Composition, Performance and Evaluation:
A Dance Education Framework for AI Systems

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Abstract

Most AI-based dance generation methods consider dance as a selection of movements. While these methods aim for realistic outputs and synchronization with music, domain-specific knowledge related to dance is often not incorporated in these models. This results in outputs that are far from what the dance community considers as high quality dances. Therefore we present CoPE, a dance education framework for AI systems with three key components: Composition, Performance, and Evaluation. By analyzing nowadays dance education, we suggest how to incorporate principles from the dance community into AI-based dance generation systems by aiming for more realistic pieces of art.

Introduction

Over the past few years, the development of generative models and pose estimation methods has shown major improvements (Goodfellow et al. 2014), (Güler, Neverova, and Kokkinos 2018), (Cao et al. 2019). These methods have been further developed for AI-based dance generation methods while aiming for high quality outputs, realistic body movements, a large variety of dance styles, and a proper synchronization between music and dance (Chan et al. 2019), (Li et al. 2020). For the majority of these works the goal is either motion transfer from experienced dancers to inexperienced dancers by using video-to-video translation or to create a sequence of new dance movements. In this light, dance is considered as a selection of movements, at times performed on music.

The dance community considers dance as more than a selection of movements. Dance is an art form that aims to communicate an idea through movement, which must have a foundation for logical development (Smith-Autard 2010). To compose a dance is to create a work of art. According to (Robinson 2009) 'it involves putting your imagination to work to make something new, to come up with new solutions to problems'. (Redfern 1973) describes that 'dance can be considered as art when it is formulated as a whole or a structured something, where the relationship and coherence of constituent parts increases the interest and importance'. A dance that is created with the composer's intention to communicate an idea or emotion, can be for example about people, happenings, moods, or even the movement itself (Smith-Autard 2010). Movement content is selected as

an abstraction of the actual feeling or happenings to suggest meanings that are significant to the dance idea.

By comparing AI-based dance generation methods and composers or choreographers, we can distinguish a clear difference in their creation processes. Dance generation methods take existing dance videos and let the model learn from the movements that are present in the video. Note that all dance generation methods considered in this work are AI-based, but we use the terms interchangeably. The movements, whether copied or inspired by the original dance videos, are then evaluated by metrics that measure the similarity between movements and sometimes their alignment with music. The dance community has used several methods to educate dance over the twentieth century. Back in the early days, it was focused on a Laban model which emphasized the experimental child centered process of dancing as a means of developing personal qualities. Then it shifted towards a theater art model with an emphasis on the dance product. More recently (Smith-Autard 2010) introduced a midway model, one that incorporates aspects of both the Laban model and the theater model. This method has been widely used at universities for performing arts. She distinguishes three key components that are central in nowadays dance education for students: composing, performing and appreciating/evaluating dances.

Previous works have mainly explored how practices from dance composition can be used in AI systems. In (Jacob et al. 2013), researchers in computational creativity collaborated with a contemporary theater group and created interactive narrative artworks with the help of an agent, considering perception, reasoning and action modules. They used a compositional technique named 'viewpoints' that enables dancers to communicate through movement and gesture, builds a vocabulary and allows them to improvise. (Rett and Dias 2017) studied to what extent Laban's Movement Analysis can be implemented with the help of probability calculus and Bayesian theory. Also (Gujrania, Long, and Magerko 2019) studied Laban's Movement Analysis and presented a framework that can be applied to real-time interaction in games by using full-body gestures. These studies have a main focus on dance composition and less on the performance and evaluation aspects. Furthermore the type of AI systems considered in these works are mostly interactive and agent-based whereas recent studies on AI-based dance

generation methods use Deep Learning based methods.

In this work, we study to what extent dance generation methods can learn from nowadays dance education. We present the framework CoPE that is based on the key components Composition, Performance, and Evaluation, which can be used by dance generation methods. For each of these three components we describe its role in dance education, its main components, and suggestions to incorporate it into dance generation methods. Our aim is not to cover all aspects of dance education, but to present a starting point. For developing dance generative methods we encourage researchers in computational creativity to use dance education handbooks such as (Smith-Autard 2010) or to involve dance professionals to include the dance-specific domain knowledge into new dance generation methods.

Composition

The composition of a successful dance requires that the composer has knowledge of 1) the material elements of a dance, 2) the methods of constructions which give form to a dance, and 3) an understanding of the style in which the composer is working (Smith-Autard 2010). No book can provide all the ingredients necessary for the production of dance art works. For students in dance, it is up to the student's imaginative use of the concepts and principles that should be promoted through a program designed by a dance teacher. Other useful resources are attending live performances, recordings of professional choreography and workshops from professional dance artists. This section summarizes the three principles for composing a dance that are defined by (Smith-Autard 2010). For each of these principles, recommendations for dance generation methods are provided.

