Exploring Dance Movement Techniques that can be used to Animate Salsa Dance

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ABSTRACT
In this literature review we investigate the various types of formal dance notations and identify how they can be used to develop 3D dance animation. In this literature review, focus was aimed at discovering the general trends and challenging aspects of dance pedagogy and identifies current and emerging software teaching methods. As teaching dance is becoming more complex and relevant, development of tools to aid instructors in teaching choreography is a necessary and important research topic. In particular, we focus on the different techniques and frameworks used to classify human motion that can be used in encoding dance.We examine four key areas from previous research:
dance notations, transformation of dance notation into conceptual models, using notation to create 3D animation and artificial intelligence in creating dance choreography. Through this research, it is noted that very little work has been done to transform paper-based Salsa dance moves into 3D movement. Overall we conclude that additional research is required to model a graphical representation of dance. This paper finalises by discussing recent tools and Computer-Aided Choreography Systems developed to graphically represent human motion with respect to dance. A focus is on introducing these systems as a proposed solution for our research topic.

CCS Concepts
· **Human centred computer→Human Computer Interaction (HCI)** · **Artificial Intelligence→Genetic Algorithms**

Keywords
Labanotation; Benesh Movement Notation; Ontology; Semantics; Conceptual model;Segmentation; Multimodal data.

1. INTRODUCTION
Dance is the most elementary of the art forms, that involves expressions through bodily actions. Alike, it is a great therapeutic activity but it was not until the 21st century that creative art therapies, such as dance, evolved as a form of medicine for psychological and physical illnesses [1]. As a result, dance has become increasingly popular worldwide.

The pedagogical operation of dance in education has recently changed drastically. Dance pedagogy has historically followed a transferral method of teaching. This is where students learn by emulating certain movement vocabularies by an expert teacher. It is now globally accepted that transformation of dance content into knowledge for teaching and learning involves more than dance skills and control, and that teachers need a vast range of teaching programmes to motivate and capture their students attention [28].

There are a limited number of tools available for beginners to learn dance moves. Video lessons are usually difficult to follow as moves are not characterised clearly into steps and positions. There are several paper based languages formulated that describe the notation of steps [23][27], however, there is little further work being done to implement this. The goal of this literature review is to provide an overview and comparison of these aspects with the aim of finding the most suitable development of a tool where instructors can describe dance moves and learners can reassess the moves and experiment with different sequences. Section 2 introduces and defines Salsa dance concepts and movements, Section 3 gives an overview of the types of Formal Dance Notation and their transitions in time. Section 4 classifies 3D motion of movement in dance. A discussion of their applicability is provided in Section 5. In Section 6, we draw conclusions based on the findings in this literature review.

2. SALSA DANCE
Salsa is a popular dance form that originated in Cuba. Salsa is believed to be one of the most practiced dances in the world today. Salsa is also one of the most popular of the Latin dance fads, and since the early 1990's, Salsa has experienced added attention from American audiences who have put a large amount of money into learning Salsa dance[3]. In this section we discuss the background of Salsa dancing and the formalisation of the salsa dance style.

2.1 Background
Compared to language, dance is one of the least studied sections of communication, due to, not only to the lack of research interest of the past academics worldwide, but also to the untouchable characteristic of dance and the absence of methodologies to document and study it in a methodical manner [29]. Students learn by coping movement in dance performed by an expert instructor. Students use different methods to document the dance motion taught by an instructor. Historically, technology been used as a tool to expand creative opportunities in choreographic processes with multiple choreographic support tools [5]. However, few of these tools support creative development with interactive or generative components. At present, documentation of dance through mobile phones and various other devices of a live dance performance are favoured methods but it has its own intrinsic disadvantages [26]. Often it is difficult to comprehend the exact dance movement by looking at it on a low quality video on a mobile phone.

Instruction in dance based on notation produced gave rise to greater recognition capacity for learners in school, good combination of the skills needed for advancement in dance, and fundamental skills in performing movement taught to students in schools and Universities [31]. Many authors [9], declare that symbolic representation of movement in comprehensive notational systems, takes dance cognition to another level by establishing a structure for understanding the concepts used in movement. There are a variety of computational creativity projects that explore the generation or augmentation of movement material for choreography which is discussed in-depth in Section 4. These principles are of particular interest to our area of research, as a core tool to assist us in developing and computerising a dance language to record dance moves.

2.3 Dance Paedology

Dance is a physical and mental response to experiences of the world suggested by [2]. This author suggests that the combination of our physical and intellectual beings can occur in learning of dance. It been advised by many theorists as crucial to comprehend the various advantages of education in dance.

