A Tool for Translating Dance Notation to Animation

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ABSTRACT

There is a need to develop tools to automatically read and translate dance scores. Dance has been one of the last artforms to develop objective records. Scores for dance, analogous to scores for music, have existed for more than half a century, but the notation systems are known only to a relatively few trained notators (also, there are a number of competing notation systems). In North America the Labanotation system is most widely used and LabanWriter, a computer based editor for this notation has been developed. Updating a report at WCGSÕ01, this paper describes progress with the project to develop a translator between LabanWriter and Life Forms™, a human animation system for the choreography and animation of human movement. The prototype translator will be demonstrated.

Categories and Subject Descriptors

J.5 [**Arts and Humanities**]: Performing Arts..

General Terms

Algorithms, Experimentation, Human Factors, Standardization..

Keywords

Dance, Notation, Scores, Human Figure Animation.

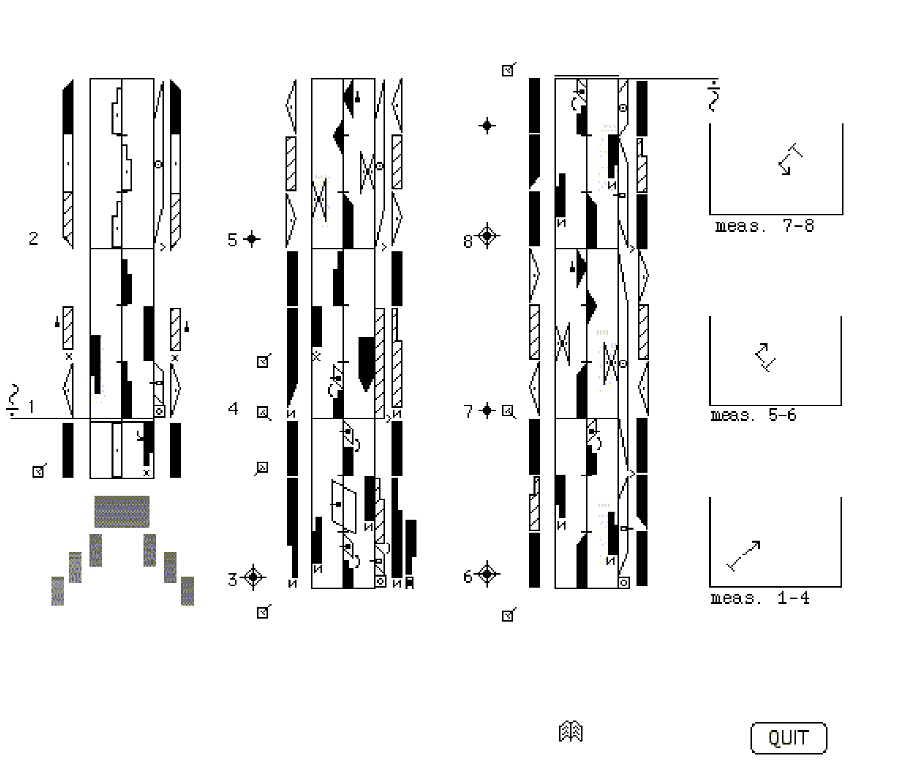
1. BACKGROUND TO THE PROBLEM.

As discussed at WCGSÕ01, dance has long been considered an ephemeral art. However, with the advent of dance notation, a means was found for long-term objective documentation of dance that preserves works that would otherwise be lost. The Dance Notation Bureau (DNB —www.dancenotation.org) in New York has been working for 60 years to create, house and disseminate dance scores produced using the dance notation system called Labanotation [13]. Scholars, students, performers and the public are provided an easily accessible, detailed record of choreography that allows for the study of the dances themselves in a way that no other medium does. An example of a Labanotation score is shown in Figure 1. (Others systems of dance notation exist — e.g. Benesh Notation[3], but Labanotation is the most widely used in North America.)

As discussed, it has been recognized that a translator between Labanotation scores and human figure animation could dramatically increase the dance fieldÕs ability to make use of existing scores and to create new scores. This paper provides an update on an ongoing project that aims to develop a translator between the Labanotation scores produced in the LabanWriter [20] notation editor and the Life Forms™ human figure animation program [www.charactermotion.com] and vice versa.

