

Walking with Pens

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Abstract

Believable 3D animation of walking or running characters still requires complex motion capture technology or extensive skills in manual keyframing. We present an inexpensive, yet natural input method: The user “walks” on a digital graphics tablet, striding over the surface with two pens in his or her hands, where each pen represents one leg. This technique leverages the popular graphics tablets that can track two drawing tools at the same time. We implemented recording software and a plug-in to use the data in off-the-shelf 3D animation software.

Categories and Subject Descriptors (according to ACM CCS): I.3.7 [Computer Graphics]: Animation

1. Introduction

The input of gait animation is notoriously difficult, due to its complexity and the sensitivity of human perception concerning implausible motion. Character animators rely on a huge amount of expertise and on motion capture methods, which often are expensive and require lots of space and setup. The method presented here is based on a digital graphics tablet that can track two tools at the same time, such as the Intuos and Intuos2 series by Wacom. The user strides over the tablet with the electronic pens, see Figures 1 and 2.

This method has the following advantages:

- The input of both the spatial and the temporal features of the gait is natural, precise, and robust.
- Most graphics designers own the necessary equipment, which is inexpensive compared to standard motion capture solutions.
- The method requires neither huge space, complex setup, nor the collaboration of several people.

Our recording software stores the position as well as the start and the end time for every “footprint.” We use these data in the 3D animation software Autodesk 3ds Max and with help of a plug-in module also in Maxon Cinema 4D. There is no real-time 3D display because the height coordinate of the feet is not available from the graphics tablet as measurement data, but has to be estimated afterwards from the complete motion. However, on-screen feedback is not necessary due to the immediate feedback through the pens. A printed floor plan on the surface of the graphics tablet allows the user to take care of doorways and obstacles.

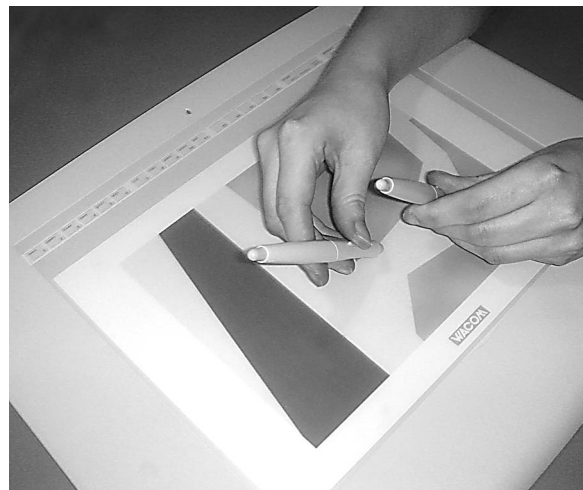


Figure 1: The user records the animation by “walking” over the floor plan on the tablet with a pen in each hand.

Typical graphics tablets do not sense the rotation of a drawing tool about its axis. However, they can sense the direction of tilt. We use this to control where the toes point: The user holds the pens slightly tilted; the direction of tilt is taken as the orientation of the corresponding foot. In our experiments, tilting the pens to the forward direction turned out to be more effective than tilting them backward because it allows to “walk” without collisions between the pens.

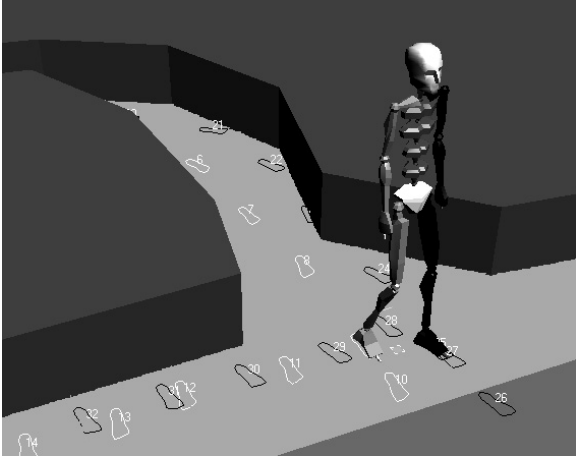


Figure 2: Autodesk 3ds Max can immediately use the recorded footprints.

This paper is structured as follows: Section 2 reviews related work. Section 3 details the extraction of footprints for Autodesk 3ds Max Character Studio. The use of the data in other 3D software is described in Section 4. Section 5 summarizes the results and outlines future work.

2. Related work

Real-time control of computer-animated characters through joysticks, data gloves or specialized interaction devices can be considered puppetry [Stu98] [RFM02]. Gobetti and Balaguer [GB95] devised a system for live input and editing of animation using a 3D input device and a mouse. Laszlo et al. [LvdPF00] employ the mouse to control alternatively the left and the right leg in a gait animation.

