# Visualizing Out-of-synchronization in Group Dancing

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## ABSTRACT
Prior work on choreographic learning support systems lacks supports of group dancers. In particular, existing systems cannot quantify the degree of synchronization, which is a critical factor for successful group dancing. In this paper, we create a system to support multi-person choreographic learning. The system visualizes body parts of dancers which are out of synchronization. Our interface aims to enable dancers to quickly identify moments where they need additional practice. This paper presents our current prototype interface and demonstration.

### Author Keywords
Multi-person Choreographics; Dance Practice Support; Visualization; Human Motion Analysis.

### CCS Concepts
**•Human-centered computing → Interface design prototyping;**

## INTRODUCTION
In multi-person choreography, synchronization is crucial for successful performance. Although prior work has developed various choreographic learning support systems [1, 2, 4], existing systems focus on single-person use, and they do not consider synchronicity. Learning systems for multi-person choreography, thus, need a method for detecting and visualizing out-of-synchronization moments of dancers.

In this paper, we create a multi-person choreographic learning support system. Our algorithm can accurately analyze the degree of synchronization for group dancers and detect out-of-synchronization moments by calculating the similarity of body postures using skeleton data. Dancers can simply record their dance practices with a camera, and our system analyzes the videos to visualize how much out-of-synchronization occurs in their dancing. The system then highlights body parts of dancers that are out of synchronization in a frame. This paper describes our current system implementation and demonstration (see the accompanying video).


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## INTERFACE DESIGN
Figure 1 shows our interface which displays the visualization of out-of-synchronization along with the originally recorded dance videos. This thermal-image-like visualization offers users which part of their bodies are out of synchronization. Red colors indicate large discrepancies among dancers. In this manner, users can identify when out-of-synchronization occurred and how they should fix it.

## SYNCHRONIZATION ANALYSIS
Our methodology is based on a multi-person 2D-pose-detection framework. The system first detects multi-person poses with AlphaPose, a deep learning based framework [5]. Based on the pose information, we calculate the degree of out-of-synchronization by considering the overall variance of all the body parts, including movements of arms, legs, the torso and heads. The system then creates a heat map based on the calculation results and integrates it with the original video frames as ultimately shown in Figure 1.

### Multi-person Pose Detection
Referring to COCO dataset[1], we abstract the human pose to 18 key points, such as shoulders and knees. We utilized AlphaPose [5] as the multi-person pose detection algorithm in our system. The algorithm is based on a deep learning framework which utilizes pose flows to overcome multi-person ambiguity and occlusion issues, resulting in improved efficiency and robustness. Our informal experiment results (Figure 2b) show that the algorithm can successfully discern dancers' skeleton information in various poses.

[1] http://cocodataset.org

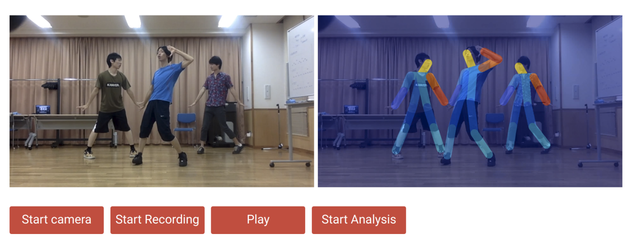
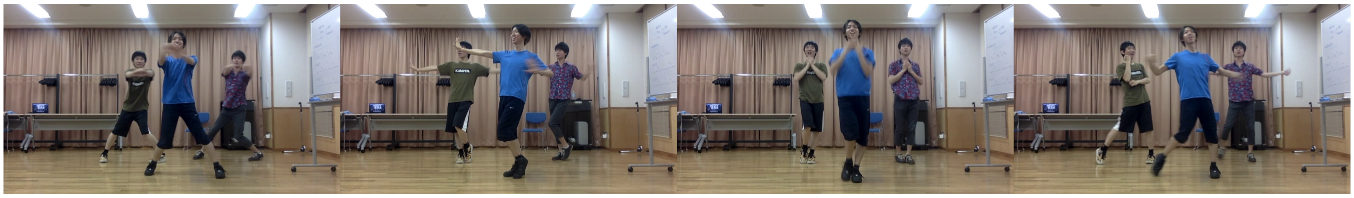
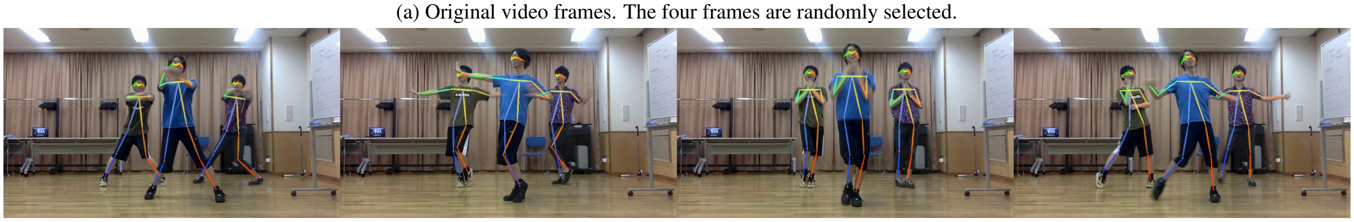



