Midpoint displacement

Midpoint displacement algoritme (*vaak toegepast in procedural content generation in games*)

Van strategie tot algorime

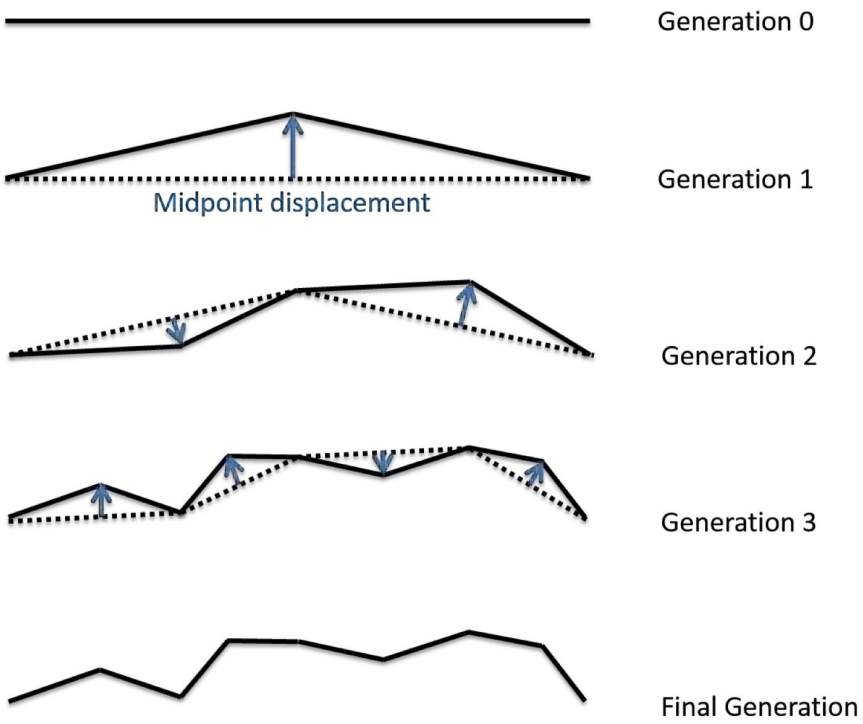

Fig. 4.8 The Midpoint Displacement algorithm visualized.

Midpoint displacement

uit **procedural content generation** (PCG) in games

1. start with a horizontal line.
2. find midpoint of this line
3. move midpoint up / down by a random amount
4. repeat 2 - 4 with lower range of random amount

image source: Yannakakis, G. N., & Togelius, J. (2018). **Artificial intelligence and games**. Springer.

Midpoint displacement → *Applied freely to a sequence of notes*

uit **procedural content generation** (PCG) in games

1. start with a horizontal line.
2. find midpoint of this line / line fragment
3. move midpoint up / down by a random amount
4. repeat 2 - 4 with lower range of random amount

1. start with two notes
2. insert new note between each set of 2 notes
3. move pitch of new note up / down by a random amount
4. repeat 2 - 4 with lower range of random amount

Midpoint displacement → *Applied freely to a sequence of notes*

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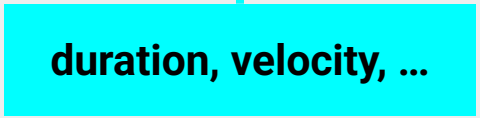


Iteration #1

input: 

INS #1:

output:

Midpoint displacement

Applied freely to a sequence of notes

1. start with two notes
2. insert new note between each set of 2 notes
3. move pitch of new note up / down by a random amount
4. repeat 2 - 4 with lower range of random amount

Iteration #1 *index: 0*

input:

INS #1:
index 0

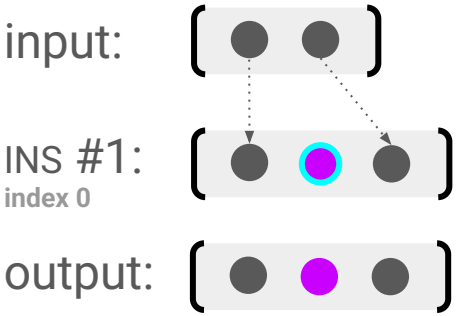
output:

Midpoint displacement

Applied freely to a sequence of notes

1. start with two notes
2. insert new note between each set of 2 notes
3. move pitch of new note up / down by a random amount
4. repeat 2 - 4 with lower range of random amount

