Macedonian folk dance characteristics, dance recognition, dance attributes

1. Introduction

One of the primary interests of every nation is to preserve, protect and pass on the cultural heritage to the next generation. The cultural heritage can be tangible or physical, and intangible or non-physical. The physical cultural heritage like artifacts, monuments, etc. can be conserved and preserved, while the tangible ones, like music, dances, language, etc., are passed from one generation to another and are more difficult to preserve than physical objects.

As the technology progressed, new ways of non-physical heritage preservation started to emerge like pictures, CDs, video recordings, etc. Because of the importance of cultural heritage, greater accent is given on the process of digitization and in many countries this is one of the priority goals [3, 7].

1.1. Macedonian folk dances. The folk dances are part of cultural intangibles. The Macedonian term for Macedonian folk dance is *oro*. In general for every traditional Macedonian folk dance the movement of the legs is dominant and dances are composed of a series of hops and side steps. The dancers are aligned next to each other, holding hands and dancing, as shown in Figure 1. All dancers are dancing synchronously to the rhythm of the music, performing the same steps [5].

Figure 1: Dancers dancing *oro*

The leader of the group determines the trajectory of the dancers' movement and often stands out, showing great dancing skills. The basic and most used movements in the traditional choreographies include moving left, moving right, jumping, hopping, dropping to knees, and other similar movements involving legs. The arm movement is minimal and in most cases it is not defined by the choreography, i.e. it is rather the same for most of the dances.

The rhythm of the traditional Macedonian folk dances is unique and complex. The most common metric is 7/8. Other metrics are also found 5/16, 9/8, 11/8, 2/4, 4/4, etc.

The most popular Macedonian folk dances which are included in this research are: *Ramnoto*, *Pajduško* and *6 Napred 3 Nazad*[1].

There are also slight variations in some of the movements of the dances. For example, in the dance *Ramnoto*, males tend to raise the right leg, while the females just put the right leg slightly forward. Also, there can be differences in the length of performed steps, depending on the moveable free space and the tempo variations.

1.2. Kinect sensor, Kinect SDK. Kinect sensor (shown in Figure 2) is a motion sensing and speech recognition input device, developed by Microsoft [6]. This sensor is very popular in the area of gesture recognition and it allows the users to control and interact with an application using real gestures and spoken commands. The arrival of this sensor introduced a new way of human-computer interaction with a huge impact in many industries, including education, robotics, healthcare, and beyond. In our case, the user tracked by the sensor is the dancer who performs the choreography moves from the Macedonian folk dance.

Figure 2: The Kinect sensor

The reasons for the popularity of the Kinect sensor, compared to other existing sensors for motion tracking, are: low price, possible use with conventional computer hardware and the existence of developers' tools for application development.

Several successful projects for dance recognition used this sensor. The examples are the Harmonix's Dance Central [1] and Ubisoft's Just Dance [4], where a dancer repeats the motion posed by an animated character in the game.

Developers working with the Kinect sensor can use software libraries that speed up and help the development process. One of them is the official Kinect Software Development Kit (Kinect SDK) from Microsoft, used in our application [10]. Using this SDK, three streams of data can be acquired: RGB (Red Green Blue), depth and skeleton data streams. The RGB data stream gives color information for every pixel, while the depth data give the distance information between the pixels and sensor. The skeletal data stream gives the positions of

[1] The English translation of the dance *6 Napred 3 Nazad* is "6 Forward 3 Backward".

numerous skeleton joints of the users that are in the tracking area of the sensor [9]. The tracked skeleton joints of the user's body are shown in Figure 3.

2. Computer-driven dance recognition

Human experts in dancing and even the enthusiasts can easily conclude if someone is performing the right sequence of movements of dance choreography, and if it is to the rhythm of the music. But, if the task is given to the computer, it would not be easy, because the computer only works with numbers.

