**DOKUZ EYLÜL UNIVERSITY**

**GRADUATE SCHOOL OF NATURAL AND APPLIED SCIENCES**

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

**by**

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**İZMİR**

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

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**by**

**İsmail Hakkı PARLAK**

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

**ABSTRACT**

In recent years, sensors have become smaller enough to be used in every system, positive developments in the academic environment, and a decrease in prices have increased the interest in sensors. Sensor-based systems have spread rapidly to all areas of daily life, especially in industrial areas. Massive amounts of raw sensor data from sensor-based systems, the area of use of which has increased considerably, pose a fundamentally new set of research challenges, including their structuring, sharing, and management in a common framework. Although there are many academic studies on the integration of sensor data between different sensor-based systems, these studies focused on the integration of the data as syntax rather than semantic integration.

Nowadays, the semantic sensor web approach, which enables us to enrich the meaning of sensor data in order to provide more advanced access to sensor data and add annotations, has been seen by some researchers as a critical technology in solving these problems. The grand goal of this thesis is to provide a standard data model for heterogeneous sensor data from different platforms by extending the ontology of semantic sensor networks. The proposed system was tested using 8 indoor parameters collected in the Application and Research Center and Intensive Care Unit within Abant Izzet Baysal University. Sensor data collected from selected use-cases were added to the proposed framework and an RDF data set was created. Classic machine learning algorithms have been implemented on the RDF data set created and compared from different angles.

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

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

**ÖZ**

Son yıllarda, sensorların her sistemde kullanılabilecek kadar küçülmeleri, akademik ortamdaki olumlu gelişmeler ve fiyatların düşmesi sonucu sensorlara duyulan ilgiyi arttırmıştır. Sensor tabanlı sistemler Endüstriyel alanlar başta olmak üzere günlük yaşamın her alanına hızla yayılmıştır. Kullanım alanı önemli ölçüde artan sensor tabanlı sistemlerden elde edilen çok fazla miktarda ham sensor verisi, ortak bir çerçevede yapılandırılması, paylaşılması ve yönetilmesi de dahil olmak üzere temelde yeni bir dizi araştırma zorlukları ortaya çıkarmaktadır. Sensor verilerinin farklı algılayıcı tabanlı sistemler arasında entegrasyonu konusunda bugüne kadar pek çok akademik çalışma bulunsa da bu çalışmalar genel olarak verilerin anlamsal entegrasyonu yerine sözdizimi olarak entegrasyonuna odaklanmıştır.

Günümüzde, sensor verilerine daha gelişmiş erişim sağlamak ve ek açıklamalar eklemek için sensor verilerinin anlamını zenginleştirmemizi sağlayan anlamsal sensor web yaklaşımı, bazı araştırmacılar tarafından bu sorunların çözümünde kritik bir teknoloji olarak görülmüştür. Bu tezin en büyük amacı anlamsal sensor ontolojisini genişleterek farklı platformlardan gelen heterojen sensor verileri için standart bir veri modeli sağlamaktır. Önerilen sistem Abant İzzet Baysal Üniversitesi bünyesinde bulunan Uygulama Merkezi ve Yoğun Bakım Ünitesinde toplanan sensor verileri ile test edilmiştir. Seçilen kullanım durumlarında toplanan sensor verileri önerilen çatıya eklenmiş ve RDF veri seti oluşturulmuştur. Oluşturulan RDF veri seti üzerinde klasik makine öğrenmesi algoritmaları entegre edilmiş ve farklı açılardan karşılaştırılmıştır.

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

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# CHAPTER ONE

# INTRODUCTION

## Overview

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.

## Problem Definition

WSNs provide many advantages over traditional methods in terms of self-organization, fast transmission, flexibility, and secure data transmission.

## Objectives of This Thesis and Contribution to Literature

These objectives may be separated into two categories as general and specific objectives. The objectives and scope of Lite are as follows.

### General Objectives

These objectives are related to data science, data mining, machine learning, wireless communication, electromagnetic systems, and embedded systems.

### Specific Objectives

The specific objectives of includes the use-case environments where the proposed ontology is implemented.

## Thesis Organization

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

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.

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.

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