Iteration #1 *index: 0*



Midpoint displacement

Applied freely to a sequence of notes

1. start with two notes
2. insert new note between each set of 2 notes
3. move pitch of new note up / down by a random amount
4. repeat 2 - 4 with lower range of random amount

Iteration #1

index: 0

input:

INS #1:
index 0

output:

Iteration #2

input:

INS #1:

INS #2:

output:

Midpoint displacement

Applied freely to a sequence of notes

1. start with two notes
2. insert new note between each set of 2 notes
3. move pitch of new note up / down by a random amount
4. repeat 2 - 4 with lower range of random amount

Iteration #1

index: 0

input:

INS #1:
index 0

output:

Iteration #2

indices: 0, ...

input:

INS #1:
index 0

INS #2:

output:

Midpoint displacement

Applied freely to a sequence of notes

1. start with two notes
2. insert new note between each set of 2 notes
3. move pitch of new note up / down by a random amount
4. repeat 2 - 4 with lower range of random amount

Iteration #1

index: 0

input:

INS #1:
index 0

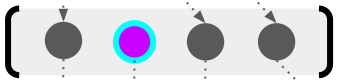
output:

Iteration #2

indices: 0, 2

input:

INS #1:
index 0



INS #2:
index 2

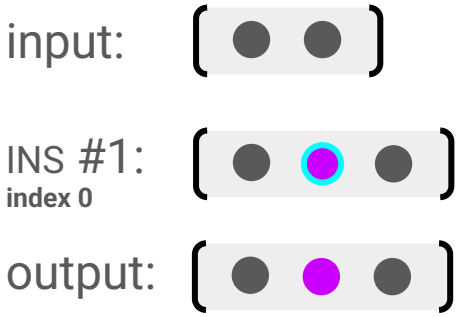
output:

Midpoint displacement

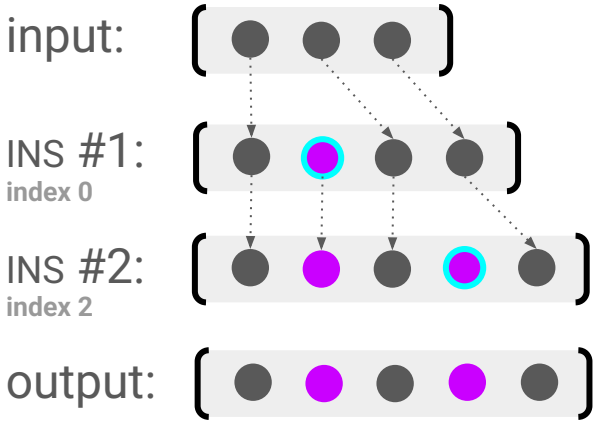
Applied freely to a sequence of notes

1. start with two notes
2. insert new note between each set of 2 notes
3. move pitch of new note up / down by a random amount
4. repeat 2 - 4 with lower range of random amount

Iteration #1 *index: 0*



Iteration #2 *indices: 0, 2*



Midpoint displacement

Applied freely to a sequence of notes

1. start with two notes
2. insert new note between each set of 2 notes
3. move pitch of new note up / down by a random amount
4. repeat 2 - 4 with lower range of random amount

Iteration #1

index: 0

input:

INS #1:
index 0

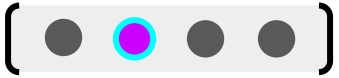
output:

Iteration #2

indices: 0, 2

input:

INS #1:
index 0



INS #2:
index 2

output:

Iteration #3

input:

INS #1:
index 0

INS #2:
index 2

INS #3:
index 4

INS #4:
index 6

output:

Iteration #1

index: 0

input:

INS #1:
index 0

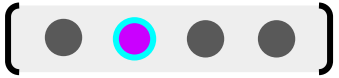
output:

Iteration #2

indices: 0, 2

input:

INS #1:
index 0



INS #2:
index 2

output:

Iteration #3

indices: 0, ...

input:

INS #1:
index 0

INS #2:

INS #3:

INS #4:

output:

Iteration #1

index: 0

input:

INS #1:
index 0

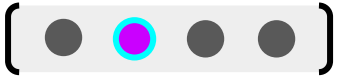
output:

Iteration #2

indices: 0, 2

input:

INS #1:
index 0



INS #2:
index 2

output:

