ELECTRONIC SOUND CREATURES

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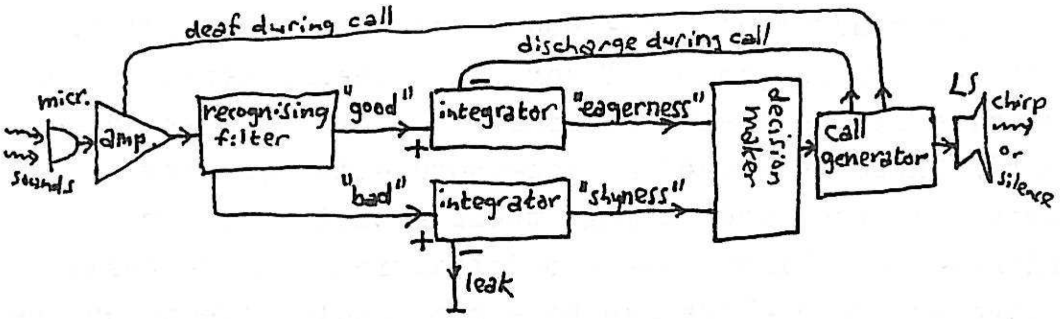
Abstract

The acoustic communications between animals like frogs, cicadas or grasshoppers often give rise to group concerts or choruses. Both order and chaos appear to be present in the resulting sound patterns, and one may notice various rhythms and wavelike movements. Similar group processes can be realised with machines built specially for such a purpose. I developed several groups of small electronic machines which produce simple choruses. In ECAL'93 a live performance by a group of such "sound creatures" is presented.

Frog calls serve as a means of communication between frogs. The males call, advertising their position and interacting acoustically, and their calls attract the females. There exists an amazing variety of calls: frogs may croak, chirp, click, rattle, whistle. Yet it is not the individual calls that interest me; it is the frog chorus as a whole, the pattern of calls in time and space, the wavelike movements of the sound, the rhythms. It is also the balance between order and chaos. When listening to a frog chorus, it is easy to become aware of several rhythms, but the details of the sound patterns are unpredictable. The sound of leaves rustling in the wind and the sound of waves rolling onto a beach are similar in these aspects, but there is also a difference. Unlike the sound patterns created by a multitude of tiny objects under the influence of wind or rain, the main rhythmic structures in a frog chorus result from interactions between the individual callers. Similar patterns can be heard with certain insects, such as cicadas and grasshoppers, or be seen in the "concerts-for-the-eyes" produced by groups of fireflies.

I first became aware of these qualities in a frog chorus when I was listening to small tree frogs (Litoria ewingi) in the hills of Adelaide. Enchanted by the frogs of Australia, I acquired sound recording equipment and managed to capture many frog choruses on stereo tape. However, listening to a recording is not the same as listening to live frogs, obviously. A live frog chorus is interactive, it is sensitive to the circumstances and to the behaviour of the listener. This live, interactive quality is lost in a recording. That simple fact prompted me to try and generate a live group process with machines. I concentrated on one feature: the acoustical interaction between the callers. It seemed to me that a rather simple mechanism might account for some of the most fascinating aspects of a frog chorus. This thought led to the design of electronic "sound creatures", which are capable of generating their own chorus. A set of devices that listen and call. Each of them reacts to the sound environment, which is in part created by themselves. The more conspecific calls they hear, the more eager they become. Other sounds (human voices, footsteps, traffic noises, a slamming door) make them shy, and they may fall silent. The progress of the chorus in time depends on the spatial distribution of the creatures, the acoustic properties of the space, the ambient noises, and on the behaviour of the human audience.

The machines consist of simple electronic parts (analogue electronics, no microprocessors). One type of "sound creature" works schematically as follows:



Schematic diagram of an electronic sound creature.

