# 2 - Literature Review

## 2.1 - Generative Algorithms - Overview

Generative algorithms appear in many forms, but at their core, they work by pseudo-randomly generating the next step, based on the current step. How the algorithm generates this next step can be based on precomposed music, which the program analyses and works out the musical structure, it can also use a rule-based system, created from music theory, to generate this structure or a combination of these in a hybrid system. In the past decades, there has been a number of variants that have been utilised to produce music, some of which are more appropriate for in-game music generation than others. This section will outline some examples of these and their uses.

### 2.1.1 - Neural Networks

Neural networks were originally inspired by biological networks (Bishop, 1996), mainly the human and the way in which it can processes information with a series of interconnected processing units and can also modify the connection between these units, thus allowing it to learn (van Gerven, 2017). Neural networks have been long been used for pattern recognition, for example, given pictures of letters it would be able to learn to identify, or produce, pictures it was not trained on.

A music sequence would then be an ideal pattern for a neural network to be trained to produce. For example, Colombo et al. (2017) developed a system which produced music in the style of Irish and Klezmer folk, as this is the style they chose to train it on. Or Johnson (2017), who intentionally didn’t give information about the musical domain of the pieces used so the trained network produced more ‘rounded’ music. However, in both of these experiments their chosen analysis method was to look at the distribution of notes compare to the training music, while they found that the produced music was mathematically similar they do not get human experts to evaluate how ‘good’ the music sounds, a common trend in many papers ADD MORE HERE. This is not always the case, for example, Prisco et al. (2017) utilises an algorithmic evaluation and a group of musical expert, whom all had more than ten years in the music field. Who found the music produced was of high quality and stylistically coherent, the expert were also able to point out flaws in the rhythmic elements of the music, giving Prisco et al. avenues for future work. However, as many of these paper’s goals are not focused on producing the music in real-time they make no mention of the time it takes for their systems to be trained, produce the music, or their computational cost. This would make their use in a video-game scenario is questionable.

### 2.1.2 - Genetic Algorithms

### 2.1.3 - Markov Chains

Markov chains are used for modelling a finite number of states and the probability of transitioning between them (Snodgrass and Ontañón, 2014). For example, if a small musical melody is ‘D, D, F#, D, D, E, ’, if the current note being generated is ‘D’, then the next note will have a 50% chance to be ‘D’, a 25% to be ‘F#’ and the same for ‘E’. This process is then applied to an entire piece.

A recent example of this is ‘Rise of the Tomb Raider’ (Crystal Dynamics, 2015) utilising the ‘dynamic percussion system’ (Intelligent Music System), this was originally developed by Brown (2012) for his PhD and utilises a combination of Markov chains, Genetic algorithms, and music theory to produce music at run-time. While the original application was created to produce scored music for piano, it was utilised in ‘Rise of the Tomb Raider’ exclusively for the dynamic percussion, which would react to the various states that the player could find themselves, from being completely hidden and the enemy not being aware of the player, to being engaged in combat. This dynamic drums was then set against precomposed music (Lamperski and Tahouri, 2016)

### 2.1.4 - Other Algorithms

## 2.2 - Music Theory - Overview

This sub-chapter will discuss the various musical rules that can be utilised in narrative elements of video games, and the ways in which music can be used to directly affect the player’s experience of a game.

### 2 - Brightness

When composing a piece of music with a particular emotional theme, a common technique is to use a major scale if the song is to have a positive feel and a minor scale if it is to be negative. This is actually an example of the concept of musical ‘Brightness’, in regards to major and minor scales they are actually part of a larger group of seven modes, in decreases brightness these are;

* Lydian
* Ionian (or major)
* Mixolydian
* Dorian
* Aeolian (or minor)
* Phyrigian
* Locrian

These mode can then be used

Musical brightness can also be changed by other factors can increase brightness

* Increase in pitch
* Tempo
* Rhythmic density

(Jayden Chan *et al.,* Oct 2017)

### 2 - Music Theory