A TRANSLATOR FOR HUMAN MOVEMENT NOTATION

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ABSTRACT

Human movement notation have been developed to record dances to prevent their loss or corruption. Their use has spread to other fields. The most widely used notations are Benesh Movement Notation (BMN) and Labanotation.

There have been a number of computerized tools developed for notation users, including interactive editors, and interpreters for animating notated scores. A translation system between notations would be useful as very few notators know both notations. It would widen the repertoire of scores available to dancers as well as broaden the means of communication between human movement notators.

The system described is for translation from BMN to Labanotation. A set of movement primitives was chosen as an intermediate representation that draws on representational techniques developed for both notations. Translators from BMN to the intermediate representation and from the latter to Labanotation have been developed.
A Translator for Human Movement Notation

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1. INTRODUCTION

The dance world has had to face the problem of how to record human movement in a way that is concise, and that allows accurate reconstruction. This has been to prevent loss or corruption of compositions with time. A variety of human movement notation schemes have been developed, the most widely used being Benesh Movement Notation (BMN) and Labanotation. Since their development, the use of these notations has extended into other fields such as anthropology and physiotherapy.

There have been a number of projects for the development of computerized tools for users of movement notation. These include interactive editors for the entry and modification of notation scores [Brown and Smolian 1976, Sealey 1980, Singh et al. 1983, Ryman and Hughes-Ryman 1986, Hunt 1988, Hagist and Politis 1989], and interpreters that take movement notation scores to produce animation [Calvert et al. 1982, Badler and Smolian 1979, Savage and Officer 1985, Politis and Herbison-Evans 1987].

Another useful tool would be a translation system between notations. There are few notators that know both BMN and Labanotation, while there are numerous dances that are recorded in only one of the two notations. If scores in one notation can be translated into the other, it would widen the repertoire of dances available [Herbison-Evans 1988]. More generally, a translator would broaden the means of communication between human movement notators.

The system described here is for translation from BMN to Labanotation. The approach taken was to choose an appropriate set of movement primitives as a general intermediate representation of human movement. A translator from BMN into the intermediate representation, and one from the latter to Labanotation have been developed.
BMN and Labanotation are described in the Appendices.

2. BACKGROUND

Translation between human movement notations was suggested by Brown and Smoliar as early as 1976. Their proposed approach was to establish a set of generalized movement primitives, and then develop translators to and from these primitives [Brown and Smoliar 1976]. Singh proposed the same approach, noting that two-way translation between Labanotation and three-dimensional body data was made possible by research at Simon Fraser University [Singh et al. 1983, Calvert et al. 1982]. Although human movement representations have been developed (reviewed below), the main interest has been to produce animation rather than with movement notations.

3. TRANSLATION SYSTEMS

It is useful to relate what has been learned about language translation to the problem at hand for two reasons, namely, to ascertain the advantages of an intermediate representation approach, and to consider how human assistance may be incorporated into the translation process.

3.1 Need for an Intermediate Representation

Michie comments that Winograd’s work “has left no doubt that machine translation can only be solved by knowledge-based systems” [Michie 1986], meaning that the translation process must use an internal representation of the subject matter involved. The simpler approach of parsing, applying a dictionary translation to each term, and reconstructing with the appropriate syntax is incapable of dealing with ambiguity, idiom and different analyses of the subject matter. (As an example of the latter, compare the English “I have some food” with the Japanese “food exists”. “Food” is the object of the sentence in English, but the subject in Japanese.)

Whereas human movement notations have been carefully designed to avoid ambiguity, they invariably analyse human movement differently, and have their own short cuts and exceptions to rules. For example, BMN does not usually distinguish between a foot merely touching the ground and one touching and bearing weight. On the other hand, Labanotation always distinguishes. Therefore, whereas a Benesh notator may begin to analyse a movement by asking, “where are the
hands and feet?", a Labanotator may begin by asking, "how is the body supported?".

