

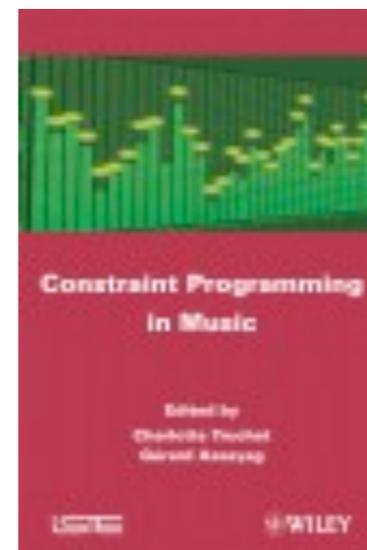
# 8 problèmes musicaux résolus grâce à Gecode

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Séminaire MaMux

vendredi 4 novembre 2010

Programmation par contraintes en musique



# Using Gecode to solve musical constraint problems

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- Approche plus musicale que computationnelle
- Utilisation pratique de Gecode
- Chapitre du livre Constraint Programming in Music

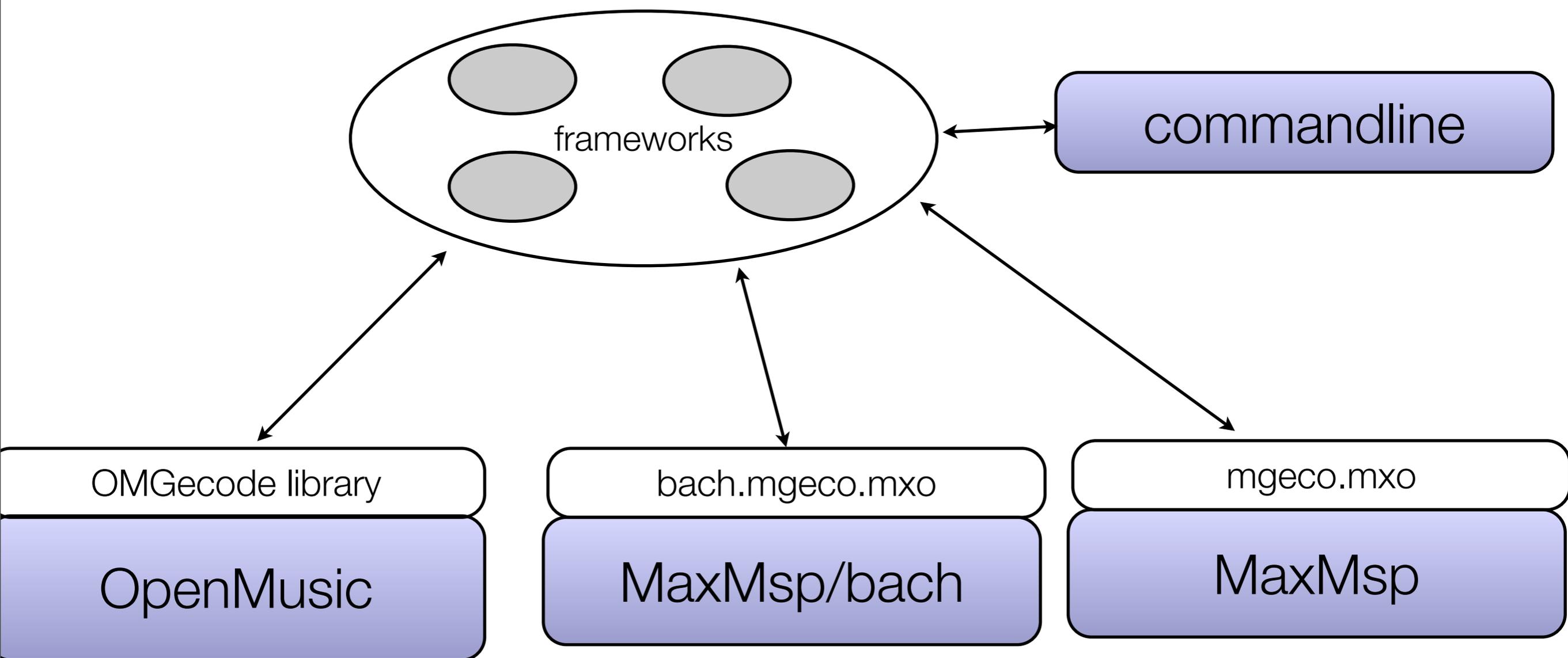
# Pourquoi Gecode ?

