EasyChair Preprint

№ 1805

Quantitative Evaluation for the Quality of the Military Parade

Yohei Okugawa, Masao Kubo and Hiroshi Sato

October 31, 2019

Quantitative Evaluation for the Quality of the Military Parade

Yohei OKUGAWA[1†], Masao KUBO[2] and Hiroshi SATO[3]

[1]Dep. of Computer Science, National Defense Academy of Japan, Kanagawa, Japan
(Tel: +81-46-841-3810; E-mail: em57037@nda.ac.jp)
[2]Dep. of Computer Science, National Defense Academy of Japan, Kanagawa, Japan
(Tel: +81-46-841-3810; E-mail: masaok@nda.ac.jp)
[3]Dep. of Computer Science, National Defense Academy of Japan, Kanagawa, Japan
(Tel: +81-46-841-3810; E-mail: hsato@nda.ac.jp)

Abstract: The highly synchronized parade can impress audiences how strong the troops seem to be, whereas it is difficult to train for the good parade because of its complex collective behavior. However, there is no scientific research about what the important factor to train and produce a good parade is. One of the bottlenecks to the scientific approach is the difficulty of measurement of a group as same as other swarm researches. In this paper, we measured the posture data of members in the parade with OpenPose, which is a cutting-edge pose estimation technology of deep learning. By this measurement, we propose a numerical evaluation for the quality of the parade, and it is confirmed by questionnaire. In conclusion, our evaluation method is applicable for the quantitative evaluation, and it was suggested that the variation level of the arm swing angles was related to the quality of the parade.

Keywords: Collective Behavior, Parade, Autonomous Distributed System, OpenPose

1. INTRODUCTION

1.1 The characteristics of the parade

Parade, or marching, refers to the organized, uniformed, steady walking forward in rhythmic time. In military organization, the parade is used to exhibit the apparent military strength. The military parade is a formation of soldiers whose movement is restricted by the movement of the close members, and each member in the parade need to refer their movement each other.

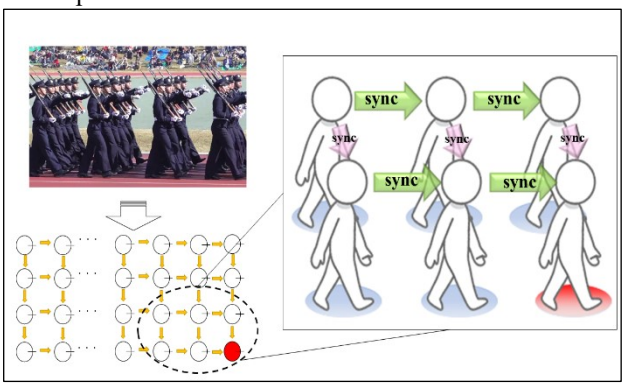

Fig.1 The network of the parade

The parade consists of the sum of local interaction that they adjust the walking movement with nearby members (Fig.1), but the parade has different characteristics from flocking behaviors, such as pedestrian movement[1], where a member of them has no purpose about the whole shape of their swarm[2].

On the other hand, each member of the parade has the common purpose to synchronize each other. The member tries to fix small gaps between its neighbors as soon as possible. This strong motivation produces complex dynamics because they are coupled with each other tightly. This trait makes them keep their synchronization difficult, and the parade takes long time for the training.

1.2 The current status and issues for the parade

At National Defense Academy of Japan (NDA), cadets conduct the parade training many times; however, their training needs a lot of participants, and the training is not based on the scientific knowledge.

PARADE EVALUATION SHEET

	Category		Description	Satisfied	Not Satisfied
1	Dress Code	i	Name plates and badges are well fixed	✓	
		ii	They hold bags properly	✓	
		iii	Uniforms are dressed well	✓	
2	Turn	i	The arm swing are synchronized during the turn		✓
		ii	The lines are straight	✓	
		iii	They turn regularly, not in disorder		✓
3	Arm swing	i	The rows are straight	✓	
		ii	The cycle of arm swings are synchronized	✓	
		iii	The height of arm swing is good	✓	
		iv	The elbows are squared		✓
4	Salute	i	The salute order is loud	✓	
		ii	The form of salute is good	✓	
		iii	They turn their gaze on properly	✓	
		iv	They salute uniformly	✓	

Fig. 2 The example of the parade evaluation sheet

Fig. 2 is an example of the parade evaluation sheet, which we use for the parade evaluation at NDA. According to the parade evaluation sheet, the parades are checked whether the categories are satisfied or not.

However, we do not have any quantitative evaluation method, and we have some problem about the current evaluation system. For example, the parade quality score of the small party tends to be higher than the big party, because of the heuristic evaluation, and the evaluation seems not to be fair for each parade. Therefore, the quantitative evaluation for the quality of the parade is required.