Another important distinction is that BMN treats space as continuous and discretizes times, whereas Labanotation discretizes space and treats time as continuous [Herbison-Evans 1988]. In computing terms, BMN uses a keyframe approach, whereas Labanotation uses an event list approach. This has ramifications in particular in the way in which overlapping actions in time are notated (and translated), as shown in Figure 1.

Figure 1. Arm movements overlapping in time (not computer translated).

(a) BMN

(b) Labanotation

3.2 Human Assistance Considerations

Although people with the ability to translate between BMN and Labanotation are few and far between, problematic sections in scores needing human assistance may occur even with a well-advanced machine translator. It is too early to know the type of assistance needed. Possibilities would include Tomita's list of four forms [Tomita 1986]:

- passing sentences that are too hard for the system to handle to a human translator;
- interactive human assistance during translation;
- pre-editing the input to fit the syntax and vocabulary limits of the system;
- post-editing the output.

The last two forms of assistance have the advantage that the human assistant requires knowledge of
only one language.

4. INTERMEDIATE REPRESENTATIONS

4.1 Survey

A variety of human movement representations have been used in animation systems. We shall briefly examine them and discuss their applicability to the problem at hand.

**Movement functions.** One of the earliest movement representations is defining the position of the moving object as a function of time [Baecker 1969]. The output of Ginsberg and Maxwell's human tracking system is of this form [Ginsberg and Maxwell 1986]. BMN's movement lines and Labanotation's floorplans are also forms of this representation. While it is general and independent of any notation, it is very low level. Except for movement lines and floorplans, that level of detail is not recorded by notations, and generating it in the translation process is unnecessary.

**Three-dimensional keyframe representation.** The use of keyframes is a more compact approach. The animator defines a sequence of static positions of an articulated figure, typically by controlling either the position of or the three-dimensional transformation parameters at each joint. The figure may be defined hierarchically, so that the transformation at a shoulder, for instance, affects the entire arm (see also Sturman 1984). BMN itself is a keyframe representation. A limitation of keyframes that makes them inappropriate is that movements overlapping in time are awkward to represent.

**Dynamic modelling.** An approach that has recently attracted interest is to model the body's dynamics. Wilhelms stores the force or torque at each degree of freedom of the body as a function of time [Wilhelms 1987]. This method is inappropriate for the task at hand because the forces are generally not known by the performers or notators of the movement. On the other hand, qualitative aspects of the dynamics are notated, and ballistic motion (jumping) and balance considerations must be catered for.

**Procedural representation.** Zelter has developed a procedurally-based animation system [Zelter 1982]. A task manager compiles high-level requests into "skills" that represent classes of motion the figure can perform (walking, grasping, etc.). Skills are implemented by "motor programs" that invoke low-level "local motor programs". The latter have localised control over the orientation.
part of the figure. While this is a promising approach for animation control, it is not applicable to storing human movement in a generalized form.

Labanotation-based representations. Badler, and independently, Calvert have used representations derived from Labanotation itself [Weber et al. 1978, Calvert and Chapman 1978]. Its description of the movement of each part of the body in a separate column as a function of time led Badler to understand it as the description of a set of concurrent activities. A score could then be compiled into programs for a set of parallel processors, each one controlling some part of the body. Alternatively, a Labanotation score can be thought of as an event list, detailing initiation times and durations of movement events. This is the approach adopted.

BMN-based representations. Although a keyframe approach in general cannot easily handle actions overlapping in time, BMN uses some important representational techniques that can be adopted. Firstly, any orientation of the body apart from the limbs, i.e., of the trunk and head, can be concisely represented by three sets of three Eulerian angles, one set at each of:

- the neck, specifying the orientation of the head with respect to the trunk;
- the waist, specifying the orientation of the body from the waist up with respect to the pelvis; and
- the pelvis, specifying the orientation of the body from the pelvis up with respect to the legs.

Secondly, locomotion is classified into three types:

- jumping (including hopping, running and so on) in which there is a period of time when neither foot contacts the ground;
- stepping (including walking) in which at least one foot is continuously contacting the ground; and
- sliding, in which both feet are continuously in ground contact.

