

## Robots get better, people don't.

Three events, all in 1958, have marked my early childhood, as I came to discover not so long ago:

1.- The Philips Pavilion at the world exhibition in Brussels, where I was submerged night after night in the visual and sonic environment of Varese's 'Poème Electronique'.

2.- The launch of the Russian 'Sputnik', the spark that lit my deep fascination for the world of electronics.

3.- My enrolment at age six, in the Ghent Conservatory and the two pianos we had at home which I refused to play unless the mechanism was disclosed.

Ten years later, the magic year 1968, these components one way or another came together as the Logos group was founded. We wrote a manifest wherein we stated to refuse to play old music, to work on new sounds and instruments and to experiment with alternative methods of music making. Although not so obvious for musicians these days, it appeared to be clear that there was no great -if any- future for musicianship in the very traditional sense. The reasons are manifold: first of all, why would the collection of instruments thought at our conservatories be suitable for expressing musical needs of our time? These instruments all have been developed in the 18th and 19th century and therefore are perfectly suited for playing the music of that past. There is no ground for a claim that they would be suitable for music of our time. Moreover, learning to play these instruments well, is a tedious job and the overall quality of players is going down at a steady pace. After all, who nowadays wants still to spend eight hours a day of her or his youth, practicing the violin? It is not at all amazing that the finest players of these antique western instruments now invariably have an Asiatic or Russian (for the time being...) background. What we see in our culture is that in all fields of craftsmanship, automation made its appearance: we drive cars, use welding robots to make them. Computers are omnipresent and can be found in even the simplest household appliances. Lathe work is replaced by CNC machining, the entire printing and publishing business is automated, aircraft can fly without pilots and even with them still present, heavily rely on automation. So how come music production is not yet fully automated? In reality though it is already to a large extent: in commercial music, most shows are merely playback... 'Serious' music has long thought to have escaped from this. After all, only a very partial truth, as most 'classical' music is consumed via media as Cd's, broadcasts and Internet and these recordings are the result of a high degree of automation anyway.

In 'serious' contemporary music however, experimentalists have since the beginning of the 20th century shown great enthusiasm for the possibilities offered by technology. Thus electronic music, electronic instruments and computer software to generate, manipulate and treat sound, were developed and found many adepts. The endeavors of those experimentalists even found an outlet in commercial musics of kinds.

However, as it came out, electronic instruments have proven not to be the exclusive alternative for the traditional instruments of the past. One of the fundamental problems with electronic sound-generating instruments of any kind is that their final sound production relies exclusively on the use of loudspeakers. These devices virtualize the sound as they obscure the real origin of the acoustic vibrations we call sound. As a consequence, the performer using electronic instruments finds himself on stage deprived from the fundamental tools essential for musical performing rhetorics. The actions required to produce sounds being arbitrary, irrelevant and in any case dissociated from the resulting sonic reality. This dissociation undermines the convincing power of live electronics to a great extent. To put it extreme: there is no noticeable difference between playback and real-time music production. The human body becomes obsolete.

For this amongst other reasons, we noticed a lively interest amongst experimentalists to turn 'back' to real acoustic sound sources.

In our own career, we have gone through all stages: starting using and designing analog electronic equipment since the late sixties and in the early seventies, delving into digital technology since the very early eighties until we started applying our competence in electronics to real acoustic sound production. This is where the robot orchestra we have been working on since the late eighties comes

from. The crucial idea behind it was, and still is, that we wanted to automate the control of the sound source to the largest possible extent, yet always preserving the acoustical sound production. Thus amplification became our initial taboo as it would introduce the loudspeaker. Only in the last couple of years, we reintroduced loudspeakers, but now as drivers for acoustic resonators. The robot orchestra basically consists of two categories of automated musical instruments: at the one hand we have novel sound sources and noise makers and at the other, existing musical instruments that we attempted to automate as fully as possible including many extended possibilities hitherto unimaginable to achieve from the same instruments when played by humans. For a complete description of the orchestra, at the time of this writing consisting of 70 robots, we refer to the catalog available on the Logos Foundation's website [4].