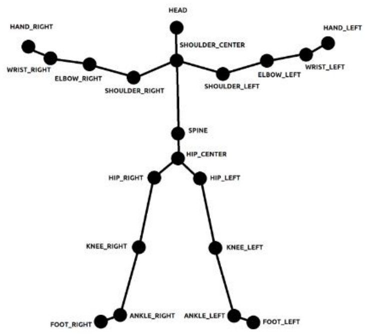

Figure 3: Tracked skeleton joints of the user's (dancer's) body

The computer needs some visual input data for dancer's tracked movements in order to be able to give some information about dancing. This gathering of movement data can be done with the use of the Kinect sensor. The sensor tracks many skeleton joints, as shown in Figure 3, so very large quantities of data need to be processed for proper recognition. For this purpose an appropriate data representation model is needed.

In [8], a set of features were inferred from a skeletal representation of the tracked skeleton joints, shown in Figure 3. Using these features, the torso's motions were intuitively and robustly described.

Similarly, by analyzing the characteristics of common Macedonian folk dances choreographies we introduce several characteristic attributes which can help in the process of recognition [5]. As described before, the movement of the arms is minimal in Macedonian folk dances and in most cases it does not affect dancing, so, the defined characteristics involve the legs and torso. First, we defined some basic initial attributes, which gave us an idea how to define even more attributes for better recognition of the dances.

2.1. Initial attributes. The following attributes were defined as initial attributes:

- **Euclidean Feet Distance (EFD)**: the length of the vector between the left foot ankle and the right one ($\overrightarrow{\boldsymbol{EFD}}$), shown in Figure 4;
- **Torso Side Movement (TSM)**: the scalar projection of the vector between two sequential skeleton hip center joints ($\vec{\boldsymbol{a}}$) on the vector between the left hip joint and the right one ($\vec{\boldsymbol{b}}$), shown in Figure 5.

Equation (1) shows the calculation of the EFD attribute. The (x_1, y_1, z_1) are the coordinates of the left foot ankle joint, and (x_2, y_2, z_2) are the coordinates of the right foot ankle joint.

$$EFD = \sqrt{(x_2 - x_1)^2 + (y_2 - y_1)^2 + (z_2 - z_1)^2} \qquad (1)$$

The EFD attribute can answer the question: “Does the distance between the two feet increase or decrease?” This attribute can have only positive values, giving the distance between the two feet.

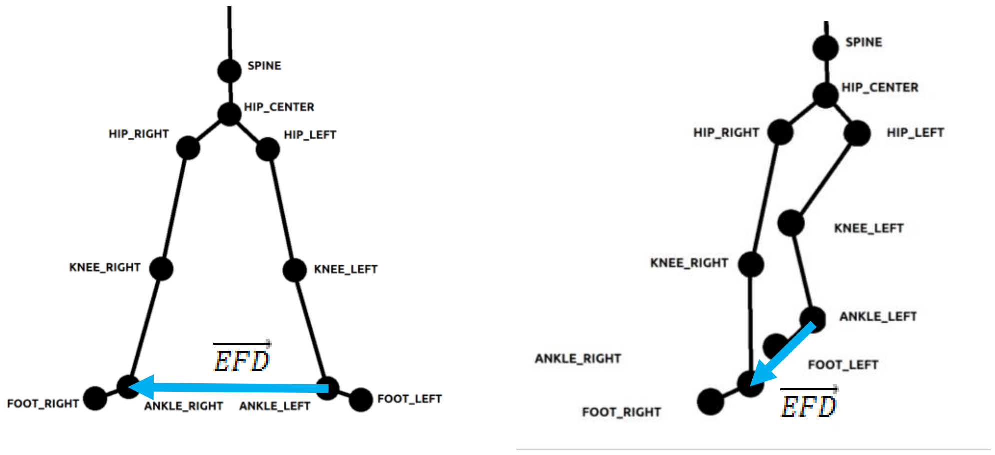

Figure 4: EFD attribute calculation when the dancer is moving sideways (left) and when he lifts one of his legs (right)