With the prototype that has been developed for such a translator, artistic directors, students and dancers with little or no knowledge of notation could have the ability to see the movement recorded in the DNBÕs 600 scores and the thousands of Labanotation scores existing around the world. The publication *Laban Notation Scores: An International Bibliography* published by the International Council of Kinetography Laban, lists 70 different categories in its genre index including dances of Armenia, China, Hungary, Bali and Mexico as well as character, modern, ballet, tap and historical dance. The interface will facilitate access to these materials by all dancers. Both Life Forms and LabanWriter are tools that can be used with any dance form.

A reverse translator from animation to Labanotation scores could yield an enduring written record that requires only refinement by a notator, increasing DNBÕs ability to provide important resources to researchers and students. Simultaneous generation of a Labanotation score, for example by Merce Cunningham and other choreographers who use Life Forms, would be a significant first step towards a lasting heritage for future dancers and students. In addition, many choreographers and dancers have suggested that motion capture technology be used to facilitate the development of Labanotation scores. Since Life Forms can accept most standard motion capture data as input, the translator also provides a way to create notation directly from live dance.



2. COMPUTER GRAPHICS TOOLS FOR CHOREOGRAPHY AND NOTATION

The idea of using computers to assist in recording and animating dance goes back at least to the 1960Õs and NollÕs article in Dance Magazine [15]. Cunningham also discussed these issues at about the same time [11]. Perhaps the first attempt to apply computers to Labanotation was Zella WolofskyÕs 1974 Simon Fraser University masters thesis on the interpretation of selected Labanotation commands [21]. Subsequently there were a number of projects that focussed on different aspects of interpretation of Labanotation (Brown et al, [4]; Smoliar et al[19]; Badler and Smoliar, [1]; Calvert and Chapman, [5]), Benesh Notation (Ryman et al, [16,17]) and other systems [12]. The parallel work on human figure animation is summarized in Barsky et al [2]. In 1986 Calvert proposed a synthesis in the form of a language for movement [8].

Out of this considerable interest two tools emerged that were of value to working notators and choreographers. LabanWriter was developed at Ohio State under the leadership of Lucy Venable [20] and at Simon Fraser University Tom Calvert lead the team developing Life Forms [10]. LabanWriter took advantage of the graphics capabilities of the relatively inexpensive Macintosh computer to provide a simple and intuitive word processor like system for creating and editing Labanotation scores. (MacBenesh - a similar system for Benesh Notation was developed by Rhonda Ryman and her colleagues at University of Waterloo [16,17]). At about the same time Life Forms was developed to provide choreographers and animators with a simple, user friendly system to experiment with patterns of movement in animated human figures. Scholars, students, notators, educators, and choreographers have been using both LabanWriter and Life Forms and many have suggested that they should be linked.

2.1 Design of a LabanWriter to Life Forms Translator

During the first phase of this project, the emphasis was placed on learning and understanding Labanotation while trying to build a framework that would be adaptable to various translation techniques. We adopted an approach that consisted of translating the data in stages, moving from the original LabanWriter score to an internal representation with added contextual information, to key frames and finally to a LifeForms animation.

We applied this approach to a subset of Laban symbols in an attempt to understand the translation process. We found that different classes of symbols lent themselves to certain translation strategies. For instance, the group of symbols that denote motion of limbs or limb parts in the three Cartesian axes (*direction* symbols) lent themselves to a simple heuristic approach where each symbol mapped to a joint angle which was applied to the limb at the correct time. For the class of symbols that denote weight transfer including locomotion (*support changes*) we used a lookup system that selected an animation from a database and inserted it as key frames into the final animation.

Upon surveying the rest of the symbols associated with Laban we also identified several scenarios that could arise in the future. These included the possible use of inverse kinematics to generate joint angles, conversion from local to global coordinate systems for certain cases, and the possible use of a motion blending technique.

Considering this pattern of changing strategies for different classes of symbols and some of the problems encountered using this staged approach led us to expand this approach to be more comprehensive, incorporating a number of different translation strategies, and encompassing more of the symbols that will appear in a Laban score. In general, the new approach will consist of the following:

- parse the LabanWriter file
- create Laban ÒsentencesÓ
- normalize Laban sentences
- use a rule base to interpret Laban sentences
- generate keyframes
- check generated keyframes for correctness

An overview of this process is illustrated in Figure 2. Each stage will be discussed in turn.

