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Masataka Goto (2001). "An audio-based real-time beat tracking system for music with or without drum-sounds." *JNMR*, 30(2):159-171, 2001.

This paper describes a real-time beat tracking system that recognizes “the hierarchical beat structure comprising the quarter-note level, the half-note level, and the measure level (bar-lines)” from input audio signals sampled from compact discs. The system first detects the beat-tracking cues in audio signals, and then higher-level processing using musical knowledge is used to interpret the cues for beat structures. The author describes these steps as an inverse procedure of the forward processes by music performers who implies the beat structure when performing music, then produces the musical sounds through singing or playing an instrument.

However, there are tight restrictions under which the system can perform the above tasks. The input songs are limited to a sub-genre of popular music. The higher-level musical knowledge used to interpret the cues is tailored to best fit this specific domain, in this case chord changes and drum patterns are used with the later as predefined pattern templates. Furthermore, the only time signature allowed is 4/4. This implies that the music is in simple time, with major note divisions of exact half notes and quarter notes. With all these limitations as known facts before the music is being processed, the nature and difficulty of the problem has changed significantly from trying to track beats in the dark to mapping the beat with given hierarchical beat structures. This is further illustrated when the system fails whenever it encounters an exceptional to its predefined musical templates, for example when the chord changes occur on the fourth quarter note in measure, when there were many syncopations in the basic accompaniment pattern. Thus, expanding the domain of music input would imply adding all the characteristic patterns of those music to the system.

In the conclusion, the author claims that this system can be generalized to other music genres. By demonstrating the beat-tracking system by scaling down the problem to such a fictional level, it is not convening that this approach will still be applicable when the music patterns become exponentially less predictable.