

# Dancing Nao Robot

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**Abstract**—How to analyse music to make a robot dance to it.

## I. INTRODUCTION

**T**HE goal of this project was to make a robot to anything the algorithm can identify as music. We used Essentia for Music Information Retrieval and a predefined set of dancing moves.

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### A. Essentia

Finding the right music analysis framework was a bit difficult, because there a lot of frameworks for this in Python. But we found a research paper[1] that compared the many different music analysis libraries and Essentia was the best library with Python bindings. Essentia is used in many different applications like: freesound.org, KORG, Fretello and Crypt of the NecroDancer [3].

To use Essentia you have to load the music with one of the different loaders and then you can apply one of the many algorithms of the library on it [2].

We used RhythmExtractor2013 for the Beat Detection, Intensity to get the mood of the music and Danceability to decide if the given sound file represents music.

### B. Key Frames

The NAOqi library ALMotion provides methods which allow complex movements of the NAO. It contains commands allowing to manipulate joint stiffness, joint angles, and a higher level API allowing us to control the moves.

The following methods are important for the implementation of our movements `angleInterpolation(names, angleLists, timeLists, isAbsolute)` and `getAngles(names, useSensors)`.

For basic postures, we implemented it using API from NAOqi. Next, angles of Nao joints are gained through `getAngles` function to create particular movement.

Creating working key frames for the dance moves of the robot proved to be more difficult, than we expected. Therefore, a complex choreography for the Nao has been built in this project using the timeline functions of the Choregraphe software. Choregraphe is a multi-platform desktop application which allows us to create our dance, test them at home and monitor Nao through programming. Every move had to be tested directly with the robot to check its stability so that the robot would not fall down while dancing. We had to optimize every move for a variable speed derived from the beats per minute of the music.

### C. Dance Generation

First the sound file is loaded with an Essentia loader. Then we analyze the Track with the RhythmExtractor2013, Intensity and Danceability algorithms. We use the outcome of the Danceability algorithm to decide if the sound file represents danceable music. The result of the Intensity algorithm determines if the use of relaxed or more aggressive dancing movements. Then combined this moves get combined to form a choreography. The speed of the movements is adapted to the beats per minute of the song determined by RhythmExtractor2013 algorithm. RhythmExtractor2013 gives us also the position of each beat so that we can time some moves to a beat position. Then the music starts and the robot gets it movement commands to dance to the music.

## II. CONCLUSION

At the beginning of our project, we wanted to make sure that the robot could do a real-time beat analysis, but we had problems, whereas we could not access the recorded file from Nao and do the real-time analysis in the computer, and since the Nao CPU as also the Computer CPU were not so fast, we would have a even larger delay with the command and action. Because of that, we choose to do only a beat analysis with the Computer and tried to close this gap with algorithms from Essentia like danceability and intensity. Nevertheless still faced problems with delay and network connections and the algorithms weren't accurate. It might be even possible with a faster Nao CPU and Hardware to do the music analysis in real time.

## APPENDIX A BEAT DETECTION

For the project we created three main codes(`naorecord.py`, `keyframes.py` and `choreographies.py`).

With `naorecord.py` we made three functions:

`beatDetection` wich is used for the beats, bpm and duration analysis of a music file is only possible with Essentia. With those analysis, we can determinate wich moves the robot will make and with wich tempo.

`musicPlayer` function as the name says, is for the music, with the help of `pydub` library we can reproduce a music file and with this we can call the movements of the robot.

`doDance` function will use the analysis from `beatDetection` to determinate if the robot will dance or not and for how long will he dance.

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