

# A CONTOUR-BASED JAZZ WALKING BASS GENERATOR

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## ABSTRACT

This paper describes a contour-based algorithm for the real-time automatic generation of jazz walking bass lines, following a given harmonic progression. A brief description of the walking bass procedure will be presented, and also a brief survey on some common implementations and techniques.

This algorithm was implemented in the Max/MSP graphical programming environment.

## 1. INTRODUCTION

### 1.1 The Walking Bass Practice

The walking bass is a very common playing procedure used in jazz music, in which the bass walks through the chord and scale notes in a regular pulse. This is especially used when accompanying a solo, firmly setting the base pulse like a metronome, and simultaneously exposing the underlying harmony of the song. This procedure has its roots deep in the first decades of the twentieth century, and was developed through the years with bass players like Jimmy Blanton, Ray Brown, Ron Carter and Charlie Mingus, amongst many others. A very good insight on the evolution of the bass role and many of the key innovators in jazz history can be found in *The Jazz Bass Book, Technique and Tradition*, by John Goldsby [1].

The basic idea of a walking bass line is to go from one chord to the next, linking them by filling the middle beats with notes of the chord or scale, typically describing a smooth melodic line or pattern. Far from being completely passive, however, the roll and behavior of the walking bass can dramatically change from almost neutral smooth lines to very abrupt register changes and energized rhythms, dynamically contributing to the overall group energy and musical result. The continuous flow of the regular walking bass notes, together with its harmonic and melodic content, form one of the most charismatic and important elements in traditional jazz playing.

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The learning of this technique usually implies the learning of melodic licks, for each of the commonly used chord progressions. These licks are small melodic phrases that are particularly efficient and musical, and are usually related both to the available notes of the current chord and underlying scale and to physical placement of the notes and fingers on the bass. Bass learning methods like the ones by Ron Carter [2], Ray Brown [3], Bob Magnusson [4] and Steven Mooney [5] lead the student through a series of these licks, covering most common harmonic progressions, in order to provide the student with the basic formulae that can then be adapted to any song. As the walking bass player develops his technique and gains more experience, however, he will be able to use these phrases more articulately. More importantly, he will be able to move away from them, intuitively creating more natural sounding lines and integrating several other elements like ornaments, theme-specific elements and group feedback.

“(...) musicians string together a sequence of motifslicks as they used to be called modified to meet the constraints of the chord sequence. (...) Yet, the motif theory cannot be the whole story.” [6]

### 1.2 Implementations

Due to the non-repetitive nature of the walking bass technique, its use in computer software is actually quite limited. Commonly, walking bass lines in use are pre-recorded or manually written for the entire song length, whether as audio recordings or MIDI events. This practice has its roots in play-along recordings, like the widely known Jamie Aebersold [7] long list of score + CD Play-A-Long albums, with comping tracks recorded by real jazz musicians, allowing the practitioner to play-along with the recording. Computer software facilitates this method by easily allowing the independent mixing for each track, as well as change the tempo and transpose an audio or MIDI track, even on iOS devices with apps like Smudge Apps Band [8] with multi-track recordings and mixer.

More advanced software use pre-recorded small phrases for each chord-type and/or chord progressions, which are then transposed and chained together according to some more or less intelligent algorithm. This seems to be the case with software like the extensive Band-in-a-box [9], and more recently iReal b [10], on the iPad. This kind of implementation can use audio or MIDI clips. While audio

clips keep all of the little nuances, sound and groove of the original player, the MIDI clips allow more flexibility for editing notes, instrument, and even tempo and phrase elements.

These implementations based on the use of pre-recorded phrases, whether audio or MIDI, have however some limitations:

- If the number of pre-programmed phrases is small, the output will easily sound repetitive;
- The larger the number of pre-programmed phrases, the larger the chances of melodic inconsistencies and non-musical results;
- In order to obtain smooth transitions between chords, the pre-programmed phrases have to be very neutral, resulting in a very neutral sounding bass line;
- It is not easy to handle less conventional harmonic progressions.

