Vol. 17, No. 1, 2022. ISSN 1840-1503

TECHNICS TECHNOLOGIES EDUCATION MANAGEMENT

TTEM

JOURNAL OF SOCIETY FOR DEVELOPMENT OF TEACHING AND BUSINESS PROCESSES IN NEW NET ENVIRONMENT IN B&H

ISSN 1840-1503
9 771840 150002

TECHNICS TECHNOLOGIES EDUCATION MANAGEMENT

EDITORIAL BOARD

Editor: Dzafer Kudumovic
University of Sarajevo, (Bosnia and Herzegovina)
Lana Kudumovic
Fatih Sultan Mehmet Vakif University, (Turkiye)

Secretary: Nadja Sabanovic

Technical editor: Eldin Huremovic

Lectors: Mirnes Avdic, Adisa Spahic

Members:
Klaudio Pap
University of Zagreb, (Croatia)
Nikola Mrvac
University of Zagreb, (Croatia)
Damir Modric
University of Zagreb, (Croatia)
Davor Zvizdic
University of Zagreb, (Croatia)
Janez Dijaci
University of Ljubljana, (Slovenia)
Tadeja Zupancic
University of Ljubljana, (Slovenia)
Rajendrakumar Anayath
University of Science & Technology, (India)
Anastasios Politis
International Hellenic University, (Greece)
Jelena Ivanovic Sekularac
University of Belgrade, (Serbia)
Nebojsa Vidanovic
University of Belgrade, (Serbia)
Hasan Hanic
Union University in Belgrade, (Serbia)
Samir Causevic
University of Sarajevo, (Bosnia and Herzegovina)
Amir Pasic
University of Sarajevo, (Bosnia and Herzegovina)
Vesna Maric-Aleksic
University of Banja Luka, (Bosnia and Herzegovina)
Isad Saric
University of Sarajevo, (Bosnia and Herzegovina)
Vahidin Hadziabdic
University of Sarajevo, (Bosnia and Herzegovina)
Muharem Sabic
University of Sarajevo, (Bosnia and Herzegovina)

Address of the Editorial Board: *Sarajevo, Bolnička bb*
phone/fax 00387 33 640 407
ttem_bih@yahoo.com, http://www.ttem.ba
Published by: *DRUNPP, Sarajevo*
Volume 17 *Number 1, 2022*
ISSN *1840-1503*
e-ISSN *1986-809X*

Table of Contents

The Integration of the Flavor Imitation with Moral Virtue Education

Guangyong Zhu, Genfa Yu
Shanghai Institute of Technology, Shanghai, PR China

Abstract

Flavors have been widely used in many products, and play a crucial role in food industry. Flavor Imitation is a basic curriculum providing comprehensive information about how to construct flavor formula and how to imitate flavors with natural and synthetic aroma raw materials. It is a compulsory curriculum opened for student whose major is flavor and fragrance technology and engineering. The mission of the university is not only to impart professional knowledge but also to cultivate and educate students. In order to better strengthen moral virtue education and cultivate students, moral virtue elements were integrated into the teaching process of flavor imitation. By the integration of flavor imitation with moral virtue education, students could not only grasp the knowledge of how to construct flavor formulas, but also could be fostered the rule awareness. Furthermore, this learning process is also helpful to make students always endeavor to do still better, train students to consider things from every angle, and will help train student to form unceasingly the enterprising habit. After a period of exploration and practice, it proved that the integration of flavor imitation with moral virtue education can result in a coordinated development of professional knowledge and moral virtue.

Key Words: *teaching exploration; flavor imitation; moral and virtue education; professional course*

1. Introduction

Flavors have been widely used in many products, such as baked goods, chewing gum, frozen dairy, gelatines, puddings, jams, condiments, relishes, alcoholic and nonalcoholic beverages, snack foods, gravies, and candy. Flavors also play a crucial role in food industry and in driving consumption. Flavoring agents and adjuvants are defined as substances added to impart of help impart a taste or aroma in food by the U.S. Food and Drug Administration (Burdock, 2010). Flavors are mixtures blended with various aroma materials of natural and synthetic origin based on formula. Flavor and fragrance formulas are usually trade secrets in flavor and fragrance industries. Flavor imitation is a new course introduced for undergraduate students in the second year in Shanghai Institute of Technology. It is a compulsory course for flavor and fragrance technology and engineering major. Flavor Imitation is a basic course providing comprehensive information about how to construct flavor formula and how to imitate flavors with natural and synthetic aroma raw materials. This course teaches students how to design and create a flavor by selecting various aroma ingredients. The prerequisites include a background in Flavor Compounds Chemistry and Organic Chemistry. The most important thing is that students should be familiar with the odor characteristics and applications of various synthetic and natural aroma raw materials prior to taking this course.

The mission of the university is not only to impart professional knowledge to students but also to educate and cultivate students (Yu and Zhu, 2021). When teachers impart professional knowledge to students, they must also teach students how to behave and achieve the educational goal of cultivating students at the same time (Zhu et al., 2021). It is necessary to persist in taking the morality and cultivating students as the key point, put ideological work throughout the whole process of teaching, and realize full direction system of education and cultivating students in the whole teaching process. Professionals majoring in flavor and fragrance technology and engineering must not only have profound professional knowledge, but also have good moral accomplishment. In order to better strengthen moral virtue education and cultivate students, moral virtue elements were integrated into the teaching process of flavor imitation.

2. Methods

The aim of the study is to better strengthen moral virtue education and cultivate students in the teaching process of professional course. Moral virtue elements, such as the rule awareness, consciousness for ever greater perfection, and the enterprising habit, were integrated into the teaching process of flavor imitation. After a period of exploration and practice, the following experiences on the integration of moral virtue education into flavor imitation were summarized.

3. Results and discussion

3.1 Foster students the rule awareness

Flavor formula construction is one of the main contents in this course. Flavor safety is of utmost importance to everyone around the world. When selecting raw aroma materials for designing flavor formula, students are cultivated to obey the regulation and standards. In China, all food additives are described in the National Food Safety Standard and the Standard of Using Food Additives (GB-2760). The principles of use of aroma components are stipulated in this standard. The permitted aroma components, the range of use and the maximum amount or residual amount of these components are specified in GB-2760. The raw aroma materials for blending flavors must be permitted in the standard GB-2760 in China. Otherwise, even if a raw material has a good aroma, it cannot be adopted as an ingredient in the formula for blending a flavor. Furthermore, the aroma ingredients used for blending flavors should meet the corresponding quality specifications. The amount of aroma ingredient in food should not exceed the maximum allowable amount. The purpose of the addition of flavors in food is to produce, change or improve the taste or aroma of food. The amount of flavors used in food should be as little as possible on the premise of achieving the desired purpose. Of course, flavors are banned from some foods such as sterilized milk, rice, and fresh fruits in China. This learning process not only teach students how to select aroma ingredients for designing formula and constructing flavors, but can also enhance the rule awareness.