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- Excellentes performances
- Communauté très active
- possibilité d'appliquer différents moteurs de recherche sur le même problème.
- "timelimit"

# Implémentation

- script -> librairies (frameworks), facile à étendre ...



# liens

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- la librairie OMGecode est disponible :  
<http://repmus.ircam.fr/openmusic/libraries>
- exemples musicaux :  
<http://contraintesmusique.lina.univ-nantes.fr/ContraintesMusique/index.php?page=musical-excerpts>
- catalogue de problemes : <http://www.csplib.org/>

# Exemples Musicaux

*Congruences* score excerpt (bars 20-24)

## *étude n°8*

by Serge Lemouton

on all interval chords

(cf Figure 5.10, p.131)

## *Congruences*

By Michael Jarrell

for flute, oboe, ensemble and electronics.

1989.

Ensemble Intercontemporain; Peter Eötvös,  
dir.

(Beginning of first movement)

## *Exemple of melodic interpolation*

(cf Figure 5.14, p.135)

## *Elet... fogytiglan*

By Marco Stroppa

pour quinze instrumentistes et électronique.

1989.

Ensemble Intercontemporain ; Peter  
Eötvös, dir.

(Beginning of fifth movement)

# 8 problèmes : Présentation en forme de démo de l'interface avec bach

problème	applications musicales	programmation par contraintes	gecode	to do ..
all-interval	historic dodecaphonic probleme : Berg, Carter, ...	mcsp lib problem 7	performance (benchmark) different formulations of the problem ("model")	
jarrell	<i>congruences</i>		maximisation des résultats par optimisation d'un coût (branch and bound search)	
chord sorting		théorie des graphes (tsp problem)	path and circuit constraints (new)	le model "diff" marche en OM mais pas en Max ? path constraint
chords			contraintes sur des ensembles (set variables)	
blocks	Etudier le rapport entre les codes de hamming et les block designs à la Tom Johnson/Moreno Andreatta	hamming codes		généraliser au block design
melodic interpolations			heuristique aléatoire	other heuristic (more constrating results ...)
profils			domaine controlé par des enveloppes temporelles(bpf)	
vertical pitch structures	Marco Stroppa : <i>elet</i> (cf [ST88a])		non-linear constraints	harmonic domain set, variable interval "weighths"

# Séries tous intervalles

## 1. all-interval series : un grand classique !

12 number of notes

2 number of results (0 : all)

