Non haptic control of music by video analysis of hand movements : 14 years of experience with the «Caméra Musicale»

Jacques Rémus
Ipotam Mécamusique
19 rue des Frigos 75014 Paris France
+33 1 45 82 874 40
jr@directmail.org

ABSTRACT
The "Caméra Musicale" is an interface which allows a musical practice based on the movement of hands and fingers under a camera. Born from technologies and methods developed in the early eighties to create music from choreographic movements, the "Camera Musicale" has evolved during the nineties to become a user friendly device since 2003. This article describes its fundamental principles of operation, which have remained relatively unchanged. It then focuses on the importance of the choices necessary to be made while analyzing the video image.

Keywords
Musical Camera, camera musicale, non haptic instrument interface, musical hand's mappings, Jacques Rémus'sound sculptures and mechanical musical machines.

1. INTRODUCTION
The "Caméra Musicale" is an instrumental interface which allows musical practice based on the position and movements of hands in space, in the scope of a video camera. After the first prototype was elaborated, its development was insured by constant experimentations. The first version (1992) had an audience interact by moving their hands in mid-air, controlling large and mechanical musical devices. The appeal of this version lied in the contrast between the immaterial nature of the movements and the materiality of the music produced by the machines.

The system was immediately embraced by audiences of all kinds : Festival audiences, school kids, the handicapped, and of course, musicians. As years went by, thousands of people have played "Caméra Musicale" in various contexts. Consequentially, its development was in close relation with the audience and the "Caméra Musicale" evolved on grounds of experimentation - a very pragmatic, rather than scientific approach**.**

These experiments also led to the development of another technology: an interface controlling audio or MIDI systems.

2. ORIGINS AND DEVELOPMENTS
The "Caméra Musicale" was born from research and works by Sylvain Aubin, with the "Manorine.

A first prototype was developed in 1982 " (patent n° 82695, december 1982). The point of this work was to combine a logical interface between a video camera and analogical synthesizers. The main goal of such a machine was to create music for choreographic performances (Stéphanie Aubin, performances, Paris, Rennes 1986).

The principle was based on the analysis of a clear surface (the body, or a part of the body) being detached in hyper-contrast on a black screen. This analysis brought up many characteristics of the moving spot:

X and Y, global parameters giving the position of the object

dX and dY, local parameters describing the size of the object

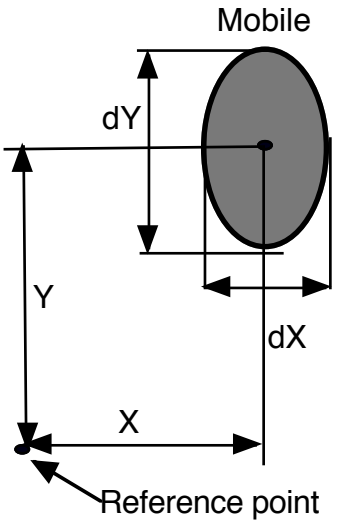

Figure 1. Global and local parameters.

After these first experiments, focusing on dance movements generating music, it was clear that the prototype was a relevant tool for artistic creation. However, its potential was restrained by the fact that it was hard to operate by non-technicians.

In 1992 Jacques Rémus, Sylvain Aubin and Gwek Bure Soh, artist, associated to undertake the project of the "Caméra Musicale".

A Manorine with a MIDI interface coupled with developments on the Max [1] software was then created.

David Rokeby's VNS ("Very Nervous System") [2] initially

developed for dance as well, was connected in parallel to the Manorine-MIDI, hence completing the first version of the "Caméra Musicale".

The analysis of the Manorine was the core of the system, while the VNS was used to enhance the movement/sound reactions.

3. GENERAL PRINCIPLES

The "Caméra Musicale" is assembled in part from mainstream elements, available in the market. Those elements are combined to relatively easy developments, considering one is familiar with live electronics software (Max-MSP)

Here are its main components:

- A black and white camera. A standard IR photo filter, positioned on the lens, allows exclusive infrared detection. The camera is aimed towards the floor and stands 1 to 3 meters above the player's hands.

- An infrared projector - the type used for night surveillance (invisible in darkness). Next to the camera, it also aims towards the ground. This system allows the "Caméra Musicale" to remain unaffected by the various lightings, often problematic in live performances.

