**DOKUZ EYLÜL UNIVERSITY**

**GRADUATE SCHOOL OF NATURAL AND APPLIED SCIENCES**

**TURKISH MAKAM MUSIC COMPOSITION BY USING DEEP LEARNING TECHNIQUES**

**by**

**İsmail Hakkı PARLAK**

**August, 2021**

**İZMİR**

**TURKISH MAKAM MUSIC COMPOSITION BY USING DEEP LEARNING TECHNIQUES**

**A Thesis Submitted to the**

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**Philosophy in Computer Engineering**

**by**

**İsmail Hakkı PARLAK**

**August, 2021**

**İZMİR**

**Ph.D. THESIS EXAMINATION RESULT FORM**

We have read the thesis entitled **“TURKISH MAKAM MUSIC COMPOSITION BY USING DEEP LEARNING TECHNIQUES”** completed by **İSMAİL HAKKI PARLAK** under the supervision of **PROF. DR. YALÇIN ÇEBİ** and we certify that in our opinion it is fully adequate, in scope and quality, as a thesis for the degree of Doctor of Philosophy.

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İsmail Hakkı PARLAK

**TURKISH MAKAM MUSIC COMPOSITION BY USING DEEP LEARNING TECHNIQUES**

**ABSTRACT**

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**Keywords:** Deep learning, Turkish Makam Music, artificial intelligence, algorithmic music composition, artificial composition.

**DERİN ÖĞRENME TEKNİKLERİ KULLANILARAK TÜRK MAKAM MÜZİĞİ BESTELENMESİ**

**ÖZ**

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Anahtar kelimeler: Derin öğrenme, Türk Makam Müziği, yapay zekâ, algoritmik besteleme, yapay besteleme.

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# CHAPTER ONE

# INTRODUCTION

## Overview

Human beings have embraced artistic creativity as a faculty of their existence. The human mind, which has evolved through time, has made aesthetic beauty a part of its creations and has turned it into a symbol of advancement. Music, just like architecture, literature, and other forms of fine arts, has become the stamp of nations and reflected their history, culture, sentimental life, and experiences. Throughout history, great composers of various cultures either exploited conventional methods or invented new techniques to create new music. Canonic composition in the late 15th century (Burkholder et al., 2010) and Mozart’s *dice music* (Parlak & Kosemen, 2018) are examples of algorithmic composition before the invention of the computer.

Deep learning is a fast-growing domain which mostly focuses on solving classification and prediction problems (Briot et al., 2017). Availability of relatively low-cost general-purpose graphics processing units (GPGPUs) and huge amounts of data enabled researchers applying deep learning techniques on a wide spectrum of problem sets such as self-driving cars, machine translation, speech recognition and artistic creation.

Google’s “Deep Dream” attracted very broad attention in 2015 by creating psychedelic artistic images. Music, as being another form of art, is still in progress of investigation by deep learning researchers. However, even though there are a few examples of classification projects, Turkish Makam Music (TMM) drew very few researchers’ point for automatic composition. In this study, automatic TMM composition by using deep learning techniques will be attempted.

Music can be thought as a combination of temporal and spatial interplay. Different vibrations produce different musical notes and sequential placement of musical notes in certain durations produce music. Each cultural system has its own music rooted from its history and environment. Tuning systems and structure of music can greatly vary from culture to culture.

Classical Western Music (CWM) and Turkish Makam Music can be very easily distinguished even by an untrained listener. The most noticeable difference between TMM and CWM is CWM revolves around chord progressions whereas TMM focuses on melody. Although being monophonic, TMM is very rich in creating melodies for different purposes in a wide variety of musical modes called “Makam”s. Makams are modal structures, where the melodies begin to form around an initial note and end around a final note (Ederer, 2011).