symmetry ⇅

symmetric chor ⇅ options



bach.mgeco all\_intervals

play

Onset 3896.0 Cents 11500.0

# Cellules mélodiques

## 2. michael Jarrell melodic cells

**16** number of notes

**60** first note (0 = any)

**0** last note (0 = any)

**1** solution number

model

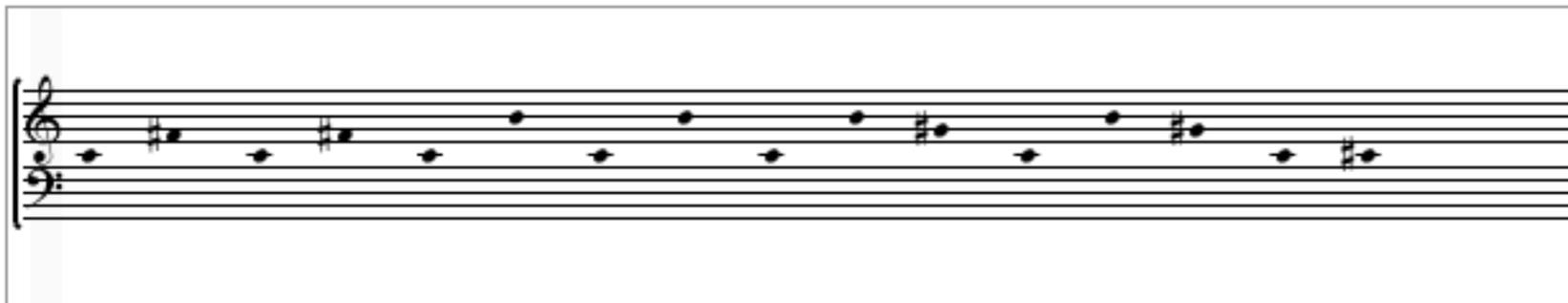
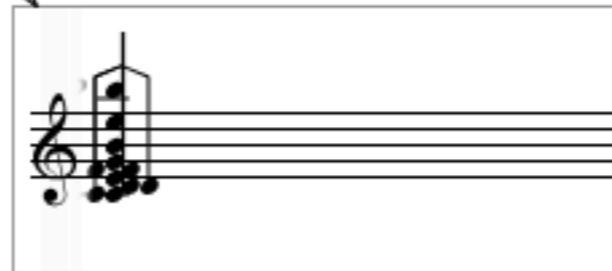
**2000** timelimit



intervals



clear



# parcours harmoniques

## 3.sort harmonic progression by minimizing distance between successive chords (shortest path problem)

### attributes

model : 0, diff: minimise le nombre de notes différentes entre accords successifs, parcours (ignore la distance entre le dernier et le premier accord)  
1, circ : circuit hamiltonien, path\_length should be equal to n  
2, path : hamiltonian path

path\_length = longueur du parcours;  
distance = nombre de notes différentes maximales entre deux accords successifs

dump



p simpleTest

8

path\_length \$1

n \$1

17

distance \$1

circuit

model \$1



bach.mgeco chord\_sorting @n 32 @path\_length 12 @model 2 @distance 18 @n\_solutions 1

play



# contraintes harmoniques

## 4.chord generation

**4** number of notes

**0** number of results (0 : all)

all  model

**60** low note (0 = any)

**76** high note (0 = any)

((0 1)(0 2)(2 4)(1 6)(1 6)(2 7)(0 12)) intervals

((2 1)(1 2)(0 3)(1 6)(0 10))

((1 3)(1 4)(1 7))



bach.mgeco gchords

play

p to Score

Onset 1360.0 Cents 9650.0

# blocks

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## 5.hamming codes

in a 6 -notes set

find 7 chords all differing by 3 notes



**1** number of results (0 : all)



```
bach.mgeco hamming @timelimit 10000
```



# interpolations mélodiques

## 6.melodic interpolation

dump

from  to 

in 5 steps

4 number of results (0 : all)

ordered

(0 1 4 6) forbidden intervals

()

