Markov Chains for Music Generation

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Describe your project's research area and why it is interesting/important (e.g., the project is on face recognition ...)

The project will be mostly focused on discovering how to compose unique music fragments from already existing pieces and create a new melody. It will combine Linear Algebra and Markov Chains to create musical compositions using probability vectors.

As we know that Markov Chains show the state change, so in our case, we will have notes/chords, and we need to discover which notes/chords are more probably to become the next finding our its probability.

For generating a new piece of music, we can also use already existing ones from various composers such as Bach, Vivaldi, or Handel.

It is interesting for our team to create similar algorithmic software such as Max, Csound, and SupperCollider, which are used for music composition. It is important for the project to involve P&S and LA courses' knowledge that is important in the musical industry.

Describe the aim of the project and tasks you want to achieve (e.g., develop an automated face recognition system using LA techniques)

The main aim of this project is to develop software for music generation (each user can create the music based on the combination of previous favorite pieces). This approach is further used in AI applications that generate songs for photos or videos based on user preferences.

Describe possible approaches and available solutions (literature review) and explain which method you'll use and why

There are a few major approaches to the problem of generating music. The music obtained from the user should be transformed to the first or n-th order Markov transition matrix.

As the music part does not provide sufficient information to create the music, it will be better to use the transition matrix of second (or higher) order (based on pitch and duration) to predict the next state of the Markov chain based on the previous two for a better phrasal integrity of the resulting piece.

Then generating starts from the initial state, which can be chosen by random or by getting the initial probability vector of every sound object appearing in the music piece.

After constructing the corresponding transition matrix, we use it for predicting next states and thus generating the desirable k-note improvisation of the music piece.

In such way, Markov chains possess a good ability to create that improvisation of the actual music due to the probabilities of the chord/note to be followed by another harmonic chord/note of the same key structure.

Describe the pipeline of the implementation (if any)

1. Input data based on music pieces
    a. Extract the main data from them, chords, duration, etc.
2. Generation of the improvisation of new music pieces

    a. Create a Markov chain and a corresponding transition matrix based on data (1. a).
    b. Building an algorithm for getting the next state (sound object) from the Markov chain.
    c. Apply it to the sample of music pieces.
    d. Testing the algorithm on other samples.
3. Building a web application
    a. Using the first two stages, create a web application where the user can download the music piece and get the generated improvisation.
    b. Creating front-end and back-end for the web application.
    c. Testing it for better performance.
4. Final Report and Presentation
    a. Creating the Final Project Report gathering the theory, application, and implementation of the Markov Chain for generation music pieces and drawing conclusions based on the work done.
    b. Creating Final Presentation.

How will you test your implementation? Do you have the necessary data?

Essentially, all data we need is music, which is everywhere. The only initial processing we will require is to decompose this music into notes/chords etc., depending on the instrument/approach we choose.