TMM is taught orally for centuries (Uyar et al., 2014). For this reason, musical rules have not fully settled yet, hence, performances of classical TMM pieces can differ from performer to performer. Also, TMM tuning system is not 100% standardized unlike CWM. There are different theories about how TMM tuning system should be. Today, the most common system is Arel-Ezgi-Uzdilek (AEU) theory (Arel, 1968). The AEU theory divides a whole tone into 9 equidistant intervals, whereas CWM divides a whole tone into 2 equidistant intervals (Uyar et al., 2014). Expanding this knowledge, in CWM an octave is divided into 12 intervals (Şentürk & Chordia, 2011), whereas in TMM, suggestions for octave division fractions vary between 17 to 79 (Yarman, 2008). Considering these differences and many more, TMM is very different than CWM and should be treated differently in the field of computation.

## Purpose

The essential incentive of this work is investigating the complex and delicate matter of artificially composing Turkish Makam Music (TMM), and hopefully, providing a preliminary solution to it by implementing a deep learning (DL) based system.

This research’s main purpose is composing new TMM songs similar to past pieces by using deep learning and fill this gap in literature. The resulting songs may induce new ideas for TMM composers or be a source of art and entertainment. Existing deep learning techniques are going to be studied and evaluated for TMM composition and are going to be improved in case of necessity. Also, this research may build a foundation for other researchers who are willing to work on this domain.

Computational research on TMM is very few and is mostly trying to solve classification problems. This research will apply state of the art methods and technologies for automatic TMM composition.

Secondary purpose of this research is to enhance existing datasets on TMM by adding more pieces which have written musical sheets but not converted to computable format yet. All source code, results and training set will be released open source having MIT license on GitHub.

Finally, the resulting trained system will be able to produce mp3 files and digital representations of automatically composed songs. A listenable result is much more functional than a musical sheet without the audible song.

## Contribution to Literature

Lorem ipsum.

## Organization of the Thesis

This chapter, the overview, problem definition, and objectives of the thesis and the contribution to the field are stated. The general aim of this section presents a summary of exactly why this work was done and the motivation of the thesis. The rest of the thesis is given in the following paragraphs.

General information about three important areas used in this study is given in Chapter 2 of this thesis. These areas are WSNs, Semantic web technologies, and machine learning. This section aims to conduct a detailed examination of these academic fields, which have been researched, discussed and subject to this thesis for a few last decades.

Finally, conclusions and discussion of the findings obtained in previous chapters are presented in Chapter 7. Also, this chapter contains future directions of the thesis, recommendations for more efficient sensor ontology in after studies.

# CHAPTER TWO

# LITERATURE REVIEW



## TMM History

In his book, Tıraşçı (2019) gave voice to the history of Turkish music. According to his work, before the Huns, Turks were located at the northern and southern regions of The Tian Shan (Tengri Mountains). Around 2000 BC, Altai Mountains and Siberia became two significant sites for Turks. At that time, music was performed only by the religious men, who were known as Shamans, for protection, spiritual and healing purposes.

At the age of Huns (3rd century AD), Turks used the pentatonic scale. And, later, music became militarized. Military music was institutionalized; thus, the repertoire and the musical activity grew in return. At the age of Göktürks (6th century AD), Turks became neighbors with cultural centers such as China, Persia, Byzantine, and India which led Turkish music to progress in terms of genre and form. Also, at the age of Göktürks, music was a part of Khan’s (The leader) assemblies. At these assemblies, musicians payed greater attention to the artistic aspect of the performed music which led to separation of art and folk music. At that era, Turkish music got rid of being used only for religious purposes and started to appeal to perceptions such as pleasure and aesthetics.

Uygur Turks (8th - 9th century AD) used 7 tone - diatonic scale and later, they began using the 12 - tone chromatic scale. The oldest Turkish musical note system belongs to Uygur Turks, in which every musical note was represented by a symbol from the Uygur alphabet. Before adopting Islam, Turkish music genres were:

* Religious music: Shamans used to utter sacred words in a musical manner. They used drums and various percussive instruments to accompany their ceremonies.
* Tuğ music: This genre was performed during military and official ceremonies. Various percussion, cymbals and horn instruments were used. It is believed to be the ancestor of Mehter music.
* Heroic, epic music: This type of music was revolving around epic and heroic events and tales. It was used to increase the mood of community and soldiers. It also served as transferring historical knowledge to future generation.
* Toy music: This genre was performed by palace’s musicians at the important formal events such as receiving ambassadors or accession to the throne.
* Daily life music: This genre was performed by the folk which expressed their feelings of love, pain, sorrow, or longing.
* Yuğ music: This genre was performed after events of death of beloved ones to express sorrow and grief.
* Hunting music: When presidents were going out for hunting, Turks used to pitch tents and sing sacred words for the hunt’s abundance. This custom continued even after Turks adopted Islam.

