



# Procedurally Generating Music Using Superposition

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## Our Question

We have come to know and love the music and melodies of our time. From Bach's classical pieces to Coltrane's jazz to Swift's sensations. Music is everywhere and we constantly have melodies in our heads to remind us of a feeling. Think of all the melodies you can hum from movies. All those melodies have a certain feeling that surely couldn't be fabricated by a machine. Or could they?

## What is Our Algorithm

What our algorithm is:

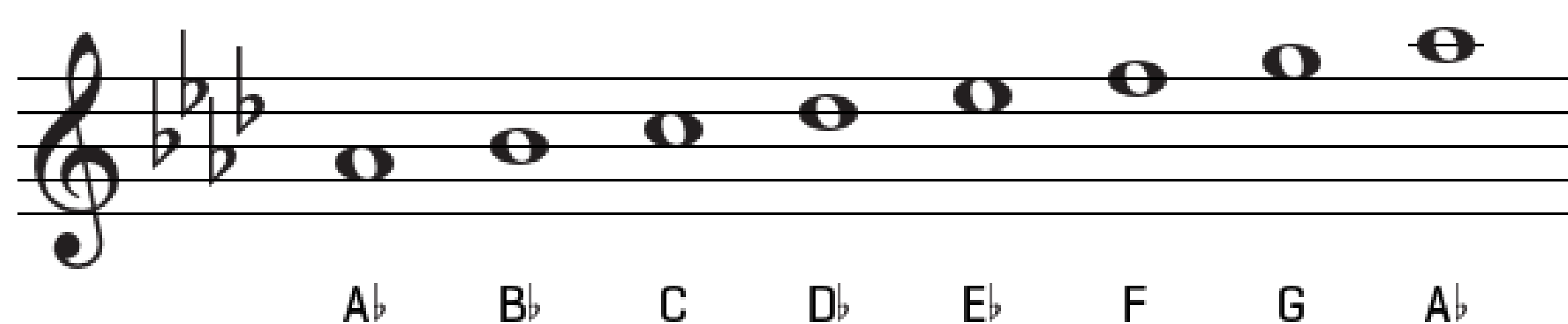
- It creates a melody randomly from nothing
- Is bound to stay within a certain key
- That key is the only restriction made to it beforehand
- As of now, it's a very simple involving simple rhythms and harmonies

Our algorithm was made to make up a melody using as little human input as possible. We could've designed the algorithm to just play whatever notes at whatever time, but that would have sounded like a complete mess. So, in order to organize the music a little more, we told the algorithm to stick to one key and pick randomly inside that key.

- A key in music is just a scale, set of 7 notes, with a note at the "root"
- The root sounds like a resolution
- When "playing is a key", that just means playing notes from that key's scale