3.2 Make students always endeavor to do still better

Dairy product flavor imitation is another main content in the course. Dairy products are various products made from cow milk, goat milk as the main raw materials. The main dairy products include milk, cream, butter, condensed milk, yogurt, cheeses and so on (See Figure 1). These dairy products have different flavors.

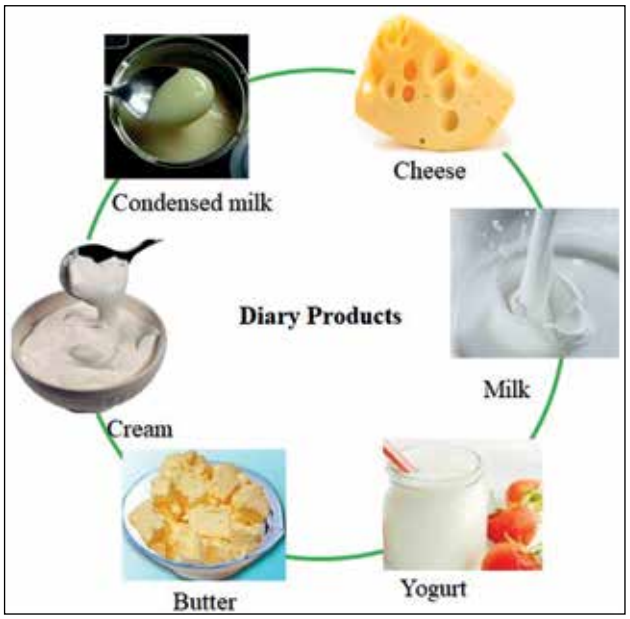

Figure 1. The dairy products

Milk is a whitish liquid containing proteins, fats, lactose, and various vitamins and minerals. The fresh milk we usually eat is pasteurized milk. Cream is the yellowish fatty component of unhomogenized milk that tends to accumulate at the surface. Animal whipped cream is obtained by separating the fat in milk. Butter is a soft whitish or yellowish fatty solid that separates from milk or cream when it is churned. Vigorous agitation of the milk or cream can cause the protein film of the milk fat globule to rupture, and the milk fat flows out of the globule. After losing the protection of protein, fat and water separate. Fats slowly float up, gather, and become pale yellow. The upper layer of fats is separated and squeezed to remove water. Thus, the butter is obtained. Condensed milk is a dairy product and a beverage made from fresh milk or goat milk after sterilization and concentration. Usually the fresh milk is vacuum concentrated to remove most of the water.

Its characteristic is that it can be stored for a long time. Yogurt is a tart, custard-like dairy product made from milk curdled by the action of bacterial cultures. Cheese is a solid fermented dairy product prepared from the pressed curd of milk.

Different dairy products have different processing techniques, so different chemical reactions occur during the processing. The chemical reactions in dairy products processing include enzymatic hydrolysis reaction, thermal reaction, oxidation reaction, microbial fermentation reaction and so on. It is these reactions that produce aroma components. Fatty acids can be obtained by enzymatic hydrolysis of milk fats. Especially some short-chain fatty acids can enhance milk flavor. Fatty acids are dehydrated by thermal reaction and some aroma products such as ketones and lactones can be obtained. Sugars and amino acids undergo Maillard reaction under heating and some aroma sulfur-containing and nitrogen-containing compounds can be produced. Some aroma aldehydes can be obtained by oxidative cleavage of unsaturated fatty acids. Lactic acid, aroma alcohols and esters can be produced by microbial fermentation of sugar and lactose. Different dairy products have different aroma characteristics due to the various reactions in different processes. When simulating the odor of dairy product, students should know the influence of chemical reaction in the processing of dairy products on aroma substances. The odor characteristics of various dairy products should be grasped. Furthermore, the odor characteristics of raw material should be very familiar. δ-Lactones, such as δ-dodecalactone, δ-decalactone and δ-undecalactone (see Figure 2) have milky aroma. These δ-lactones can be adopted in flavor formula to provide milky note.

Some ketones, such as pentanedione, butanedione and 3-hydroxy-2-butanone (see Figure 3) have buttery aroma. These ketones can be selected in flavor formula to provide buttery note (Burdock, 2010; Surburg and Panten, 2006).

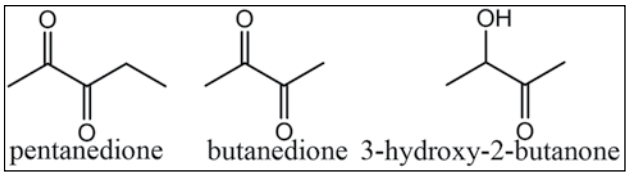

Figure 3. The chemical structures of three ketones

Although these aroma compounds with milky note and buttery note can be used as the main raw material for blending flavors of dairy products, the application of other materials should also be mastered. For example, although the odor of oleic acid (see Figure 4) is faint, it can provide fatty taste in condensed milk flavor.

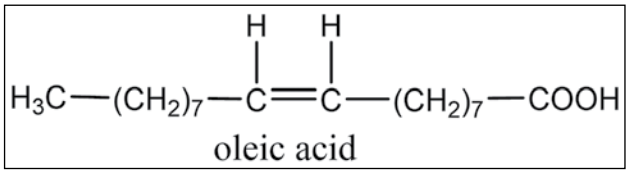

Figure 4. The chemical structure of oleic acid

Not only the odor but also the taste should be considered in flavor imitation. Oleic acid darkens on oxidation, and a lard-like taste and odor can be produced. Although cis-6-nonenal (see Figure 5) has a fruity odor reminiscent of melon, in milk flavor it can improve the fresh feeling (Zhu and Xiao, 2017). It will promote students to think further. This learning process is helpful to make students always endeavor to do still better.