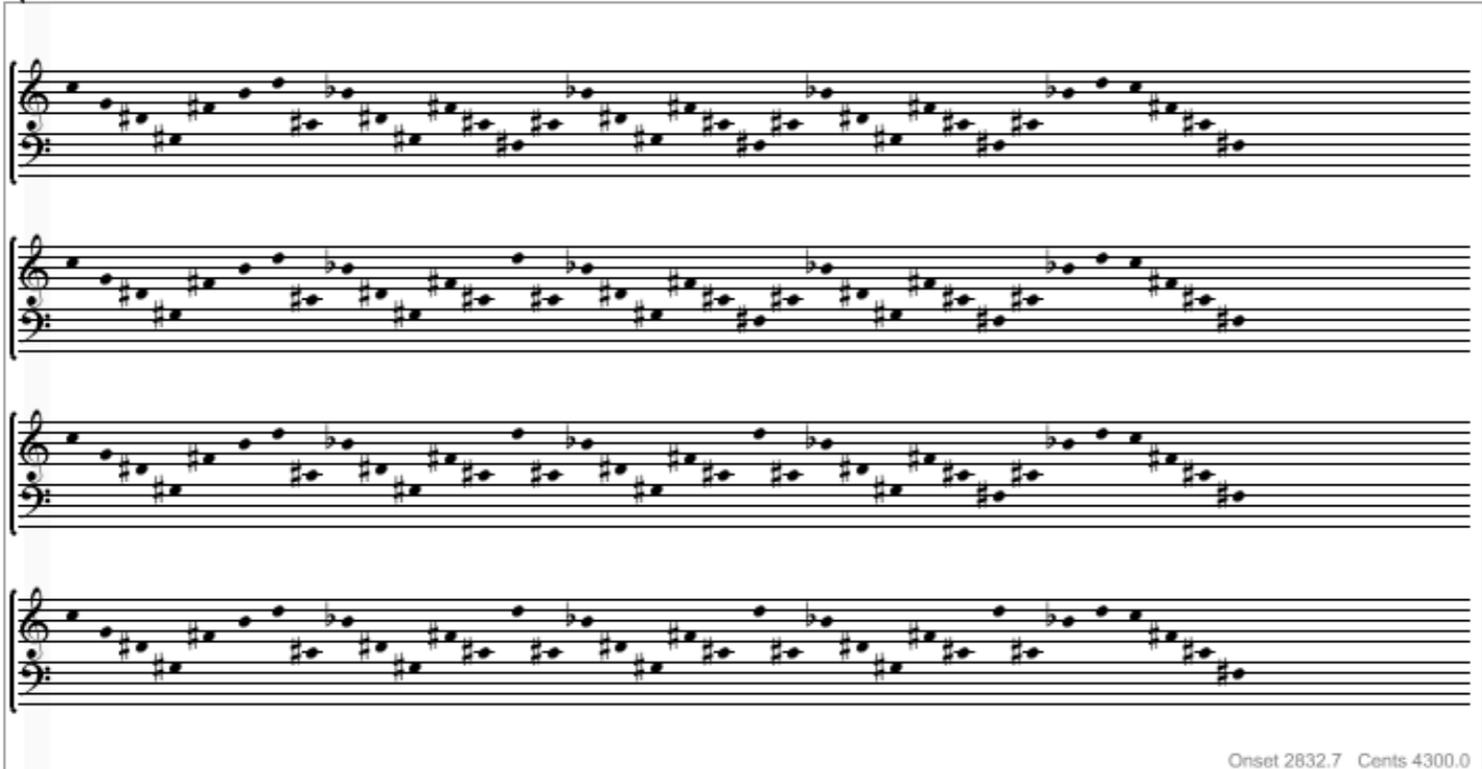
bach.mgeco interpolation

196

zoom \$1

0 speed

play



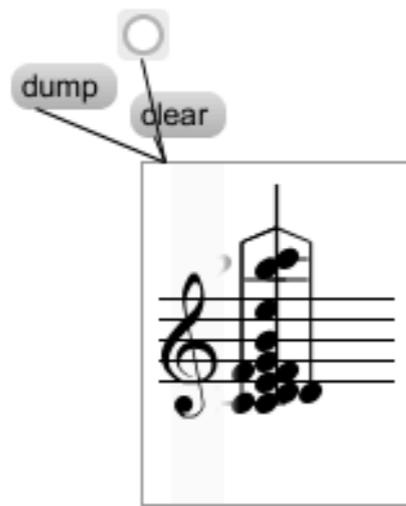
Onset 2832.7 Cents 4300.0

# profils

## 7.melodic profiles

(upper and lower voices are controlled by breakpoint functions)

(60 61 62 63 64 65 66 68 71 76 82 84)