BMN also specifies the foot or feet to which support is transferred, and the direction of travel.

Constraints. A consideration in human movement representation is the ability to specify constraints [Badler and Smoliar 1979], such as specifying contact between a part of the body and some object or another part of the body, or where the body is supported, or that a hand is grasping something. Such
constraints can be specified by movement notations, and must be handled correctly by a translation system. Hence they must be able to be represented in the intermediate representation.

4.2 Representation Used

The following intermediate representation has been developed. The initial position of the body is specified first. This is followed by a sequence of movement events, each giving the start and finish times of the movement and the movement details. Movement types include limb movements, body movements, locomotion and turning (or facing). In a further developed system, finer movements, for example, opening and closing the fist, mouth or eyes, turn out of the feet and facing of the arms, and movement of the shoulders would have to be accommodated.

*Initial position.* The initial orientation of the limbs can be conveniently specified in terms of twelve unit vectors, giving the orientation of each segment (upper limb, lower limb, hand/foot) of each limb. The body's orientation can be given in terms of three sets of three Eulerian angles. Any contact or support constraints that hold initially are also specified.

*Limb movements.* These events specify a limb, the orientation it is to achieve, and any constraints affecting the movement or the achieved position. It has been found convenient to specify the orientation as follows:

- the upper limb moves to a given orientation, or retains its current orientation;
- the lower limb moves to a given orientation, or retains its current orientation, or moves to the same orientation as the upper limb (i.e., the limb is straight);
- the hand/foot moves to a given orientation, or retains its current orientation, or moves to the same orientation as the lower limb.

One or more of the following constraints may be specified:

- The achieved orientation results in the hand/foot contacting some specified part of the body or the ground or some other object. If what is contacted lies at an independently specified location, the limb orientation must be regarded as an approximation, though an adequate one for BMN and Labanotation. Were the exact position required, Korein's algorithm for reaching goals in an
underspecified system may be applied (Korein and Badler 1982).

- The limb in its achieved position supports body weight.

- Stationary point constraint: the point of contact of the foot with the ground remains fixed while the leg is achieving the specified orientation.

- The specified orientation is achieved by moving a specified joint (elbow/knee, wrist/ankle or fingers/toes) through a specified path in space. This is needed for translating movement lines.

*Body movements.* These events specify a centre of rotation (neck, waist or pelvis) and the three Eulerian angles of the resultant orientation.

*Locomotion.* A locomotion event specifies the direction of motion and the type of locomotion:

- a jump landing on the specified foot or feet;

- a step with the specified foot; or

- sliding with the specified foot.

*Turning (or facing).* These events specify the direction in which the body turns (left or right) and the resultant direction of facing. Alternatively, they could specify the amount of rotation in the specified direction.

5. TRANSLATION OF BMN TO MOVEMENT EVENT QUEUE REPRESENTATION

An earlier system, BI (*Benesh Interpreter*), converts a basic subset of BMN into animation of a figure performing the notated movements (Politis 1987, Politis and Herbison-Evans 1987). Input scores are entered using a locally developed editor (Hagist and Politis 1989), though we are interested in starting to use the more extensive *MacBenesh* editor (Ryman and Hughes-Ryman 1986). BI generates data for the *NUDES* animation system (Herbison-Evans 1979) that produces the graphical output. A modified version of BI has become B2Q, the translator from BMN to movement queue representation.

BI comprises four programs, B11, B12, B13 and an interface to the animation system. B11 accepts a BMN score, and, for each frame of the score, works out which part of the body each symbol in the
frame represents. Since BMN only records the bare minimum of information about the body's orientation, B12 calculates all the implicit information. B13 then interpolates between each frame to produce a smoothly animated sequence. Since B13 output is generalized and not related to any particular animation system, an interface is required to convert B13 to NUDES input. Figure 2 demonstrates sample output from the system.

