Walk-in-the-Air Paradox

Yongheng Zhang

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Abstract

A gait named Slickback gained wide popularity on social media platforms in late 2023. In user-posted short videos, dancers moved as if paradoxically walking in the air, with feet levitated during most of the time. Some suspected that the floatation was due to video editing, although this effect had been demonstrated by many others. In this short note, an inexpensive method of extracting discrete kinematic information from online videos to build an analytical model of a stick figure carrying out a variant of this gait is described. This model was used in the production of an animation which I hope would help our understanding and encourage us to try this dance on our own.

Introduction

In mid-October 2023, the TikTok video [1], in which Lee Hyo-Cheol, a South Korean middle schooler in white Crocs, danced along a circular path to the song *A Pimp Named Slickback* by musical artist LAKIM, became popular. In this 10-second video, Lee appears levitated in the air, despite that slow motion shows his feet take turns to touch the ground. This video quickly gained wider attention. Up to this time, it has had more than 239 million views, and many others have learned and posted their own versions of this gait, now commonly known as the *Slickback*.

Three years earlier, American dancer and influencer Jouberson Joseph started the *Jubislide* craze, whose popular version was to the song *Jersey Anniversary*, a remix by DJ artist KiaBHN. In this dance, whose inspiration dates back more than a decade ago to his student times [3], Joseph could move along any complicated path, with toes sliding back as if on a thin layer of air, even when climbing stairs, generating another levitation effect. Kate Moore told me that some years ago, she saw young kids doing Jubislide in a supermarket, bringing a lively vibe to the leisurely space. On closer inspection, one would conclude that both as walk-in-the-air dances, Slickback is homotopic to the Jubislide original.

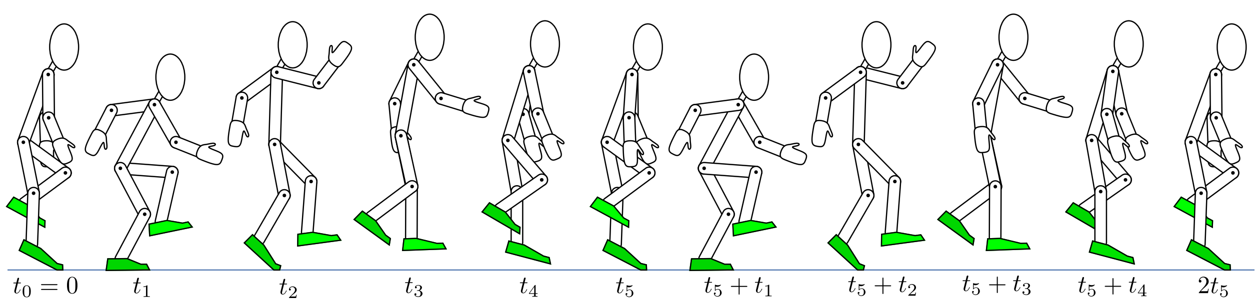

Figure 1: *A full gait cycle as shown in [5] carried out by a stick figure.*

In this note, another variant by dancer *annnoka* (TikTok) / *Turdalyan* (YouTube) [4] based in Almaty, Kazakhstan is studied. This gait exhibits a more dramatic levitation effect and the dancer moves along a wider arc, which can be approximated by a straight line. Thus, we can model this gait as a 2D movement, which is computationally less expensive and easier to understand. In the next section, we will describe a mathematical model of a stick figure (Figure 1), whose kinematics (shape change with respect to time) is generated by interpolating among discrete data captured by a cellphone and a laptop of the video [5].

Stick Figure Kinematics

The stick figure shown in the lower left of Figure 2 is modeled by 11 vectors, associated to the 11 angles: θ for the torso, ϕ_i and ψ_i, $i = 1, 2, 3, 4, 5$ for the left and right upper arm, forearm, thigh, shin, and sole, respectively. Each angle (in degrees) is measured from the positive x-direction. + and − angle values are for the counterclockwise and clockwise directions, respectively. The head and neck stay at a constant angle, and the hands point along the forearms, so we don't include them in the model. The toes' motion is complicated, whose disucssion is also left out to keep this note short, but it's been taken care of in the animation.