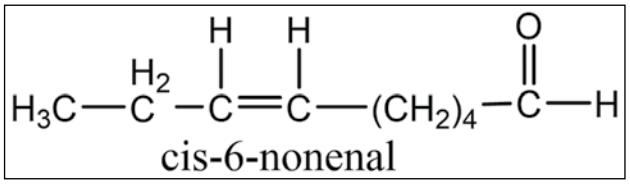

Figure 5. The chemical structure of cis-6-nonenal

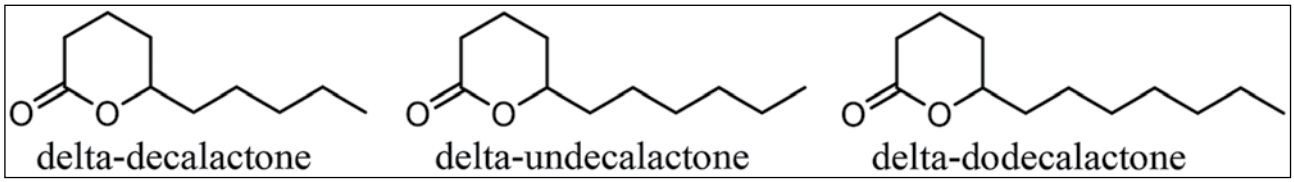

Figure 2. The chemical structures of three δ-lactones

3.3 Train students to consider things from every angle

Mint flavor has been widely used in toothpaste, mouthwash, chewing gum, frozen dairy, beverages, and so on. In this curriculum, students are required to design a mint flavor formula. L-menthol (see Figure 6) and some natural essential oils such as arvensis mint oil and peppermint oil, are used as the main ingredients of mint flavor. L-menthol is the main component of arvensis mint oil and peppermint oil. It has a cooling sensation and characteristic odor of mint. After learning the basic curriculum flavor compounds chemistry, most students are familiar with these common aroma raw materials, and can think of selecting them for blending mint flavor. However, menthol, arvensis mint oil and peppermint oil have high volatility and cannot last long. This is a new problem facing students and arouse students thinking. Students need to find a way to solve this problem. Menthyl lactate, a menthol simulator and booster, can provide a sharp and aggressive cooling impact. Ethyl menthane carboxamide can provide a long-lasting cooling effect. Menthyl lactate and ethyl menthane carboxamide (see Figure 6) can be added in formula to impart long-lasting odor (Burdock, 2010; Surburg and Panten, 2006).

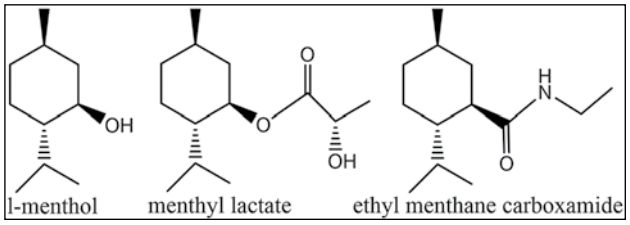

Figure 6. The chemical structures of l-menthol, menthyl lactate and ethyl menthane carboxamide

Menthol has a penetrating sensation and is irritant to mouth at high concentrations. Therefore, students need to think of ways to improve its taste. The odor and taste of star anise oil are intensely sweet. The appropriate addition of star anise oil can provide a sweet taste and reduce irritation caused by menthol. Of course, the addition of anise oil should not affect the main aroma characteristics of mint. Furthermore, roundness and fun are also important to mint flavor and can arouse students' imagination. Some aroma ingredients with spicy note, fruity note, or floral note can also be added in mint flavor formula to add roundness and fun. Eucalyptus oil also has cooling taste. The appropriate addition of eucalyptus oil in mint flavor formula can also enhance antibacterial and anti-inflammatory effects (Zhou and Xiao, 2007). The blending of mint flavor can stimulate students to think in many ways. This learning process can train students to consider things from every angle.

3.4 Forms unceasingly the enterprising habit

Flavor imitation cannot reach the goal in one step. Firstly, students should smell the standard sample to identify its odor characteristics. Secondly, they should select natural and synthetic aroma raw materials to construct an initial flavor formula based on the notes they identified by smelling the standard sample. Thirdly, students blend the flavor based on the initial flavor formula that they designed before (Zhu and Xiao, 2015, 2017; Zhou and Xiao, 2007). When all the aroma raw materials are added completely and the initial flavor is produced. They should evaluate the flavor by nose using smelling slips. Usually, after numerous modifications and adjustments, a desired flavor can be obtained. In this process, students may experience countless failures. Only by overcoming many difficulties and after many revisions can the desired flavor be obtained. And as such, this learning process will help train student to form unceasingly the enterprising habit.

4. Conclusions

Flavors have been widely used in many products and play an important role in food industry. Flavor imitation is a basic curriculum opened for students whose major is flavor and fragrance technology and engineering in Shanghai Institute of Technology. By the integration of flavor imitation with moral virtue education, students could not only grasp the professional knowledge, but also could be fostered the rule awareness. Furthermore, it was also helpful to make students always endeavor to do still better, to train students to consider things from every angle, and to train student to form unceasingly the enterprising habit. It proved that the integration of flavor imitation with moral virtue education can result in a coordinated development of professional knowledge and moral virtue.

References

1. *Burdock, G.A. (2010), Fenaroli's Handbook of Flavor Ingredients, CRC Press, Boca Raton. Available at: https://doi.org/10.1201/9781439847503 (accessed 20 October 2022)*

2. *Surburg, H. and Panten, J. (2006), Common Fragrance and Flavor Materials, Wiley-VCH Verlag GambH & Co, Weinheim. Available at: http://dx.doi.org/10.1002/3527608214 (accessed 20 October 2022)*

3. *Yu, G. and Zhu, G. (2021), "A preliminary study on course ideology and politics education in flavor compounds chemistry", University Chemistry, Vol. 36 No. 3, 2008062. DOI: 10.3866/PKU.DXHX202008062.*

4. *Zhou, Y. and Xiao, Z. (2007), Preparation Technology of Flavors, China Textile and Apparel Press, Beijing. Available at: https://book.douban.com/subject/2256624/ (accessed 20 October 2022)*

5. *Zhu, G. and Yu, G. (2020), "A pineapple flavor imitation by the not method", Food Science and Technology, Vol. 40 No.4, pp. 924-928. Available at: https://doi.org/10.1590/fst.26019 (accessed 20 October 2022)*

6. *Zhu, G. and Xiao, Z. (2015), "Study on creation of an indocalamus leaf flavor", Food Science and Technology, Vol. 35 No. 4, pp. 647-651. Available at: http://dx.doi.org/10.1590/1678-457X.6770 (accessed 20 October 2022)*

7. *Zhu, G. and Xiao, Z. (2017), "Creation and imitation of a milk flavour", Food & Function, Vol. 8, pp. 1080-1084. DOI: 10.1039/c7fo00034k*

8. *Zhu, G, Xiao, Z, and Niu, Y. (2021), "Professional course flavor imitation accelerate internalization of moral virtue eduction", Basic & Clinical Pharmacology & Toxicology, Vol. 128 No.Supplement 1, pp. 85-86. Available at: https://onlinelibrary.wiley.com/doi/full/10.1111/bcpt.13542 (accessed 20 October 2022)*

Corresponding Author
Guangyong Zhu,
Shanghai Institute of Technology,
Shanghai,
PR China,
E-mail: zgy012@126.com

Review of the recent restoration of the Vefa Kilise Camii

Mine Esmer

Fatih Sultan Mehmet Vakıf University, Istanbul, Turkey.