For example, the key of A flat is just using these notes

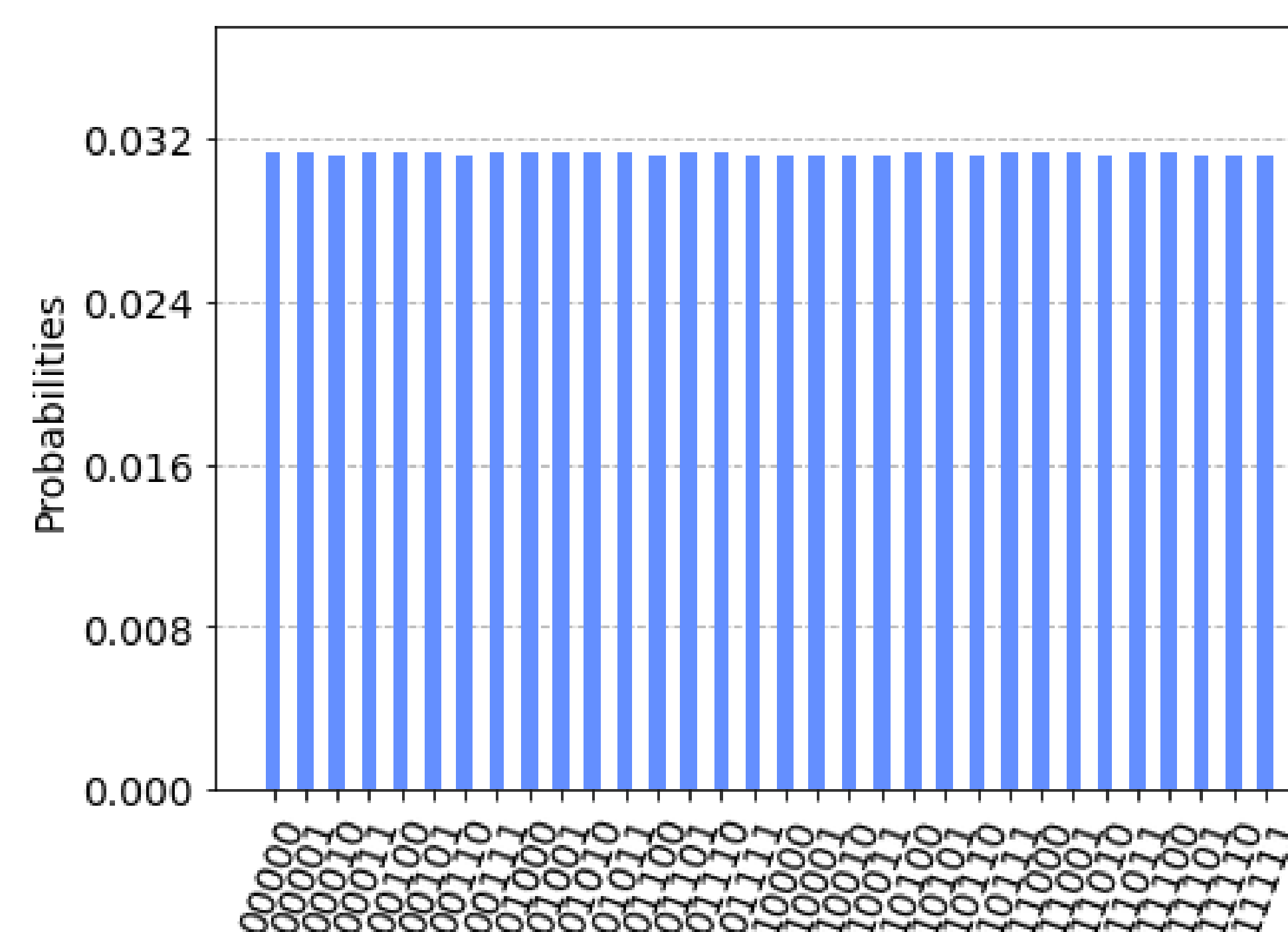
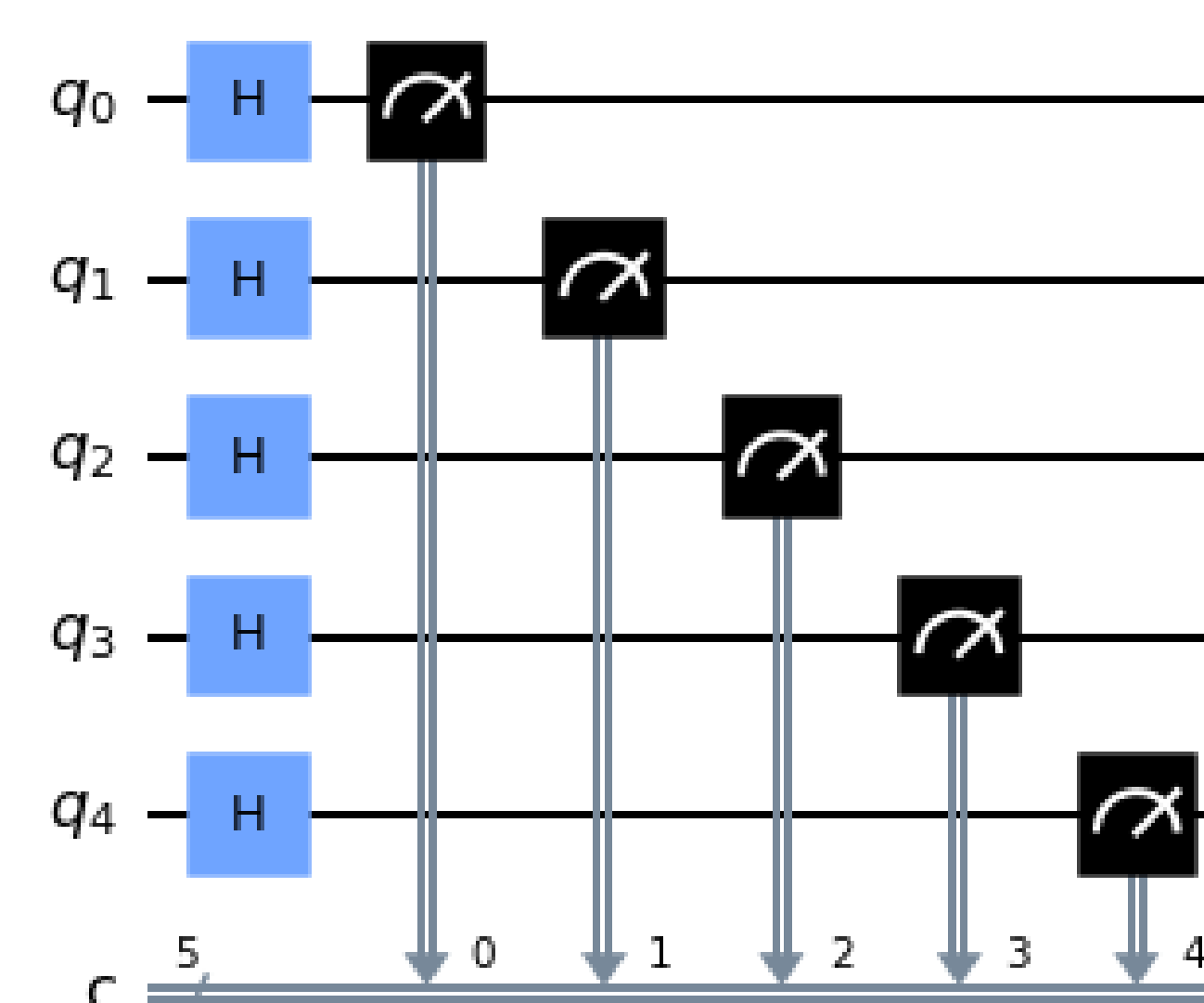
### A flat major scale