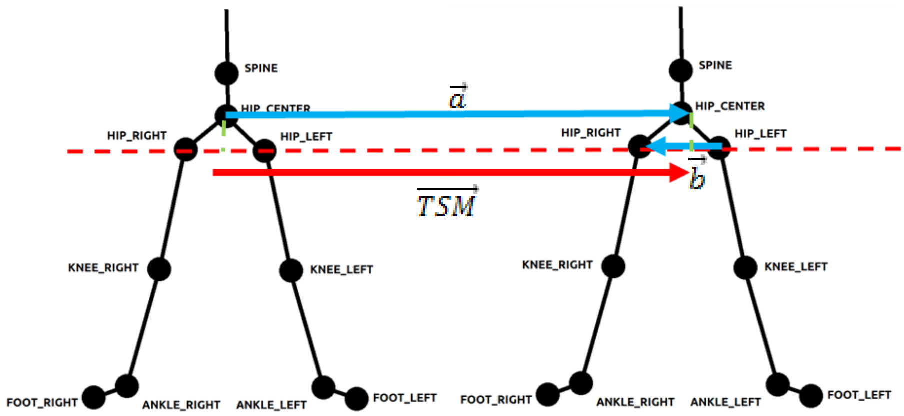

Figure 5: TSM attribute calculation when the dancer moves sideways

Equation (2) shows the calculation of the TSM attribute. The vectors are marked as described before.

$$TSM = \left|\overrightarrow{TSM}\right| = \frac{\vec{a} \cdot \vec{b}}{\left|\vec{b}\right|} \qquad (2)$$

The TSM attribute is calculated when two consecutive skeleton data are obtained in order to calculate the traveled distance and the moving direction of the torso. The scalar projection is used in order to calculate the right traveled distance even when the dancer is faced sideways to the sensor.

As Macedonian folk dances are composed of feet movements alongside with torso movements, studying the values of the EFD and TSM attributes for one period of a given dance, makes the process of dance recognition easier. But, there is a problem with the EFD attribute: it cannot be properly distinguished whether the dancer is raising his leg, moving the leg sideways or putting one of his legs in front of the body. In order to solve this problem we introduced several new attributes for improved recognition.

2.2. New attributes for improved recognition. We defined the following new attributes for improved recognition:

- **Feet horizontal side distance (FHSD)**: the horizontal side distance between two ankles
- **Feet vertical distance (FVD)**: the vertical distance between two ankles
- **Cumulative torso side movement (CTSM)**: sum of all previous TSM attribute values.

The FHSD is calculated as a scalar projection of the vector between the ankles ($\vec{a}$) onto the horizontal vector between the left and right hip joints ($\vec{b}$). In this way the FHSD compared to the EFD gives only the horizontal distance between the feet, so when the dancer raises one leg vertically, the FHSD value does not change, as shown in Figure 6 (right). The equation (3) gives the calculation of the FHSD.

$$FHSD = \left|\overrightarrow{FHSD}\right| = \frac{\vec{a} \cdot \vec{b}}{\left|\vec{b}\right|} \qquad (3)$$

Appropriately, the FVD attribute, compared to the EFD gives only the vertical distance between the feet. So, using the FVD attribute helped us deduce when the dancer is raising his legs. The calculation of FVD is similar to the FHSD attribute (4), but now the projection vector is the vertical one: between the spine and hip center joints ($\vec{b}$), as shown in Figure 7.

$$FVD = \left|\overrightarrow{FVD}\right| = \frac{\vec{a} \cdot \vec{b}}{\left|\vec{b}\right|} \qquad (4)$$