Abstract

The Vefa Kilise Camii is a small but interesting Byzantine structure in Istanbul that has been of particular interest to researchers because of its mass, facade layout, and spatial composition. It was converted into a mosque in 1484 and listed as *Kilise Camii* in the *Vakıflar Tahrir Defteri*. Before its last repair in 2018, the structure was damaged by neglect, unplanned repairs, deterioration of materials, fires, earthquakes, functional changes, and vandalism. Both its Byzantine and Ottoman components were damaged. To this end, the Regional Directorate of Pious Foundations began repairing the structure in 2018 and reopened it to worship in early March 2021. The article presents an assessment of the restoration and makes a remark on general threats against its preservation, and maintenance. Restoring medieval structures requires a multidisciplinary, multi-expert team to define, repair, and maintain them. Vefa Kilise Camii repairs have revealed that a few things could have been handled better.

Key Words: *Mid-Byzantine Era, Constantinople, Vefa, Kilise Camii, preservation.*

Introduction

Despite being a relatively small structure among the Middle Byzantine Period (843-1204) monuments in Istanbul, the Vefa Kilise Camii has been of particular interest to researchers. The building, which is almost a jewel on the western slope of the third hill, has been affecting the passers-by for centuries with its mass formation, facade layout and spatial setup. Charles Texier's sketches after the 1833 fire provide the earliest visual representations of the building.

Initially constructed as a church in the 11th century, the building was converted into a mosque and registered as Kilise Camii (Church Mosque) in the foundations registry in 1484 by Molla Gürani, Mehmet II's instructor. In memory of its founder, Molla (Şemseddin) Gürani, the street passing to its south as well as the surrounding neighborhood were named after him. However, in 1934 Kilise Camii's neighborhood, which had been named after Molla Gürani, was combined with Hoca Gıyaseddin neighborhood, and as a consequence its own neighborhood could not survive to our day. Following its restoration in 1937, the Kilise Camii gained increasing attention, especially among Byzantine scholars, with the discovery of outer narthex mosaics by Miltiadis Nomidis, and Hidayet Fuat Tagay. As a cultural asset, Vefa Kilise Camii was registered on 15.07.1937. The registration records can be found in the *Encümen Archives* (file number 24917, cardboard box 124) with an inventory template completed by Aziz Ogan on 02.06.1942.

Having undergone significant interventions since 1995, the Regional Directorate of Pious Foundations began repairing the building in 2018, and it was reopened to worship in early March 2021. The goal of this article is to provide a general assessment of the restoration of this important edifice, which was part of my doctoral dissertation in the restoration program at Istanbul Technical University.

1. Location and surroundings of the building

Vefa Kilise Camii lies in the Vefa quarter of the Süleymaniye Urban Area in Istanbul's Fatih District on the third hill of the Historic Peninsula. Vefa quarter's borders are defined by Bozdoğan Aqueduct in the south, Küçükpazar neighborhood in the north, Süleymaniye and Hoca Gıyaseddin neighborhoods in the east and Atatürk Boulevard in the west.

The Kilise Camii whose initial name in the Byzantine period is unknown, was located on the western slope of the third hill, in the tenth region according to the Late Antique city plan (Müller-Wiener, 2007, p.169). In today's city, the building, which was founded by Şeyhü-l-Islam Molla

Gürani, is situated on Tirendaz Street in the Hoca Gıyaseddin neighborhood (Ayvansarayi, 2001, p. 251). To distinguish it from other mosques converted from churches (like Eski İmaret, Fenari İsa, and Zeyrek), it is also called Vefa Kilise Camii after the name of the quarter (Eyice, 1995, p. 375).

Vefa, with its proximity to the branch of Mese leading to Adrianapolis/Kharisius Gate (Edirnekapı) and to Makron Embolos (Uzunçarşı Street – the street descending from today's Istanbul University Headquarters to the Golden Horn) during the Byzantine Period, was a district where nobles and wealthy people lived (Kuban, 2000, p. 83). With the decline in population in the city in the late Byzantine Period, two monasteries were established in the beginning of 1300, and a third monastery in the second quarter of the 14th century, on a large area that includes today's Vefa (Mango, 1990, p. 429). "Gorgoepekoos", one of these three monasteries, was built around 1300 by adding an annex to an existing church (Mango, 1990, p.429). According to Mango, the features of this last church fit well with the Kilise Camii (Mango, 1990, p. 429). Due to their proximity, the cisterns located to the west and south of the Kilise Camii were likely related to the monastery whose katholikon the Kilise Camii was (Figure 1). In the last repair, traces of Byzantine structures that had been part of the monastery have also been discovered to the east of Kilise Camii.

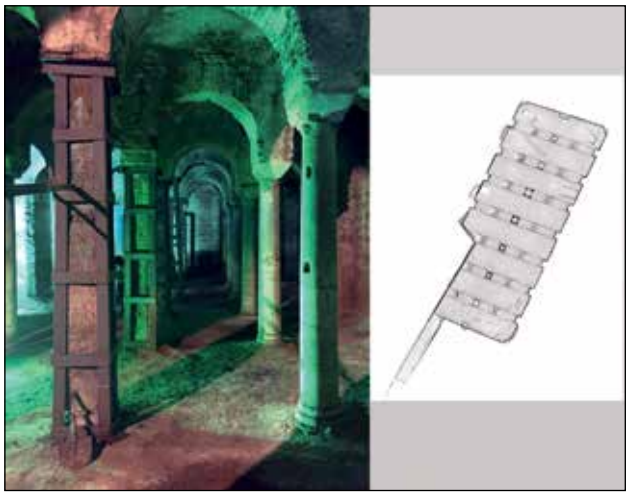

Figure 1. The cistern located 30 meters west of the Kilise Camii (2018). In overview map on the right, it is seen that one of the walls of the cistern is partially cut because of the structure built illegally on it in 1966.

After the city was taken over by the Ottomans, Mehmed II settled in the palace district of the former Byzantine capital. Located north of the Forum Tauri, the Old Palace was the first imperial palace to be built in the city by Mehmed II where currently the buildings of Istanbul University, the Süleymaniye Mosque, and the Biology Institute are standing today (Kuban, 2000, p. 205; Ayverdi, 1953, p. 7). Sultan Bayezid II (1481-1512) had his mosque complex built on the Forum Tauri on the 3rd hill (Kuban, 2000:224). Starting from the reign of Mehmed II, tradesmen groups such as saddlers, blacksmiths, coppersmiths, etc. started to concentrate around the 3rd hill (Eyice, 2006, p. 76). During the reigns of Mehmed II, and Bayezid II, scholars such as Molla Hüsrev, Molla Gürani, and Şeyh Vefa Efendi established neighborhoods and built monuments in their own names at Vefa quarter (Erdoğan, 1941, p. 5).