Pedagogical practice in dance education has evolved exponentially. Dance pedagogy has conventionally followed a system of teaching, where the students learn by copying a variety of movements practiced by an expert instructor. It is currently globally accepted that transforming dance content into knowledge for teaching as well as learning purposes requires more than dance skills and that experts need a broad range of teaching programmes to motivate and encourage students to learn dance.

Dance now integrates technological aspects in teaching, performance and choreography. Due to the rapid technological advancements, it is increasingly important for novice dancers to keep up their technological expertise and advances used for creating, producing and documenting their dance attempts. Teachers are encouraged to be open to and dedicated to use the new method of teaching dance with their capabilities. Distance education has also become an increasingly popular method of teaching dance [21]. These technological approaches will give students the tools for developing their own environment of exploring movements and reflecting upon them. By bringing in creative practical tools, it allows students take the necessary steps for the world they will enter and dance teachers and enrich students experiences using a technological platform to teach dance.

2.2 Introduction of Salsa Dance Steps

Salsa allows for a variety of creative improvisation. Hence, a variety of styles have developed periodically. Despite the different styles of dance, the basic steps are essentially the same. A step is described as the shortest achievable piece of movement that can uniquely recognise a repeatable dance movement over a period of time. Salsa dance motion is naturally defined in terms of steps. These steps are constructed as successive sub- steps that are synchronized with a musical beat. One sub-step usually lasts one fourth of the time of a step. Only three steps are performed for every four beats where there is one step for each beat and one beat is skipped. These steps can occur from side to side or forward and backward and in a circle. The basic rhythm is quick, quick, slow; quick, quick, slow, using the 1,2,3 and 5,6,7 beats with beats 4 and 8 being omitted. Salsa is usually performed in a pair with a leader and a follower.

Dancing involves spontaneously creating and performing various movement combinations. During the weight change of the body, the upper body stays almost immobile. This means that the hips form most of the motion for this Latin dance form. In the upcoming sections, focus is placed on the various skeletal joints of the human body that are linked to dance movement.

3. DANCE NOTATION SYSTEMS

Dance notations are used to record dance choreography and allow them to be reproduced by dancers and choreographers. Dance notation has a symbolic representation that is similar to music. It has basic mathematical content that lends itself to machine representation. Various notation systems have been attempted for analysing human movement. In this section, we will compare various methods, namely Labanotation and Benesh Movement Notation (BMN).

3.1 Benesh Movement Notation

Benesh Movement Notation is one of the oldest notation systems for analysing and documenting human movement by using symbols [8]. Benesh Movement Notation is a 2D notation that records human movement in 3D of space which has been successfully implemented in the production of scores for a wide range of dances [27]. BMN is recorded from left to right on a five-line stave (just like music notation), to produce a matrix of the human form. A matrix represents the dancer's motion from head to toe, looking at the back of the dancer. Positions and movement lines are plotted on this matrix. Timing signals are situated above the staff. The complex movements that are not possible to indicate visually are written with extra signs and numbers above the staff. BMN has been implemented in diverse areas such as dance, gymnastics, circus performances and neurology [22].

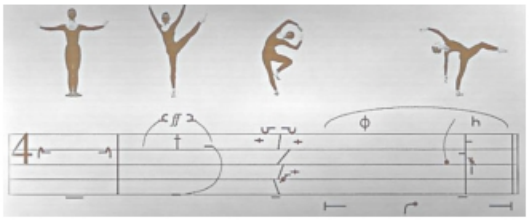

Figure 1. Recoding of movement in Benesh Movement Notation

3.1.1 Development of BMN from a Notation

A novel dance movement notation was researched in 2012 by Saad et al [25]. An approach was presented [25], for the semantic annotation of human movement using videos. This approach is based on an ontology and semantic conceptualisation classification using BMN. The BMN method was used as the main sugggestion for building Video Movement Ontology (VMO). Using the ideas in Artificial Intelligence, ontology deals with reasoning about models. This is the first time the ontology is used with BMN to discuss the video human movements. However, this literature lacked possibilities of complex movements inferences for dance such as turns and complicated foot movement. Further, checks have to be conducted to verify the acceptability of the VMO approach and human perception. The most recent study in 2018 shows [17], that finding and applying a conceptual model or ontology for describing human movement is a challenging issue as there are unlimited possibilities of combinations of movements and it becomes hard to represent. While, BMN provides a theoretical approach for doing so, it is not part of everyday language of all dance instructors. Web-based Movement Library (WML) was proposed to provide an intuitive interface for accessing recordings and gather "ground truth" data on how the dance experts characterize different segments of the recordings regarding their movement aspects [17]. More specifically, the user can search the recordings by dance genre, and search by using keywords that are included as metadata or in the annotations of the recordings. The keywords refer to various areas of movement. Graphics editors for Benesh notation also exist and are available to use, such as MacBenesh and Benesh Notation Editor [8]. MacBenesh is a Mac tool that allows creation of a single dancer where BMN scores can be saved in a document. There is also Benesh Notation Editor that is a Windows tool for writing Benesh Movement Notation scores [27]. It is similar to a word processor where the Benesh scores can be saved in a document. In the work above, an annotation tool was created, which is integrated in an archival system. However, this tool has not been implemented to recognise salsa dance moves. Hence, further research must be done to describe movement in Salsa dance.

