MuM Tutorial

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Introduction

MuM is an algorithmic composition framework. This framework was developed to facilitate the manipulation of music information, when implementing music composition algorithms. The framework is designed around the concept of "Musical Material", an open designation for any length of musical information, which can be manipulated in order to create more complex musical information. In this sense, music material can be a motive, a melody, a chord, a multi-voiced choral, a complete orchestral piece or a single musical interval. In another words, any data from which a composer could extract musical ideas for new compositions. MuM models this idea in a class of objects which can store any combination of notes and voices.

MuM is based on a discrete concept of sonic events, in which a composition is ultimately represented as organized groups of notes. Furthermore, even though there is support for manipulating and storing timbre information, the main focus is on pitch and rhythm organization. Thus, the framework is not particularly useful for music which is centered on continuous transformation of sound. The framework is built with standard (ANSI) C++. Therefore it is easily portable to various platforms in source code form. Its output may consist of either Csound score files or Standard MIDI Files (*TBD*).

MuM is free software. It may be copied, modified and reused in any way, as long as it retains the credits for the original developers (as noted in this document and in source code) in the derived work's source and documentation files. The original MuM implementation was writen by Carlos Eduardo Mello, at the University of Brasilia. Continued maintenance and expansions are currently being implemented by NCM (*Núcleo de Computação Musial*) at UnB. The project is available as opensource thourgh Git Hub.

Tutorial

This tutorial is an attempt to introduce basic ideas behind the design of the **MuM** algorithmic composition framework. As you will see down the road, using MuM is actually very simple and intuitive. You only need two things in order to employ MuM in your composition algorithms: (1) know how to programm in C++ and (2) have a working knowledge of music theory. With these two pre-requisites, you can go through the lessons here and try to grasp the basic feeling for the framework. When you want to know more details about MuM's classes and their methods you can consult the MuM Reference Manual, which shold be found in the same place you found this document.

MuM is small. Some may say it doesn't even deserve to be called a framework. In any case, it is a collection of interrelated classes, which help you define a common ground for developing composition algorithms. Some of these are internal classes which you'll probably never use directly. Others are only used sporadically, depending on your needs. But there are a couple of classes that most programs will use for everything: `MuNote` and `MuMaterial`. These are the classes we will concentrate on, in this tutorial.

Lesson 1 - Defining a Note

Declaring a note in MuM is as easy as declaring any other built in type like *int* or *float*:

```
MuNote aNote;
```

The next thing you need to know is how to define the parameters for that single note. As in many other classes in MuM, this is done by accessor methods. These usually come in pairs, one for *setting* and one for *getting* the data. The "get" methods take on the name of the parameter, starting in upper case; the "set" version simply adds "Set" to this name. Thus, for example, for dealing with the pitch of the note, you would use `Pitch()` and `SetPitch()`.

```
aNote.SetPitch(60);
short thePitch = aNote.Pitch();
```

The code above defines the pitch of middle C (following MIDI pitch format) for the note and then retrieves this value from the note. Besides pitch, MuM uses 4 other fixed parameters: instrument, start time, duration and amplitude. (Beyond these five, extra parameters can be stored through a parameter block - see `MuParamBlock` for more details). So for a full definition of note we would use something like this:

```
MuNote theNote;
theNote.SetInstr(1);
theNote.SetStart(0.0);
theNote.SetDur(3.0);
theNote.SetPitch(67);
theNote.SetAmp(0.5);
```

The lines above define all the built-in parameters for theNote. Instrument numbers are positive integers. 'Start' and 'Duration' are in seconds. 'Pitch' is a 7-bit integer in MIDI pitch format. 'Amp' is a value between 0.0 and 1.0 (For more details, check the **MuM Reference Manual**).

Lesson 2 - Note Output

The **MuNote** class exists mostly to carry note definitions to be modified by the **MuMaterial** class. It has no dynamically allocated members. Even the parameter block it contains is a regular member (which happens to be an object and handle its own internal memory allocation). Instances of the note class are always passed by value or reference. You will use this class whenever you need to generate isolated note data to place in a material object.