Iteration #3

indices: 0, 2, ...

input:

INS #1:
index 0

INS #2:
index 2

INS #3:

INS #4:

output:

Iteration #1

index: 0

input:

INS #1:
index 0

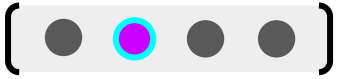
output:

Iteration #2

indices: 0, 2

input:

INS #1:
index 0



INS #2:
index 2

output:

Iteration #3

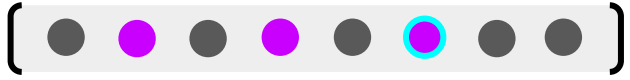
indices: 0, 2, 4, ...

input:

INS #1:
index 0

INS #2:
index 2

INS #3:
index 4



INS #4:

output:

Iteration #1

index: 0

input:

INS #1:
index 0

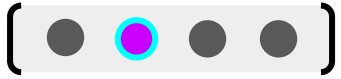
output:

Iteration #2

indices: 0, 2

input:

INS #1:
index 0



INS #2:
index 2

output:

Iteration #3

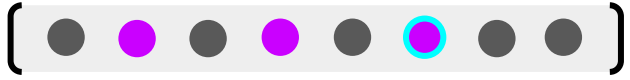
indices: 0, 2, 4, 6

input:

INS #1:
index 0

INS #2:
index 2

INS #3:
index 4



INS #4:
index 6

output:

Iteration #1

index: 0

input:

INS #1:
index 0

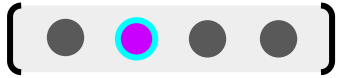
output:

Iteration #2

indices: 0, 2

input:

INS #1:
index 0



INS #2:
index 2

output:

Iteration #3

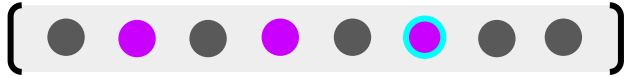
indices: 0, 2, 4, 6

input:

INS #1:
index 0

INS #2:
index 2

INS #3:
index 4



INS #4:
index 6

output:

Midpoint displacement

Applied freely to a sequence of notes

How to generate the necessary indices?

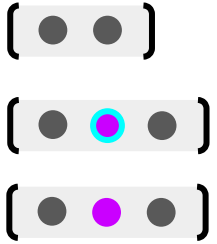
Iteration	**indices** of notes to split	# **INS**	# **INS** *expressed as power of 2*
1			
2			
3			
4			
5			
6			

Iteration #1 *index: 0*

input:

INS #1:

output:



Midpoint displacement

Applied freely to a sequence of notes

How to generate the necessary indices?

Iteration	**indices** of notes to split	**# INS**	**# INS** *expressed as power of 2*
1	0	1	2 ^ 0
2			
3			
4			
5			
6			

Iteration #1 *index: 0*

input:

INS #1:

output:

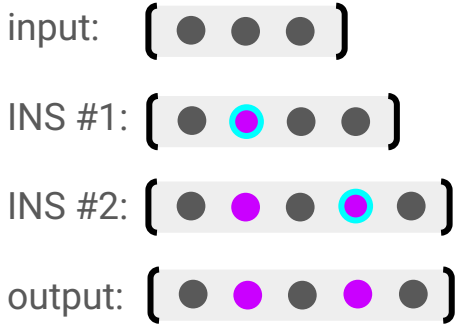
Midpoint displacement

Applied freely to a sequence of notes

How to generate the necessary indices?

Iteration	**indices** of notes to split	# **INS**	# **INS** *expressed as power of 2*
1	0	1	2 ^ 0
2	0, 2	2	2 ^ 1
3			
4			
5			
6			