## 2. A CONTOUR-BASED APPROACH: TECHNICAL DESCRIPTION

The work presented in this paper stems directly from the research that led to the development of the GimmeDaBlues app [11]. It describes the algorithmic generation of melodic phrases that connect the chords in a previously defined harmonic grid, by calculating a path from the current chord to the next, according to user-defined settings controlling the direction and range of the melodic contour.

The phrase generation algorithm consists basically in three stages: Target Note calculation, Trajectory calculation, and an event manager (Player). The general structure is showed in Fig.1.

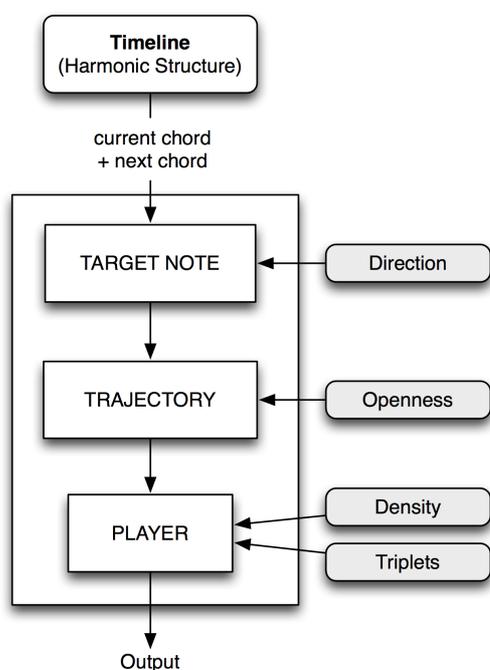


Figure 1. Algorithm structure.

### 2.1 Target note calculation

The algorithm needs to know the current chord and the next one in order to be able to calculate a phrase. The target note is the last note of the phrase to be generated. A simple probabilistic algorithm chooses which of the notes belonging to the next chord will be used e.g. fundamental, 3rd, 5th, 7th, etc.. Currently, in order to maintain a strong sense of the base harmony, a setting of 100% probabilities of choosing the fundamental note of the chord is used. Then, according to the current note and to a direction parameter, the algorithm will find the chosen chord note in the right octave.

The direction parameter defines whether the target note will be selected up or down, relatively to the current note, and there are five different settings: lowest, down, nearest, up, and highest. The down and up settings tell the algorithm to search for the nearest note in that direction, while with the lowest and highest settings, the algorithm will select the lowest and highest note in the instruments range. This parameter can be defined manually or automatically. So, for example, considering a double bass instrument defined with a range from E0 to G3 (having C3 as the middle C), if the current note is a C2, and the target note is an F, the direction parameter will define which F will be selected. The down setting would select F1, while the up setting would select F2. The lowest note setting will return F0 - the lowest F on the defined range - and the highest setting will return F3 the highest F on the defined range.

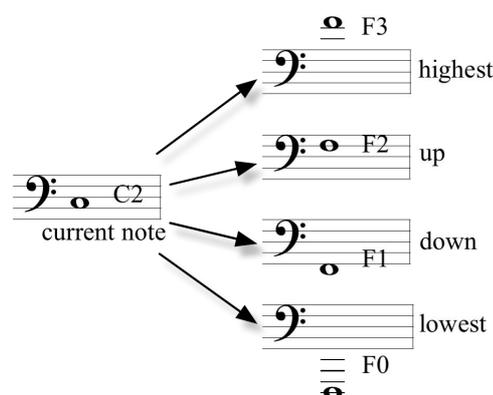


Figure 2. Possible target notes for the four direction settings.

With the "nearest" setting selected, the algorithm will automatically go up or down, choosing the F that is nearest to the current C2, which will be F2, because its a Perfect 4th interval, while F1 would be a Perfect 5th.

### 2.2 Trajectory

The trajectory is constituted by a selection of notes that define the path the bass line will take from the starting (current) note to the final (target) note. In a typical case for a chord duration of one bar in a 4/4 measure with the bass playing quarter notes, the complete generated bass line will have five notes, in which the fifth is the first note of the next

measure. The three passing notes between the starting note to the target note are calculated recursively, going from the strongest beats of the measure to the weakest, and depending on the trajectory calculation algorithm.

