

Exploring the usage of Video Annotations as a Tool for Social Dance Education in a Mobile Application

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Abstract

In this literature review, we explore the use of annotations in education and how this can be applied to novice social dance education. This is a software development problem that requires the design, development and testing of a custom solution. We explore the theory of dance education to get a background in what has been the standard teaching styles. We examine existing software solutions that aim at providing dance education to analyze the methods used therein. We discuss the necessity for participatory design with respect to a cross-discipline application such as this and we examine annotations from the following aspects: their applications to education, the application to dance education, vocabularies for dance annotation systems, their use in a mobile context and the methods for storing and querying them. We find that an Annotation system using a co-design vocabulary specific to the educator and dances within a mobile application to be the best solution.

CCS Concepts: • **Annotations** → Annotations on Mobile; Storage and Querying; Annotations for Education; Annotations for Dance; • **Participatory Design** → Co-design; User Testing.

Keywords: Dance Education, Participatory Design, Dance Education and Technology, Annotations for Dance Education

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1 Introduction

Over the last ten years the advancement of Dance preservation and education has seen numerous additions due to technological projects. Primarily the focus has been on providing systems for the analysis and enrichment of dance videos for the purposes of study and retrieval by professionals, choreographers and novices [2, 7, 12]. Work has also progressed in the realm of dance education with novel technologies such as Virtual Reality [2] and Infrared Optical Systems [13] being used as methods to teach dance in situations where you do not need a dance teacher present while flipped classroom methods have been implemented to supplement and improve in-person teaching capabilities [9].

Currently, there has still not been much research and development of annotation systems as a means for a dance educator to provide precise feedback on student dance videos in a social context [6]. With the current worldwide situation due to Covid-19 encouraging a mix of in-person and distance learning for all subjects the importance of systems like these have been highlighted in everyone's mind. The aim of this project is to examine the current technology used for teaching dance, the methods of classical dance teaching and its notations and the use of annotations in education and prior dance applications in order to apply them to a mobile application which can be primarily used to provide feedback to students from a dance instructor with a secondary focus on the storage and retrieval of annotation enriched dance videos for the purpose of learning Latin dances in a social dance class setting.

2 Background of Dance Education

In this section, we will look at the styles of dance education and how they have shaped the ways that students learn. In addition, we will also look at previous ways that dance has been described on paper in the form of the existing notations and how they are limited in regards to teaching novices.

2.1 Theory of Dance Education

Based on findings from Raheb et al. and Cisneros et al. [2, 15] four main approaches have been identified for teaching dance. These are the Mimetic, Traditional, Generative and Reflective Methods.

The Mimetic method focuses on a student imitating the movements of the teacher after a demonstration and receiving feedback. The approach has also been referred to as the "see and do" approach.

The Traditional method focuses on the teacher making all decisions for the student and greatly emphasizes the students as being either right or wrong. There is a large focus on accuracy and precision in this method. It is also referred to as command style teaching.

The Generative method focuses on the teacher providing the student with an exercise/phrase or sequence as a starting point which they can use to achieve either a creative or technical goal.

The Reflective method focuses on the student mastering or exploring aspects of movement rather than reproducing specific moves by giving the student a movement-image or task to work with and allowing them to improvise with no specific end goal and then getting feedback from the teacher.

The Generative and Reflective methods for dance teaching offer far more creativity and imagination to the student than Mimetic and Traditional and have become more prevalent in recent years. Although, for the context of Social Dancing it is more likely that teachers will be working with far larger groups that are not practising as regularly and so will prefer the Mimetic and Traditional methods. The relation of the Mimetic and Traditional methods and the ability to use annotation as a tool to teach them will be discussed in Section 6.

2.2 Dance Notations

Before the onset of modern technology, Dance Education has only left the physical medium through the use of notation systems to record the choreography of a dance. Simple versions of notations such as simple images or jotted down notes may be used by choreographers to keep track of a new dance as they choreograph it [5]. More complex notations such as Laban [21] and Benesh [20] captured far more detail than a choreographer's notes and can be used to capture and analyze each movement in a dance piece. These formats are not commonly used due to their complexity and the lack of Movement Notators who are able to write these notations. While novice dancers looking to become professionals within the theatre spaces or at professional dance schools will likely be exposed to these notation systems they are not widely used in novice education due to the level of complexity they present.

