

## SYNCHRONIZATION OF MOVEMENTS OF A REAL HUMANOID ROBOT WITH MUSIC

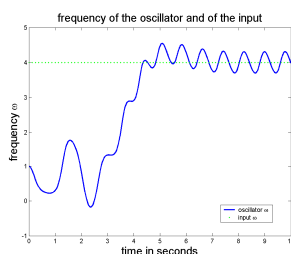
*Aïsha Hitz, Faculty of Microengineering*

*Assistants: Sarah Degallier, Ludovic Righetti*

*Professor: Auke Jan Ijspeert*

How do people synchronize with music? When listening to music, people intuitively detect a tempo and adapt their movement to the rhythm of music. They are then strongly influenced by an external signal that is the music. This behavior could be imitated using oscillators, dynamical systems that have the capability to synchronize to an external signal. Music could, in fact, be described as a periodic signal characterized by its frequency and its phase. As the frequency represents the tempo, the phase symbolizes the beats that are detected by people, when tapping along the rhythm of a song. Like people, oscillators should then adapt their behavior to the music, by modifying their frequency and their phase.

The purpose of this Master project was to implement adaptive frequency oscillators, dynamical systems which can adapt their frequency to the tempo of any music and to transmit it to a drumming controller of a humanoid robot. This last step helped to recreate visually a human-like behavior on a robot when listening to music.

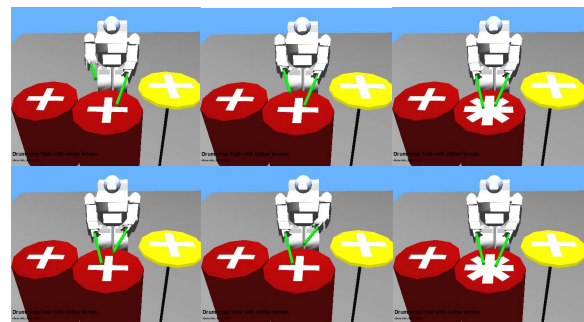


*Frequency adaptation of the oscillators.*

The advantage of these adaptive frequency oscillators is their continuous adaptation. As long as there is an external signal applied to them, they adapt their frequency. The tempo

detection can then be implemented in real-time, at the same time as music plays. It can support any changes in tempo and be robust to irregular beat, i.e. beats that are divided in different spaced meters and which can create perturbation.

The adaptive oscillators method developed in this project needed onset detection. An envelope extractor which emphasizes the sudden changes in sound, i.e. the moment of beat pulses, became the basis of the music pre-processing. Moreover, the efficiency of this method depends on the initializations of the parameters and of the initial conditions of the oscillators. Thus, if these are well fixed, the method allows a tempo detection of any kind of music, from simple impulse functions to electronic music, or from classical music to dance music.



*The humanoid robot with its instrument.*

As the study showed, there are many different aspects that are linked to tempo detection. Coordinated periodic movements as intuitively produced by human beings are not an easy task to be recreated, even if oscillators were good models to be used.

Some of the simulations done in Webots can be found on the website <http://birg.epfl.ch/page67315.html>.