Building acoustical robots is obviously only a very partial answer to the fundamental questions we raised in the introduction to this paper. In particular, the problem of musicianship was in no way touched upon. Moreover, we have been cheating the reader a bit in that so far we did describe automated acoustic instruments but left out the real robotic aspect they do have. Lets have a throw at it..

It's a trivial fact that no matter what instrumental sound we make, it inherently necessitates motoric action. Our body has to move. No action, no sound. Moreover, the very fact that we move for making sound, is what makes attendance to a live concert performance into a meaningful ritual. Long before we started the project of the robot orchestra, we developed a system capable of detecting body motion and gesture using Doppler sonar as well as radar technology. The 'invisible instrument' is a completely wireless system based on detailed analysis of reflected waves by the naked human body if exposed to ultrasonic or microwave radiation. The recognition software is largely based on fuzzy logic for classification of gesture properties. A defined set of about twelve expressive gestures can be recognized. Namuda dance technique [3] requires a mutual adaptation of the performer and the software parameters. In order to make the study of Namuda dance possible, we have designed a series of études in which each single gesture prototype can be practised. Since visual feedback to the performer is very problematic in the context of performance, for it greatly hinders freedom of movement and is by nature too slow, we have opted for auditory display. The robot orchestra as we have designed and built it, makes a good platform for such auditory display, particularly since the sounds are not virtual (loudspeakers) but real acoustic sounds emanating from real physical objects. In fact just about any musical instrument can be seen as an example for auditory display as it by its very nature truthfully converts a certain subset of fine motor skills and gestures into sound. The gestures underlying music practice may very well constitute a basis for the embodiment underlying the intelligibility of music. [5] The motor skills and gestures entailed by playing traditional musical instruments are obviously instrumental in nature. They are dictated by the mechanical construction of the instrument. Therefore, as an extension of the body, an instrument can, at most, be a good prosthesis. By removing the necessity of a physical object, the body becomes the instrument. But this in no way removes the need for motor skill and gestural control.

### 1. Namuda études and recognisable gesture prototypes

Each gesture prototype is mapped to a different subset of responding robots. In this respect, the study of Namuda gestures is quite similar to the study of any musical instrument. A certain level of fine motor control has to be developed in the player. Only once that level has been reached can the recognition software be modified by changing the parameters slightly. One would never buy a new and better violin for a child every time it makes a handling and playing mistake. Only once it knows the basics reasonably well should buying a better instrument become an option. Fortunately, in the case of the invisible instrument, we do not have to buy a new instrument but we can improve the software and adapt it to the player. This last possibility opens a whole new perspective for future developments in instrument building.

These are the gesture prototypes:

- Speedup
- Slowdown
- Expanding
- Shrinking
- Steady
- Fixspeed
- Collision
- Theatrical Collision
- Smooth (roundness)
- Edgy
- Jump (airboredness)
- Periodic
- Freeze (no movement)

Parallel to these recognition-based gesture properties, the implementation also offers a full set of very direct mappings of movement parameters on sound output:

- moving body surface: The most intuitive mapping for this parameter seems to be to sound volume or density.
- speed of movement: The most intuitive mapping for this parameter seems to be to pitch.
  - spectral shape of the movement: The most intuitive mapping for this complex parameter seems to be to harmony.
- acceleration of the movement: The most intuitive mapping for this parameter seems to be to percussive triggers.

Of course there is nothing mandatory in the way the mappings of gestural prototypes have been laid out in these études. It is pretty easy to devise mappings more suitable for use out of the context of our own robot orchestra. The simplest alternative implementations consist of mappings on any kind of MIDI synth or sampler. However mapping the data from our gesture recognition system to real time audio streams (as we did in our 'Songbook' in 1995, based on human voice sound modulation via gesture) is an even better alternative.