Additionally, to quantify the local and global status of the group will be helpful not only for the parade but also for other collective behaviors.

In this paper, we measured the parade with

† Yohei OKUGAWA is the presenter of this paper.

OpenPose[3], which is a posture estimation system with deep learning. In our method, we used the arm swing angle as the evaluation value for the quality of the parade. In order to verify that the evaluation value is applicable, we had questionnaire surveys for 29 people. Moreover, in order to analyze the local interaction of each member in the parade, we measure each member in the parade with OpenPose.

This paper is organized as follows. After introducing OpenPose, we describe the data processing method to obtain the evaluation value with OpenPose. In the last part of section 2, we propose the quantitative evaluation method for the quality of the parade. After explaining the experiments with the questionnaire, we show our results, and the current situation of the detailed analysis for each member in the parade.

2. PROPOSED METHOD

In this section, we propose the quantitative evaluation method for the quality of the military parade focusing on the arm swing angle of the members. In the following, we explain the proposed method in order.

2.1 The posture data with OpenPose

OpenPose represents simultaneous posture recognition of multiple people on single images. The left side of Fig.3 shows an example of the pose estimation to the parade with OpenPose. The right side shows the points of posture data. As the three-dimensional data on each point, we can obtain 75 data for one person of posture information.

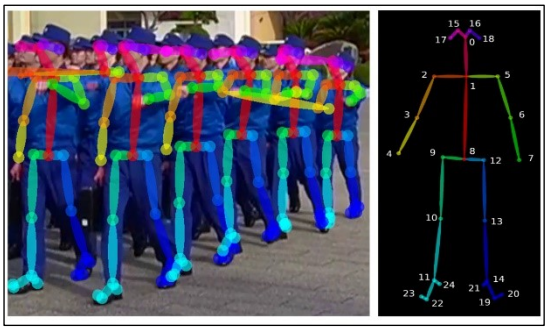

Fig. 3 The military parade with OpenPose

The values and the accuracy of the posture data are different depending on the position and body size. Therefore, it is necessary to use the trend data, such as fluctuation point of the arm swing angle, for quantitative evaluation, which is not influenced by position or height. When the movements of the members are synchronized, we can get the same trend data from each member.

2.2 The focus points

In this research, we focus on the left arm swing angle data, which is the most remarkable data for the quality of the parade at NDA. Now, we conform the process of getting the arm swing angle data to the paper[4].

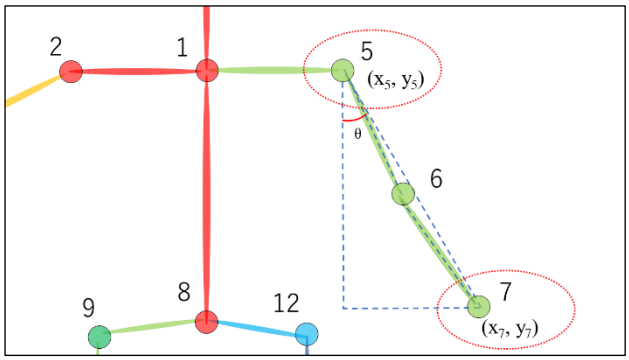

Fig. 4 Focus Points and the feature value

First, we obtain the data of left shoulder (point 5 in Fig.4) and left perm (point 7 in Fig. 4) with OpenPose. After we get time series data of each member in the parade, we convert the data into the left arm swing angle θ.

There are some missing values in the data from OpenPose; hence, in that case, we complemented the missing values in the series data. Additionally, the series data has a little noise, so we did smoothing process for the data to read the trend of the series data easily.

2.3 The evaluation value

Though we considered many kinds of values for the quantitative evaluation, we analyzed the standard deviation (SD) of the left arm swing angles in the parade as the evaluation value, which represents how the left arm swing is regulated.

$$SD_t = \sqrt{\frac{1}{n_t}\sum_{i=1}^{n_t}\left(Ang_{(t,i)} - \overline{Ang_t}\right)^2} \qquad (1)$$

Eq. (1) shows the SD of frame *t*. With OpenPose, we get the posture data in each frame. n_t is the number of a piece of posture data in frame *t*, and $\overline{Ang_t}$ is the average of the left arm swing angle in frame *t*.

Fig. 5 shows the time series data of SD of the arm swing angle, and we can see the transition of the SD depending on the arm swing. When the SD is high, the arm swing angle is not regulated, and when the SD is low, the arm swing angle is regulated.