3.2 Labanotation

Labanotation is a general body motion notation that is commonly used as it does not depend on any specific dance. This form of notation is a favoured way of representing dance scores among choreographers. The majority of Labanotation is defined in three levels: staff, Laban symbol and decoration. The score starts with a vertical staff with three lines. These lines define 9 vertical tracks, each for a part of the human body: four for the left side and four for the right side. Each of these sets of four contains a track for that side's foot, leg, upper body and arm. The ninth line is for the head.

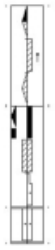

Figure 2. A section of a Labanotation score, consisting of a staff with directiom symols.

Considering that Labanotation is built on graphical representations, it is also globally accepted as a readable and understandable notation [23]. Symbols are written on the columns split by a horizontal line. This horizontal line is regarded as a measure of time. A shape of a symbol represents direction of a body movement, level is represented by a texture and the time span is represented by its length. To show a movement of a particular body part, a symbol is added on the column of the staff.

3.2.1 Semantic Models Using Labanotation systems

In 2006, Nakamura and Hachimura discussed an XML (eXtensible Markup Language) representation of Labanotation, called LabanXML [23]. This language allows a user to input and edit movement of dance in the human body as well as exhibit animation of a human body model in 3D graphics. This research was improved upon by Hatol et al [12] using MovementXML which is based on LabanXML. Its purpose is to represent the semantics of Labanotation in XML. MovementXML is a useful XML preliminary plan to encode dance movement. MovementXML allows smaller movements to be joined together to form a higher- level movement. Furthering this research in 2012, a Knowledge Based System was implemented for reporting and storing dances which exploits the expressivity of Description Logics [10]. The elements of the ontology and their ability to construct the dance model are based on the semantics of the Labanotation system. However, limitations occurred when using this system. Searching for a specific movement in the system is not possible as you lose the whole image of a printed score. Respectively, you cannot see the whole picture of the body shape unless you revert to previous states. Therefore, this approach would not be useful in our research task of encoding dance. In 2014, the existing semantic models, presented in related works above were further examined [18]. Researchers attempted to implement an easier solution to classify semantic models for movement. The Labanotation based ontology above is a model between the Labanotation concept layer and General Movement Concepts layer. In the above models, rules were not put in place to directly connect the Labanotation symbols from their actual scores into an instance of the ontology in an automatic way. El Raheb et al [18] focused on jotting down the definitions to proceed from a layer to another. This layering is set out as a useful lead to categorise

semantic models for motion. For example, mentioned in the paper of Saad et.al [25], is a change between a notational layer (Benesh) and a conceptual layer based on the notations description of movement characteristics. Extending this research, Whatley et al [19], developed a conceptual framework to create a vocabulary for preparing and capturing dance movement sequences and allow the re-use of these sequences in various contexts. Experts devised a framework that allows for a cross- genre analysis of dance practices, providing the necessary conceptual categories to assist in the building of tools to support the teaching and learning of dance. For our purposes, these findings prove useful in our research area. This framework will assist us in learning the categories associated with Salsa dance.

An elementary issue with Labanotation and Benesh notation is that not many understand these notations and very few people are specialists in the field. Here the annotation process involves the expert to visualize the representation of the notation and to translate the movement to the dance learners. Further, these annotations exist in a paper-based form only and no visual form exists [15].

4.CATEGORIZING DANCE GESTURE

Dance is a sequences of several limited, distinct gestures. Gesture involves two major aspects: spatio- temporal variability and segmentation ambiguity [13]. This section will focus on the ongoing research on the modelling of expressive gesture in multimodal interaction and translating notation scores into 3D animations for dance movement purposes.