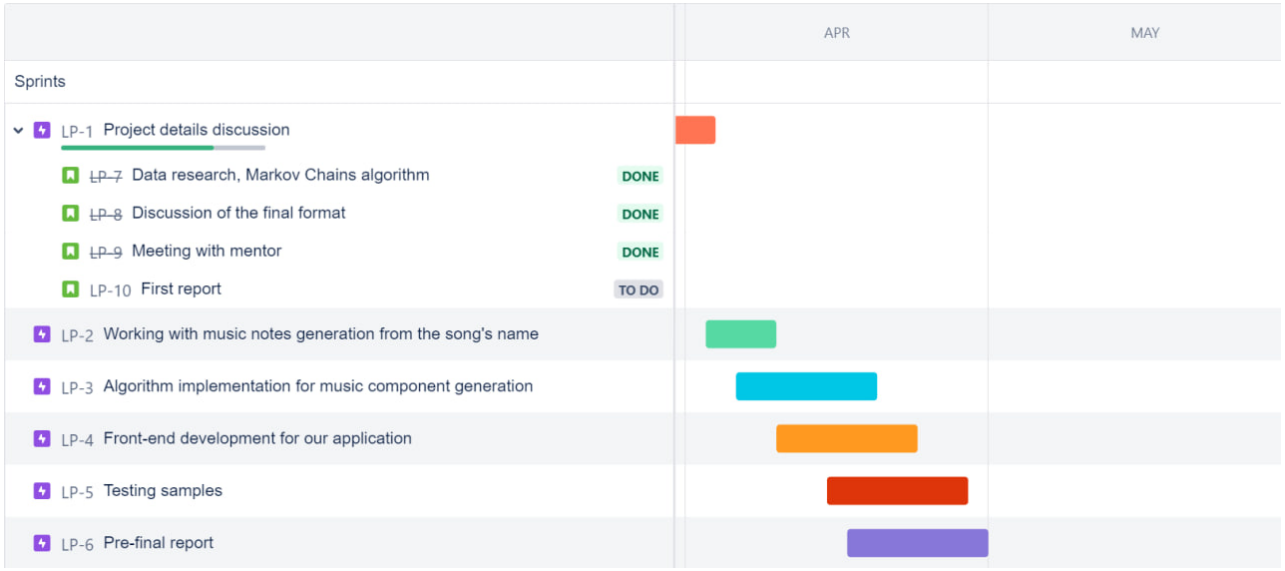
Luckily, for almost every music piece nowadays, it is easy to find the corresponding note sheets on the internet. This is a, so to say, manual approach, which is certainly valid and reliable, but not really convenient.

On the other hand, there is a possibility to use MIDI files to obtain notes' sequences automatically. From what we have seen so far, there also is a sufficient amount of them available for free use on the internet. That was about having the initial data.

To test it, we would simply take the generated sequences and convert them into MIDI files and then into audio format (wav or mp3) to enable listening on any machine. For those purposes, there are corresponding python libraries. In particular, midiutil and midi2audio.

Then we will listen to the results and ponder if we are satisfied with them, or if there is something wrong that needs fixing.

Briefly outline the plan of future research (tasks to perform and time schedule)



Are there any challenges that might hamper your work?

Although we have found significant ground for the project, after further research into the matter, it became apparent that still, challenges remain.

Some of them have a known solution which, however, will require hard work to be put in, and some may pose a sort of a trade-off or a compromise to reach the best result possible.

At this moment, the potential challenges/troubles are as follows:

1. Poor decision-making algorithm may result in primitive, unsophisticated pieces
   a. A small range of notes, primitive patterns, etc is a problem.
   b. All equal sound durations are also a problem (reduces pieces' interestingness)
2. Converting generated note/chord sequences into sensible music
   a. Mapping sequences with time
   b. Setting notes'/chords' durations
   c. Synchronizing multiple instruments
3. Quality MIDI to MP3 conversion
4. Source of a sufficient amount of MIDI files to generate new pieces. Or a script that would decompose MP3 files (possible but unlikely).
5. Technical problems related to not having too much experience with developing web apps yet.

Sources:

- http://www.math.utah.edu/~gustafso/s2019/2270/projects-2016/zhang-bopanna/zhangJie-bopannaPrathusha-MarkovChainMusicComposition.pdf
- https://ocw.mit.edu/courses/21m-380-music-and-technology-algorithmic-and-generative-music-spring-2010/pages/assignments-and-projects/design-report-2/
- https://towardsdatascience.com/markov-chain-for-music-generation-932ea8a88305
- https://dke.maastrichtuniversity.nl/gm.schoenmakers/wp-content/uploads/2015/09/Linskens-Final-Draft.pdf
- https://medium.com/@vanessaseto1/using-linear-algebra-and-markov-chains-to-algorithmically-generate-music-compositions-7dc88edda642
- https://scholarship.claremont.edu/cgi/viewcontent.cgi?article=1848&context=jhm