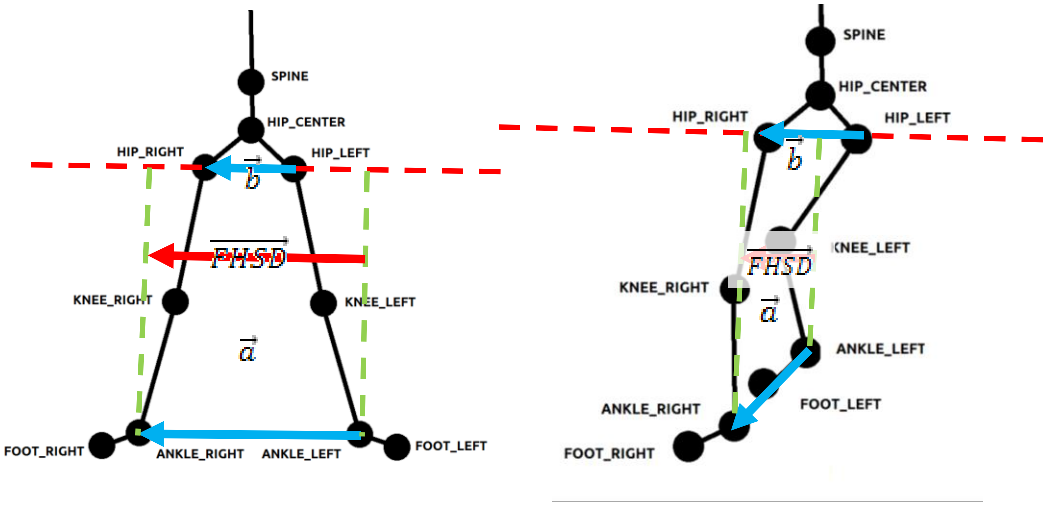

Figure 6: FHSD attribute calculation when the dancer spreads his legs (left) and when he raises one of his legs (right)

The CTSM attribute gives a global picture on which side (left/right) the dancer has moved more so far. The CTSM attribute can also be used for transition calculation – points where the dancer has started moving in the opposite direction. This can be achieved by searching for global extremes in the given execution of the dance.

For n given calculations of the TSM attribute (TSM_1, …, TSM_n), the CTSM attribute is calculated as shown in (5).

$$CTSM_n = \sum_{k=1}^{n} TSM_k \qquad (5)$$

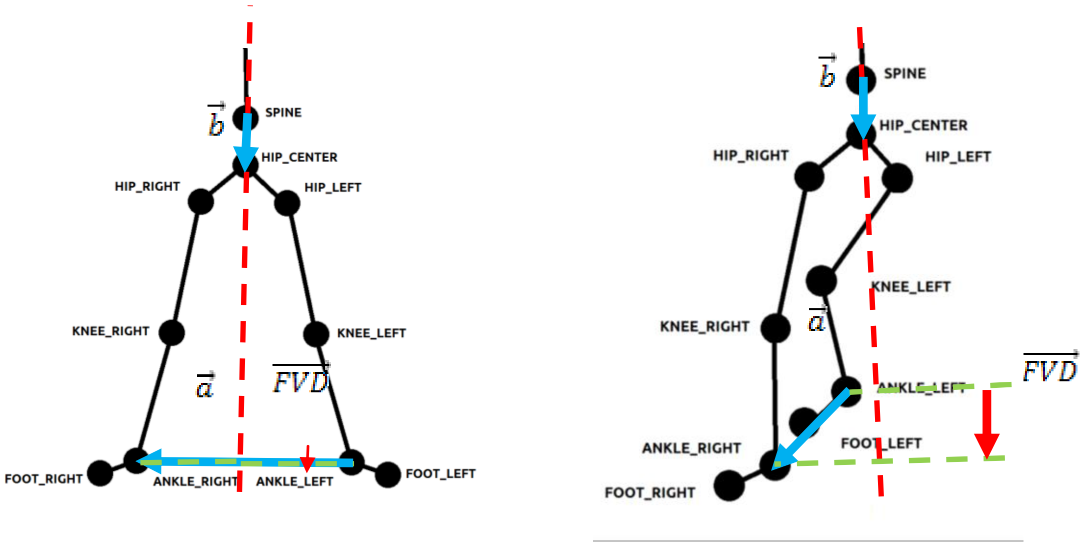

Figure 7: FVD attribute calculation when the dancer spreads his legs (left)
and when he raises one of his legs (right)

Figure 8 shows the TSM and CTSM attributes, calculated for one performance of the dance *Ramnoto*. The dancer's skeleton data were collected synchronously, on every 50 ms (labeled on the X-Axis as a sequence starting from 1). In the execution of the dance, two periods of dancing were recorded, each consisting of approximately 100 skeleton data (5000 ms). The values of the attributes are shown on the Y-Axis.