Iteration #2 *indices: 0, 2*

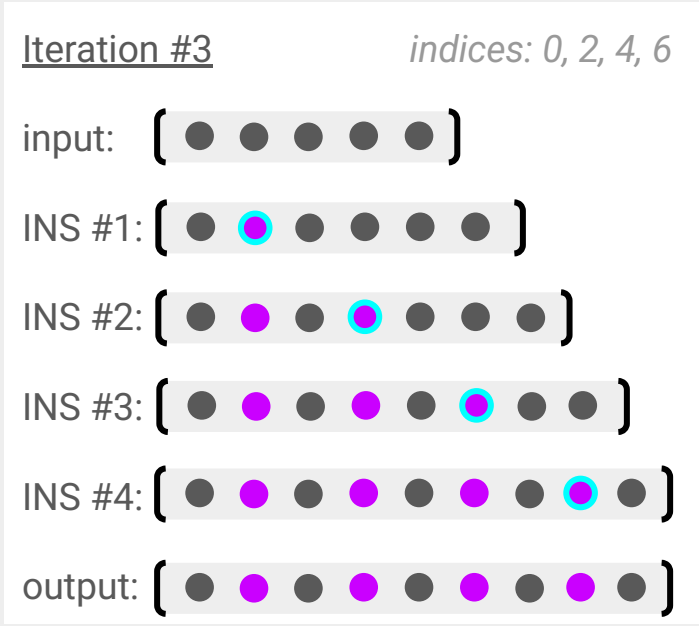


Midpoint displacement

Applied freely to a sequence of notes

How to generate the necessary indices?

Iteration	**indices** of notes to split	# **INS**	# **INS** *expressed as power of 2*
1	0	1	2 ^ 0
2	0, 2	2	2 ^ 1
3	0, 2, 4, 6	4	2 ^ 2
4			
5			
6			



Midpoint displacement

Applied freely to a sequence of notes

How to generate the necessary indices?

Iteration	**indices** of notes to split	# **INS**	# **INS** *expressed as power of 2*
1	0	1	2 ^ 0
2	0, 2	2	2 ^ 1
3	0, 2, 4, 6	4	2 ^ 2
4	0, 2, 4, 6, 8, 10, 12, 14	8	2 ^ 3
5	0, 2, 4, 6, 8, 10, 12, 14, ..., 30	16	2 ^ 4
6	...	32	2 ^ 5

Midpoint displacement

Applied freely to a sequence of notes

How to generate the necessary indices?

Iteration	**indices** of notes to split	# **INS**	# **INS** *expressed as power of 2*
1	0	1	2 ^ 0
2	0, 2	2	2 ^ 1
3	0, 2, 4, 6	4	2 ^ 2
4	0, 2, 4, 6, 8, 10, 12, 14	8	2 ^ 3
5	0, 2, 4, 6, 8, 10, 12, 14, ..., 30	16	2 ^ 4
6	...	32	2 ^ 5

pseudo code

?

output

```
0
0
2
0
2
4
6
0
2
4
6
8
10
12
```

Midpoint displacement

Applied freely to a sequence of notes

How to generate the necessary indices?

Iteration	**indices** of notes to split	**# INS**	**# INS** *expressed as power of 2*
1	0	1	2 ^ 0
2	0, 2	2	2 ^ 1
3	0, 2, 4, 6	4	2 ^ 2
4	0, 2, 4, 6, 8, 10, 12, 14	8	2 ^ 3
5	0, 2, 4, 6, 8, 10, 12, 14, ..., 30	16	2 ^ 4
6	...	32	2 ^ 5

pseudo code

```
for i in range(num_iterations):
    num_splits = 2 ^ i
    for j in range(num_splits):
        index = j * 2
        print(index)
```

output

```
0
0
2
0
2
4
6
0
2
4
6
8
...
```

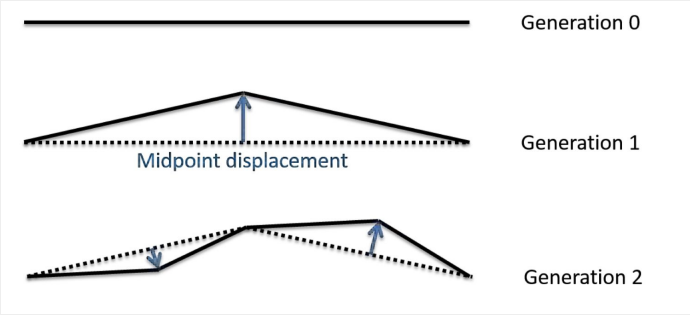
Midpoint displacement

Applied freely to a sequence of notes

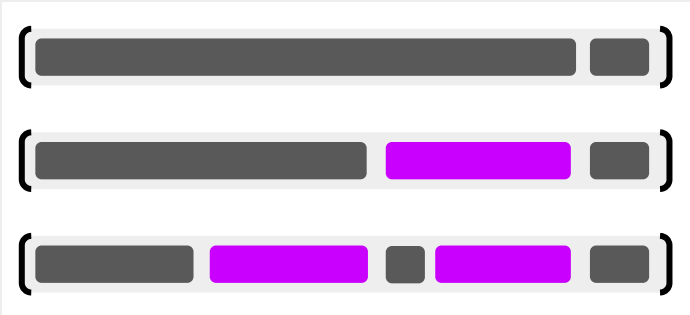
How to **insert / split** a note?