3 Dance Education and Technology

Dance Education as a field has been traditionally oral and demonstrative. As a medium, most learning will take place in person with an instructor rather than in any distanced capacity. In this section, we discuss the technology that has

been used in Dance Education and look at the current relationships Dance Education has with modern technology.

3.1 Current Technologies

Through the use of digital videos, wide-spread personal computer and mobile phone adoption the ability to combine dance teaching with technology has been investigated over the past decade. Importantly, a large takeaway has been that technology for dance education should exist as a supplement to the in-person instruction of a teacher rather than a complete replacement due to the current limitations of technology.[6]

3.2 Existing Dance Education Systems

Many systems currently digital systems currently exist for the purpose of assisting with dance education however, most have made use of annotations for the purpose of analyzing data and enriching it for the purposes of storage and searching. Additionally, most dance education applications have been undertaken as development jobs rather than research studies. As such we will be focusing on four specific examples which were done for research purposes, WhoLoDancE, Dance-the-Music, DanVideo, Web-based Music Library and dos Santos et al. [2, 6, 7, 12, 13]

Many different technologies were investigated by the aforementioned projects for the purposes of dance education. WhoLoDancE [2] created a database of motion-captured dance movements and routines using a professional motion capture studio which allowed for full 360-degree interaction with the rendered model within the system. This model was then used to allow a dance educator, choreographer or learner to make use of Virtual Reality or Augmented Reality headsets to learn dancing using avatars. One of the avatars was a "blob" of varying sizes, to determine difficulty, which a learner would try to stay inside of to learn how to perform the dance steps. In comparison, Dance-the-Music [13] made use of a template-based approach to create fixed-size multi-dimensional feature arrays forming the spatiotemporal template which contained all the gestural parameters for a specific dance. These templates were created from uploaded videos from teachers performing the dances. With these templates gamification was used to allow a learner, while wearing IR sensors, to dance the steps they had learnt and be given feedback based on how well they compared to the instructor's avatar. WhoLoDancE [2] additionally offered tools to assist in self-reflection from motion capturing a dancer's own performance to tools that could be used by choreographers to create a new dance routine using the library of motion-captured movements. The issue with these approaches to dance education as mentioned within the projects and by users is that they are not easily affordable or portable due to the IR sensors, headsets and other technology needed to make use of them and they are primarily intended to be used

by dance practitioners and educators of a professional level versus a social one [2, 13].

WhoLoDancE, WML, DanVideo and Dos Santos et al. all made use of annotations with dance videos [2, 6, 7, 12]. WML is specifically aimed at being used by dance educators, choreographers, movement and dance practitioners and experts as a tool to browse, search, observe and reflect on particular movement descriptors and characterize them [7]. This differs from WhoLoDancE and DanVideo which do intend their annotation systems to be used by novices although the main focus does align with WML in that they also are mainly using the annotations to analyze the movements and improve the experience of browsing and searching for a particular movement that a novice would like to learn [2, 12]. As such these three systems make use of annotations primarily for the purpose of analyzing and enriching data with a secondary additional benefit of this boosting the dance videos applications for education.

Contrarily the project by dos Santos et al. [6] focused on using annotations for a form of direct teacher to student feedback. A system was implemented to allow a student to upload a video of themselves dancing a particular step or sequence of steps and then this could be received by the dance educator and annotated to highlight where the student made mistakes and where they could improve [6]. A downside as mentioned within the user studies of the WhoLoDancE application is that they are not particularly portable as they are all web-based applications which are thus less suitable for use on a mobile device and require more effort to make use of on the go [2]. It can be assumed that this issue would extend to all the above-mentioned applications as they are all web-based.

4 Annotation Systems

The process of Annotating Videos has seen many uses from Machine learning to educational applications. This section will focus on Annotation systems, how they have been applied and how they can be applied to Dance Education in a Mobile Context.