After meeting with Islam, Turkish music heavily interacted with Arabic / Islamic music and evolved significantly. Al-Kindi (9th century) was the first to write on music theory amongst Muslim philosophers. He related musical notes to celestial bodies and systematized Islamic music. He inspired Al-Farabi and Avicenna (Ibn-Sina).

Al-Farabi (10th century), studied music through the works of Grecian philosophers and Al-Kindi. He corrected missing and erroneous theoretical information of Greek philosophers and made exceptional studies on physics of music.

Safiyuddin Urmevi (13th century) solved the problem of temporal representation in music with his musical notation system. Before him, there was no representation for temporal information of music. He placed numbers below musical notation and solved the issue of temporal representation. He also invented two musical instruments called Nüzhe and Muğni. He was first to use the term devir (cycle) to represent various scales such as Uşşak, Neva, Rast, Hicaz, etc.

Mahmud Şirazi (14th century) was one of the first who used the term Makam. In his works, he mentioned of 17 Makams and their scales.

Until the 15th century, there was no distinction between Turkish, Persian, and Arabic music. But after 15th century, Turkish artistic and cultural thought began to find its own place within the new and emerging theoretical studies. Yusuf bin Nizameddin (15th century) wrote up the first Ottoman musical theoretics known as Risale-i Musiki. He believed that the movement of the Universe created harmonious sounds which form the basis of music. Inheriting Al-Farabi’s thoughts, he defined 12 Makams which relate to 12 zodiacal constellations.

At 18th century, Kutbü'n Nâyî Osman Dede developed a new musical notation system and created various writings on music theory. He also composed the largest musical piece in terms of structure and duration.

In 20th century, Anatolia was housing to three different types of musical groups. The first group was dealing with western music, whereas the second one was advocating the traditional Turkish music. And the last group was trying to combine the two. Up until the 20th century, the innovations that emerged in matters such as the sound system, pitches and Makams could not be based on solid foundations. Because of this, theoretical studies on Turkish music were speeding up in Anatolia. Rauf Yekta Bey studied the theory of Turkish music, which has been neglected for five centuries, and laid the foundations of the system used today.

Hüseyin Sadeddin Arel used the accidental symbols we use in written music today. He divided a whole step into 9 commas, which added up to 54 commas per octave. But he didn’t use all of them and chose 24 usable pitches per octave. Arel’s system is being used and thought in today’s conservatoires. Some may argue that Arel’s system depends on Western music theory rather than Turkish music, or it may lack representing the musical performance, but it is the most widely used system in Turkey today.

Gültekin Oransoy suggested a 29 – tone system by extending Arel’s system, which has 24 tones. But this system was not used by the performers and only remained in books due to his lack of recognition in Turkey.

## TMM & Western Music

There are many existing books and thesis on theory and applications of TMM such as [4, 7, 8]. These publications explain the theory of TMM and its makams. The most comprehensive end-user software for TMM is Mus2 (Data-Soft, n.d.). Mus2 allows its user to write and listen to microtonal music, which is very essential for TMM. Mus2 is a commercial software bundled with Mus2okur, which is a digital education platform for TMM (*Mus2okur*, 2007).

Having a well-formed and large dataset is a key for success in deep learning, but there are very few available sources for TMM. The largest and probably the best machine readable TMM digital data source is SymbTr (Karaosmanoğlu, 2012). SymbTr data set contains 2200 pieces from 155 makams, about 865.000 musical notes and 80 hours nominal playback time. SymbTr scores are provided in text, MusicXML, PDF, MIDI and mu2 formats (Şentürk, 2017).