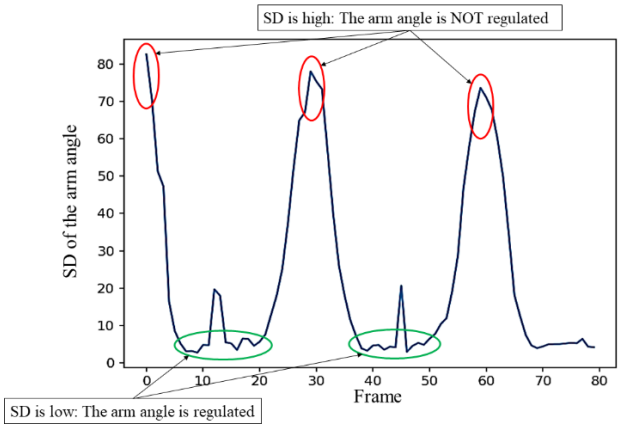

Fig. 5 The time series data of SD of the arm swing angle

2.4 The assessment of the evaluation value

In order to evaluate the quality of the parade, we need to compare the parades in same condition. As a first step of research, we had comparison tests of 2 platoons.

After we got the evaluation value of 2 platoons, we compared the evaluation value, which is the average SD of the arm swing angle in the parade.

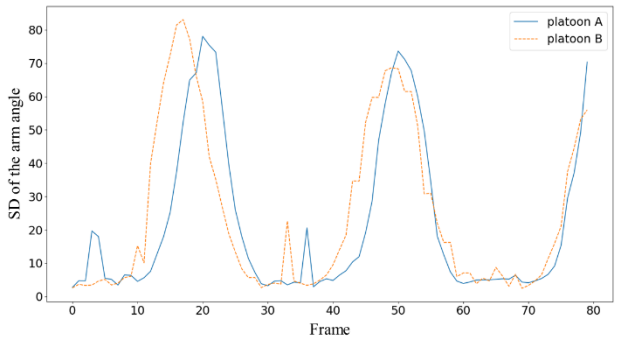

Fig. 6 An example of the time series data of average SD of arm swing angle in 2 platoons

Fig. 6 shows an example of the time series data of average SD of arm swing angle in 2 platoon movies. In our method, for the fair evaluation, the conditions of 2 platoon movies, such as frame of the movies, the number of people, and uniforms, are equal. As in Fig. 6, if the average of SD of Platoon A is lower than Platoon B, which means the arm swing of Platoon A is more regulated than Platoon B, the quality of the parade of Platoon A is better than Platoon B.

3. EXPERIMENT

In order to verify the evaluation value is applicable for the quantitative evaluation, we had a questionnaire survey. We asked 29 people, who are cadets of NDA and the experts for the military parade, to judge the 2 parade movies, and the response rate is 100%.

The cadets watched 5 pairs of 2 parades movies, which are about 5 seconds, and judge which parade quality is better. Here, the conditions of 2 parade movies, such as length, the number of people, and uniforms, are equal same to each other.

After the questionnaire, we compared the result of our method and the result of questionnaire.

4. RESULT

Table 1 shows the results of the questionnaire survey and the result of our method. It shows which platoon parade is better. The grey area of this matrix represents the better platoon in each set.

For example, in the Questionnaire, 96.9% of cadets considers Platoon B is better than Platoon A in set 1. Whereas in our method, the evaluation value of Platoon B is lower than Platoon A; therefore, it means Platoon B is more regulated than Platoon A.

Table 1 The results of the questionnaire survey and our proposed method

	Questionnaire (%)		The evaluation value (degree)	
	Platoon A	Platoon B	Platoon A	Platoon B
Set 1	3.4	96.9	35.18	27.05
Set 2	79.3	20.7	24.47	25.33
Set 3	86.2	13.8	28.25	30.43
Set 4	13.8	86.2	28.02	22.01
Set 5	93.1	6.9	22.01	24.70

In these 5 pairs, the results of the comparison for 2 platoons are corresponded respectively; therefore, as the results, we can confirm our proposed method for the quantitative evaluation is applicable for comparing the quality of the 2 parades.

5. DETAILED ANALYSIS FOR EACH MEMBER IN THE PARADE

Now, we can compare the quality of 2 parades, but it has not been clarified that which member affects the evaluation of the quality of the parade. Therefore, we analyzed the effects of individuals to the quality of the parade. However, due to the camera angle, we cannot get the all individual data; therefore, we analyze only the person who has the arm swing angle data.

In order to verify the effect of individuals, we compared the 2 parades data. Fig 7 shows the outline of comparing each series data for 2 parades. First, we use OpenPose for 2 platoons in order to get the posture data, and next, we adjust which posture data is whose.

In fig. 7, we could get the data for colored members. The 2 parades in Fig.7, which is used for detailed analysis, are same parade movies to the Set 3 in our experiment.