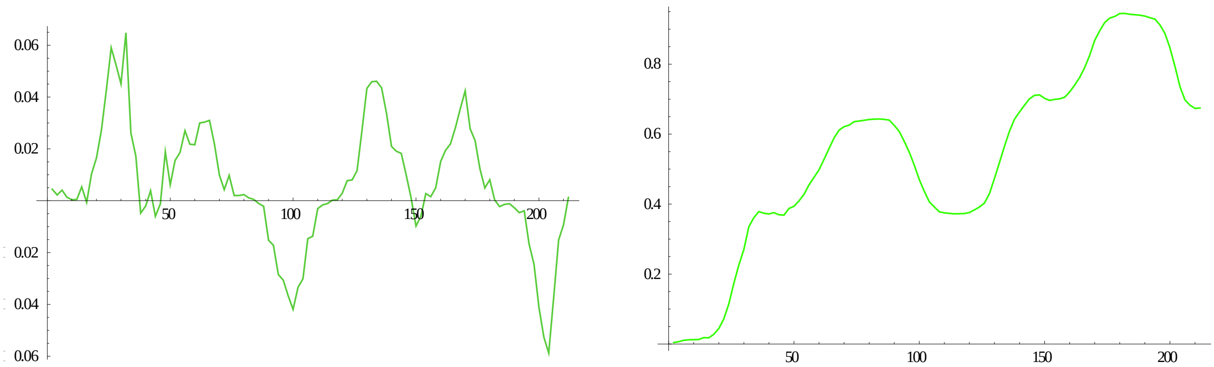

Figure 8: TSM attribute values for one execution of the dance *Ramnoto* (left)
and the calculated CTSM attribute values (right)

Studying the values of these attributes for a given period facilitates the process of recognition of Macedonian dances. The gesture representation of the attribute values is presented in Table 1. Three cases are included: when the value is negative, near zero and positive. The bigger the value means that the gesture is more expressed.

Characteristic attribute	Value less than 0	Value near 0	Value greater than 0
EFD	/	The dancer puts his feet next to each other	The dancer spreads his legs, raises one of his legs or puts one leg forward/backward

TSM	The dancer moves left	The dancer stays at the previous position	The dancer moves right
FHSD	The dancer crosses his legs	The dancer’s legs are close to each other	The dancer spreads his legs sideways
FVD	The dancer raises his right leg	The dancer’s feet are at the same height	The dancer raises his left leg
CTSM	The dancer moves his body more to his left	The dancer travels nearly the same distance to his left and to his right	The dancer moves his body more to his right

Table 1: The gesture meaning of the values of the introduced attributes

3. Evaluation

3.1. Experiment description. In order to see the range of values of the derived attributes, we conducted an experiment in which 15 amateur dancers were recorded using the Kinect sensor while performing three most popular Macedonian folk dances: *Ramnoto*, *Pajduško* and *6 Napred 3 Nazad*. The group of dancers consisted of different type of users: males, females, people who have more experience in dancing, inexperienced ones, younger, older, etc., in order to see the differences in the dancing. The recordings were taken from 2 and 3 meters distance from the sensor.

3.2. Experiment results and final remarks. Figure 9 shows the attribute values of three performances for every dance from the experiment. The three improved attributes were measured: FHSD (first row), FVD (second row) and CTSM (third row) for each of the three dances (three columns). The thick line in the graphs represents the average values of the attributes. The last row contains all the average attribute values for the introduced attributes for every dance.

The dancer’s skeleton data were collected synchronously, on every 100 ms (labeled on the X-Axis as a sequence starting from 1). The values of the attributes are shown on the Y-Axis.

Based on the data, we can conclude that the FHSD attribute for the *Ramnoto* dance has three peaks confirming that there are three occasions of spreading the legs. The CTSM attribute shows that in the first 2/3 of the music bar there is a tendency to go to the right and in the last 1/3 to the left, which is also appropriate with the original performance of the dance. Obviously, FVD attribute values are near zero. This means that there is almost no vertical movement of the legs. This is also true for the *Ramnoto* dance but we must be aware that there are variations in the dance. All of the variations must be included in the process of recognition.