## DL & Music

In their survey, Fernández and Vico classified music generation systems under 6 categories as:

* Grammars: based on rules.
* Symbolic, Knowledge-Based Systems: again, rule based systems.
* Markov Chains: state transitions with probabilities without memory.
* Artificial Neural Networks: recurrent neural networks can remember previous relations hence can process temporal data.
* Evolutionary and Other Population-Based Methods: create generations and select best fit.
* Self-Similarity and Cellular Automata: combination of randomness and rules. (Fernández & Vico, 2013)

Temporal relationship is a fundamental feature in music. Similar to natural language processing, the next token, musical note in this case, is highly dependent on previous tokens. This fact increases the rationality of using recurrent neural networks since they outperform other methods in temporal domain.

In their paper, Choi et al. state that Hidden Markov models (HMMs) are suitable for predicting time series but they have a limited memory. In order to overcome the memory limit and remember long term dependencies without vanishing gradient problem they propose Long Short-Term Memory (LSTM) systems for music composition. They show that using char-RNN and word-RNNs alongside LSTMs can produce conventional results (Choi et al., 2016).

Oord et al. introduce WaveNet in their work, which is a novel study generating raw audio (Oord et al., 2016). WaveNets can produce state-of-the-art results when applied to text-to-speech and also is able to generate novel and realistic audio waveforms when trained with piano performances. They state that WaveNet is based on PixelCNN and it operates on 16000 samples per second audio files. Their results are accessible at <https://deepmind.com/blog/wavenet-generative-model-raw-audio/>.

Briot et al. describe deep learning techniques for music generation in their book (Briot et al., 2017). Their research received funding from the European Research Council and it is a comprehensive study which is going to be studied in thesis phase.

There are popular, open source and well-maintained software and frameworks for deep learning and music composition. One of the most popular libraries for deep learning is TensorFlow (*TensorFlow*, n.d.). TensorFlow is a Python API capable of running on both CPU and GPU. Keras is a high-level neural networks wrapper Python API and capable of running on top of TensorFlow and other several libraries (*Keras: The Python Deep Learning Library*, n.d.). Keras makes it easier to work on neural network programming. Finally, Magenta is a project from Google which is specialized on generating art by deep learning (*Magenta*, n.d.). Again, Magenta can run on both CPU and GPU.

## Evaluation Methods

For evaluating the outcome of their generative system, Shin et al. (2017) resorted to human evaluators. They obtained information on human evaluators’ musical background and then they asked evaluators to choose the most organic and well-structured sounding sample within a set of various pieces. This set contained samples from both authors’ and similar studies’ results. Then as an additional step, they carried a Turing Test (Turing, 1950) on participants to find out whether they could differentiate authors’ machine-made musical compositions from human made ones or not.

Marinescu (2019) performed experiments with different types of neural networks and network configurations. To compare and evaluate different generative models, they investigated training loss values and validation accuracy percentages.

Liang, Gotham, Johnson, & Shotton (2017) evaluated their study by means of an online survey. In their survey, they collected participants’ age and level of musical expertise information. Then they presented various synthetic, and human made music to participants without telling them their origin and asked them to determine which is synthetic and which is organic.

To evaluate their generative system, Chu, Urtasun & Fidler (2016) conducted a survey amongst 27 participants. They asked participants to compare their results with results of Google’s Magenta (Brain Team, 2020). They also collected participants’ commentaries on reasoning behind their decisions.

# CHAPTER THREE

# DATASET



## Dataset Selection

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## Dataset Preparation & Representation

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## Dataset Expansion

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# CHAPTER FOUR

# ATMMC



## Base Models

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## Composer Models

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# CHAPTER FIVE

# GUI



## Design

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## Working Principles

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# CHAPTER SIX

# RESULTS & EVALUATION



## Results

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## Evaluation

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# CHAPTER SEVEN

# CONCLUSION AND FUTURE WORK



## Conclusion

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## Future Work

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