In Sturman’s system [Stu91] the user “walks” with the index and middle fingers, which are recorded through a data glove. The locomotion of a six-legged character is derived from these data. Physical contact between the finger tips and a base surface is not employed; there is no actual or imagined “floor plan.” Sturman reports that users need time to get acquainted with his system and show fatigue.

Oore et al. [OTH02] suggest holding a tube containing an electromagnetic sensor in each hand to control a character’s thighs. Yin and Pai [YP03] place an array of pressure sensors on the ground and reconstruct gait motion from their output. Dontcheva et al. [DYP03] track an item through optical markers. The user executes the intended motion with this item, typically only controlling a subset of the parameters. Several recordings are layered to complete the animation.

Oshita [Osh04] uses a graphics tablet for high-level animation control: Position, speed, pressure, and tilt angle are evaluated to invoke and seamlessly blend walking, running, or jumping motion of a human character at different speeds,

directions, etc. At an even higher level of abstraction, Thorne et al. [TBvdP04] allow the user to sketch motion sequences using a predefined “motion alphabet.”

Many researchers have addressed the synthesis of motion from input sketched by the user. Girard [Gir97] uses the placement of footprints. His technique forms the basis of the Character Studio inside the animation software Autodesk 3ds Max. Van de Panne [vdP97] extends these ideas by first creating a globally optimal motion of the body’s center of mass. Liu and Popović [LP02] build on biomechanics. Gleicher [Gle01] proposes to process motion-capture data to comply with an edited path. Kovar et al. [KGP02] employ a database of motion-captured animations. This is also true for the system of Hsu et al. [HGP04]. Here, the user can for instance sketch a gait animation by tracing out a path with the mouse. Lee et al. [LCR*02] apply motion-capture data to control 3D characters using a video of a real actor.

Terry and Metoyer [TM04] stress the importance of timing for plausibly-looking motion. They present a system using the mouse to record timing separately from spatial position and orientation.

3. Recording footprints

Our recording software employs the pen pressure to recognize when a “foot” is in contact with the ground. If the pen slides over the surface while pressure is being applied, a new footprint is generated whenever the distance traveled exceeds a given threshold. This allows to record sliding motion, but suppresses unintentional slipping due to the slick surface of the tablet. For each footprint we store start and end time, position, and orientation. The orientation of each foot is determined from the tilt data supplied by the graphics tablet, see Figure 3. This allows to infer the heading angle. Pitch and bank angle of every footprint are set to zero.

As a file format to save the recorded data to disk, STP turned out to be a natural choice. This is a proprietary file format of Character Studio; thus, the files generated by our recording tool can be used there with no special preparation. After assigning the recorded footprints to the biped object available in Character Studio, the user is immediately presented with a plausible motion obeying timing, position, and orientation of the footprints.

4. Synthesizing keyframed motion

For animation software other than Autodesk 3ds Max, we have to convert the STP file to regular keyframed motion. It is sufficient to create keyframes for three pseudo-objects: a target for the left foot, another for the right foot, and one pseudo-object controlling the pelvis, compare Figure 5. The remaining animation data can be created on the fly by standard functions of 3D animation software: Spline interpolation converts keyframes into motion paths; inverse kinematics computes the motion of the limbs.

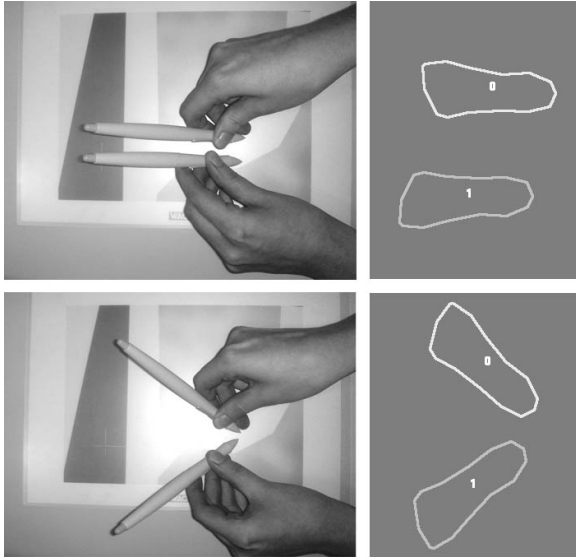


Figure 3: The tablet's tilt output controls the orientation of the feet (left: input, right: result in Autodesk 3ds Max).