2.1.1 Parsing the LabanWriter file

LabanWriter is a Macintosh application that allows the composition and editing of Labanotation scores, such as that shown in Figure 1. In Labanotation, the staff is vertical (as opposed to music where it is horizontal) and time, measured in beats, goes up the page. The centre of the staff represents the centre of the human body. The columns immediately to the left and right of the centre represent the support of the left and right sides of the body (support is most often on the feet). Going out from the centre, successive columns represent the movements of the left and right legs and arms. The torso and head are arbitrarily placed on the right. The direction and level of a movement are indicated by the shape and shading of a symbol. The lowest point on the symbol indicates the start time of the movement and its duration in time is indicated by its height. Thus, the process of creating a score involves choosing an appropriate symbol for a movement, placing it in the appropriate column for the body part concerned and adjusting its level and height to achieve the correct timing.

LabanWriter is a good graphical editor that is intuitive and easy to use, but the program has little or no problem knowledge (cf. a text editor with no rules for punctuation, spelling or grammar). The file that represents the score stores an identifier for each symbol with modifiers for shading, orientation and size, and the x-y coordinates of its placement on the page. Thus, the first step in interpreting the file is to identify the column, start time and end time for each symbol. With a well-composed score this is straightforward, but Labanotation makes extensive use of modifiers —special symbols that modify the meaning of others and these must be located and then associated with the main symbol they are modifying.

The principal result of parsing the LabanWriter file is essentially a channel for each body segment that shows all support changes and gestures for that body segment together with the start times and duration of these movements. This, of course, is getting much closer to the information we need for animation. A secondary result is the other miscellaneous information about repetitions, floor paths, etc.

2.1.2 Create Laban Sentences

As mentioned above, Labanotation makes extensive use of modifiers. Many symbols have meaning on their own, but that meaning can be altered, for example, by a *presign* to change the joint it refers to, by a *bow* to associate it with one or more other symbols that further alter its meaning, or by other modifiers. Hutchinson [13] notes the similarity between Labanotation and the syntax of a language. We can use this concept to simplify the translation process.

All the Laban symbols that pertain to a single motion are considered a sentence. Identifying sentences in the LabanWriter score is a matter of associating symbols that are connected syntactically. Symbols that are clearly modifiers must be linked spatially to the symbol they modify, so a nearest neighbor criterion (with a preference for the nearest symbol in the same column) is used.

2.1.3 Normalization

There is often more than one way to notate a movement using Labanotation, which is to say there are equivalent representations for the same movement. Some would be considered more correct by a notator by being more concise, or succinct, making the score easier to read or interpret. For instance, there is a class of symbols that describes *bending* or *contraction* of limbs in various ways. A bend or contraction can be notated by using direction symbols to specify the rotation of the upper and lower parts of the limb. These are equivalent notations.

There are also certain motions or positions that are implicit or assumed in Labanotation. For example, when the upper part of a limb moves, the lower part moves with it. Exceptions to this rule include the use of a *space hold* to notate that the rest of the limb should remain in place. Other examples of implicit motion include assumptions about which way a limb is facing when it is directed to bend, constraints on the joints due to human physiology, and conventions due to particular styles of dance.

Finally, although most symbols in Labanotation specify an end position in the same way as key frames in animation, there are also certain assumptions about the paths a limb should take when transitioning from one position to another. Thus, if the notation says the arm is to pass from the front of the body to the back, Laban assumes that it will not rotate from the shoulder through 180¡, but that the wrist will move toward the shoulder, and then behind the body in a straight line.

By normalizing sentences, we mean that we will reduce representation to the simplest possible form for the computer to effect translation, and explicitly encode assumptions about limb positions and about transitions. We can pass each Laban sentence through a rule based system where it looks up the symbol, or sentence type, and substitutes it with its equivalent and simpler representation. By simpler we mean that it will be reduced to a sentence for which weÕve already developed a technique for translating.