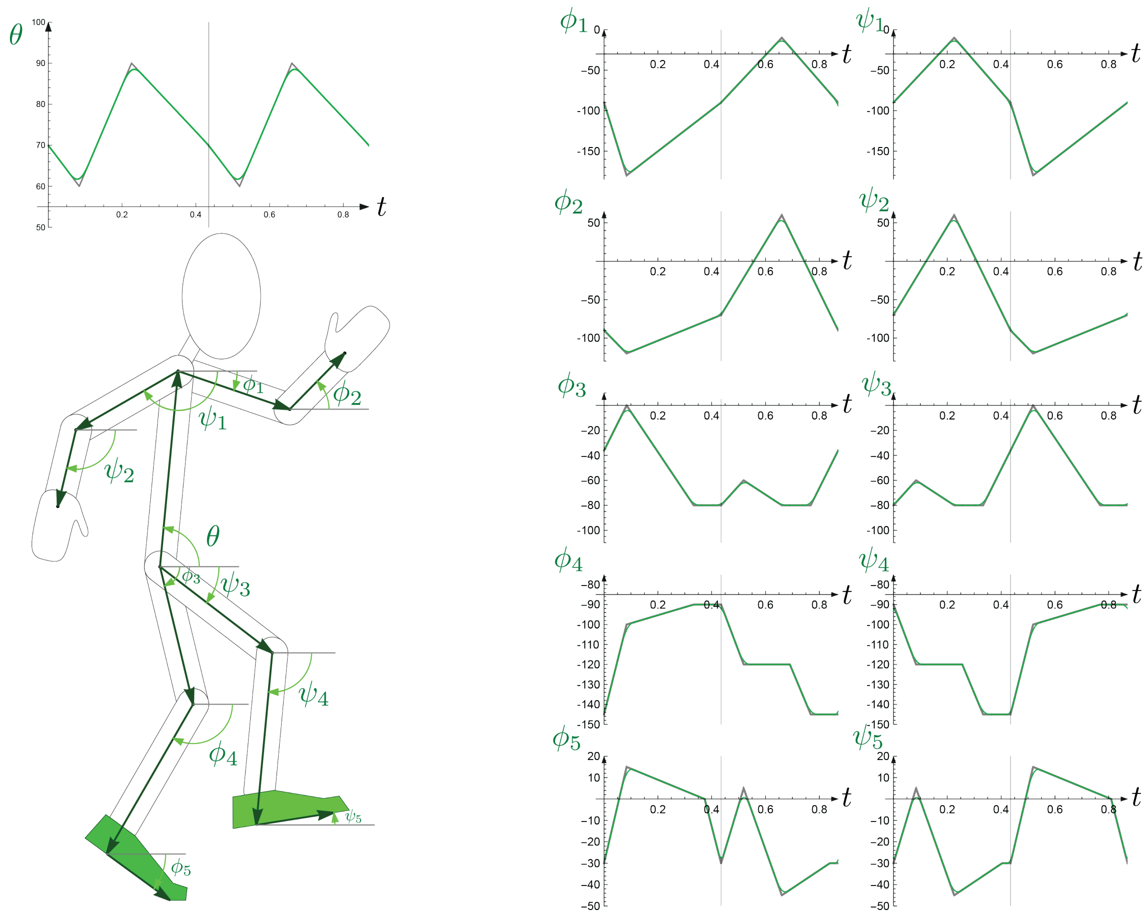

Figure 2: *Definition of angles and their interpolated functions of time.*

To find the functions of the above angles with respect to time t, six frames at times t_0, t_1, t_2, t_3, t_4 and t_5 (Figure 1) were sampled of the 6th step of the dancer in [5], from when the right toes just land to when the left toes just do, constituting half a gait cycle, whose duration is less than 0.5 second. To determine these times, [5] was recorded by a cellphone, and then the result video was played in QuickTime Player at 0.5 speed, which in turn was recorded by the cellphone, and then the result video was played at 0.5 speed again. This continues until the 5th time, when the video was played at $\frac{1}{32}$ speed, an online stopwatch accurate up to $\frac{1}{1000}$ second was run by the side of the slow motion video, both of which were then recorded again. After normalization at $t_0 = 0$, it was found that $t_1 = 0.08378125$, $t_2 = 0.2255625$, $t_3 = 0.333$, $t_4 = 0.4039375$, and $t_5 = 0.43484875$ in seconds. In each frame, the angles were then estimated by visual inspection, producing the corner points in Figure 2, which were then interpolated to form the piecewise linear functions in gray. Then the left and right half cycles alternate to form full cycles, after which 5th degree polynomials were used to replace the sharp corners, resulting in the second order continuously differentiable functions in green.

Though varying with the body configuration, the hip joint is approximately the body center of mass. During the ground contact phase from t_0 to t_2, the hip joint's trajectory is determined by the sum of the three vectors of the supporting leg (the left green curve in Figure 3). During the float phase rom t_2 to t_5, the whole body levitates in the air. Once the horizontal displacement is chosen, even though 2nd-degree is more physically correct, 3rd-degree polynomials (the red curves in Figure 3) were used to connect the previous and the next ground contact phases. The overall produced trajectory of the hip joint is continuously differentiable, even though the transition from red to green appears sharp to the eye.

This stick figure kinematic model was used in the animation [6], which shows more than a thousand frames generated from the analytic model. The relative lengths of the head, neck, torso, upper arm, forearm, hand, thigh, shin, sole, and toes are 1.6, 0.5, 2.5, 1.5, 1, 0.7, 1.8, 2.2, 1, and 0.2, respectively.

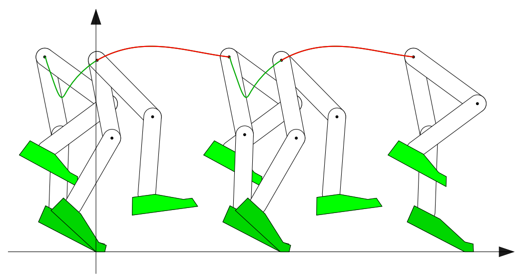

Figure 3: *Motion of the hip joint.*

Six years before the Slickback dance, high schooler Ariel Olivar popularized the *Invisible Box Challenge* [7], which is a further precursor to the Slickback. One can break down the Slickback we considered in this note into a sequence of Invisible Box Challenges, smoothly connected by naturally lowering the suspended leg while the swing leg steps over it. The last step in [5] shows another skilled completion of the Invisible Box Challenge. Such alternate gait in the air also appears in other sports and dances, for example, in the boxer skip jump rope, during the hop stage in the triple jump [8], and in the Slavic squat kick dance, arranged in increasing levels of difficulty. As with these movements, exercising Slickback is a great way to increase agility and strength, alleviate joint pains, and improve overall physical and mental health. Lastly, the method discussed can also be applied in the analysis of other sports, e.g., in the upcoming 2024 Paris Olympics.

Acknowledgement

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References

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[4] annnoka. https://www.tiktok.com/@annnoka/video/7291874373873487109; https://www.youtube.com/shorts/4rGrolZtS9k

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