The translator comprises B11 and B2Q, a modified B12. The latter has been altered to produce movement event queue data rather than keyframe data. The operation of these programs is discussed below. For more details, consult [Politis 1987].

Figure 2. Sample B1 output.

5.1 B11

B11 examines the input score frame by frame and works out which part of the body each sign represents. It maintains certain information about each sign, and uses this information, together with a set of rules, to deduce more information. The reason for this approach is to make the system easily extensible. As more of the notation is added to the interpreter and more special cases are to be dealt with, more rules can be added to handle each new aspect of the notation or each special case.

What information needs to be deduced for each sign is:

1. whether it represents one body part or two
2. whether it represents a right body part or a left one
3. whether it represents an arm body part or a leg part
4. whether it represents a hand/foot or an elbow/knee
(5) the sign of its depth (z coordinate)

(6) the magnitude of its depth (z coordinate).

Items (5) and/or (6) may not be ascertained by B11 for some signs.

The rules first work out what can be established by observation, for example:

If a sign is one of \( \{-, l, \cdot, o\} \), then it represents (1) one body part and (4) a hand or foot.

If a sign is one of \( \{\cdot, \times\} \), then (5) the sign of its depth is \(-1\) (the magnitude is unknown).

Item (6) is given an approximate value for limbs contacting the body.

Other rules then work by deduction, for example:

If a sign is attached to a movement line, then it is to be identified as the body part that was
most recently placed at the movement line's starting position in a previous frame.

If a sign is one of \( \{-, l, \cdot, o\} \) and we still don't know if it's a right hand/foot or a left
hand/foot and two left hands/feet have already been identified, then it must be a right
hand/foot.

Any of items (2) or (3) that have not yet been worked out are established using quadrant information,
for example:

If a sign is one of \( \{-, l, \cdot, o, \rightarrow, \rightarrow, \times\} \) and (2) is not known, then it is (2) left or right
according to whether it appears on the left or right side of the frame (or vice versa if it is
crossed 'i').

The output indicates what three-dimensional coordinate information has been established for each
hand, foot, elbow or knee that has been notated. Output is generated by rules so that certain
conditions can be catered for. One rule detects if no corresponding elbow or knee has been notated
for a hand or foot contacting the body, and if so generates an elbow or knee at an unknown location.
Another rule detects masking, and if present generates a hand or foot at the same projected position
as its elbow or knee.

Finally, there are rules to detect the following constraints:

For each hand or foot, whether it contacts the ground.

For each hand or foot, whether it was notated using the \( o \) sign (hence it is constrained to a
closer position to the body than its corresponding elbow or knee).

For each hand or foot, whether it is straight.

For each hand or foot, whether it contacts the body.

For each foot, whether it can be ascertained that the foot retained the same point of contact
on the ground since the previous frame.
The output of B11 is incomplete in three ways. The BMN score only provides the positions of the hands and feet, the elbows and knees when bent, and no other part of the body. Furthermore, only the sign and not the magnitude of the z coordinate (depth) is usually available. Thirdly, the position of any body part that has not moved since the previous frame is also unspecified.

B12 uses this bare minimum of information to work out the entire body's position in each frame. Firstly, it copies from the previous frame the coordinates of any limb that is not specified in the current frame. Secondly, the unspecified coordinates of each limb are worked out using deductive geometrical rules. The coordinates of key points on the body and head are then calculated.

A conventional algorithm that calculates all the unknown values of the various joints on each limb from the known ones could be written, but it would be fairly complex because of the large number of possible cases. The joints' coordinates, however, are related by simple geometric relationships. In B12, each relationship is restated as one or more formulae (or rules) that can be used to calculate unknown coordinates from known ones. B12 uses these rules to calculate the unspecified limb coordinate values.

For example, if the coordinates of an elbow are \((e_x, e_y, e_z)\), the coordinates of the corresponding wrist are \((w_x, w_y, w_z)\), and the forearm length is \(l\), then these are related by:

\[
(e_x - w_x)^2 + (e_y - w_y)^2 + (e_z - w_z)^2 = l^2
\]

We can make any of the six coordinates subjects of the equation and thus derive formulae for them.