To the north of the Bayezid Complex, Süleyman I (1520-1566) built his mosque complex. According to Kuban, Süleymaniye is an imperial stamp on the silhouette of Istanbul, as Hagia Sophia is; it is the most symbolic structure of the Ottoman empire, which is incorporated into the urban landscape. As the dominant element of the Golden Horn silhouette, it has fascinated everyone throughout history with its grandeur, and beautiful contour in the skyline (Kuban, 1998, p. 26). Also worth of mention are the mansions of Pertev Mehmed Pasha, one of the viziers of the of Süleyman I, Sultan Ahmed III's son-in-law Nevşehirli İbrahim Pasha, Kaymak Mustafa Pasha, Revani Çelebi, Payzen Yusuf Pasha, Shipyard Treasurer İbrahim Çelebi, and Recai Efendi which were all located in the Vefa Quarter (Karaman and Dağli, 2008, pp. 278, 281, 286). Those mansions of the state elders' were lining the ridges of Süleymaniye and Zeyrek, all overlooking Vefa Square, which was landscaped with trees and flowers; people flocked to this square for strolls (Erdoğan, 1941, p. 5).

Vefa preserved its significance until the end of the 19th century-beginning of the 20th century; due to its proximity to districts such as Beyazıt and Vezneciler, where scholars and students were concentrated, it continued to exist as a distinguished district (Erdoğan, 1941, p. 33). Tombstones in the Kilise Camii cemetery, and the Voynük Sücaettin Camii cemetery are good indicators that the people

buried in them were important and respected citizens (Figure 2). Vefa also kept its popularity until the 1930s due to its proximity to Şehzadebaşı, and Direklerarası, the entertainment and art centers of the Old City (Esmer, 2020, p. 298). The Süleymaniye region, which comprises the Vefa quarter, where the upper class lived until the first half of the 20th century, has changed slightly since the Constantine Era, with great fires and earthquakes. But it has not undergone major changes until the first half of the 20th century; the urban fabric exhibited an organic development which matched the land's topography (Kuban, 2001, p. 3)

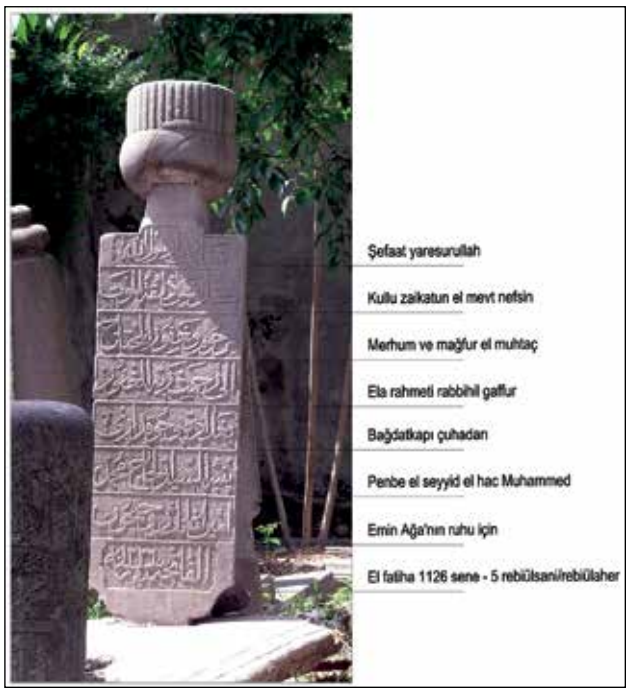

Figure 2. The tombstone from Vefa Kilise Camii hazire (cemetary) (2007).

In the 19th century the Ottoman industry started to develop on the shores of the Golden Horn due to the ease of access and transportation its shores provided. Unfortunately, the first master plan for Istanbul in the Republican Era suggested that industrial facilities should be further built on the shores of the Golden Horn. In the following years, the Golden Horn area, as well as the Süleymaniye neighborhood, became an area housing factories and ateliers of various sizes, changing the residential character. Another important factor for the change was the opening of Atatürk Boulevard on 27.02.1943. This was a major town planning act of the early 40's in the Republican Era which resulted in the demolition of some monuments as well as of many houses. It further brought about significant changes such as a major change in the volume of buildings, their average proportions and their lots. The enlarged width of roads also invited more motor-vehicles while consecutive constructions of new buildings and facilities further altered the previous residential character. Concerning the inhabitants of the area, the demographical and social status of the neighborhood changed drastically in the following years.

After the 1950's the inhabitants of Süleymaniye, responding to the changing physical and social environment factors, sold their houses in order to move to new "selected" neighborhoods of Istanbul, leaving their houses to new migrants. The neighborhood became the first "station" for migrants providing accommodation with very low rents. As the new owners/tenants of the houses could not appreciate their value, some of them were transformed into small ateliers or storage spaces while some big houses and mansions were rented room by room to migrant families, changing completely the inner spatial features. Therefore, a maintenance problem arose which resulted in the loss of many structures. The socio-demographical pattern of the new inhabitants also lead to some other problems. Extreme fanaticism blended with ignorance damaged monuments such as Vefa Kilise Camii. Concrete was poured over the spoliated parapet slabs of its minaret in 1995, as well as many other inconvenient interventions.

The Süleymaniye Urban Historical Area was selected for UNESCO's World Heritage List in 1985. However, after the 2000's, the rising value in real estate in Istanbul and the gaps in the Turkish legal system increased the problems. Although Süleymaniye was a World Heritage Site, it was declared a renewal area in 2006 by the help of the Law No. 5366. Law No. 5366 on the "Conservation through Renewal and Utilization through Revitalization of Deteriorated Historic and Cultural Properties", the "Renewal Law", issued in 2005, played a key role in transforming many historic areas. With this law, the Council of Ministers has become able to designate "urban renewal sites" while giving local authorities (municipalities) a great deal of power over these projects contrary to the conventional planning system (Esmer *et al*, 2023).

2. Brief history of Vefa Kilise Camii and its repairs

On the narrow road leading to Vefa Square, north of the Şehzade Complex, was the first church here which was built by the patriarch Sforakios during the reign of Theodosius (408-450 AD) according to Paspatis (Paspatis, 1877, p. 314). However, this early period structure was destroyed in a fire (Paspatis, 1877, p. 315). Also the quarter called Vefa today, housed the residence of the historian Nikitas Choniatis, which was burned in 1204 by the Latin crusaders (Paspatis, 1877, p. 316). Paspatis as well claimed that it was possible that the church which we call as the Kilise Camii was dedicated to Agios Theodoros, a soldier saint, or to Agios Phanourios, also a young soldier saint. The claim that this church was named Phanerotis in honor of Saint Phanourios stems from the tradition during the Byzantine period. Because those who lost money visited the church (Paspatis, 1877, p. 316). However, there is no definite evidence about certainity of these names to belong to the Vefa Kilise Camii.

According to Mango, the Kilise Camii may be the katholikon of one of the three monasteries founded around Vefa in the 14th and 15th centuries. Specifically, he suggested that Vefa Kilise Camii might be the monastery church named "Gorgoepekoos" that had annexes built around 1300 by Nikephoros Choumnos, originally built by Michael IV or V around 1034-1041 (Mango, 1990, p. 429). This is because the building phases observed in the Kilise Camii and the so-told features of this structure are very similar.