2.1.4 Rule-based translation

If a sentence is already in its simplest form, the above mentioned rule-based lookup will tell the translator to use one of several techniques to generate key frames for the sentence. As previously discussed, these techniques could involve heuristics, a database lookup, inverse kinematics, motion blending or other strategies to handle different sets of symbol classes. This system allows us to develop many different approaches to generating keyframes specific to various symbol classes, and allows us to manage the complexity of the translation process in one central place. It should be possible to try various techniques by changing the rule for a given technique.

2.1.5 Generate Keyframes

During the above process, angles are being generated for joints at certain times and are being inserted into a channel structure. Because of various assumptions implicit in Labanotation, some of these angles are absolute with respect to the stage, and others are relative to the parent joint. A final global-to-local transform is required before adding the key frames to Life Forms.

Also, we have begun to realize that there may be conflicts in interpreting the LabanWriter score where two parts of the translator will try to set conflicting angles on the same joint at the same time, leading to an incorrect result. For example, if locomotion is specified using support changes for the feet, and a gesture is also specified, it will interfere with the locomotion, possibly in an unpredictable way. A proposed solution is to catch and resolve these conflicts prior to adding the keyframes to Life Forms, either through human intervention or motion blending

2.1.6 Check for correctness

The final step in the translation process is for a notator to check the translation for correctness. A large amount of knowledge is necessary to create a correct notation of a given motion, and that same knowledge is necessary to read the notation. The method for testing we have used to date is to have a suite of scores and animations corresponding to these scores created by the notator. The testing phase is essentially visually comparing the translated animations to those created by the notators. Automating this procedure would allow for faster development and testing, so we propose to create a system for comparing two animations and generating a statistic by which we can measure their similarity.

2.2 Design of a Life Forms to LabanWriter Translator

Life Forms™ (www.charactermotion.com) is a keyframe based system for the animation of multiple articulated figures on the Mac or PC. It has multiple tools to support the user in customizing movements including inverse kinematics, a locomotion generator, different renderers, imports for motion capture data, etc. It also has interfaces to allow importation of body models from many popular modelling packages and animation sequences can be exported to full featured animation systems. Life Forms Dance is optimized for use by choreographers and comes with a CD-ROM of Ballet Moves created by Rhonda Ryman.

The translation from keyframed movement in Life Forms to Labanotation is straightforward in principle. There are some difficulties in practice however:

1. The animator may not have chosen keyframes at the same points that a dance notator would have defined key positions. This is probably not too serious, and the simple approach should result in notation that is at least reasonable. A more annoying problem may be that the resulting scores will be verbose — i.e.there will be many more keyframes than are needed for a succinct score. This will likely be a particular problem with animation based on motion capture data. As in animation, a solution is to apply a thinning algorithm to reduce the number of keyframes.
2. The straightforward approach cannot handle support changes. To handle supports, it is necessary to write algorithms that create a map of how the contact between body parts and the environment changes with time. This can then be used to deduce the direction of the change and support change symbols can be chosen. In practice this can become very complicated if all situations are considered. However, for the relatively common changes of support found in locomotion (walk, run, skip, jump, etc) it should be possible to achieve good results.
3. As in the translation from LW to LF, a good end result requires that many assumptions and conventions be taken into account. This again requires a sophisticated knowledge based system to help deduce the best notation.

3. IMPLEMENTATION OF THE TRANSLATOR PROJECT

In 1998 the Dance Notation Bureau, led by Executive Director Ilene Fox, sponsored the first stage of this project with funds received from the National Initiative to Preserve AmericaÕs Dance (NIPAD) and the US National Endowment for the Arts.

