

MULTIVARIATE KINEMATIC ANALYSIS OF PIANO PERFORMANCE : A CASE STUDY OF A PROFESSIONAL PIANIST

Dawon Park¹, Taegyun Kwon⁴, Joonhyung Bae⁴, Jonghwa Park³, Juhan Nam⁴ and Jaebum Park^{1,2}

¹Department of Physical Education, Seoul National University, Seoul, South Korea

²Institute of Sport Science, Seoul National University, Seoul, South Korea

³College of Music, Seoul National University, Seoul, South Korea

⁴Graduate School of Culture Technology, Korea Advanced Institute of Science and Technology, Daejeon, South Korea

Email: parkpe95@snu.ac.kr

INTRODUCTION

The music performance by professional pianists is remarkable from the perspectives of aesthetics, i.e., beautiful sounds, and human movement science as well. In particular, the complex and dexterous actions by the hands and fingers during a piano performance are feasible due to the structural advantage of the hands and fingers, such as high mechanical degrees of freedom. In other words, high-quality piano performance may be associated with the ability to coordinate high-dimensional elements, including hands, fingers, and trunk. By general consensus from the current control theories, the strategy of the central nervous system (CNS) toward the high dimensionality of the elements is to reduce the degrees of freedom in such a way that the elements are classified into a limited number of groups (i.e., dimension reduction) that are latent variables as to the performance skills or coordination [1]. The purpose of this study was to examine the patterns of coordinative patterns and dimension reduction of a piano performance by a professional pianist.

METHODS

One professional pianist who has worked performer and instructor for at least 20 years participated in this study. The participant played a Computer Controlled Piano (Disklavier C7, Yamaha Inc., Hamamatsu, Japan) for 30 repertoires which were composed of four techniques. (1) pulling arm legato: up, down, pronation and supination motion of wrist with released in the shoulder, (2) upper-arm gravity drops: a portion of the pulling arm cycle with a low- and high-wrist form, (3) forward gravity drops-rebounds: control of lower arm to maintain wrist height, and (4) hand bounce: produce faster and lighter repetitions of hands [2]. Spherical reflective markers were attached to the hand and each finger joint. Kinematics of upper body segments were captured using eight infrared cameras at 100Hz (OptiTrack, Natural Point Inc., Corvallis, OR). The geometric model consisting of 24 segmental angles was used for the quantification of mechanical properties of body kinematics. Principal component analysis (PCA) was performed to investigate the strategy of dimension reduction during the piano performance.

RESULTS AND DISCUSSION

(1) In pulling arm legato technique showed that the wrist, thumb, and little fingers were performed in one mode.

(eigen value=14.99, variance=34.95%) by PCA. Also, upper limb elements were grouped into one mode (eigen value=1.89, variance=4.39%). These results suggest that the group of thumb and little finger and fixed upper arm play a role in the frame for hand circle motion. (2) upper arm gravity drops were shown that upper limb elements were separated into different modes. This technique is characterized by controlling the wrist movement with the motion of the upper arm. That is, it is shown that harmony can be played continuously by using the coordination of the upper and lower arm to control the movement of the wrist. (3) Forward gravity drops-rebounds showed that the wrist and forearm were one mode (eigen value=16.13, variance=37.50%), and the index-middle, ring-little, and thumb fingers of both hands represented as independent groups. It suggested that wrist and forearm motion and finger independence play an important role in short continuous hitting motions. (4) Hand bounce was shown that the index, middle, and ring fingers of each hand were played in one mode (left hand: eigen value=11.46, variance=26.64%; right hand: eigen value=9.68, variance=22.51%). This result reflected that the character of this technique which is by playing notes quickly and lightly for a long time while fixed wrist position.

CONCLUSIONS

The current results showed the existence of a common mode (i.e., latent variable) across different piano techniques. Further, the kinematics of the thumb, little finger, and wrist joint played a significant role in the overall frame. To sum up, the control ability of wrist position and independent motions of fingers may be a contributor to the professional piano performance, albeit these should not be all about the “beauty” of the piano performance.

ACKNOWLEDGEMENTS

This research was supported in part by the Basic Research Program through the National Research Foundation of Korea (NRF) funded by the MSIT (2022R1A4A503404611)

REFERENCES

- [1] Danna-dos-Santos, Alessander, et al. *Exp Brain Res* **179**: 533-550, 2007.
- [2] Fink, Seymour. *Hal Leonard Corporation*: 1992.