4.1 Annotations in Education

Annotations have uses in education from both an educator and learner perspective. For educators, it has been found that video annotation is an important tool for reflection and subsequent growth of their teaching abilities through both peer and self-review [14]. McFadden et al. [14] show that while self-review is an important skill within their study the educators tended to rate themselves far higher than they did their peers leading to the possibility that self-reflection and peer review can be subject to a lot of potential bias although this did not dismiss the advantages that being able to receive

this feedback provides. Importantly it was highlighted using self-reflection and peer review is best when there is a structured set of criteria on which people are being critiqued. This matches up perfectly with the idea of vocabularies for dance annotation languages which will be discussed in Section 4.3. Suhre et al. [18] also showed that creating annotations while engaging with content helped to increase a students performance. In the study which used the tool Perusall and a structured course requirement in which teachers required students to annotate readings weekly with a set number of annotations, it was found that those who performed the annotation assignments regularly outperformed those who did not on exams across multiple courses. Suhre et al. [18] also discovered that the effectiveness of an annotation system for learning is highly dependent on the ease of use highlighting the importance of a well-designed application in contributing to how well it assists in learning.

Additionally, annotations can be helpful for students as a method for improving engagement and understanding with video lessons. Po-Sheng et al [1] showed that by using annotations while watching a video lesson on CPR that students increased their cognitive load and learning satisfaction when compared to a control group who only watched the video without making annotations. The experimental group also outperformed the control group on a post video comprehension test about CPR.

A different study by Sheng-Shiang Tseng [19] used undergraduate students separated into a control and experimental group to show that the use of "teacher" annotated videos increased learning engagement of the students and could increase the cognitive engagement while having no effect on the emotional engagement with the material. These two studies highlight the ability of video annotating to increase a students engagement with the content being displayed in a video and thus aid in the retention of the information.

4.2 Annotations for Dance Education

Just as in the regular educational context there is an opportunity for annotations to be used from both the learner and teacher perspectives. The studies conducted by McFadden et al., Po-Sheng et al., Suhre et al. and Sheng-Shiang Tseng in Section 4.1 display how the use of annotations can promote reflection, increased cognitive engagement and load and increased performance when combined with traditional video lessons [1, 14, 18, 19]. As these studies have reflected how this benefit has been perceived across a variety of subjects and courses it is reasonable to assume that this can be extended to dance learning.

A study by Lu-Ho Hsia and Gwo-Jen Hwang displayed the use of annotations for university dance classes [9]. Their study was conducted to research the effectiveness of the

flipped classroom method for dance education. By using the flipped classroom they were hoping to increase time for students to properly practice in front of the teacher in-person instead of spending most of the time having the teacher perform demonstrations. They made use of an application that could be used on both the web and mobile. The experimental group were given pre-class videos in which they had to identify crucial concepts, annotate the videos, shoot their own practice videos, review these practice videos and upload them and formulate questions on the videos which they would be able to answer through peer interaction online and self-study [9]. The control group were also given the pre-class videos and the tasks to annotate them and send these annotated videos to the teacher, but they did not have to do practice videos at home to upload. The teachers also had access to these videos and student annotations to answer questions and provided feedback, although most feedback came during the in-person classes. The results showed that the experimental group which followed this methodology versus the standard flipped classroom method of watching the videos could significantly increase their dance performance [9].

The project by Dos Santos et al. [6] mentioned in Section 3.2 provides an opportunity for reflective learning, especially if students are unable to attend a lesson in person, would like to do additional practise at home or would prefer to have the feedback in a more permanent place rather than simply said in class. In comparison to Lu-Ho Hsia and Gwo-Jen Hwang [9], dos Santos et al. [6] provided a simpler system entirely focused on teacher feedback to a student. While that was possible in Lu-Ho Hsia and Gwo-Jen Hwang's study the primary focus appeared to be on the flipped classroom, self-study and peer discussion rather than straightforward feedback from an instructor which is what forms the basis of instruction in a social dance class setting. This approach makes sense for a dance class where you are studying the dance it is not suitable for a social dance setting where people are there to rather learn the dance for fun.

Based on Lu-Ho Hsia and Gwo-Jen Hwang's study displaying the use of self annotation of professional instructional videos for learning [9] it could be useful in a social dance setting to provide videos with blank annotations which a student needs to fill in which can be automatically graded to assist in teaching theory to social dance students in a more enjoyable way while outside of the classroom. This is not the main focus of the project and will be investigated further during development if time allows.