It is believed that the narthex and naos of the Kilise Camii, which are the first phases of the current structure, were built in the 11th century during the Middle Byzantine period (Mango, 1965, p. 330). After the Latin invasion, the northern and southern annexes were probably added as part of the building's repair work (Mango, 1965, p. 330). The outer narthex is thought to have been built around 1320 (Ousterhout, 1987, plate:161). Vaulting evidence indicates the northern annex was added later than the naos. In the passage from the outer narthex to the northern annex, there is still a visible lower part of an arched window opening, proving the outer narthex, the last phase in Byzantine Era, was built after the northern annex (Ousterhout, 1987, plate:163).

Ottoman annexes such as a minaret and mihrab were added when the building was converted into a mosque in 1484 (Barkan and Ayverdi, 1970, p. 61). The structure is defined as follows in Hadikat'ül Cevami: "*The founder is Şeyhü'l-Islam Molla Gürani, and Abdurrahman Efendi, one of the mudarris, son of Mehmed Eminzade Hüseyin Ağa, gave up its minbar*" (Ayvansarayi, 2001, p. 251).

It wasn't until 1833 that there was much information about the structure following this change of function by the end of the 15th century. In the texts written by Evliya Çelebi and Ayvansarayi, very little is stated concerning the building than a very general description. The structure was in a dilapidated state when Texier examined it in 1833 due to the fire that had occurred in August that year (*Rebiülahir* 14, 1249) (Cezar, 1963, p. 327). Texier drew the first survey of the Kilise Camii in 1833 (Figure 3). The drawings of Lenoir, who examined the building in 1836, were published in 1852 after those of Texier. Following Lenoir's inspection, the building was renovated with some changes to its architecture (Mango, 1965, p. 324). The structure was inspected for the first time by Salzenberg after repairs were completed. During Salzenberg's visit, the building looked quite like it does now, and it was in use as a mosque (Mango, 1965, p. 324). In 1877 and 1878, Pulgher and Paspates were the researchers who examined the structure following Salzenberg.

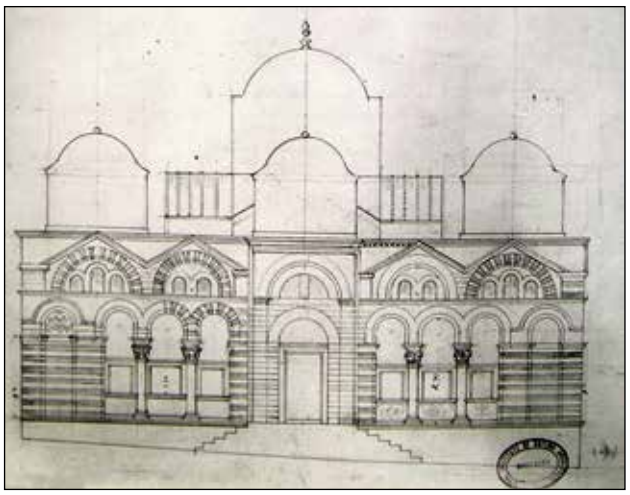

Figure 3. The survey of Kilise Camii by Texier (RIBA, 1833).

The Kilise Camii underwent a repair at the beginning of the 20th century according to a document found in the Ottoman Archives dated 30 January 1907. According to the document, some of the damaged parts of the building were explored and the building could be repaired by the state using the emanet system with the approval of the sultan. It is confirmed that the Sultan accepted this request (Figure 4).

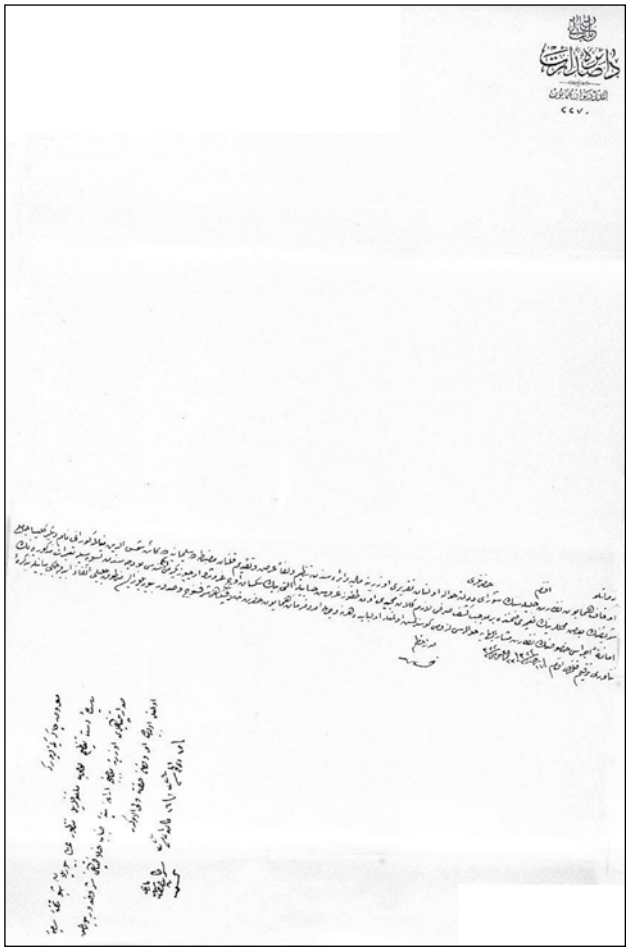

Figure 4. The archival document showing the repair of the Kilise Camii (İ. EV. / 1324 Z/8).

Following the repair, Gurlitt and Millingen in 1912 and Ebersolt in 1913 examined, photographed, and surveyed the structure. Some inconsistencies exist in the drawings of Texier, Lenoir, Salzenberg and other researchers. However it's important to note that Texier and Lenoir's drawings were made before photographic technology became prevalent and they provide information belonging to the first half of the 19th century

In 1926, another researcher, Nikolai Brunoff came to Istanbul and examined the building (Figure 5) (Brounoff, 1926, p. 13). And in 1937, an amateur enthusiast, Hidayet Fuat Tagay, worked with a topographer Miltiadis Nomidis for 10 months in the building for its repair. The most important outcome of their work were the discovery of the tomb chambers in the basement of the building, and the mosaics of the outer narthex domes (Figure 6). This repair was stopped abruptly when their permit was cancelled before they could finish uncovering, and cleaning the outer narthex mosaics (Nomidis, 1958, p. 36).

Figure 5. The Brunoff's examination of the south parekklesion (Brunov, 1930/31, p.140).

In 1955, 1965, and 1972 consecutively, superficial restorations were carried out by the Pious Foundations (Vakıflar) on the facades of the Kilise Camii resulting in the loss of some traces in the masonry (Figure 7). The interview for my dissertation with Semavi Eyice revealed that the repairs were made without a restoration project. Furthermore, no detailed record of these repairs, but only some expense and material lists were found in the Archives of the Istanbul Regional Directorate of Pious Foundations. The last repair by Vakıflar in the 20th century was in 1987, again without a restoration project.