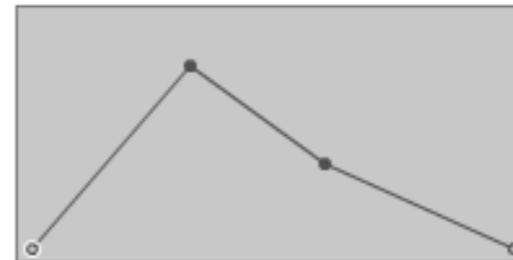
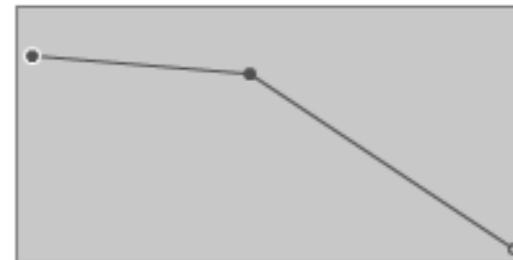
harmonic field

8 number of chords

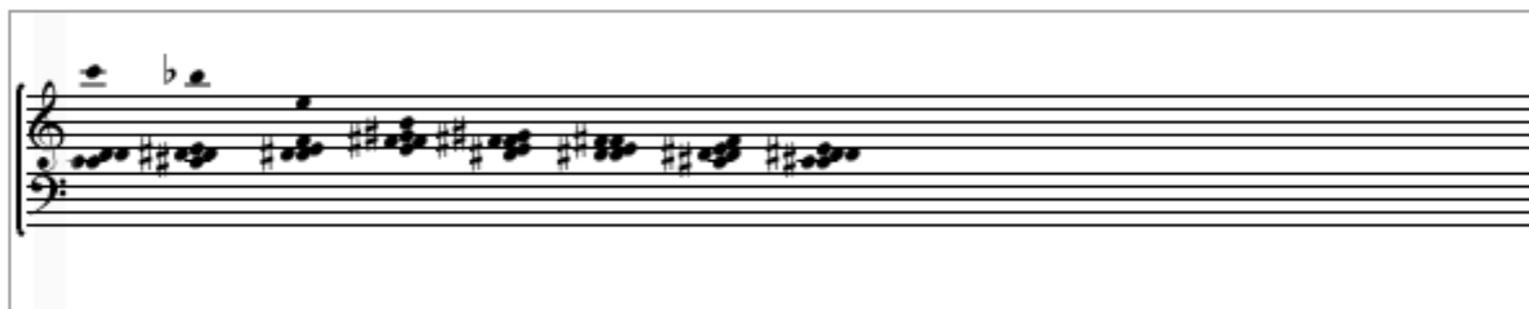
2 min number of notes

8 max number of notes

1 solution number

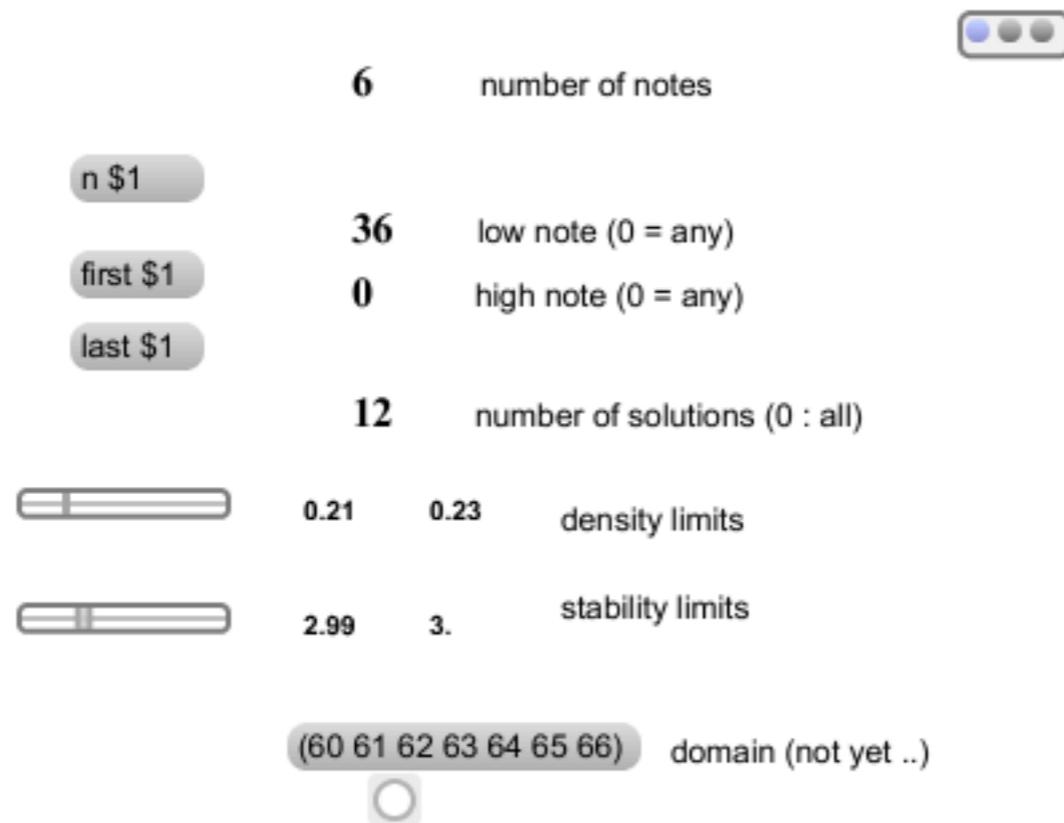


bach.mgeco profils



# Stroppa 's VPS

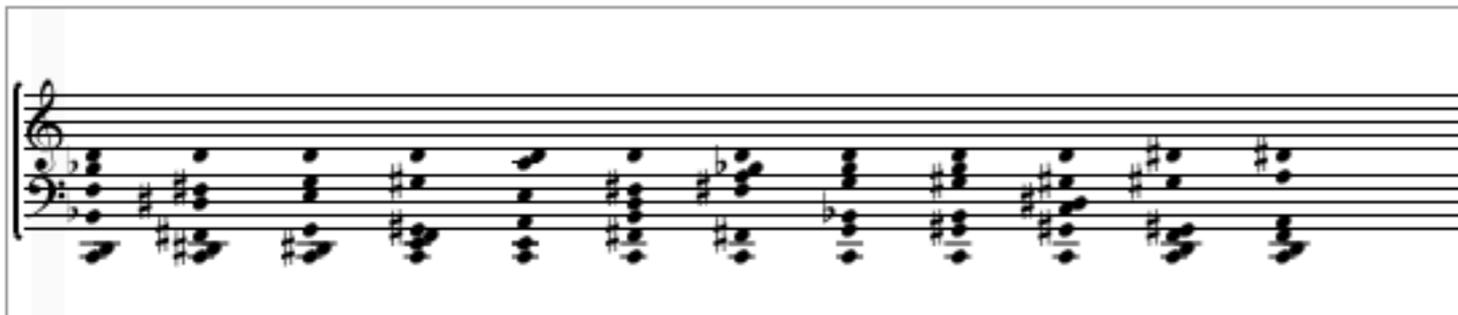
## 8.Marco Stroppa's Vertical Pitch Structures



Control panel for Stroppa's VPS software. It features several adjustable parameters:

- number of notes:** 6
- low note (0 = any):** 36
- high note (0 = any):** 0
- number of solutions (0 : all):** 12
- density limits:** 0.21 to 0.23
- stability limits:** 2.99 to 3.
- domain (not yet ..):** (60 61 62 63 64 65 66)

Additional controls include a window title bar, three buttons labeled 'n \$1', 'first \$1', and 'last \$1', two sliders, and a radio button.



# Conclusion : pour une MCSP-lib

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- modèle facile à étendre : il suffit de rajouter de nouveaux scripts, en partant de ceux-ci
- thèse de charlotte : 14 exemples (problèmes mélodiques déjà faits : 8 = jarrell, 9 = all-interval.)

(cf Truchet et Codognet : *Musical constraint satisfaction problems solved with adaptive search*, Soft Computing 8, 2004)

- d'autres problèmes ?