

**Beat Tracking**  
**Initial Project Proposal**  
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## **Objective**

To design and produce a beat tracking unit that processes and displays the beats per minute from an acoustic audio signal.

## **Introduction**

### Background

Within any given genre of music, there is an underlying pulse that unifies the individual timbres, intonations, and beats within the piece. It has long been the ability of humans to successfully locate and identify this recurring pulse regardless of changing tempos or meters. This process, commonly referred to as “foot-tapping,” comes to humans without much thought or computation. The tempo at which the foot tapping occurs is called the pulse or beat. In a broader sense, this “foot tapping” when analyzed and processed yields information commonly referred to as the tempo. Generally, the tempo is measured in Beats Per Minute (BPM).

### Applications

Uses for the BPM of a song are quite varied. The BPM is used to classify and label music. The BPM, when computed electronically, can inform the user of the song tempo. This BPM may be further manipulated to trigger specific events strictly related to the beat of the song. It is within the electronic processing and application of the BPM that this project will focus on.

### Intended Application

The concept of tempo and tracking the BPM is bound tightly to various genres of music. Such a genre is Electronica<sup>1</sup>. The strong “bassy” pulse within this type of music makes it a very good candidate in beat tracking

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<sup>1</sup> Electronica is genre of music that combines both digital sounds and acoustic ones to deliver a type of music that is highly energetic, simply organized, and very dance oriented. Within the genre of Electronica are smaller genres such as House, Trance, and Drum n’ Bass. These styles all have similar traits and place an emphasis on tempo and rhythm.

because the central bass pulse can easily be filtered and separated from the music.

From a disc jockey's standpoint, the ability to be aware of and control the BPM is important. By using two turntables (with +/- 10% pitch adjust) and a BPM monitor, the disc jockey is able to effectively and accurately mix together two records of different BPMs and produce the illusion that one song simply "fades" into the other.

### Preliminary Design

#### Design Overview

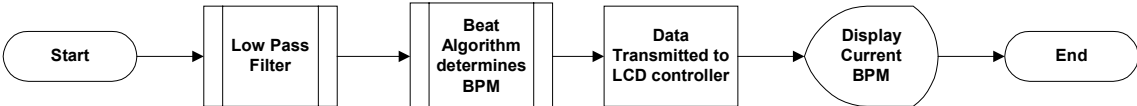
Intended features:

- Real-time beat analysis
- Acoustic signal input
- Three digit LCD display
- Efficient beat identification
- Mobile unit

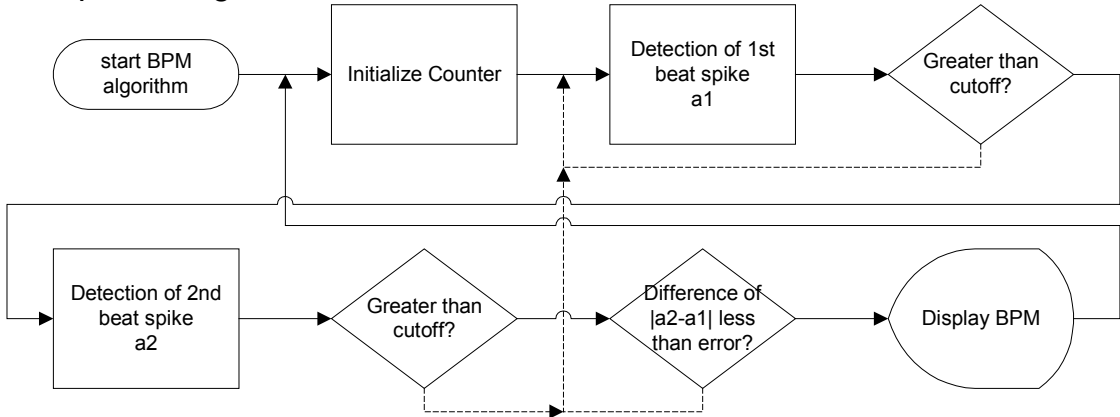
Necessary Components:

- Low pass filter constructed at desired cutoff frequency
- Microprocessor to understand signal data from filter

#### Proposed Design Flowchart



#### Proposed Algorithm Flowchart



## Proposed Algorithm Code

```
current_BPM = 0
 $\alpha_1 = 0$ 
DO while = TRUE
  call TIMER
  IF incoming_frequency  $\geq$  cutoff_point
    count = timer_output
     $\alpha_2 = \text{count}$ 
     $\Delta_1 = \alpha_2 - \alpha_1$ 
     $\alpha_1 = \alpha_2$ 
    IF incoming_frequency  $\geq$  cutoff_point
      count = timer_output
       $\alpha_2 = \text{count}$ 
       $\Delta_2 = \alpha_2 - \alpha_1$ 
       $\alpha_1 = \alpha_2$ 
    END IF
  END IF
  IF  $\alpha_1$  AND  $\alpha_2 = 0$ 
    Display_BPM = 0
  END IF
  IF  $|\Delta_2 - \Delta_1| \leq \delta$ 
    old_BPM = current_BPM
    current_BPM =  $60 / ((\Delta_2 + \Delta_1) / 2)$ 
    IF old_BPM = 0
      display_BPM = current_BPM
    ELSE
      display_BPM =  $((\text{current\_BPM} + \text{old\_BPM}) / 2)$ 
    END IF
  END IF
END IF
END DO
```

## Project Benefits

- The 2001-2002 school year marks the beginning of my EE education. It would be excellent to compliment what I am learning with a project that captures my interests and passions.
- Provide an excellent lead-in to a possible senior project on the subject of algorithm detection methods related to beat induction and tracking.
- Computer usage to perceive and understand music is one branch of AI, a possible field to look into.

## Project Issues

- Beat detection routine may not be powerful and robust enough to provide accurate BPM counting, may have to improve and redesign.
- Understanding of principles involved within this project may be beyond current understanding – additional reading may be required.
- Due to class, lab, and swim schedule time to work on this project may be difficult to arrange – but not impossible.
- Additional processes and/or components may need to be integrated into initial design.