After 2006, the Vefa Kilise Camii, and its surroundings were transformed into one of Istanbul's Renewal Areas. In a report filed by the Renewal Board, it was stated that the marble parapets and column capitals were plastered and covered with a thick layer of paint. The building underwent a restoration campaign by the Pious Foundations in 2018, and was reopened to worship in March 2021.

EXONARTHEX — Coupole Sud

		PROPHETES							
		Salathiel	Jechonias	Achim	Sadoc	Azor	Eliakim	Abiud	Zorobabel
		S.	S.-E.	E.	N.-E.	N.	N.-O.	O.	S.-O.
CORPS :									
Hauteur totale:									
nimbe y compris	en m.	1.47	1.475	1.448	1.412	1.43	1.48	1.49	1.404
couronne y comprise	»	1.40	1.415	1.395	1.378	1.37	1.435	1.41	1.345
jusqu'à la couronne	»	1.332	1.341	1.303	1.279	1.287	1.364	1.329	1.283
jusqu'aux épaules	»	1.172	1.169	1.174	1.123	1.13	1.212	1.132	1.14
jusqu'à la partie inférieure de la livre inférieure	»	1.24	1.245	1.225	1.183	1.17	1.274	1.21	1.165
Largeur maximum	en cm.	65.5	62	59.5	67.2	71.5	60.7	72	65.5
Largeur aux épaules	»	28	27	28	30.2	31	32	31.5	29
NIMBRE :									
Diametre	»	32.5	327	31	31.5	32.6	32.7	32.8	32.8
Forme géométrique		Cercle regulier							
Nombre de pierres de la circonférence	Pièces	68	74	69	64	66	72	75	64
Dimensions des pierres variant entre	en mm.	13x11	14x115	13x105	13x11	145x105	16x12	19x11	14x115
et	»	6x6.5	5.5x5	6x6	8x7	6x7	7x6	5.5x5	7x6.5

— 39 —

Figure 6. The article of Nomidis presented details of the repair work (Nomidis, 1958, p.39)

3. Problems of Preservation Before The Last Repair

There has been multiple changes to the original structure as one can imagine during its millenial lifetime. Apart from various changes during the Byzantine Era, in the 15th century, during its conversion to a mosque a number of liturgical interior elements of the church were lost, including the ambon and iconostasis. There has been a cut in the eastern facade in the lower part of the diaconicon, and the entire protrusion of the prothesis, and the apsis of the north annex is also demolished at an unknown date. A fire in 1833 damaged the parekklesion adjacent to the south facade; four marble columns supporting the main dome of the naos were replaced by stone piers. There are no remaining original wooden Ottoman annexes such as its minbar and sultan's lodge.

However, prior to the last repair in 2018, the structure suffered from severe problems as never before such as: negligence, unplanned repairs, deterioration of materials, fires, earthquakes, functional changes, user-caused problems like vandalism, and unproper additions/interventions (Figure 8). Natural, environmental, and human factors all contributed to the problems. It can also be noted that elements from both the Byzantine and Ottoman periods were similarly damaged.

In the years since the last well documented repair at the Vefa Kilise Camii in 1937, which was cut short for an unknown reason, only superficial and unplanned repairs have been conducted. An incorrect jointing on the south facade caused masonry traces to be lost in 1972, and the roof shape of the north annex also changed.

In 1979, a member of its congregation whitewashed the hand-drawn decorations from the last Ottoman restoration and the mosaics. As a consequence, the appearance of Ottoman hand-drawn decorations along with Byzantine mosaics, which encompass different cultural layers, was muffled. The conservative attitude combined with ignorance caused some residents in the quarter to scrape and plaster some reliefs on the monument's west facade.

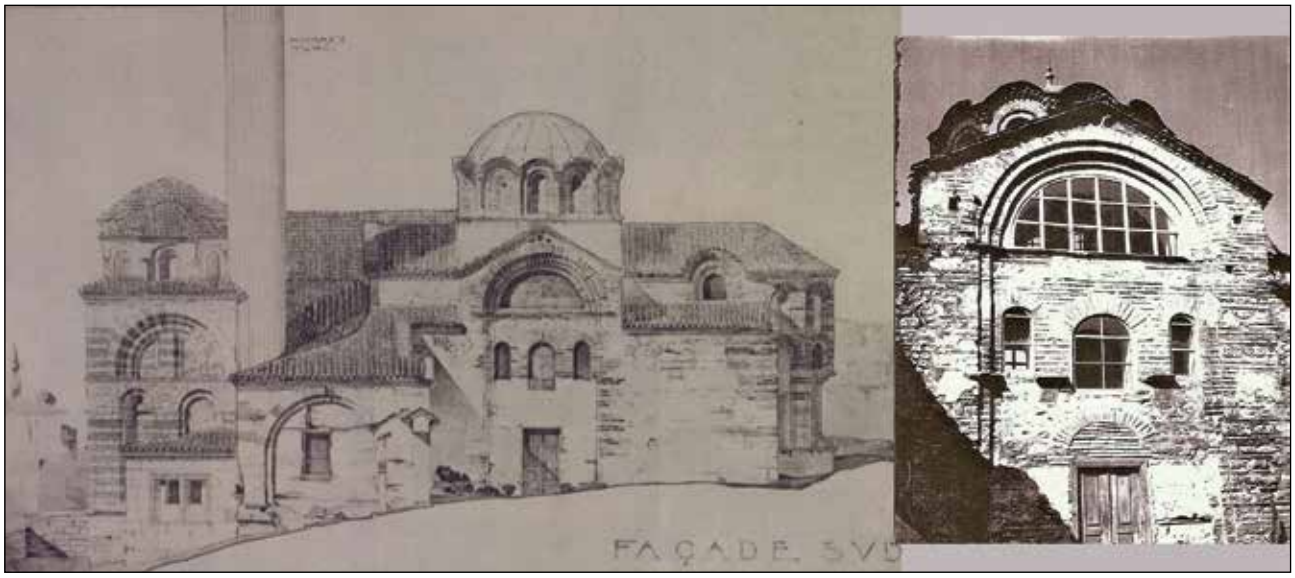

Figure 7. The traces of arches on the south facade (Ebersolt, 1913-Şengül Tümer, 1953)

Figure 8. The condition of the north annex prior to restoration (2007).

Crosses on the marble parapets of the western facade, which now look clean after restoration, were scraped off before cement was applied. An Artamanov photograph from the 1930s shows one of these intact crosses. There is a possibility that those who scraped away the crosses learned that damaging historical monuments is illegal and covered the areas they damaged.

Figure 9. The condition of the roof prior to restoration (2007).