Figure 1: Our interface shows a recorded video and visualization result of out-of-synchronization side-by-side. The blue color represents small out-of-synchronization while red and yellow mean large.



(a) Original video frames. The four frames are randomly selected.



(b) Pose detection with AlphaPose [3, 5]

(c) Out-of-synchronozation visualization. The framework applies a pre-trained model[2] for the performance test.

Figure 2: Example results of our synchronization detection and visualization. Our system first applies AlphaPose to recorded videos (Figure 2a), and thus achieves multi-person 2D skeletons (Figure 2b). We then use the skeleton information to quantify out-of-synchronization scores for part of bodies, which constitutes our final visualization results (Figure 2c).

### Out-of-Synchronization Analysis and Visualization

To calculate the degree of out-of-synchronization, the system first defines the pose feature vector of each person. One feature vector is composed of 13 unit vectors, 12 of which are the unit vectors of each directional line segment illustrated in Figure 2b. The last feature vector is the unit vector pointing from the nose to the neck. Such simplified features are informative enough to represent dancers' poses at each frame.

With the mathematical definition of each person's pose feature, we calculate the degree of out-of-synchronization by quantifying the distance of each vector among dancers. This is achieved by the following formula:

$$D(\vec{\mathbf{V}}) = \sum_{i,j} d(\vec{v}_{ij}, \overline{v}_j) = \sum_{i,j} (|\vec{v}_{ij} - \overline{v}_j|^{2\lambda}), \qquad (1)$$

where $\vec{\mathbf{V}}$ is a set of multi-person features. $\vec{v}_{ij}$ represents the $i$th unit vector of the $j$th person while $\overline{v_j}$ is the average unit vector of the $j$th person. $\lambda$ is a trade-off parameter controlling the weight of different degree dissimilarity, which is set to 1 through our informal explorations in our current prototype. For each feature vector, the out-of-synchronization score takes a value between 0 and 255, where 0 represents perfect synchronization.

This numerical result allows us to create a thermal-image-like visualization for each frame in the recorded video. We assign our out-of-synchronization score to each of the feature skeleton. Scores are mapped into a color space shown in Figure 3. Figure 2 shows four frames in an example video of multi-person choreography along with our visualization results. Although we have not formally tested the detection performance yet, the system highlights body parts of dancers where out-of-synchronization is salient.

Figure 3: Color mapping used in our current prototype.[1] Colors toward red and blue are mapped with large and small out-of-synchronization scores, respectively.

### CONCLUSION

In the paper, we present a system to visualize out-of-synchronization in multi-person choreography. The system addresses an important issue inn synchronization detection and offers feedback to dancers. In our future work, we will revise our interface and add features to better fit dancers' practices. We also plan to conduct system evaluations and user studies on our system.

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