4.1 Motion Classification in Human Computer Interaction

Masurelle and Essid developed a corpus used to exemplify, develop and test a variation of tools. [11]. This corpus is centred on an online dance class where students, with avatars operated by any 3D capture technology, can learn choreographies with teachers instruction in an online virtual dance studio. Tasks include: Human motion analysis, dance movement recognition and pose estimation using depth sensors which makes tracking more powerful. Advances in human-computer interaction technologies have improved significantly and facilitated the multi- modal findings of spatio-temporal features of the human body using devices such as the Kinetic etc. Masurelle and Essid extended the multimodal dance corpus approach to recognise Salsa dance movements. To perform the gesture recognition tasks to predict Salsa dance steps, two classifiers were investigated: Gaussian mixture models (GMM) which is usually used to approximate static probability models and HMM which is an extension of GMM that replicates temporal variations [24]. This literature [16] demonstrated a newly discovered multimodal dance movement classification system. However, Masurelle and Essid use only the skeletal joints below the waist of a subject under the assumption that over-the-waist joints are uninformative in the context of Salsa dance. In 2016, the experiments of Masurelle & Essid was extended by Ververidis et al [16]. They make use of six and twenty step Salsa classes, on male and male and female data, with below and over-the-waist joints. An open-source, dance motion tool, DanceAnno, was created that allow a user to construct annotations of occurrences in order with motion trajectory signals with frame-by-frame recording of the entire activity. In conclusion, it was shown that the model discussed does not take into account time lags or other spatiotemporal distortions.

4.2 3D Representation

LabanDancer system was created to interpret Labanotation scores (written in labanWriter editor) into 3D human figure animations [20]. However, LabanDancer produces movement for the body parts that have clear notation and movement for the rest of the body is omitted. LabanDancer also does not have a function that prepares Labanotation scores which is useful in enabling dance movements to be accurately interpreted. In 2014, GenLaban was developed to allow user to translate body motions to scores [8]. GenLaban is advantageous as Dancers can document their body movement and change them to Labanotation which can be used as a memory support. Dance teachers can use the system for creating teaching materials. Only LabanEditor can produce Labanotation scores and show animation of the score. Nonetheless, there is no software obtainable for representing the dance in 3D animation. Secondly, there is no standard of translating notation scores to 3D animation. In 2017, researchers [30] proposed a framework for a traditional Thai dance, by developing an ontology using knowledge engineering based on Labanotation. It does this by transferring notation scores to represent the Thai dance in 3D Animation [30]. The framework assists dancers, notators and knowledge engineers to successfully communicate with each other. This tool could potentially be useful in our research to assist us in translating the notation into 3D animation for the purpose of teaching Salsa dancing. Highly complex systems are more prone to failure than smaller projects. Thus it is important to realise that the methods for evaluating success need to be logically possible and objective if our research is to be trusted.

4.3 Artificial Intelligence in Dance Choreography

4.3.1 Genetic Algorithms in Dance

Many attempts of automated choreography was described using dance visualization. In 2014, a model was developed to represent an indian dance (BharataNatyam) step through a unique thirty attribute dance position vector [26] used to generate non-conventional dance poses which were accepted by prominent dance instructors. Nevertheless, in order to visualize every resulting BharataNatyam dance, a human model has to pose according to the moves. This obstacle was overcome by creating a stick figure generation. This literature proves useful in our research as these tool can be used to model a stick figure to suit a dance pose in order to visualize movements. In 2015, researchers extended on this literature and proposed “Art to SMart” as a system to model BharataNatyam [14]. This system creates dance poses. Moreover, experts created a stick figure generation module to help envision the dance vector

system as mentioned in the research above. This system generates simple steps using evolutionary programming and is a tool for the dance teacher to improve his/her skills. Following the previous research, Genetic Algorthm (GA) were used to determine appropriate BharataNatyam dance steps. An important implementation uncovered in this paper [14] was the action of filtering out impractical and impracticable steps by maintaining a database of illogical dance steps. This is crucial in every genre of dance because a variety of moves are not doable or not practiced in all dance. The dance position vector successfully modelled the major limbs (right hand, left hand, head, waist, right leg, left leg) of the figure to represent the dancers position at the termination of a beat. This GA tool can be used as a tool for the choreographer to generate each move to his/her advantage.