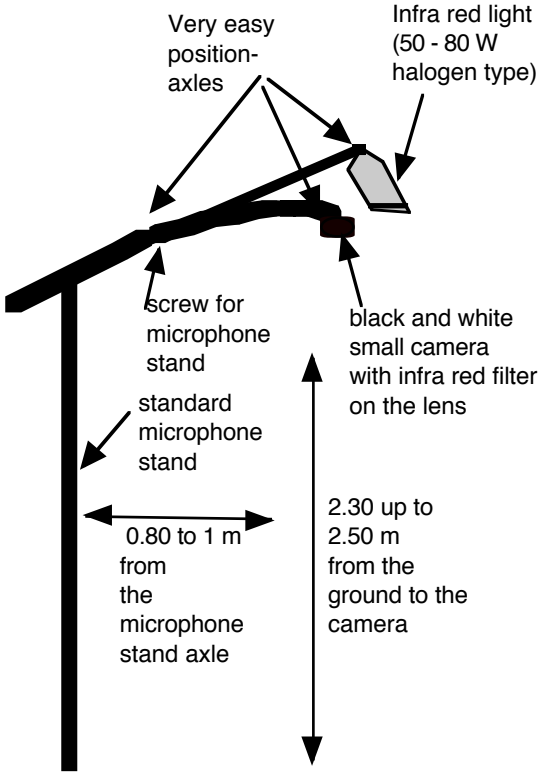

Figure 2. Structure of the "Camera Musicale".

- An interface or a standard video computer card (e.g. a TV card for computer can very well do the job)

- A software development on Max-MSP-Jitter [1], allowing to control and chose, live, various parameters of video analysis and musical patches. Cyclops [1] or VNS [2] plug-ins or Jitter [1] developments are used to filter simple information from the very complex original image. The filtered data then enters in Max, in the form of a continuous flow (25 or 30 images per second). It's basically a software "Manorine" with important improvements from the plug-ins.

- Musical instruments: synthesizers (expanders), musical machines, sound sculptures or computer generated sound (Max-MSP)

- One or many screens, showing the hands, allowing visual interaction for the player and audience.

4. DESCRIPTION OF THE VIDEO/MIDI GENERATED INFORMATION

The information resulting from the video analysis remain the center of the development. As described above (§2), there are four:

- X and Y measure the position of the mobile

- dX measures the widest part of the mobile's image.

- dY measures its highest part.

The dynamic of the mobile's movement (hands or fingers) is essentially rendered by the speed in which X', Y', dX' and dY' evolve. Their calculation in Max creates four new data flows. The calculation of the second derivation of the first four parameters (accelerations X", Y", dX", dY") creates once again four new data flows.

The hands and fingers can be individualized and independent (by definitions of areas or mobile objects' individualization).

On this basis, all the data that can be rendered by pixel variations in defined areas (principle of the VNS) and the indications of the grids from Cyclops complete and enrich the possible video analysis parameters

5. NUMBER OF INDEPENDENT PARAMETERS A MUSICIAN CAN CONTROL

The essential choice while operating the "Caméra Musicale" is the number of independent parameters the musician can control with the camera.

In theory, the "Caméra Musicale" allows to play with a number of parameters, dependent or independent, in various predefined areas in space (drawn on the screen). (cf. §4) However, if the complexity can produce gratifying results with lots of feedback and automatisms, they are seldom relevant.

The number of independent parameters a classical instrumentalist can control is relatively low: pitch, intensity, articulation, timbre and rhythm (succession of events in time). It hardly exceeds four or five.

The same goes for the "Caméra Musicale", with three or four independent parameters. The time parameter, rhythm, is considered independently from the others.

The "Caméra Musicale" is developed to read a limited number (from one to four) of data flows from the incoming information.

Only very simple patches with two to four independent parameters could allow a good control of the outcome. This applies to the beginner as well as to the accomplished musician.

On the other hand, the chosen parameters can be very different from one try to another : X, X', X", Y, Y,' Y", dX, dX,' dX", dY, dY', dY", surfaces, number of pixels and their variations, etc.

Example 1 (basic) : X specifies the pitch of the note or sound, Y specifies the intensity and dY" a change in the attack or timbre.

Example 2: dots or small areas defined in X, Y are drawn on the screen and the parameters in which they accelerate to reach one another are used (variations of pixels combined with dX" and dY" ensembles). For example: the faster the movement is, the

longer (or shorter, or harmonically transformed...) the note at the point of release (X, Y) will be. The hands move in space at different speeds and "touch" predetermined points (X, Y) which trigger the sounds, modulated by the speed of the movements.