The Material Elements of a Dance

Dance Education   In daily life, communication can take place through movement. Many verbal expressions describe moods or thoughts in terms of movements, for example 'jumping for joy'. Since dance is used to communicate an idea, it can be seen as a language. While dance composition might use every day movements, they are usually used as an abstraction of the actual feeling or message. The material elements of a dance have been described by von Laban and are still widely used today (von Laban and Ullmann 1971). He broke down dance into four main components: action of the body, qualities of movement, space environment, and relationships. The action of the body considers the body as an instrument that can use body parts and make body shapes. The quality of movement is related to properties of time, weight and flow, where combinations of these aspects can determine the form and style of an action, e.g. 'quick' and 'light'. The space environment describes how the body moves into space, by considering the size of the movement, pathways on e.g. the floor and in the air. Lastly, the relationship describes how the dancer relates to objects and other people in the space and how movement responds to this, e.g. by mirroring movements or dancing in canon.

Dance Generation Methods   The action of the body itself has the main focus and the other three components defined by the Laban method are less studied. For example, different movement qualities might be learned from existing seen dances unconsciously and used randomly, but methods don't derive those actively. Regarding space and relationship, most methods have used training data where a single dancer is dancing with a focus to the front, without any interaction with objects or other dancers and without exploring the space. Enforcing the other material elements of dance can be done by using a wider variety of input videos for training models, that are not focused on a single dance performer in front of a camera, e.g. recordings of dances in the theater performed by multiple dancers. Another way is to set constraints to the model related to moving in space or interactions between dancers or a dancer and an object. Letting the generative model independently learn how to select the best movement quality for a particular movement in a sequence is a challenging task. An easier way to incorporate movement quality in generated dances would be to use manipulative generative methods with the use of attributes, to be able to adapt the dance after it has been created.

The Methods of Construction

Dance Education   The beginnings of composition consist of stimuli, decision on the type of dance and the mode of presentation, improvisation, evaluation of improvisation, selection and refinement, and motif (Smith-Autard 2010).

Stimuli for dance compositions can be auditory (eg. music, words), visual (eg. pictures, objects, patterns), ideational (ideas), tactile (eg. the feel of a material) or kinesthetic (movement itself). Whenever one or more stimuli are selected by the composer, the type of dance is selected. Types of dances can be described by styles such as ballet, modern, jazz, contemporary, hiphop etc. or by mode of presentation, such as pure, abstract, lyrical, or dramatic. Nowadays the division between styles is less strict and more and more choreographers use combinations.

After deciding on the type of dance and mode of presentation, a composer starts experimenting with movements and tries to realize imagined movement images into real movement expression. This initial exploration is called improvisation. In this phase, the composer may use several criteria to decide whether movements are a suitable starting point of this work: 1) the movement has meaning or relevance to the idea for the dance, 2) the movement is interesting and original in action, dynamics and spatial patterning, 3) the movement has potential for development. Whenever the starting point for movement is selected, evaluated and refined, it can be set as the initial motivating force for the rest of the dance. This movement or movement phrase is called the motif.

When the motif is established, the composer will create dance material and arrange this. The motif can be repeated by varying aspects related to the material elements of a dance described before: action, quality, space, and relationship. However, the goal of the dance is to have a form and an overall shape, since it aims to communicate an idea and therefore is much more to it than an arrangement of movements. For a viewer who has seen the dance, the goal is not to remember each movement and the order of the piece. Rather, the impression of the whole is remembered,

its shape, the excitement of the development, its main message and its originality. So apart from selecting movement content, the composer should set the movement into a constructional frame which will give the whole its form.

Dance Generation Methods   The main focus is on kinesthetic movement as a starting point, because of the use of dance videos as training input. Sometimes auditory input can play a part, such as in (Tendulkar et al. 2020), although in most works music is only used for alignment with the dance. Other stimuli are not considered, but could be extracted from non-dancing videos that represent those stimuli and can be shown to the model in the training phase, for example by letting the model extract shapes from natural movements caused by waves or the wind. Another approach could be to create methods that combine different multimodal inputs, to represent e.g. shapes, ideas or patterns, such as audio or single images.

Apart from motifs, (Smith-Autard 2010) distinguishes seven other important elements of construction: repetition, variation and contrasts, climax and highlights, proportion and balance, transition, logical development, and unity, where unity is the overall aim. In dance generation methods, repetition of dance movements on specific parts of the music is sometimes considered and occasionally climaxes are also linked to music. However, all other aspects are not the key of attention and not integrated intentionally. Some of them are not easy to integrate, but important to create enough interestingness for the dance. As an example, transitions in dance are highly important and are among the most difficult aspects of dance composition (Smith-Autard 2010). Transitions can be between positions or between sections of the dance. Nonetheless, in dance generation the focus is not on transitions, but on dance movements themselves. (Lee et al. 2020) take a first step in this by disentangling a dance unit into two latent spaces: an initial pose space and a movement space. An explicit consideration of all these elements might be very useful to create realistic dances that are interesting to watch.

The Style of a Composer

Dance Education   Style in dance is considered the same as technique, since it often means the content of the idiom and not only how it is presented (Smith-Autard 2010). Each technique consists of a set of principles that need to be mastered to perform a dance piece in the way it is created. To master this technique, a dancer needs years of training to acquire these skills, to exercise the body and to practise movements to achieve perfection. For example ballet requires turnout, which is a rotation of the leg at the hips which causes the feet and knees to turn outward. Popping is a dance style that requires extreme control in contracting and relaxing body muscles, e.g. in the arms and chest. On top of this style, each choreographer has its own personal style, which is a personal interpretation and a way of using the technique.