1. start with two notes
2. **insert** new note between each set of 2 notes
3. move pitch of new note up / down by a random amount
4. repeat 2 - 4 with lower range of random amount

insert



split



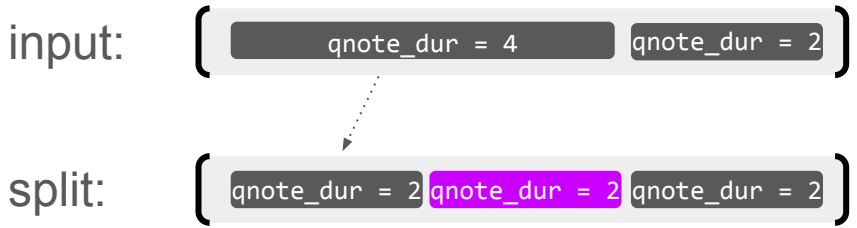
Midpoint displacement

Applied freely to a sequence of notes

How to **split** a note?

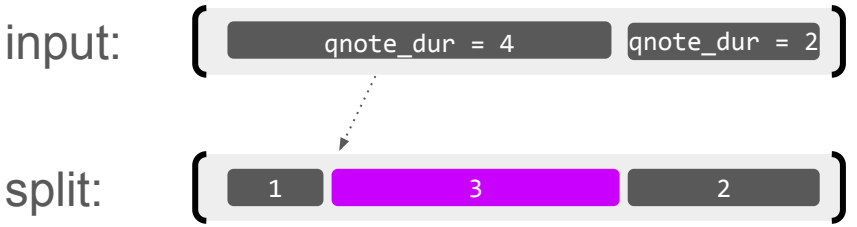
Example 1

split_amount = 0.5



Example 2

split_amount = 0.25



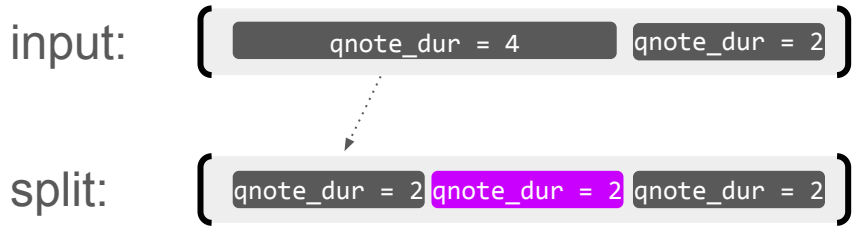
Midpoint displacement

Applied freely to a sequence of notes

How to **split** a note?

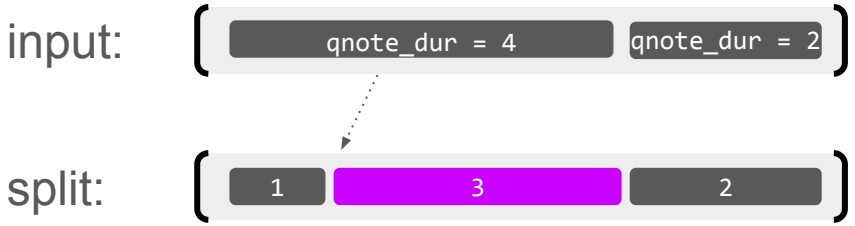
Example 1

split_amount = 0.5



Example 2

split_amount = 0.25



pseudo code

```
// split amount → divide in half, in a quarter, in an eighth
split_amount = random.choice([0.5, 0.25, 0.125])
// retrieve current note and its duration
note = notes[index]
// NOTE: qnote refers to quarter note (not enough space)
dur = note[“qnote_dur”]

// calculate new note duration and rest value
new_dur = dur * split_amount
rest_dur = dur - new_dur
// store new note duration to current note
note[“qnote_dur”] = new_dur
// generate new note with rest duration value
new_note = {“qnote_dur”: rest_dur}

// insert new note
notes.insert(new_note, index + 1)
```