Example 3: a 12 note loop is automatically played: Its speed is increased in Y, its velocity in X, the length of its notes in dX and their attack in dX'. The mapping then takes into account the width of the hands, or the distance between both hands (dX). However, if we add a change of timbre for dY', the control of yet another parameter would become too difficult.

Once the choices are made, the possibilities of the mapping remain very wide, even if in practice (see § 7) the movements chosen by the players tend to imitate those of a pianist, harpist or drummer !

6. NON "HAPTIC" BODY LANGUAGE.

These gestures are performed in mid-air and the player has counterbalance every movement he makes with its opposite, in order to keep balance. It is hard to master at the beginning, like all non return (non haptic) interfaces, but this doesn't take away the fact that the mapping is precise and pleasant. Moreover, the body being entirely engaged in these gestures, the musician's body language can become an object of interest for the audience.

Practice has proved that the changes between playing modes should be done by a different system that the gestures and the camera. Simple midi-pedals now allow such changes, with no risk of errors due to bad control of the gestures.

7. EXPERIENCE WITH PUBLIC AND MUSICIANS

The "Caméra Musicale" in use since 1992 by large audiences with midi robotized acoustic machines and since 2003 by musicians on electro-acoustic sounds

The "Caméra Musicale" was first used by the "Concertomatique N°2" ensemble [3] [9] made up of several pipe organs, a string quartet, percussion and machines with ringed pipes [3] [5]. Then, it was coupled with the "Carillons des Zic-phones" [3] [6]. the "Carillon Concertomatique N°3" (Festival Résonnances, Ircam, 2002) [3] [7]. and recently, with the "Pic-Verts" (Green Woodpeckers) [3], the "Ensemble des machines à laver musicales" (The Musical Washing Machine Ensemble) [3] [7] [8] and the "Orgabulles" (Bubleorgan) [3].

In concerts, expositions, installations, animations and festivals, thousands of people played with such installations and the mappings were progressively developed and improved. All these experiments show the strength of cultural perceptions related to musical gestures of the instrumentalists or conductor. Surprisingly enough, such gestures were particularly present with musicians.

The "Caméra Musicale" has always proposed innovative mappings (examples 2 and 3 from §5 only being a sample), but users will usually seek three primary types of gestures:

1) The movement related to percussion - with the tip of the finger or pretending to hold a drumstick or mallet (triggering related to a neutral zone at the edge, below the screen, which takes into account the entry of the finger, hand or arm in the image (area drawn in X Y)

2) The movement referring to the organization of pitches on a keyboard (low pitches at the left, high pitches at the right: X parameter).

3) Reference to the intensity, or strength they put in their movements (Y', Y" or more oftenly, dY' and dY" or the variations of pixels in the VNS).

If some mappings do not respect one of those three primary approaches, they are considered to be difficult, beyond understanding or unnatural.

The "Caméra Musicale" is not adapted to the type of movements an instrumentalist would do, in order to imitate the basic technique of his instrument: moving the fingers, trying to find the notes on an invisible instrument.

Research has to take account of such requests, but usually focuses on exploring other possibilities.

It is actually with pre-written modules in the patches that the "Caméra Musicale" takes form of an original instrument: automatic arpeggios, prerecorded loops, prewritten sequence modulations (as the Max Mathews sticks) erase the note interpretation difficulty, and opens to modulations related to a conductor's work.

In addition, the relationship with the Theremin is acquired by pitch-bends on the midi system and more easily again with sounds generated by calculation (Max-MSP).

Finally, the last developments ("Signa" duo concerts with theremin player Rolf Sudman (Berlin)[3]) focused on the live treatment and samples (scratching) of the sung voice, spoken word and noise. The deformation of sound was, in all cases, controlled by movements based on the three primary criteria..

Table 1 indicates the use of the parameters in the plays.