## How Does it Work

The code works by first simulating a quantum circuit with five qubits. The code then applies a Hadamard Gate to each qubit, putting each qubit in a superposition of 0 or 1 with a 50% probability of being either. With five qubits being either 0 or 1, this gives 32 possibilities, creating what is essentially a 32-sided dice. Our code makes use of this random number generator to create new music.

The algorithm works by taking in pre-determined factors, such as key, starting note, and the number of notes. Then it uses the scale as a base to randomly choose notes that follow it, with all the notes being contained in the key. However, it will usually not make large octave jumps, and will generally stay around the previous notes pitch. It will also assign a random note length to each note, being either quarter, dotted quarter, or eighth note.



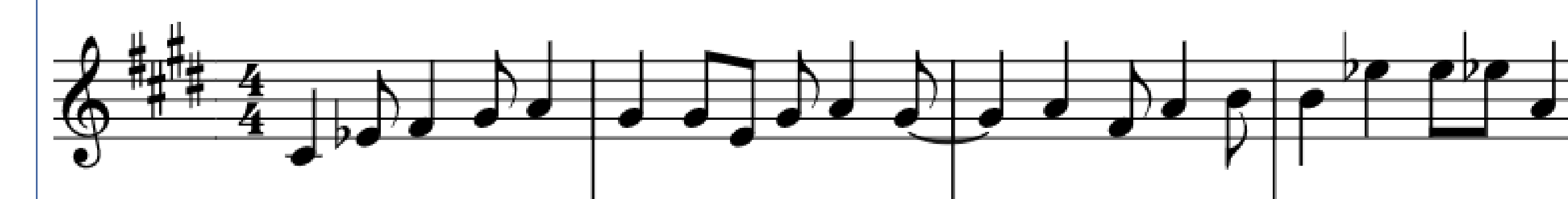
## Results

The algorithm was largely successful. It ended up being able to produce a randomly generated melody within any key that we set. We have examples below of what it produced, translated onto Noteflight.

Struggles:

- Potential octave jumping due to the randomness, which made the melody sound bad
- Not repeating the same simple melodic patterns

Example in C# Minor:



Example in Bb Major:



## Aspirations

While our algorithm is very simple, it can be adapted in many ways to create more interesting and realistic music. As music evolves the algorithm can evolve as well by implementing ideas such as:

- Different, more complex rhythms
- Rests with altering lengths
- Syncopations in the rhythm
- Using multiple keys in one piece of music
- Chromaticism
- Grace notes
- Addition of basslines or counter melodies to go along with the main melody
- More complex harmonies
- Dynamic changes

## Acknowledgements

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