4.3 Vocabulary of Dance Annotation Systems

Dance Annotation Systems make use of a language or set of terminology to describe the most likely to be used annotations for easy access. Currently, most Dance Annotation

systems are being used with the purpose of analyzing the choreography or enriching the dance videos for the purposes of storage and retrieval by dance professionals, choreographers and professional dancers with a secondary focus on their use for education [2, 7, 12]. This results in most of the language and terminology used being focused on providing additional detail to the actual recording rather than providing feedback based on what is seen. The purpose behind the annotation gives rise to the vocabulary used for annotation. These vocabularies provide a method of categorizing the different annotations based on what aspect of the dance is being annotated. This structure not only improves the ease of use of the annotation tool but also helps to improve the performance of querying the now enriched data [2, 7, 12]. The Web-based Movement Library (WML) [7] and WhoLo-Dance [2] made use of three main categories of movement descriptors which are:

- Movement Quality Descriptors
- Movement Principles Descriptors
- Action Descriptors

The three main categories are elaborated on as follows based on the WML project. The movement quality descriptors relate to movement qualities such as fluid, rigid, light etc. Importantly these types of qualities would need to be adapted to the needs of the project at hand as not all dance styles will make use of the same movement qualities.

The movement principles descriptors are related to Movement principles, high-level concepts that are used across all dances regardless of genre, such as symmetry, directionality, rhythmicity, coordination, etc.

The action descriptors consist of a list of basic actions such as jump, turn, step, arm gesture etc.

Dance Annotation systems also allow adding additional detail to each annotation based on which body part is being referred to by the annotation, who the dancer is being annotated, the location of the dance, the song playing and customizing the start and end time for when the annotation applies.[2, 7, 16].

In the realm of education, the idea of a set of terminology or keywords was also used by dos Santos et al [6] and generated by recording a think-aloud session of dance teachers critiquing videos of their novice students to build up the vocabulary of most commonly used keywords.

The core keywords generated were as follows:

- Synchronicity
- Weight Transfer
- Limb/Join Movements
- Quality of Movements
- Posture
- Gaze

It was found that Synchronicity and Weight transfer represented 67% of the comments and so were chosen as the two

keywords to focus on for the project. These two keywords were then used to generate a list of "Skills" which were used as the categories for annotations within the tool. The Skills generated were as follows (brief descriptions or clarifications are used where needed for some of the categories):

- Rhythm: dancing with consistent rhythm
- Pause: pausing at the right time
- Synchrony: moving with the beat of the song
- Time between movements
- Weight Transfer
- Step Size
- Dance Jumping: to be avoided
- Stepping Strongly: to be avoided
- Hip Movements: ensuring it is done correctly

Annotations were then able to be selected from one of these categories, which were all colour coded to aid in ease of use, and could then be added to the video. The quality of the category could be selected, eg. for a Pause you could select "No Pause", and a free-text comment could also be added to the annotation to provide more details. The input from the teachers to generate the keywords highlights the importance of co-design, as mentioned in Section 5, for developing a tool for dance education.

4.4 Annotation Systems on Mobile

Due to the widespread adoption of mobile devices, it makes more sense within the context of Social Dance Education to develop this tool on mobile devices as we are essentially guaranteed that this will allow all students and teachers access to the application. Due to the different constraints of a mobile device compared to a computer, there are additional factors to consider when designing an annotation application on mobile. The primary concerns identified are as follows [3, 4]:

- Intuitive Addition of Annotations
- Virtual Keyboard Input
- Display in different Screen sizes
- Variable Screen Orientations
- Duration of Display of Textual Annotations
- Video Selection
- Annotation Navigation
- Multiple Annotations Displaying Concurrently

To address screen size and the layout of such an application. Cunha et al. [4] found positive results from users by making use of a simple interface that allowed users to pause or play a video and then type any comment and click an "Add" button to add the annotation. MoViA [3] made use of a similar display with the additions to allow annotations to take the form of text, audio and digit ink which is an advantage in allowing a user more freedom in how they make the annotations.