Dance Generation Methods   Different styles have been considered, varying from ballet to hiphop and commercial styles, although the majority is focused on the latter, since its ease of use of having a single dancer facing the front. However, current methods do not use any style specific information regarding rules or constraints. This results in generated dances that are full of incorrectly performed movements when considered on a technical level. For example, ballet dances are created where representations of bodies did not learn the exact posture of the body that is required for this technique. When specific styles such as popping are given as input data, models are able to copy the shapes of the movement, but do not learn the principle of muscle contraction. This is caused by the limited representation of the human body by the model that only consists of a set of keypoints and does not represent muscles. We therefore encourage researchers in this field to focus on a specific style or set of similar styles as a starting point.

Performance

Dance Education   Performing a dance on stage differs from dancing in a classroom or studio. Dancers strive to perfection for this moment and aspects such as a decor, light, and costumes will be added to make the performance a whole. Apart from mastering the physical and technical skills, it is important to bring the dance with the right intention and emotions as suggested by the composer. (Smith-Autard 2010) describes that traditional approaches to learn a dance piece were very focused on copying the teacher or dance artist who performs the piece first. These days dance students are often involved in the creation process and encouraged to involve their own style and personality in the performance. During the process, dancers are corrected to come as close as possible to the perfect execution of the dance that the choreographer has in mind.

Dance Generation Methods   As explained before, the final product aims to match an existing dance as close as possible or to create new movements. It is up to the model to correct dance movements in some way and to make sure the output is as desired. But in the end, the output is not as optimal as we would like, since as discussed in the previous section, not all items that should be taken into account are considered. Instead of putting constraints from the start, an option would be to incorporate user feedback from experts, either during the training process or by being able to make modifications to the final outcome.

Another aspect that contributes to a correct execution of the movement is the representation of the body. The representation of the human body in joints in dance generation methods varies from just a basic set of key points as shoulders, elbows, hands, knees, feet and hands by (Zhuang et al. 2020b), to 14 slightly more detailed keypoints by (Lee et al. 2020) and 63-dimensional 3D joint positions by (Ahn et al. 2020). However, the use of specific constraints for each style with respect to keypoints, rotations and muscles, as explained before, will be required to create realistic performances.

Evaluation

Dance Education   According to (Smith-Autard 2010), there exists no objective formula to evaluate a dance. It can

only be measured as successful relative to the experience and background of the person who sees it and to the composer's stage of development in composing. However, there will always be aesthetic judgments. Although there is no universal set of criteria to compare dances, one of the environments that uses criteria are commercial dance competitions. Here the judging is typically a guided rubric that evaluates performance, choreography, technique, and overall appearance. More specifically judges tend to look for quality technique, performance quality, clear lines and transitions, musicality, personal style, professional overall appearance, appropriate costume choices, and memorability (Wollins 2014). However, these criteria are not standardized.

Dance Generation Methods Mostly quantitative evaluation methods have been used and sometimes user studies with non-experts in dance. Regarding metrics, the Fréchet Inception Distance (FID) is used to measure how close the distribution of generated dances is to the real (Huang et al. 2020), (Lee et al. 2020), (Zhuang et al. 2020a), (Zhuang et al. 2020b) and the correspondence between each dance step to a temporal window in the input music is measured by a Pearson correlation (Tendulkar et al. 2020). Some works (Huang et al. 2020), (Tendulkar et al. 2020) compare dances in user studies based on musicality, unpredictability, creativity, inspiration, realism, smoothness, and matching with music. (Zhuang et al. 2020b) uses the same criteria for generated dances individually without making a comparison. On the other hand, (Pettee et al. 2019) evaluates its algorithm by letting it assist choreographers during a creation process and by analyzing the latent space.

Evaluating dance is subjective to some extent, but aspects related to the dance technique can be judged in an objective way. Expertise in evaluating dances comes with practical dance experience as well as watching many professional dancers and companies. Whenever dance generation methods will be evaluated by non-experts in dance, we might end up optimizing for either simplified or even incorrect metrics. Therefore, this field would highly benefit from involving dance professionals in this evaluation process.

Discussion

Most recent dance generation methods aim to transfer dance movements to inexperienced bodies or aim to create new choreographies. However, there is a large gap between dance generation methods and dance education practices. For this reason, we present the CoPE framework to give guidelines for developing realistic dances by generative models. In general we would highly encourage researchers in computational creativity to work together with dance practitioners to get a better feeling of the complexity of creating a dance and to ensure something realistic is created. An example of such a successful work is (Pettee et al. 2019), which is a multi-disciplinary project done by a team of dance artists, physicists, and machine learning researchers. By working closely together, they show that technology can actually help stimulating creativity in the dance composition process. By encouraging such collaborations, we hope that future dance generation methods will be on such a level where they are able to inspire choreographers and help them in their composition process.

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