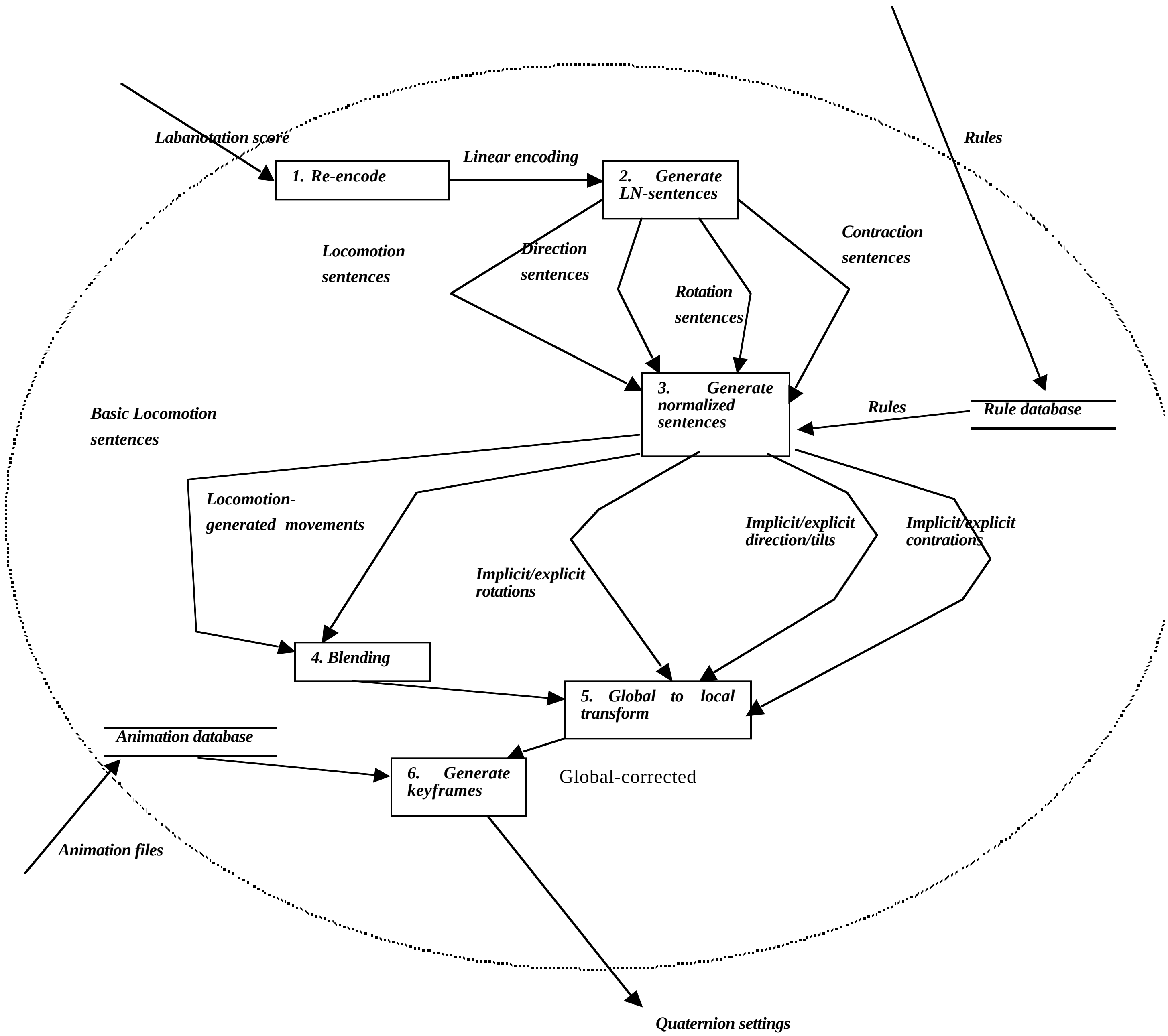


Figure 2. An Overview of the Translator Architecture

The project participants were the DNB, the developers of LabanWriter from Ohio State University, Tom Calvert, the original developer of Life Forms from Technical University of BC, Credo Interactive Inc., the Vancouver company that distributes and continues to develop Life Forms, and Rhonda Ryman, Associate Professor of Dance, University of Waterloo.

During this first stage, a working prototype has been developed that can translate the gestural and support commands in a LabanWriter score. Although some aspects of this are crude and not completely satisfactory, the results are extremely encouraging and the prototype is on the point of being quite useful. The major deficiency is the need to develop a flexible knowledge based system and reasoning engine to allow the numerous implicit specifications, conventions and exceptions to be handled. This requires very careful collaboration between the software developers and the notation experts. In addition to building the knowledge base for the LW-LF translator we need to start the LF-LW translation. We expect this reverse translation to go much more quickly because many of the special problems associated with notation have been encountered in the first phase.

4. IMPLEMENTATION

The Translator is implemented as a plug-in for Mac Life Forms. This allows the LabanWriter file to be read into Life Forms like any other file and all of the editing capabilities of Life Forms are available to refine the results.