Mappings type		X	Y	X'	Y'	X"	Y"	dX	dY	dX'	dY'	dX"	dY"
INSTR.	impuls	5	5										
INSTR	pitch	5	2						3				
INSTR	velo		4		5				4		4	2	2
INSTR	modul		2					3	2	1	4	2	3
ORCH.	impuls												
ORCH.	pitch	5	1										
ORCH.	velo		4										
ORCH.	modu							3	4				
THER.	impuls												
THER.	pitch	3	3										
THER.	velo	3	3										
THER.	modul							1	2			2	2
D.AUD	impuls	5	5										
D.AUD	pitch	4	1		3			2	1				
D.AUD	velo		4		2				4			2	3
D.AUD	modu	2								1	1		

Table 1. Frequency of the parameters in the mappings (classified from 1 to 5)

Legend :
NSTR. = INSTRUMENTAL, ORCH. = ORCHESTAL
THER. = THEREMIN LIKE, D.AUD = DIRECT AUDIO
impuls = impulsion, velo =velocity, modul=modulations.

This table is not a statistical study, but merely a representation of the users' tendencies. The numbers (0 to 5) represent about fifty mappings: 1 = seldom use to 5= always or almost. We notice that instrumental mappings and mappings using the audio are related to the instrumentalist's basic movements whereas the theremin or conductor mappings allow more fantasy and imagination in the choice of movements.

8. CONCLUSION

The "Caméra Musicale" is an interface for musical performance and also a tool for musical creation. Other research has been developed in the same direction. In addition to the works of David Rokeby, already mentionned [2], the works of Tom Demeyer with the Big Eye software [10] have influenced this type of work - particularly with the residence at the Steim foundation.

The "Caméra Musicale" opens new paths for future musical practices. Its originality and reliability has been tested and approved by a wide audience. Still far away from its full potential, it should however always consider the natural movements of instrumentalists.

9. REFERENCES

[1] Cycling 74 home page : http://cycling74.com

[2] David Rokeby home page : http://homepage.mac.com/davidrokeby/

[3] Jacques Rémus and Ipotam Mécamusique home pages : http://jacquesremus.com http://mecamusique.com

[4] Yamawaki, K., Jacques Rémus: the musical garden with informatics, robotics and musical instruments In *Artec'97, The 5th International Biennale in Nagoya 1997*, official catalogue, (June 1997), The council for the international Biennale in Nagoya, Naganae printing Co, Japan, p.42-49.

[5] Rémus, J. The music of ringed pipes In *Proceedings of the International Symposium on Musical Acoustics* (July 2-6, 1995), SFA Jouve, Paris, France, p.69-73.

[6] Rhobiny, S., Because of the wonderful things he does, In *Kilometer zero N°3*, The Kilometer zero project, 2002, ISSN: 1629-3274, p.50-56

[7] L'oeil de la nuit 2003 Parcours Paris Rive Gauche, official catalogue of Nuit blanche 2003, Paris Musées, Les Musées de la ville de Paris, Paris, ISBN 20042-87900-831-X, p.136-137.

[8] Installation sonore, Lavage de tympans In Nova Magazine, Connexions pirates, N°101, Paris, Mai 2003, p.25.

[9] Official Catalogue of Musique en Scène Festival, Grame, Lyon, France, april 1995, p.8-9.

[10] Steim foundation, (Amsterdam) homepage : http://steim.org

[11] Mécamusique, In *La marionnette et les autres arts*, *Musiques en mouvement*, Puc n°6 1993 Editions Institut International de la Marionnette, France, ISSN 0993-0701, p.56-57.

[12] Jacques Rémus,Double Quatuor à cordes, De la Motte-Haber, H., *In Klangkunst,Tönende Objekte und klingende,* Räume, Laaber-Verlag, 1999,ISBN 3-89007-432-4, p.160-161.

[13] Jacques Rémus, Musica ex machina, Nicollet, G., Brunot V., In *Les Chercheurs de sons, Instruments inventés, machines musicales, sculptures et installations*, Ed Alternatives, Athènes, 2004, ISBN: 2-86277434-8, p.120-125.

[14] Arts Ménagers, arts sonores , Le Graverend, F., In *Area Revues, Délirantes ou célibataires, les machines dans l'art*, N°11, Area corp, Paris, march 2006, ISBN: 2-35276-002-X, p.160.

[15] Les nouveaux gestes de la musique,Genevois, H., de Vivo, R., Parenthèses , collection eupalinos, cultures musicales may 1999, ISBN :2-86364-616-8.

[16] La Sculpture sonore, pratique artistique en recherche de définition, Rémus, J. In *Musiques Arts Technologies, pour une approche critique, Music arts tecnologies, toward a critical approach*", (Barbanti R., Lynch E, Pardo, C., Solomos, M), L'Harmattan, France, june 2004, ISBN : 2-7475-6691-9 , p.61-75.