For the *Pajduško* dance, the FVD attribute is crucial and from the data we can conclude that there are 6 raisings of the legs: 4 at the beginning and 2 at the end of the interval. This is a perfect match with the original performance of the *Pajduško* dance. As far as body movement is concerned, from the CTSM attribute we can conclude that this dance tends to move to the right side, especially at the beginning. The FHSD attribute varies the most and shows that there is slight spreading of the legs.

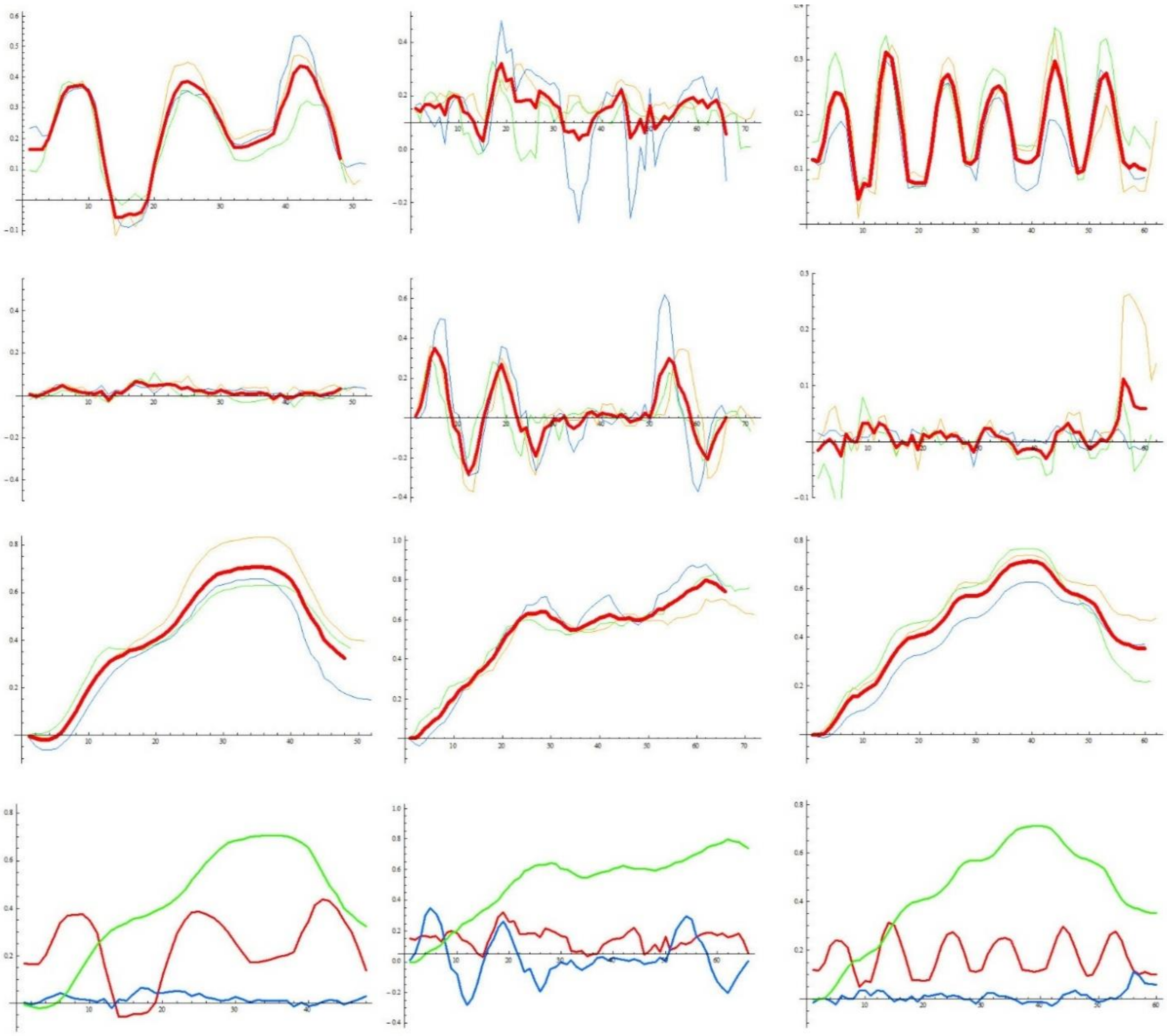

Figure 9: 1st row: FHSD, 2nd row: FVD, 3rd row: CTSM, 4th row: all average attribute values
Columns: *Ramnoto* (left), *Pajduško* (middle), *6 Napred 3 Nazad* (right)
The thick line in the graphs represents the average values of the attributes

The *6 Napred 3 Nazad* dance is also well described by these three attributes. There are 6 peaks in the FHSD attribute (6 spreadings), 2/3 of the music bar is movement to the right and there are minimal vertical movements.

We can conclude that these three attributes can help the process of dance recognition by studying the values for a given period of the dance. In order to fully show that, in Table 2 we analyzed and included the change of the attribute values for every part of the dance for the most known performance of the *Ramnoto* dance and included the most common variations of the dance. For every part of the dance, we have assessed the parameters using the following criteria:

- Sign of the value:
  - **+** : the value of the attribute should be positive
  - **-** : the value of the attribute should be negative
- Change of the value:
  - **inc**.: the value of the attribute should be increasing compared to the previous one

- **dec.**: the value of the attribute should be decreasing compared to the previous one
-

Ramnoto: 3 bars 7/8 rhythm	1 bar (3+2+2)			2 bar (3+2+2)			3 bar (3+2+2)		
Accented beat	3	2	2	3	2	2	3	2	2
FHSD	+ inc.	+ dec.	+ dec.	+ inc.	+ dec.	+ dec.	+ inc.	+ dec.	+ dec.
			- inc.			- inc.			- inc.
FVD	≈0	≈0	≈0	≈0	≈0	≈0	≈0	≈0	≈0
	+ dec.				- inc.	- inc.	- dec.	+ inc.	+ inc.