We have developed a plug-in for Maxon Cinema 4D to read an STP file and generate a corresponding motion of the three pseudo-objects. Keyframes for a foot are created at the start and the end of all of its footprints. To lift the feet off the ground between the footprints, the plug-in adds tangent data to the keyframes, see Figure 4. From this results a plausibly-looking arc for the motion of the foot through air.

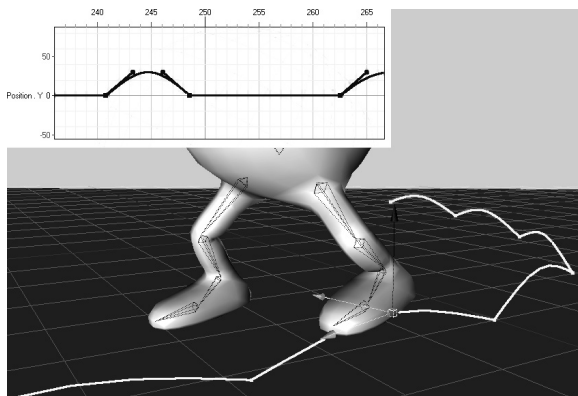


Figure 4: To lift the feet off the ground, the tangents of the keyframes are bent upward (screenshot from Maxon Cinema 4D; character designed by Arndt von Königsmarck).

The motion of the pelvis is derived from that of the feet. In contrast to gait generators such as [SM01] that have been described in the literature, our approach aims at leveraging functionality present in standard 3D software, in particular inverse kinematics. For each footprint we generate one

keyframe for the pelvis. The user can control globally where this keyframe is situated in time; we achieved the best results with placing this keyframe at 20 % of the duration of the footprint. The height y recorded for this keyframe is set to a fixed value; the horizontal coordinates x and z and the heading are computed as weighted averages of the corresponding values of the feet at the same instant of time. The user can control the weighting to emphasize either the current foot (i. e., the one the footprint of which is regarded at the moment) or the other foot, which possibly is lifted. On the scale of 0 to 100 % ranging from “other foot only” to “current foot only,” the setting of 50 % leads to a smooth motion of the pelvis, resembling a heavy character, see Figure 5. A setting of 60 % produces a lightweight, swaying motion.

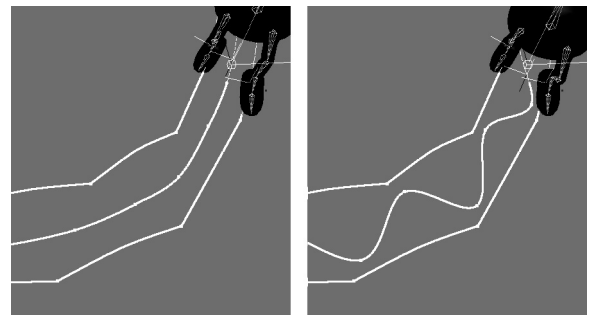


Figure 5: Keyframes for the pelvis are computed by averaging the data of the current and the other foot with adjustable weighting (left: 50 %, right: 80 %).

5. Conclusion. Outlook

We have presented a natural and inexpensive input method for bipedal gait animation. To the inexperienced user, this method offers plausible results in short time. The method may also be helpful for character animators to rough out ideas. The pens and the floor plan offer intuitive real-word feedback; the user does not need to focus on a representation on the computer's screen while acting blindly with the pens, in contrast to the usage of a graphics tablet with painting software.

Our current solution aims at storing and processing a minimum amount of data. Future work may add a mode in which the motion is recorded fully, frame by frame. This would allow both complex sliding of the feet and complex motion of a lifted foot. Note that a pen is tracked well even if its point is more than half an inch away from the tablet's surface. Another option is to apply the pressure sensitivity or the pen's buttons to control details of the motion.

The system does not prohibit overly large or small strides. The former violate kinematic constraints and thus lead to incorrect motion. However, during our tests we did not run into such problems, since the printed floor plan offers much orientation as to how far apart from each other the footprints

should be placed. Nonetheless, we are experimenting with visual and aural feedback mechanisms to signal to the user when the pens do not span a typical stride length.

Wacom has abandoned the simultaneous tracking of two tools in the current product line Intuos3, due to the lack of applications. However, a great number of the earlier graphics tablets is still in use. In addition, we hope that the method presented here adds to the number of such applications. If “dual track” support was even available for TabletPCs or for LCD monitors with built-in graphics tablets, this would allow to show the floor plan electronically, maybe with animation or interaction, instead of printing it. Further hardware support may be realized as an inexpensive add-on to existing graphics tablet technology. Figure 6 shows one of our ideas regarding novel input devices.



Figure 6: Specialized sensing devices such as thimbles equipped with small shoes may lead to an even more intuitive gait input via the graphics tablet.

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