It turns out that only two formulae are useful:

\[
e_x = w_x \pm \sqrt{l^2 - (e_y - w_y)^2 - (e_z - w_z)^2}
\]

\[
w_x = e_x \pm \sqrt{l^2 - (e_x - w_x)^2 - (e_y - w_y)^2}
\]

From these B12 can calculate \(e_x\) and \(w_x\) when the other coordinates in their respective formula are known. The \(\pm\) ambiguities that arise are resolved fairly readily.

Some rules are only used under certain constraints, such as if the limb under consideration is straight, or if it is bent.
5.3 B2Q

B2Q performs the same calculations as B12 but instead of generating keyframe output, produces movement event queue data. The data from the first BMN frame is used to work out the initial position. For each subsequent frame, B2Q checks, for each limb, if it has moved since the previous frame, and if so, generates a movement event for it.

At present, only translation of limb movements is implemented. Once we start using the more extensive MacBenesh editor, we can implement the translation of other types of movements. Movement lines must be deprojected by B2Q into paths in three-dimensional space. This non-trivial task has already been implemented in B13. Body movements, locomotion and turns can be readily translated into movement queue representation, as the latter is based on the BMN representation.

Establishing whether or not a foot contacting the ground supports weight is not always straightforward. For the time being, all feet on the ground are assumed to support weight. If both feet are contacting the ground and one is directly below the body, then it is unclear whether the other foot supports weight. It is proposed that this be resolved by interactive human assistance.

BMN does not explicitly specify what part of the body a contacting hand or foot is touching. This must be determined by context. For computer translation, a mapping from location of the hand or foot to parts of the body needs to be established. This mapping may be complicated by the presence of body or head rotations.

6. TRANSLATION TO LABANOTATION

A translator from movement event queue representation to Labanotation has been developed, called Q2L. Q2L generates the Labanotation for the initial position. Then, for each movement event, produces an appropriate symbol or group of symbols. It keeps track of the last movement of each body part in order to generate hold signs as needed, and also keeps track of how it has used the columns.
6.1 Initial Position

For each arm and gesturing leg, if it is straight, Q2L generates an appropriate direction sign. If it is bent, Q2L generates presigned direction signs for the upper and lower limbs. The direction sign is based on the direction of the unit vector of the limb or limb segment. Unit-vector space is divided into twenty-six regions as shown in Figure 3.

Figure 3. Direction signs based on unit vector direction.

For each supporting leg, a direction sign is generated in the appropriate support column. Its direction is based on the position of the point of support with respect to the point directly below the body. Its level is at present based on whether the leg is bent (low level), straight (middle) or raised at the ankle (high). This will not handle all cases, but is a suitable starting point for further refinement. Some translated examples are shown in Figure 4.
6.2 Limb Movement Events

Each event becomes one or two direction symbols. The starting and finishing times of the event determine the position and length of the symbol(s). There are three ways of classifying limb movements.

*Arm or leg gestures.* If the limb is straight or straightens, an appropriate direction sign is generated. If it is bent or bends, then if both upper and lower limbs move, two presigned direction signs are generated, but if only the upper or lower limb moves, only one presigned symbol is generated. In the latter case, it is placed in the conventional arm or leg column, or in the adjacent column if it is the lower limb and the adjacent column is already being used for that purpose. Figure 6 illustrates some possibilities.
Foot landing into a supporting position. These are notated with a direction sign in the appropriate support column. The direction and level are worked out as per supporting feet in the initial position (Section 6.1), so that the direction corresponds to the position of the point of landing.

If the other foot does not begin a movement at the same time as the current event, a hold sign must be written for it at the starting time of event, even if it means repeating an earlier hold sign (Figure 7).
This is implemented by checking if a hold sign is pending for the other foot, and if so, generating it and advancing the position of the pending hold to the start of the current event (see Section 6.3).