CTSM	+ inc.	+ inc.	+ inc.	+ inc.	+ inc.	+ inc.	+ dec.	+ dec.	+ dec.

Table 2: Assessed change of the attribute values for every part of the *Ramnoto* dance

The real change of the values was calculated for every performance of *Ramnoto* in the experiment. The collected data from the performance were split into appropriate parts with the appropriate length that corresponds to the rhythm and structure of the *Ramnoto* dance. The results of that calculation are shown in Table 3. The FVD attribute is omitted because it has most variations and the recognition can be done using the other two attributes. The expected values in every part are marked with gray colors, according to the Table 2.

We can conclude that most of the calculated changing values of the attributes match the expected changing values.

Ramnoto: 3 bars 7/8 rhythm		1 bar (3+2+2)			2 bar (3+2+2)			3 bar (3+2+2)		
Accented beat		3	2	2	3	2	2	3	2	2
FHSD	Inc. (%)	77.98	13.52	43.26	80.56	16.67	34.94	80.55	16.66	32.15
	Dec. (%)	22.02	86.48	56.74	19.44	83.33	65.06	19.45	83.34	67.85
CTSM	Inc. (%)	95.79	99.26	96.24	99.23	98.33	85.62	20.85	3.4	20
	Dec. (%)	4.21	0.74	3.06	0.77	1.67	14.38	79.15	96.6	80

Table 3: Real change of attribute values for every part of the *Ramnoto* dance

4. Conclusion and future work

In this paper we have introduced several characteristic attributes which can help in the process of recognition of traditional Macedonian folk dances. These attributes were defined according to the features and characteristics of the dances. The defined characteristics involve only the legs and the torso, because the arm movements in most cases do not affect the dancing. An experiment was performed which included the most common dances in order to see the range of the attribute values for every part of the dance. We concluded that the defined attributes can be used in the process of recognition of the dances.

Our future work is focused on the use of these attributes as an output symbols for Hidden Markov Models [2]. We plan to build a Hidden Markov Model for every dance and use it in the process of recognition of the dances.

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