MoViA [3] made use of a baseline display time of 3 seconds for textual annotation and increased it dynamically

based on the length of the annotation. This allows annotations to be easily read even on a smaller screen which is a requirement for them to be useful. A problem that did not appear to be addressed was how the system would handle displaying overlapping annotation [3]. This provides an area for advancement within our project.

For navigation they made use of studies from Hürst et al. [10, 11] to determine that a thumbnail size of 90 pixels provides good recognition results within small screens to decide the size of the image to accompany the annotation text in the navigation section.

Due to limited storage space on mobile devices storage is also an additional concern. Cunha et al. and MoViA [3, 4] made use of the Simple XML library to generate and manipulate the annotations stored within XML files as Simple XML requires little space while offering high performance.

4.5 Storing and Querying Annotations

As mentioned in Section 4.3 the majority of Dance Annotation systems have been used for analyzing dance pieces and the ease of querying databases of dance videos using a larger and more in-depth set of metadata. Most projects have made use of MPEG-7 XML files to store the annotations. The main issue brought up here is how to effectively store the dance videos and annotations to facilitate the fastest retrieval when a user queries the database. The DanVideo project made use of the MPEG-7 format and a tree embedding algorithm [8] to facilitate the search and retrieval of information [12].

The Web-based Movement Library [7] made use of a layered architecture where the Dance Videos and Annotations were stored on a server and database respectively in a Data Storage Layer and were controlled by the Comprehensive Knowledge Archive Network (CKAN) data and metadata management system which is an open-source data portal for the storage and distribution of open data.

Ramadoss and Rajkumar [16] present a Dance Video Content Model (DVCM) that makes use of an Inverted File Index Search for containment queries which they proved to substantially lower the run-time for a search as the number of items to return increased.

An important consideration for searching through annotated videos is how the user will interact with the front-end to facilitate the search. The DVCM project [16] made use of two methods for searching; the user could make use of a query screen where they could specify each category, defined based on the annotation vocabulary, with what they were desiring to search or else formulate a free-text query. Alternatively the user could enter a free-text query from which the application would extract relevant text related to the annotations

vocabulary and use it to build the final query. The WML [7] made use of a query interface that offered searching by dance genre and a search bar in which movement descriptors or free text could be entered as keywords to facilitate the query. DanVideo [12] provided a user interface referred to which allowed the user to input free text queries which were then processed to extract relevant concepts as per the predefined annotation vocabulary. DanVideo additionally implemented a specialized syntax for queries structured as follows, <vg, actor, agent, action, speed> where:

- vg is the video granularity (a shot, scene or compound scene)
- actor is the name of the character role played by a dancer
- agent is the name of the body part of the actor
- action is the movement, gesture or action of the agent
- speed is the speed of the action (slow, medium, fast, etc.)

As the main focus of this project is on the educational implementation as a tool for feedback first and storage and querying second these concepts will not be explored in greater depth.

5 Participatory Design

Participatory design is the practice of involving users and other stakeholders in all steps of the software design process. This is becoming a very important concept as in software development there is a risk that the product developed or invented will only be useful to certain people in the user group, or none of them. Participatory design looks to reduce this risk by allowing potential users to provide input to the design of the software from the early stages of development, thereby ensuring that the final product will suit their needs [17]. The need for participatory design is highlighted by dos Santos et al [6] from the keywords they generated needed to cover the most commonly used areas of critique among dance teachers in different styles and by WML, DanVideo and WhoLoDancE which made use of participatory design to formulate their annotation vocabularies and ontologies for the storing and querying of dance videos [2, 7, 12] In the case of WML this was all done as a result of the project being interdisciplinary. This methodology will be useful within our project specifications as the annotation software will be developed with the specific intention of being used for teaching Salsa and Bachata within a social dance class and thus there will be keywords that will be unique to these styles which will improve the teacher's experience if they were included in the system.

Participatory design is also highlighted by the use of user tests. These are important as annotated systems are more often than not for use by non-experts of the computer field and are subject to usability issues in interface design as most

software is. The WML, WhoLoDancE, DanVideo and dos Santos et al. [2, 6, 7, 12] all made use of user tests to ensure the quality and usability of their annotation systems as these were not being developed for a theoretical proof of concept but to be used by professionals and novices in the dance industry. This highlights the need to ensure that the system is usable by the target audience and by conducting user tests we are able to get direct feedback from the intended users. This feedback can then be used to advise the direction of the project over subsequent iterations.