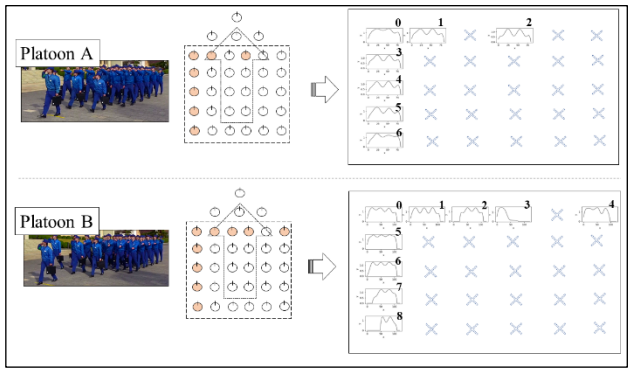

Fig. 7 Comparing each series data for 2 parades

For the identification of members, we tagged each member with numbers. For example, in Platoon A, we could get only 7 series data, so we tagged each member with the numbers 0 to 6.

Fig. 8 and 9 are the individual series data for the 2 parades in Fig.7. The numbers in figures shows the data of the member who has same identification number in Fig. 7. We also plotted the maximum peaks and the minimum peaks for each series data. It shows the fluctuation points; therefore, we can analyze the trend of

the arm swing angle data for individuals. The 2 parades are same to the Set 3 in the experiment part; therefore, we considered the quality of Platoon A is better than Platoon B from our results (Table 1).

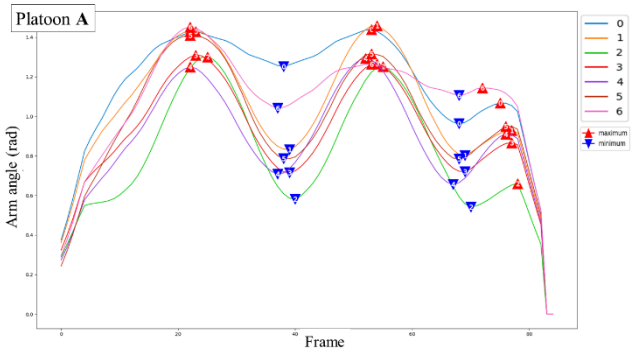

Fig. 8 The individual series data of Platoon A

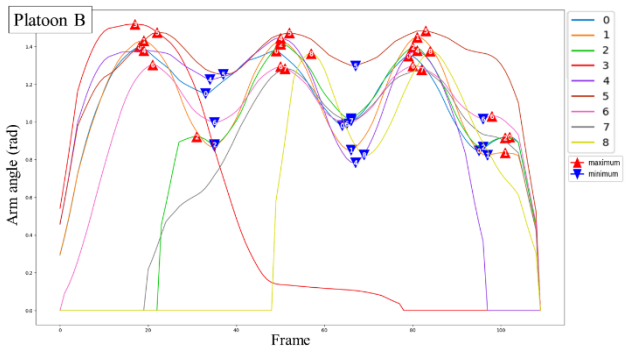

Fig. 9 The individual series data of Platoon B

As you can see the figures, the fluctuation points of Platoon A are more regulated than Platoon B. It is suggested that the parade quality of Platoon A is better than Platoon B.

For example, the fluctuation of no. 8 in Platoon B is a little bit late comparing to other data. No. 8 in Platoon B is in the last row of the parade; therefore, it is suggested that the network of the parade affects the arm swing.

Therefore, it is confirmed that we could get the individual data of the parade members with OpenPose.

6. CONCLUSION

We proposed the quantitative evaluation for the quality of the parade using OpenPose. We focus on the arm swing angle of the members in the parade for the quantitative evaluation, and we applied the average of the SD of the arm swing angle for the evaluation value.

As a result of the questionnaire survey, we confirmed the evaluation value of our proposed method is applicable for the quantitative evaluation.

We also analyzed the effects of individuals for the quality of the parade. Though further studies are needed, when the quality of the parade is better, the fluctuation points of the arm swing are regulated in the parade.

In NDA, all cadets are well trained for the parade, it is difficult to judge which parade is better. Therefore, as a future task, the evaluation method which can distinguish the subtle difference among the good parades is needed.

REFERENCES

[1] D Helbing, J Kelsch, P Molnar, “Modelling the Evolution of Human Trail Systems”, *Nature*, 1997.

[2] Yohei Okugawa, Masao Kubo, Takato Shimohagi, Tento Ishihara, and Hiroshi Sato, “Analysis of a Parade with the Kuramoto Model -For Better Performance without Trainings-”, *In Proceedings of IEEE SMC*, pp, 4005 – 4010, 2018.

[3] Z. Cao, T. Simon, S.E. Wei, and Y. Sheikh, “Realtime multi-person 2d pose estimation using part affinity fields”. *In Proceedings of the 2017 IEEE Conference on Computer Vision and Pattern Recognition*, pp. 7291-7299, 2017.

[4] Yohei Okugawa, Masao Kubo, Hiroshi Sato and Bui Duc Viet, “Evaluation for the Synchronization of the Parade with the OpenPose”, The 2019 International Conference on Artificial Life and Robotics, 2019.