Other than the methods we've seen so far, MuNote has a couple of utility features which let us retrieve and debug pitch infomation in Csound format. A call to `CsPitch()` returns the note's octave and pitch class separated in the fields of a structure of type `cs_pitch.` `PitchString()` returns this same information in text form. `CsString()` returns the entire note definition in Csound format. Like this:

```
MuNote note;
note.SetPitch(72);
cs_pitch thePitch = note.CsPitch();
cout << thePitch.octave << "." << thePitch.pitch << endl;
cout << note.PitchString() << endl;
```

The last two lines of code produce exactly the same output to the screen:

```
>  9.00
>  9.00
```

You would use the `struct` when you need to manipulate the octave/pitch class information separately (for example, to transpose the note and octave independently). MuNote also has a special `SetPitch()` method which takes a `cs_pitch` structure as input. This helps when we need to modify pitch class or octave, or both, without worrying about what the original pitch was. For example, to move a minor 15th down (Minor 7th plus octave), instead of trying to figure out the correct pitch number, you could do this:

```
cs_pitch csp = note.CsPitch();
csp.pitch += 2;
csp.octave -= 2;
note.SetPitch(csp);
```

The text form, on the other hand can be useful for building debugging statements or when constructing a Csound score manualy (as you will see further down the tutorial, in most situations MuM does it for you automatically).

Lesson 3 - Notes and Materials

Once you have a note definition there are various methods you can use to place it inside a material object. The simplest one is `AddNote()`. This is how you use it:

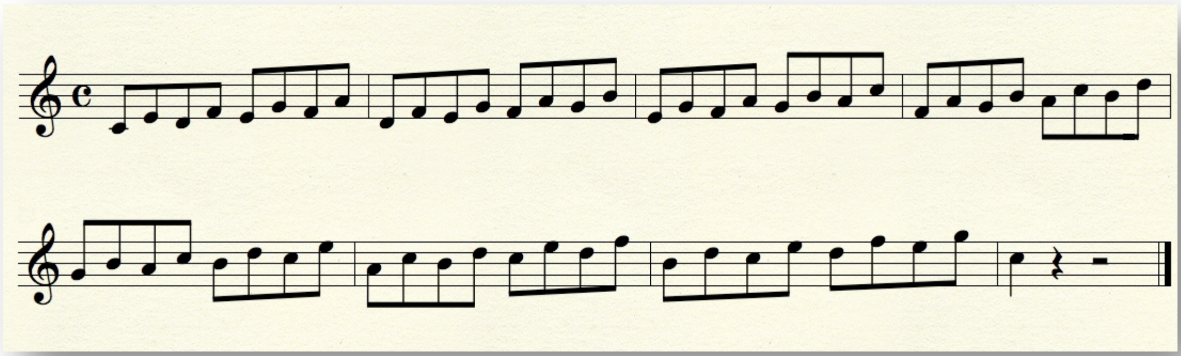
First declare an `MuMaterial` object - your musical material.

```
MuMaterial mat;
```

Then just call `AddNote()` and pass it the note object.

```
mat.AddNote(note);
```

Ok, but... so what? That doesn't do anything! We should try to do something more interesting. Let's say we want to build a sequenced pattern from a major scale. Something like this (**Figure 1**):



Here is one way to do it. First we define the melodic pattern. Then we write a loop to construct the notes for the pattern and place them in a material object.

```
MuMaterial mat, transp, seq;
MuNote note;
int i;
short pattern[8] = {60, 64, 62, 65, 64, 67, 65, 69};

for( i = 0; i < 8; i++)
{
     note.SetInstr(1);
     note.SetStart(i * 0.5);
     note.SetDur(0.5);
     note.SetPitch(pattern[i]);
     note.SetAmp(0.6);
     mat.AddNote(note);
}
```

At this point we have the pattern inside the material. Every note is an eighth-note *(for MM = 60)* with a dynamic range around *mezzoforte.* (By the way, this could be made a little more efficient if we left 'instrument', 'duration' and 'amplitude' out of the loop, since they never change.)

Now we need to sequence this melodic pattern to every scale degree by moving up the scale and transposing the material. It looks like we should use MuMaterial's transposition features. So let's try this:

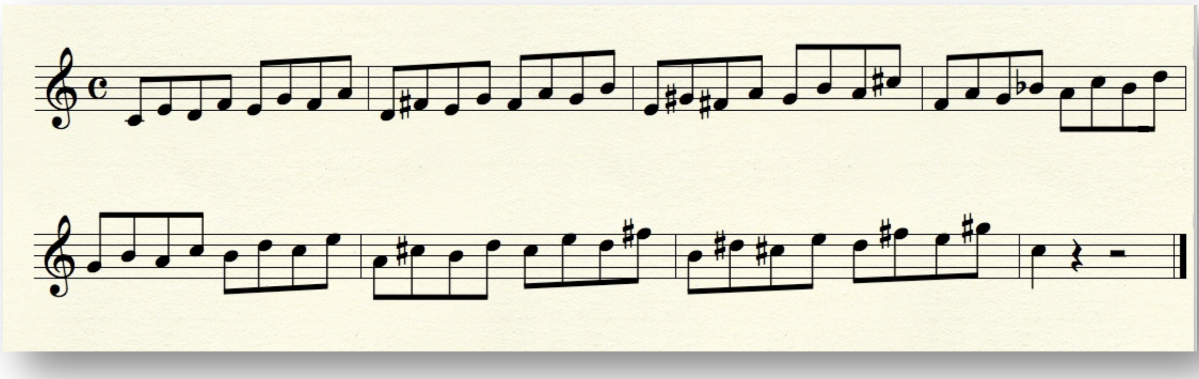
```
short scale[7] = { 0, 2, 4, 5, 7, 9, 11 };

for( i = 0; i < 7; i++ )
{
     transp = mat;
     transp.Transpose( scale[i] );
     seq = seq + transp;
}
```