An openness parameter will set how direct or indirect the path will be, influencing the selection of the middle notes in the calculated bass line. The name relates to the notion of closed and open forms of a chord. The closed position will be the more direct path to the target note, while more open path will tend to use a wider trajectory, using chord notes in an open form.

The notes to use will be drawn from chord tones, scale degrees and chromatic inflections, according to each steps beat position. The stronger beats of the bar will tend to have chord tones, while the weak beats will tend to have scale notes acting as passing notes from one chord note to the next. The last beat of the bar can also be a chromatic approximation to the target note. This is a very commonly used technique, as the chromatic passing note creates a strong attraction to the target note, emphasizing it as well as the sense of direction in the melodic phrase.

Fig. 3 shows four examples of possible trajectories of the calculation of a bass line for a C7 F7 progression, where the initial note is C2, and the target note is F2.



**Figure 3.** Phrase b) is the same as a) but with an ornamental triplet repeating the G in the third beat.

### 2.3 Ornaments

Although the construction of the phrases are the base of the walking bass technique, there are several other aspects regarding the notes, rhythm and articulations that have an important role in a good performance. These aspects, here referred to as ornaments, are little nuances and additions to the phrases that don't change nor define the main contents of the phrases, but nevertheless can contribute considerably to the quality and the dynamic of the walking bass lines.

The current implementation allows for the use of eighth-note triplet variations (or eighth-notes with a swing feeling) that can be set probabilistically. This is one of the most common rhythmic variations in the walking bass technique, in which some of the notes are anticipated by one triplet (or swung eighth) with the same or another pitch. The control is done by a single percentage value, setting the probability factor.

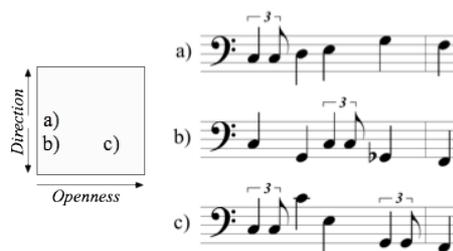


**Figure 4.** Phrase b) is the same as a) but with an ornamental triplet repeating the G in the third beat.

### 2.4 Control

The combination of the direction selection and the trajectory openness provide a contour-based definition of the walking bass line, which not only creates smooth and natural lines but also allows an effective and intuitive control in interactive real-time implementations.

A simple example of a possible manual controller for this walking bass generator would be a joystick type controller, where the vertical axis would control the direction parameter, while the horizontal would control the openness parameter.



**Figure 5.** Example phrases with different settings.

Figure 5 shows three example phrases with different settings:

- a) direction: nearest / openness: low;
- b) direction: down / openness: low;
- c) direction: down / openness: high.

## 3. CONCLUSIONS AND FUTURE DEVELOPMENTS

The overall outcome of the described algorithm is quite effective and promising, mainly due to its flexible nature, by adapting to any arbitrary harmonic progression and by allowing a meta-control over the bassist behaviour. Future implementations will focus on the way the phrase generation can be controlled algorithmically, exploring the contour shapes for the creation of motivic oriented groups of phrases. Several strategies can be approached, like Markov models and genetic algorithms, to control the succession of phrase parameters musically.

Due to its recursive nature, the current algorithm only deals with multiples 2/4, 2/2 and 4/4 measures. In metrical terms, the beat hierarchy in measures with an odd number of beats is not so clear, and thus the algorithm has to know how

to handle them appropriately. Also, and relating to metrical aspects in the phrase calculation, is the notion that the phrases played by good bass players tend to have very often a length of two measures instead of just one. This creates more fluent lines contributing to the smoothness of the musical form but also to the musical dynamics and movement by relieving the measure-by-measure step size.

Regarding harmony, some interesting developments can include the introduction of harmonic variations like chord substitutions and alternate chord progressions, which is a very common practice with advanced players, described in books like the ones by Nettles and Graf [12], or Felts [13], and addressed in the work by Steedman [14] [15].

Also, in order to make it sound more human and active, the ornaments features regarding rhythm, dynamics and articulation will have to be addressed.

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