4.3.2 Computer-related Choreography Systems

A framework was developed [32] that shows dancers as seperate computer items that can select dance steps and move around on a dance floor. This began with the creation of an agent-based model of Swarm simulation. The conduct of the computer agents can create a range of dances (movements and positions) with the DanceForms software [4]. DanceForms is a human figure animation system that is made optimal for dance. The Swarm model is able to create different dance movements based on the given rules. This model is a potential tool that can be devised in our area of interest. The implementation of the tool is flexible and it is possible for new rules to be added. Cochereo, [6] was developed in 2016 for creating novel keyframe animation for choregraphy. Cochoreo generates movement outline by using parameters from Laban Movement Analysis, an existing movement framework, to generate unique keyframes that are used as seed material for choreographic process. Cochoreo is a sub-module of the idanceForms (idF), a mobile animation tool. idanceForms (idF), a redesign of DanceForms, is a creative support tool that captures choreographers' movement process. idanceForms enables choreographers to design movement poses as keyframes and then animates them. Cochoreo is also an extension of the Scuddle system [7], a generative system for movement catalysts. Scuddle generates movement as static positions with instructions to be performed in order to be translated by a choreographer. Researchers suggested that this can be an inspiration for designing new novel movement. Autonomous creativity systems that currently exist include the Cochoreo, Tour Jete, Pirouette and Scuddle described above. This project [7], uses the current libraries of motion within the DanceForms software to create sequences automatically from a series of single movements onto a group of avatars [6]. This createdgroup movement sequences explored by Choreographers who considered the movement too challenging to perform exactly as the system did. Conclusively, experts suggested that these computer related choreography systems depict a high precision in movement description. They represent mulitiple figures in 3D which we can use to generate a seuqence of moves in Salsa dance and an advantage is that it allows the user the freedom of final selection of moves.

There are many Computer-Aided Choreographic Systems that can be employed in dance movement generation and representation. Table 1 provides us with an overview of some of the common systems that were mentioned above and their comparisons.

Table 1. **Comparison of Computer-Aided Choreographic Forms**

Computer-Aided Choreographic Systems	Movement Generation	Sequence Generation	Precision of Movement
DanceForms	User	User	High
Tour Jete, Pirouette	User	Swarm technique	High
Cochoreo	User	User	High
Scuddle	Genetic Algorithm	Order of creation	Low

5. DISCUSSION

This literature reviews discusses a number of dance classification areas. This literature includes writing dances notations, developing semantic models using notations and finally classifying human motion to convert dance notation into 3D animation. Using a wide range of research papers is a necessary requirement in understanding the complexities of encoding and decoding dance. Through this research, we are able to discover what problems researchers face and how they are solved. There are a limited number of tools available to computerise a dance language in order to record animations of dance. We are interested in using a tool to animate dance movement by using systems such as Cochoreo,Scuddle and Tour Jete Pirouette [6][7][32]. These systems present high precision of movement so it will be best suited to our research to ensure all moves are depicted accurately. The problems we are likely to face is that none of these tools have been developed using Salsa dance movement so our aim is to repurpose these systems for Salsa movement. This relates to previous discussions in the background section [4].

In this review, many of the papers are successful in what they aimed to achieve, however, they not offer what we need. These problems do not have much similarity to our research in terms of their aims and achievements, meaning that the work is largely not applicable. Many methods were suggested for various dance genres but only a few for Salsa Dance. Specifically, [11] [16] concentrated on translating Salsa dance to skeletal joints. This led to focusing on papers that described movement for other dance genres which means potential tweaking to make it appropriate for use in our research area.

Initially, our focus was centred around the two most common dance movement notations and discussed how ontology models were developed to annotate dance movement [17][18][25]. The

optimism of the researchers that applied these ontologies to construct a dance model is encouraging for the development of this topic. This was further researched and improved by developing frameworks that assisted in building tools for the teaching of dance [19]. While the literature on these topics are fairly comprehensive, there is far less research on the implementation of notations to create movements specifically for Salsa dance. Hence, this this is an avenue for further research.

Finally, we focused on technologies such open-source tools and frameworks for dance movement representation. These technologies have made easier, the multi-modal findings of spatio- temporal features of the human body [13]. Much research has been done on this topic and researchers are continuously trying to improve on previous research done.This proves that our area of research is slowly emerging to become a topic of interest in the future.

6. CONCLUSIONS

Developing a tool to formalise dance steps and animate a Salsa dance form proves challenging as there are currently limited resources available [29]. Many of the systems mentioned are not suited to Salsa dance but through modification we can use it as a tool to computerize the dance. In this paper, approaches to using tools in computerising a dance language (or lack thereof) was analysed. Some technological solutions are still new and developing so, focusing on improving existing solutions can lead to more positive outcomes.

In this literature review, we have focused on understanding the previous tools used by researchers to encode dance sequences and how they are transformed into graphics. We have established that this can be done through developing semantic models using dance notation to classifying dance choreography movement in Artificial Intelligence.

While certain systems have been a success [6][7][32], their application in the evolving world has resulted in a number of problems discussed in section 4.3.2 and further research is needed to understand how these systems might succeed. Moving forward, when implementing system in this context, the evidence is not altogether clear on which technologies are best suited to Salsa dance.

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