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Sketch-based human motion retrieval via selected 2D geometric posture descriptor

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ABSTRACT

Sketch-based human motion retrieval is a hot topic in computer animation in recent years. In this paper, we present a novel sketch-based human motion retrieval method via selected 2-dimensional (2D) Geometric Posture Descriptor (2GPD). Specially, we firstly propose a rich 2D pose feature call 2D Geometric Posture Descriptor (2GPD), which is effective in encoding the 2D posture similarity by exploiting the geometric relationships among different human body parts. Since the original 2GPD is of high dimension and redundant, a semi-supervised feature selection algorithm derived from Laplacian Score is then adopted to select the most discriminative feature component of 2GPD as feature representation, and we call it as selected 2GPD. Finally, a posture-by-posture motion retrieval algorithm is used to retrieve a motion sequence by sketching several key postures. Experimental results on CMU human motion database demonstrate the effectiveness of our proposed approach.

1. Introduction

In the last few years, motion capture technique has been widely used in various applications, such as featured films, computer games and virtual reality [1–4]. However, the process of human motion capture is very time consuming and expensive [5]. So, it is important to reuse the pre-captured human motion in database. To this end, the first and important step is to retrieve similar human motion sequences from motion database.

To retrieve a desired motion sequence from a large-scale human motion database, the user usually has to describe the character of the human motion clips to be retrieved. There are several ways to achieve this goal. The simplest way is using textual description like key-words: "kicking" and "fighting" or a more detailed sentence like "a kick of the left foot followed by a punch" [6]. The textual description is intuitive and efficient, while it requires a lot of manual work for annotating all of the motion sequences in database. To overcome this shortcoming, the content-based human motion retrieval has attracted much attention, which retrieves the motion clips via submitting a similar and short motion clip [5,7,8] as query. However, sometimes it is hard to acquire the appropriate motion clips as query. For example, if we want to retrieve a back flip and a handstand walk, it is a little difficult for the user to perform such actions. Although Numaguchi et al. [9] proposed to use a puppet interface to generate the query motion clip, such a puppet consists with several sensors and potentiometers, which is not easy to obtain for a general user.

Inspired by traditional 2D animation wherein the experienced animator sketches several key character postures, which are then used as the seeds to generate a new motion, the sketch-based human motion retrieval becomes popular in computer animation in recent years [10–13]. Different

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from the other kind of input, using a 2D sketch brings in the following benefits: intuitiveness, fast posture definition, quick production of sample and first-pass animated scenes [14]. In light of this, we also utilize the sketch interface to retrieve human motion from database in this paper.

As we known, there are many factors which may affect the motion retrieval performance including motion representation, matching algorithm, indexing structure and so on. Motion representation is a the core-stone in constructing an efficient motion retrieval system. It is also the bridge to connect the 2D sketch and the 3D human motion. Traditional geometric features such as joints location and joint–joint direction are effective to character 3D human posture but not for the hand-drawn sketch. The hand-drawn sketch is usually changeable because different user has diverse sketch style and the body proportion is hard to be unified for the same posture. Thus, we has to find a proper feature to represent both 2D sketch and 3D posture.

In this paper, we propose a 2D Geometric Posture Descriptor (2GPD) including four kinds of geometric features. Similar geometric feature has been applied in graphics and computer vision [15], while here we propose a new rich posture feature set to exploit the geometric properties and relationships between different human body parts. 2GPD emphasizes the relational body part configuration, which is consistent with human perception.

Taken the flexibility of human-drawn sketch into account, the features involved distance metric are normalized with respect to the human body height and all of the features are discretized into several intervals. To ensure the retrieval efficiency, the feature dimension should not be too high. In our work, the total feature dimension of 2GPD is 738 while not all of them are useful and discriminative to describe a 2D posture. Therefore, we design a semi-supervised feature selection algorithm derived from Laplacian Score algorithm to select a compact and discriminative feature subsect from the original 2GPD.

The remainder part of this paper is organized as follows. We first review some related work in Section 2. Then, a detailed description of 2DGP and our proposed semi-supervised feature selection algorithm are introduced in Sections 4 and 5, respectively. Section 5 presents the retrieval framework and algorithm. Finally, we give the experimental results and conclusions in Sections 6 and 7.

2. Related work

Sketch has been widely used in computer animation and computer graphics. Igarashi et al. [16] and Zeleznik et al. [17] proposed a sketch-based modeling system, which utilizes input strokes for mesh creation. Lee et al. [18] presented a method which can derive improved shadow image from single posture sketch. Sketch is also used for facial expressions by Lau [19] and Seol [20]. In computer animation, sketch also has been successfully used in motion synthesis, motion retrieval and posture design [21–27,14].

In order to establish a connection between a 2D sketch and a 3D posture, 3D posture reconstruction from 2D sketch is widely used in some research. Davis et al. [10] proposed a method which reconstructs several possible 3D postures from a hand-drawn key posture stick figure. Meanwhile, a set of constraints and assumptions are applied to return the most likely 3D postures to the user. Lin et al. [23] presented an intuitive sketch interface that allows the user to creating a 3D human character in a sitting position on a chair. They reduced the reconstruction solution space by considering the interaction between the character and environment and adding physics constraints. The reconstruction problem was formulated into a nonlinear optimization problem. Li et al. [27] utilized the human figure sketches corresponding to the initial and closing posture of a Kung-fu form to retrieval and refinement the Kung-fu motions. And sketch trajectory on specific moving joints helps the retrieval process. However, reconstructing the 3D posture from a 2D sketch posture is an ill-posed problem due to many possible solutions.

A few researchers [22,21] used sketch to define the trajectory constraints which the character or its specific joints move along. But some trajectories are hard to draw in 2D sketch interface. For example, if the user sketches a posture in the view plane *XOY* but hand joint moves along the *Z*-axis.

Another kind of method is also used to compare the 2D sketch with 3D posture. First the 3D posture is projected into 2D plain, and then the same geometric feature is extracted on both the projected posture and the 2D sketch. As far as geometric feature concerned, some information like limb length and joint coordinate are removed directly because each user has different sketch style and the body proportion is hard to be unified for the same posture. The direction of the limbs, an intuitional features, is usually used [21,28] on sketch. However, only the direction of the limbs cannot character a motion sufficiently. Just as the 3D posture representation [15], the relative geometry relation of the joints and the limbs is necessary. In the field of computer vision, multi-feature [29–31] is widely used and some method such as LDA is applied to select the features or information with high discrimination [32,33]. Inspired by those work, we propose a novel feature in this paper called 2GPD combining four kinds of geometry feature, which is effective to character the hand-drawn sketch.

The 2GPD contains four different types of geometry feature, which results in high dimensionality. To reduce the dimension of feature representation, a semi-supervised feature selection method derived from Laplacian Score [34] is used in our work. Generally, feature selection approaches can be roughly classified into wrapper and filter. The wrapper approaches evaluate the features using the learning algorithm. Thus, they wrap the selection process around the learning algorithm [35–37]. The filter approaches examine intrinsic properties of the data to evaluate the features prior to the learning tasks, which always rely on the class labels, most commonly evaluating correlations between features and the class label. Classic filter approaches include Pearson correlation coefficients, data variance [38], Fisher score [39], and Kolmogorov–Smirnov test [40]. He et al. [34] proposed a filter method for unsupervised feature selection, which evaluates a feature by Laplacian Score. In this paper, a semi-supervised feature selection [41] method derived from Laplacian Score is utilized, which seeks features with high score in a carefully designed nearest neighbor graph [42].