Here we got the intervals for transposition from the major scale structure. Every entry in the 'scale' array gives the exact interval between the corresponding degree (the array's index) and the first one (index zero). This is the interval to which the melodic pattern should be transposed, for each iteration of the loop. In order to keep the original pattern untouched, we copy it from 'mat' to 'transf', both instances of the MuMaterial class. This is where OOP comes in handy - you can copy any material to any other material without having to deal with its internals, just like you assign an **int** to another **int,** or a **float** to another **float**. After we transpose the contents of our copied material ('transf'), we append it to the sequence by adding it to the 'seq' object, yet another MuMaterial instance.

This looks pretty easy doesn't it? But in fact it doesn't quite do the trick. Try listening to this by writing the Csound score and rendering the sound with a suitable instrument.

```
seq.SetFunctionTables("f1 0 4096 10 1");
seq.Score("transposed.sco");
```

You will notice that the Transpose() method we used, performed a chromatic transposition. In other words, the intervals in the melodic pattern were transposed *exactly* like the original, without regard to the key. This is what it would look like in music notation (**Figure 2**).



In order to build the sequence as illustrated in **Figure 1**, we need to do a diatonic trasposition, that is, instead of moving each note by interval, we should move them by degree. To accomplish this in MuM we need to use the `DiatonicTranspose()` method. This method will take a key, a mode and a scale degree. The key is specified as a regular pitch value (MIDI code). The degree is an integer between 1 and 7. For the mode choice MuM has a couple of constants: `MAJOR_MODE` and `MINOR_MODE.` Theis method works by calculating the degree distance between the first note in the material and the target degree -- the degree we pass to it. Then every note is treated as a degree and transposed by that same number of degrees. If a given note's pitch is not part of that key/mode combination, it is "shifted" to the closest degree for comparison and then, after the degree transposition takes place, it is re-shifted in the original direction.

Figure 3 shows the complete code for our little exercise, using `DiatonicTranspose()`. The example ends with a long 'C', following the sequenced pattern.

```
#include "MuMaterial.h"

int main(void)
{
     MuMaterial mat, transp, seq;
     MuNote note;
     int i;
     short pattern[8] = {60, 64, 62, 65, 64, 67, 65, 69};

     note.SetInstr(1);
     note.SetDur(0.5);
     note.SetAmp(0.7);

     for( i = 0; i < 8; i++)
     {
          note.SetStart(i * 0.5);
          note.SetPitch(pattern[i]);
          mat.AddNote(note);
     }

     for( i = 1; i < 8; i++ )
     {
          transp = mat;
          transp.DiatonicTranspose( 60 , MAJOR_MODE, i );
          seq = seq + transp;
     }

     note.SetDur(1.0);
     note.SetPitch(72);
     transp.Clear();
     transp.AddNote(note);
     seq = seq + transp;

     seq.SetFunctionTables("f1 0 4096 10 1");
     seq.Score("sequenced.sco");

     return 0;
}
```

This method works better for materials which contain only notes found in the key. however, when there are chromatic notes involved, the result seems to be fairly intuitive as well -- the altered notes end up always in the same degrees, instead being transposed to far away keys. You'll probably realize how this kind of feature can be usefull after you modify the original melodic pattern to some other combination of scale degrees. The short code above will sequence it faithfully, no matter what notes it contains. Notice how we don't need the scale definition anymore, since `DiatonicTranspose()` will handle that for us. We just need to tell it which degree to use.

You may also have noticed the call to `SetFunctionTables()` right before writing the score. These "function tables" are used by Csound to store predefined wave forms in memory, for use with its instruments. MuMaterial objects store and carry these around, so they can be placed in the score for playback. Depending on the instruments you play your score with, you may need other tables.