## 2. Extending the time frame

The gesture prototypes practised in the études reflect a gestural microscale in the time domain. Their validity may be as short as 7 ms and can for most properties seldom exceed 2 seconds. The only gesture properties that can persist over longer time spans are freeze, periodic, edgy, smooth, fluent and fixspeed. Some can, by their nature, only be defined over very short time intervals: airborne and collision. These gesture prototypes are to be compared to what phonemes are in spoken language, although they already carry more meaning than their linguistic counterparts. Meaning here being understood as embodied meaning.

By following assignment and persistence of the gesture prototypes over longer time spans, say between 500 ms and 5 seconds, it becomes possible to assign expressive meanings to gestural utterances. Here we enter the level of words and short sentences, to continue using linguistic terminology as a metaphor. When we ask a performer to make gentle movements in order to express sympathy, then the statistical frequency of a limited subset of gesture properties will go up significantly. When we ask for aggression, the distribution will be completely different.

## 3. Relation to other dance practices.

Although as soon as we gained some insight in the potential for dance offered by our technology –

in the mid nineteen-seventies – we carried out artistic experiments with dancers trained in classical ballet as well as modern dance, we quickly found out that such an approach to dance was unsuitable to work well with this technology. Classical dance forms concentrate on elegance and – in general – avoid collision and a sense of mass. Position in space and visual aspects are very dominant. Immediately alternative dance practices came into consideration. In the first place butoh dance, an avant-garde dance practice with its roots in Japan, where we also came in contact with it (through Tari Ito). Thus we got in contact with dancers such as Min Tanaka, Tadashi Endo and Emilie De Vlam. This has led to quite a considerable list of collaborative performances. However, butoh is only vaguely defined from a technical dance point of view. Its non-avoidance of roughness, its nakedness [6] and its concentration on bodily expression, leaving out any distracting props and requisites, formed the strongest points of attraction. Only in some forms of contact improvisation did we find other links, but in this dance form we ran into problems with our technology, which is not capable of distinguishing the movements of more than a single moving body at the same time. As far as couple dances go, we have also investigated tango, in part also because we happen to be a tanguero ourselves. In this type of dance the problem of the two inseparable bodies poses less of a problem since movements are always very well coordinated.

#### 4. Interactive composition and choreography

It will be clear that the mastering of Namuda opens wide perspectives for the development of real time interactive composition with a strong theatrical component. Over the 40 years that we have been developing the system, many hundreds of performances have been staged.

The entire Namuda system including the invisible instrument as well as the robot orchestra is open for use by other composers and performers. Scientists interested in research into human gesture are also invited to explore the possibilities of the system.

There is still a lot of work left to be done on improvements on the robots, the hardware and recognition software as well as in terms of its artistic implementations. An open invitation to help machines always getting better. To people this does not seem to apply...

Godfried-Willem Raes

#### Endnotes

[1] The complete hardware description of the system can be found at: [http://www.logosfoundation.org/ii/Holosound\\_ii2010.pdf](http://www.logosfoundation.org/ii/Holosound_ii2010.pdf). The background to our experimental instrument-building projects is largely taken from “An Invisible Instrument”, Godfried-Willem Raes, 1997: [http://logosfoundation.org/g\\_texts/invisins.html](http://logosfoundation.org/g_texts/invisins.html), which deals in greater depth with the philosophy behind the design.

[2] The software gesture recognition layer is described in full in this paper: [http://www.logosfoundation.org/ii/Namuda\\_GestureRecognition.pdf](http://www.logosfoundation.org/ii/Namuda_GestureRecognition.pdf)

[3] Namuda is a word of our own casting and stands short for 'Naked Music Dance'.

[4] Detailed information on the robot orchestra and all robots constituting it can be found at [http://www.logosfoundation.org/instrum\\_god/manual.html](http://www.logosfoundation.org/instrum_god/manual.html)

[5] These matters were discussed in depth in my texts on the invisible instrument: Raes, 1993, 1994 and 1999.

[6] We wrote an essay on nakedness some time ago, after realizing that even nowadays there are still people around that seem to have difficulty in coping with this... The text can be read at: [http://logosfoundation.org/g\\_texts/naked.html](http://logosfoundation.org/g_texts/naked.html).

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