Each machine is battery operated and contains a loudspeaker (=mouth) and a microphone (=ear). The sounds that enter the microphone are to be interpreted as "good" or "bad". "Good" is sound recognised as a conspecific call. Operationally it is what passes through a recognising filter. It is fed to an integrator, making its level rise. This level might be called the creature's "eagerness". All other sounds are deemed "bad" and fed to another integrator, whose level might be said to correspond to the machine's "shyness". When the "eagerness" surpasses the "shyness", the decision maker (which is a comparator with hysteresis) switches the call generator on. Now the loudspeaker emits a call, the "good" integrator is discharged, the "eagerness" drops sharply and the call is switched off. Some "shyness" is lost continuously through a leak in the "bad" integrator. Since the creatures are to recognise one another, the recognising filter and call generator must fit like a lock and key. To prevent the machine from being disturbed by its own calls, its hearing is switched off during a call. In principle it does not matter what the call sounds like. In this case a cricket-like chirp was chosen. By far the most important consideration leading to this choice was to keep the call recognising part very simple. (This is no more than just a guess: in nature, comparable restraints on call recognition, rather than call production, in animals with small brains may account for the simplicity of many insect calls, whereas birds, for instance, can afford to communicate through more complex sound sequences.)

One hundred of these sound creatures were built. They perform in groups of varying numbers, depending on the size of the available space (mostly in an art context). There is indeed a frog-chorus-like quality in their concerts, even though their actual calls are cricket-like chirps. Small modifications in the basic design sketched above can have remarkable effects on the chorus. For example, adding a delay of about one second between the decision to call and the onset of the call has the effect of slowing down the concert and making the wavelike movements in the sound patterns more pronounced. By adding some of the "good" signal to the signal from the "bad" integrator, the "shyness" can be temporarily raised when a conspecific call is perceived. The result is a tendency to inhibit the decision to call whenever a nearby machine is calling. The machine then preferably starts calling just after a neighbour finishes its call. Usually some other machines were waiting as well and start their calls at the same moment. In this way the chorus may comprise subgroups of machines that appear to be synchronised. Now the chorus as a whole acquires a "marching" quality. This behaviour resembles (at least superficially) that of the synchronised choruses of certain Australian cicadas calling from trees. Each tree seems to emit its "own" marching rhythm. A third modification is adding some of the "good" signal to the signal from the "good" integrator. In this way the "eagerness" is raised when a conspecific call is perceived and after that lowered again. The result is a tendency to start calling just after the onsets of neighbouring calls. The callers now seem to "chase" one another and the chorus becomes restless and "speedy".

A more complex behaviour is displayed by the "moving sound creatures". These machines not only interact by listening and calling, but also by moving about. The curiosity that formed my main motivation in developing such machines was not primarily of a scientific nature; it had a strong artistic flavour, as the reader may already have guessed. Although the "moving sound creatures" are considerably more complex than the non-moving ones described above, they basically behave in a similar manner. They listen and distinguish between conspecific calls and other sounds. Their call recognition is more sophisticated, and they can emit and recognise two different calls. They carry two microphones, which allows them to determine the direction from where a fellow machine is calling, making use of the phase difference between the signals from both microphones. (The stereo hearing part was designed by Herman Coster, who also assisted me with most of the other aspects of this project. In all, 24 moving sound creatures were built.) The machines can move on a smooth floor by means of two wheels driven by electric motors. Just above floor level they are surrounded by a ring which serves as a touch sensor. Its circular shape allows a machine to turn around under all circumstances. The sensory input comprises signals from the microphones (hearing) and information from the sensor ring (touch). The output is both acoustic (two different calls) and motoric (moving forward or backward and turning to the left or right). The first call can be thought of as meaning "come here". When a machine recognises this call, it turns until it faces the perceived direction of the call and then moves forward for a while. The first call works as an attractive force between the machines. If this would be all, then the machines, after starting their concert, would soon cluster together and get stuck. However, when a machine hits something in its course, it will stop moving and, for some time afterwards, when it calls, it will emit the second call, which can be thought of as meaning "go away". A machine that recognises the second call will turn until it faces the perceived direction of the call and then move backward for a while. In this manner the machines go on moving and calling (as long as there are no other noises), and they perform what might be called a "dance of moving sound sources". A live performance of the "moving sound creatures" is presented at ECAL'93.

The complexity of my electronic "sound creatures" is nothing compared to that of any biological system. Yet these machines may serve as a model in the scientific sense. However, they were designed primarily to be presented in an art context. I developed them as a means to investigate the nature of listening. Through actually building machines such as the "sound creatures" one can get a "feel" for the relationship between sensitivity and intelligence. This work has only increased my respect for the frogs, who taught me to sit still in silence and listen.