Figure 7. Foot landing and generating additional hold sign.

Supporting foot moves while retaining its point of support. If the level of the support does not change, a hold sign is adequate. However, if it does change, then a direction sign giving the direction of the point of support and the new level is required. In addition, if the other foot generates a support column symbol starting at the same time, then a symbol called a staple is required to indicate that no locomotion has taken place by the supporting foot. (The foot is "stapled" to the ground.) An example is given in Figure 8.
Figure 8. Left foot retaining its point of support.

(a) BMN

(b) Labanotation

Figure 9. A more complicated example.

(a) BMN

(b) Labanotation
6.3 Hold Signs

Each time a symbol is generated, it is possible that a hold sign may have to follow it. Thus the limb or limb segment is given the status of "hold pending." Once a hold sign is generated, the limb's status becomes "held."

Each time an event is processed, the limb or limb segment involved is tested to see if its status is hold pending and if there is a gap in time between the end of its last event and the current event. If so, a hold sign is placed directly after the symbol generated for the last event. For bent limbs, hold signs may be needed for the upper and lower limbs only or for both, depending upon which part(s) of the limb had last moved and which are moving in the current event.

After all events have been processed, similar tests are applied to all notated parts of the body to generate any final hold signs.

6.4 Presigns

A record is maintained of which column is currently being used for which part of the body. If a presigned symbol is to be placed in the column already used for the same part, the presign is replaced by a caret. The same information is used to decide whether the symbol for a moving lower limb is to be placed in the limb's usual column or its adjacent column.

6.5 Future Work

Body movements. Labanotation has signs for noting rotations about each of the axes for movements of the head, upper body and entire body, analogously to BMN. Using these signs would convey the correct meaning, although idiomatically direction signs are more often used for all but axial rotations.

Paths of motion. The following algorithm is proposed for translating them. The path of motion of the moving limb can be traced along the surface of the sphere in Figure 3. A symbol is generated for each of the regions that any significant section of the path intersects. The relative lengths of the symbols should be proportional to the amount of time spent in each region. Timing can be crudely calculated as proportional to path section length by assuming linear speed, or more accurately by
assuming an acceleration-deceleration pattern in the movement [Herbison-Evans 1983].

Figure 10. Translation of movement lines (not computer translated).

(a) BMN  
(b) Labanotation

Contact. Contact between parts of the body is straightforward to notate so long as both parts involved are known. A difficulty with BMN is that the part other than the hand or foot is not explicitly given but must be determined by context. Once a mapping from hand or foot location to contacted body part is established, translation at the Labanotation end is easy.

Locomotion. Notation for all the various jumps, steps and slides can in principle be generated fairly readily. However, it is not yet clear if movement of the non-locomotive foot or any special cases will cause complications.

7. CONCLUSION

The above examples demonstrate most of the present capabilities of the translator system. The results are promising, though still too limited for practical application. The implementation of all the extensions mentioned above would only begin to cover the capabilities of the human body's motion. The chosen intermediate representation has worked well for translating from BMN to Labanotation. Its full vindication must wait until the reverse translation is designed and implemented.
APPENDIX A. BENESH MOVEMENT NOTATION

Here is a brief description of the basics of BMN. For a more authoritative and detailed description, see the references [Benesh and Benesh 1977, McGuiness-Scott].

The notation is written on a five line music stave. Forming a matrix for the human figure, the lines represent floor level, knee height, waist height, shoulder height and top of head (Figure A-1). Since human height approximately equals arm span, any upright orientation can be drawn in a square called a frame. A sequence of orientations corresponding to the body's position at each beat of a dance can be drawn in a sequence of frames.

To record an orientation of the four limbs, it is only necessary to note the positions of the hands and feet. Each of these is notated with a - , 1, or ' , depending upon whether it is in the plane of the body, in front of the body or behind (Figure A-2). If an arm or leg is bent, it is also necessary to note the position of the elbow or knee. The signs for an elbow or knee for within, in front of and behind the plane of the body are +, +, and ×. If a hand/foot is closer to the body than the corresponding elbow/knee, it is notated with a 0 sign.

