The control interface layer

Laura Ottaviani
ottaviani@sci.univr.it

Details of the implementation

This paper describes a patch developed as an higher level on the impact module realized in `pd`. Since it is driven by many parameters, strongly related one to the other, and some of them have no “practical” meaning for a non-expert of the physical laws the module is based on, with this control interface I try to reduce the number of parameters controlled directly by the user, in order to let it more usable, facing the balance between the user’s freedom and the usability.

So far I obtained a preliminary version. Actually it is all realized in `pd`, exploiting colours and comments for facilitating a user. In a future version, some parameters will be hidden by direct control and all parameters presentation will be improved.

I started from the material rendering. I based my work on the studies conducted by Avanzini and Rocchesso [1]. They conduced psychopysical experiments on material perception, exploiting the hammer resonator physical model, that was a previous version of the current one. They summarized the results, representing, for each material, the proportion of subjects who recognized it for each sound example, as a function of pitch and quality factor. The pitch corresponds to the center frequency f_0, while the quality factor q_o relates to the decay time by means of the equation $q_0 = \pi f_0 t_e$, where t_e is the time for the sound to decay by a proportion $1/e$.

Four materials are defined: rubber, wood, glass and steel. For each material, I defined a range inside which the subject can choose the pitch and the decay time. In this way he can control both the material and the size of the object. Infact, both the parameters are responsible of the material perception, but the pitch is also related to the size of the object, while the decay time influences the material perception not only of the resonator, but also of the hammer. As Avanzini and Rocchesso report, a contact sound can provide information of both the objects involved in the event. This fenomenon is known, in experimental psychology, as *phenomenical scission.* To calculate the object size, I applied the following formula:

$$f = 1.03 \cdot t \cdot \sqrt{\frac{Y}{p}} \frac{1}{L^2} \tag{1}$$

that gives

$$L = \sqrt{1.03 \cdot t \cdot \sqrt{\frac{Y}{p}} \frac{1}{f}} \tag{2}$$

where f represents the fundamental frequency, L the bar length, t its thickness, Y the Young's modulus and p the density. In tab. 1, for each material, the Young's modulus and density default values are indicated. I assume the thickness bar equal to $t = 5$ mm.

material	$Y[N/m^2]$	$p[kg/m^3]$
rubber	$1.7 \cdot 10^6$	1100
wood	$1.2 \cdot 10^{10}$	550
glass	$6.5 \cdot 10^{10}$	2190
steel	$20 \cdot 10^{10}$	7860

Table 1: Young's modulus and density for each material

The pitch ranges are, for all the four materials, defined between 1000 Hz and 2000 Hz, because [1] doesn't establish a particular pitch range. In tab. 2 the decay-time ranges, defined in the control patch according to [1], are reported.

material	$t_e[s]$
rubber	0.008 -0.0141
wood	0.0023-0.0353
glass	0.0434-1.1254
steel	0.0434-1.5915

Table 2: Decay-time ranges set for the material perception

Therefore, in the control patch there are two sliders: one for the size, directly related with the center frequency, and one for the decay-time, scaled by the appropriate values for each material.

As regards the other parameters, I decided to leave some of them fixed, such as the general scale factors, to a constant value (freq-fact = 1.0, t_e-fact = 1.0, gain-fact = 5.6234), since, in order to render the patch more user-friendly, we have to make some assumptions, loosing the freedom of the physical model per se.

Investigating the other parameters, I noticed that if the impact-force value changes, the material perception changes. Therefore, I kept also this parameter fixed (impact-force = $2.196 \cdot 10^{-005}$). Infact, what is more important, in my opinion, for the hammer-mass perception is the parameter representing the gravity force. Since it is a force, it is related both to the acceleration (constant value for the earth) and to the hammer-mass, which controls, for instance, in the bouncing case, the interval between the individual bouncings.

Two parameters of the patch are strongly related one to the other: the elasticity constant of the impact, i.e. of the whole impact event, and not only related to the elasticity intrinsic to the surface, and lambda, i.e. the dissipation of energy during contact. The elasticity constant is responsible for the object's impact or bouncing. But, the value boundary is related to the lambda parameter. Therefore, in order to preserve the event identity, I put the boundary at elasticity = 421.69, and let the setting of the lambda parameter free for the bouncing case, i.e. for values of elasticity higher than the limit, while, for the impact case, the two parameters are related by the function $\lambda = 0.7436 \cdot e^{0.0104 \cdot \text{ elast}}$. The lambda parameter, in the bouncing case, is responsible for the bouncing regularity.

The strike_velocity parameter provides the information about the height from which the hammer falls, both for the impact and the bouncing case.

A parameter that I keep fixed in this preliminary version, but that will be somehow controlled in future versions, is the alpha parameter, that represents the surface geometry of the contact, i.e. it controls the brightness of the sound.

Moreover, in this preliminary version, only one mode is controlled. In a further improvement, also the second mode will be controllable.

References

[1] F. Avanzini and D. Rocchesso, *Controlling material properties in physical models of Sounding Objects*, Proceedings of the International Computer Music Conference 2001, September, La Habana, Cuba, 2001, pp.91-94.

[2] SOb project, *Phenomenology of Sound Events*, Deliverable n. 4, 2001.

[3] SOb project, *Models and Algorithms for the Sounding Objects*, Deliverable n. 6, 2002.