It has also been necessary to develop body models to use in animation that would have an acceptable esthetic for the dance world. We created four models: *ballet woman*, *ballet man*, *modern woman* and *modern man*. Life Forms already has available a number of different body models which can be used in other situations. Once one basic *dancer body* model was developed, the other models used the same limb proportions. This facilitates copying movement from one dancer to another without it changing due to longer or shorter limbs. The contours were varied from one gender to the other and clothing was changed. It is anticipated that in the future, other models will be developed appropriately clothed for other dance forms. Changing the clothing once the model is created is relatively easy.

5. RESULTS

A static example is shown in Figure 3. At the left the LabanWriter score is shown and on the right there are two figures. The right-hand figure was created by the translator and the left by a notator who read the score and animated it by hand in Life Forms. This illustrates one of the problems very well — thetranslator has the dancerÕs right foot at right angles to the lower leg whereas the notator/animator pointed the foot. The notation does not explicitly indicate the pointing of the foot but it is done as a convention in most dance. Other live examples will be used to illustrate the paper presentation.

6. CONCLUSIONS

The problem addressed here represents a very real and practical application of computer graphics and animation to the field of dance. With the translation tool under development all choreographers and dancers will have access to the hundreds of Labanotation scores that exist in archives around the world. Perhaps more importantly for the future, new choreography created with Life Forms will be automatically captured as a Labanotation score and become available to posterity.

7. ACKNOWLEDGEMENTS

The work reported in this paper represents an ongoing collaboration between Ms. Ilene Fox and her notator colleagues at the Dance Notation Bureau in New York, Professor Rhonda Ryman at University of Waterloo, Ms. Sang Mah and her team at Credo Interactive Inc. in Vancouver, and Tom Calvert, currently at the Technical University of BC. Support for the initial developments was provided by the National Initiative to Preserve AmericaÕs Dance and the US National Endowment for the Arts. The project is currently supported by the US National Endowment for the Humanities.

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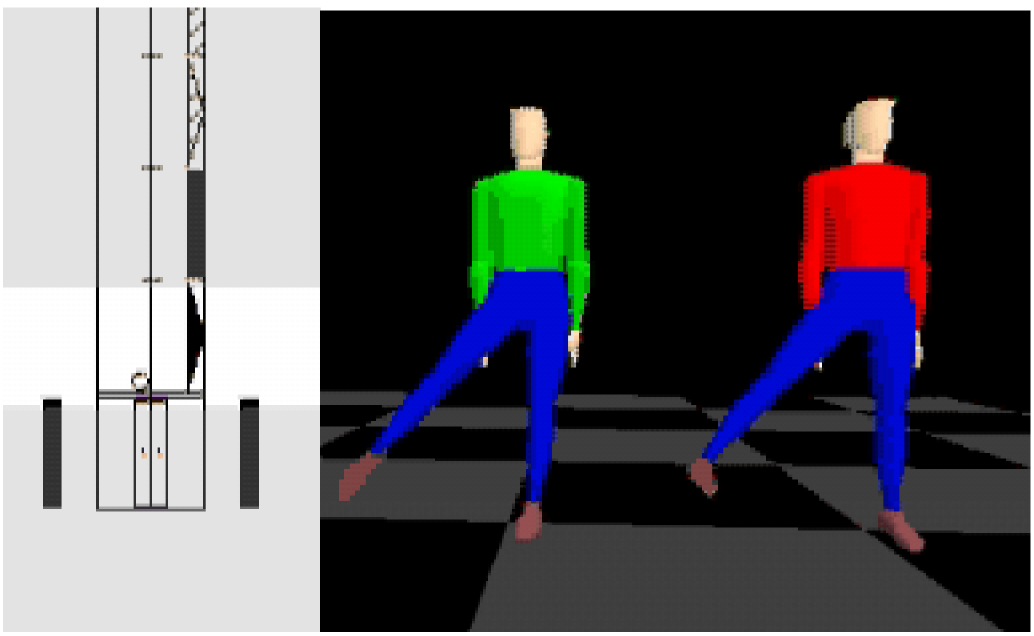

Figure 3. A sample from an animation created by the Translator. The figure on the right was generated by the Translator and the figure on the left was animated by a notator using Life Forms.