Positions are recorded in parallel projection. It is not necessary to state how far in front or behind because the fixed length of the limbs removes the ambiguity. If a hand or foot projects onto the same point as its elbow or knee, it is said to be masked. In this case, only the latter is notated, and the former is assumed to lie in the same position.

Since the same sign may represent any of four parts of the body, possible ambiguity is removed as follows. Each limb has its own quadrant of the frame. If ambiguity arises when a body part has moved too far left or right, its sign is crossed with a / sign (Figure A-3). If ambiguity arises because a body part has moved too high or low, its sign is crossed with a \ sign.

Different signs are used to indicate hands and feet contacting each other or other parts of the body. These have variants for contacting the front, side or rear of the body. If the arm or leg is bent in order to reach the position of contact, as is more often the case than not, the elbow or knee is not notated (unless it is in an unusual position).

The notation was invented to record not only still positions but movement as well. It is possible to record the path of motion of any body part between one position and the next simply by drawing its
projection onto the frame (Figure A-4). Note also that it is normally unnecessary to record any body part that has not moved since its position was last specified, unless it is a sole supporting foot.

Bending the body at the neck, waist or hips can be noted, as well as many other movements such as walking, jumping, turning and kneeling.

Bennah Movement Notation is copyright 1955 by Rudolf Bennah.

Figure A-1. Five line stave forming a matrix for the human figure.

Figure A-2. The arabesque.

Figure A-3. The use of cross-overs.
Figure A-4. Movement lines used to notate motion.
APPENDIX B. LABANOTATION

Here is a brief description of the basics of Labanotation. For a more authoritative and detailed description, see the reference [Hutchinson 1977].

Labanotation records the movement of each part of the body in a separate column of a vertical stave. The initial position is notated at the bottom of the stave; and movement is recorded as a function of time up the stave (Figure B-1).

Movement of a part of the body is indicated by a direction symbol in the appropriate column. The length of the symbol represents the duration of time taken to achieve a position, while the shape and shading of the symbol indicates the position itself. Its shape indicates the component of the orientation in the two horizontal spatial dimensions, while the shading indicates the vertical component (Figure B-2). If a part of the body is stationary, a hold sign (o) is placed at the beginning of time of inaction.

The two central columns are used to notate the body’s support and direction of movement. By default, the feet are understood to support the body. The shading of a direction sign in the support columns refers to the effects of the supporting limbs on the height of the body’s centre of gravity. The shape of the direction sign can refer either to the position of the point of support or to the direction of movement of the body’s centre of gravity. Both are measured relative to "place", that is, directly below the body’s centre of gravity.

The example in Figure B-3 shows a performer initially standing upright with arms straight down. The performer takes three forward steps, during which time the arms are slowly raised to the side.

If a foot is not supporting the body, its orientation is notated in the leg column (Figure B-4).

If a limb is bent, the upper and lower limb are recorded in adjacent columns, with "presigns" used to indicate which direction symbol records which part of the limb (Figures B-5, B-6). A following direction symbol in one of the same columns may be qualified with a "caret" (< or >) to indicate a reference to the body part previously notated in that column, or with another presign, or it may be left unqualified to refer to the whole limb. Figure B-6 shows two ways of notating the straightening of an arm.
Contact between parts of the body is indicated by forming composite signs and placing them at the side of the stave. Composite signs are two body signs (Figure B-5) joined by a bow (Figure B-7).

Locomotion, bending the body and head, and many other aspects of human movement can be notated.

Figure B-1. The stave.

Figure B-2. Direction signs.
Figure B-3. Locomotion and arm gestures.

Figure B-4. Leg support and gesture.

Figure B-5. Some body signs.

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Figure B-6. The use of presigns.

Figure B-7. Contact bows.
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REFERENCES