6 Discussion

Raheb et al. and Cisneros et al. [2, 15] highlight the four styles of dance teaching. Of particular focus for this paper are the Mimetic and Traditional as these are the main teaching styles typically employed in a social dance class setting. Based on the details of dance annotations systems discussed in Section 4.3, which highlights the use of a specific vocabulary by which to organize the annotations and categorize them [2, 6, 7], this suggests that to provide feedback based on student-submitted dance videos that it would be best to have dances which follow a structure and can be critiqued uniformly. This motivates the focus on teaching by the Mimetic and Traditional means versus Generative and Reflective while also highlighting the importance of a personalized vocabulary which will allow the annotations to be made to suit the style and context of the dance teaching. Additionally, the study by Po-Sheng et al. [1], Suhre et al. [18], Sheng-Shiang Tseng [19] and Lu-Ho Hsia and Gwo-Jen Hwang [9] all showed that students who engaged in annotating lesson videos themselves within a flipped classroom method or those who received "teacher" annotated videos performed better than those who did not. As well as increasing the engagement and retention of information by students when engaging with video lessons. As these studies all had participants being tested in different subjects per study this helps to motivate the use of annotations for learning in dance especially since Lu-Ho Hsia and Gwo-Jen Hwang [9] did focus on dance as the subject. This opens the possibility for an additional aspect of this project, as mentioned briefly in Section 4.2, to examine students being given tasks to annotate pre-recorded dance segments with purposeful mistakes to increase their knowledge of the dance techniques.

The use of the vocabulary was also used within the project by dos Santos et al. [6] which was the only project that focused on the same principle that we are investigating, that of an instructor providing direct annotated feedback to at-home practice videos of their students. This project provides strong evidence for the need for additional studies of tools of this nature as the tool was not usable across all dance styles and it was made as a web application which limits its usability on mobile due to interface design not translating well which

does impact the amount of additional learning a student can take from the system [6, 18]. Due to the lack of applications available for use in the context of Latin Dance teaching this project looks to study its effect within that genre.

As discussed in Section 4.4 the use of annotations on mobile presents many additional challenges that were not seen in most of the dance annotation tools examined as only Lu-Ho Hsia and Gwo-Jen Hwang [9] implemented a mobile version of their system too. These challenges will need to be considered as the intended audience of an application of this nature are non-experts in the computer science field and thus the application needs to take their needs into account with regards to screen size, input methods, navigation and many other aspects [4]. Both the MoViA project and Cunha et al. [3, 4] made use of the Simple XML library to generate and manipulate the annotations within a mobile framework suggesting that this is the best framework to proceed with when it comes to implementing an application of our own.

With regards to a storage and querying structure we have seen that many annotation-based applications have offered options for both free text and category-based queries [7, 12]. The advantage of a free text system would allow users to type out what they are looking for in a more traditional format similar to an English sentence although this does come with the cost of the increased processing power needed to locate specific keywords and extract them for use in a query, whereas using preset categories that are filled with annotation vocabulary based options for searching may feel more limiting, it is likely the easier implementation.

7 Conclusions

The existing literature has shown that while there have been major advancements in the research and development of dance technology in both the archival and educational domains that there are still many additional aspects to continue exploring. Currently, there are no mobile annotation systems implemented to provide educational feedback for social Latin dancing.

The research has shown common design decisions with regards to implementing a dance annotation system from the use of a custom co-designed vocabulary to offering a vocabulary based search functionality [2, 6, 12]. The use of annotations for storing and querying dance videos using enriched metadata has also been shown to be a large advantage of this research [2].

The research into mobile application annotation systems has highlighted the need to consider low storage cost frameworks such as Simple XML to implement the system as well as highlighting the additional challenges faced due to limited

screen size, storage capacity and interaction precision [3, 4].

In regards to our project to develop an educational feedback tool for Latin social dance education using annotations in a mobile context the literature has provided a perfect starting point from which to begin the development and inspiration for additional features to further enrich the design.

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