In 1995, the north annex of the Vefa Kilise Camii were transformed into a wc unit. Aside from hygienic concerns, an improper plumbing intervention affected the historic structure. And ablution faucets were placed on the north wall of the outer narthex. Daily abuse by its users gradually deteriorated the structure. A shanty structure was added to the east of the south annex which was used with the south annex as a lodgement for the *mouezzin*. However the lodgement was rented to a family not related with the Kilise Camii. Moreover another shanty-unit with a metal structure was placed at the southwestern corner of the outer narthex and a person selected by the mosque congregation was dwelling in it. Also there was a room on the second floor of the north annex above the wc unit that the congregation used like a dormitory for some youngsters without a legal permission. Since In January 2009, the joinery on the eastern facade of the building was replaced with PVC windows. Istanbul Regional Directorate of Foundations became aware of the situation, but did not initiate an action. Furthermore, during the repair work, it was discovered that cement mortar had been carelessly applied to the parapet slabs on the balcony of the minaret. As well for this, punishment should be meted out to whoever was responsible.

Rain and snow were leaking in through the building's roof and facades, causing damage to the walls and ceilings (Figure 9). Cement-based mortar used to repair the building in 1955, 1965, 1972, and 1987 consecutively contained salts that leached into the brickwork, causing efflorescence. It would therefore not be incorrect to say that the structure was in dire need of urgent repair prior to 2018 in order to stop its relentless deterioration.

4. Evaluation of recently completed repair

Following the re-opening in March 2021, the mosque began serving as a religious building, and its general view and state of conservation have improved significantly. They removed the wc unit from the north annex, shanty-unit from the outer narthex, and built ablution faucets outside in the courtyard to replace the shantystructure next to the south annex (Figure 10). Further, they uncovered the remnants of the monastery on the east side of the mosque (the

Figure 10. The new ablution faucets (2021)

masonry technique is similar, there is also a curvilinear fragment of an apse and a broken cornice on it), and the remains of the wall that formerly housed the mosque's madrasah (Figure 11).

Figure 11. The walls of monastery (2021)

It's deliberately good that they left the remnants without any re-integration. On the south facade, they discovered the bases of the collapsed parecclesion columns. Furthermore, north and south parekklesia, of which Brunov, and Thies mentioned in their research, were excavated and left open for exploration. This has made it possible to see some of the building details that were seen in Texier drawings in 1833. And in general, the pointing and plastic repairs are of good quality.

The following issues, however, might have benefited from better interventions: pointing and investigating traces in specific areas, deciding what color to paint the walls and ceilings, and some of the new fabrications. It was worth paying attention to the special decorations on the facades. Among them is the checkerstone motif between the two arches over the entrance door on the outer narthex's western facade (Figure 12). The checkerstone motif was not appropriately pointed. Even in the previous dilapidated state of the facade, the motif looked more discernable. A second motif is the meander motif on the northern facade, which Lioba Theis discovered and that I stressed in my dissertation as a point to be careful with during repair work. This part of the wall was simply pointed without investigating the motif (Figure 13). And the meander motif is probably lost irreversibly.

Figure 12. The checkerstone motif (Above: 2007 - Belove: 2021).

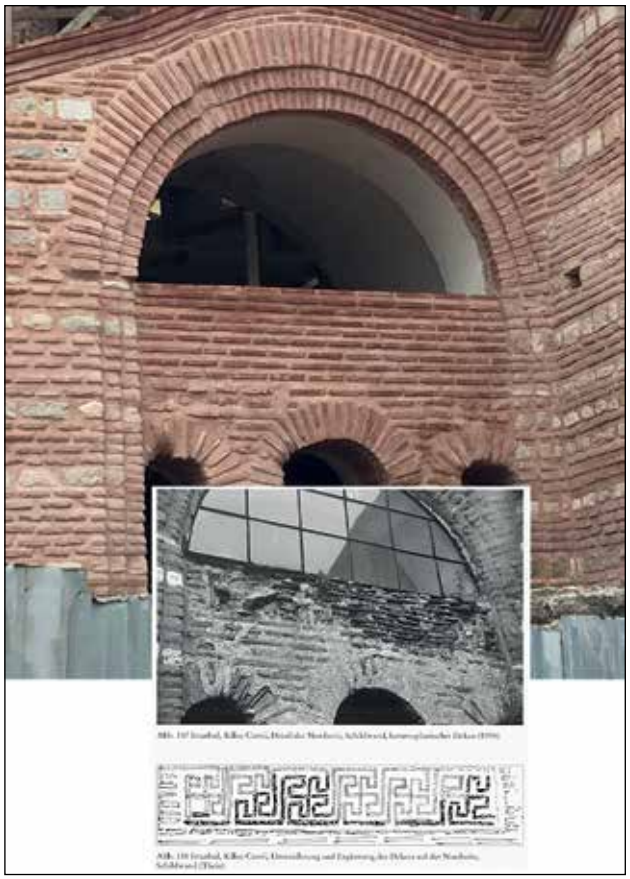

Figure 13. The place of the meander motif (Esmer, 2019 during repair- Theis, 2005)

Figure 14. The bowls left open after the repair (Hendrixe D. 2021)

There were also traces of arches on the south facade that can be seen in the drawings by Ebersolt, Van Millingen and also in the photographs by Şengül Tümer, an art history under-graduate student who completed her graduation thesis with Semavi Eyice in 1953. The traces were as well discussed in my phD dissertation. During the 1972 repairs, these traces were lost. They have also not been investigated in the recent restoration, so the facade remained same as it was before the repairs regarding these two arches (Figure 7). Furthermore, the three partially visible bowls on the south facade have been cleaned and left open, but they are in need of protection. They have probably survived so long because they were plastered during the Ottoman period and are now exposed to the sun, snow, and rain (Figure 14).

For interior a yellow color was preferred at the last repair, likely due to rasping during restoration and the discovery of old layers. However, this yellow color is very dominant and does not look convenient. A softer tone would have been more appropriate. The Ottoman decoration from its last repair is forced into any surface that is available (Figure 15). There are even instances where hand drawn decorations have been applied to asymmetric surfaces, which makes them look odd. The windows made of white portland cement on the upper elevations would look better if these were placed a little inside and had a shadow share (Figure 16). The entrance portal, especially the tone of the wood veneer could have been much better chosen (Figure 17).

Figure 15. The interior color and hand drawn motifs (2021)

Figure 17. The entrance portal (2021)

Figure 16. The windows from white portland cement (2021)

Figure 18. The wooden porch (2021)

One of the most problematic applications is a wooden porch next to the south facade and blocking the triple opening completely (Figure 18). Wooden posts with wide cross-sections were used frequently, as if they were meant to support a 3-storey building, when they only needed to support a wooden porch.

All the architectural sculpture pieces found during excavation are still standing in front of the eastern facade to be displayed, and it is hoped that the courtyard will remain clean and free of trash in following years.

During the restoration the parapet slabs of the minaret were cleaned off the cement coating but, while the majestic peacock-adorned slab and other slabs remain in-situ, the color of their stones faded and some details were obliterated while cleaning the cement on them, which is unfortunate (Figure 19). Moreover, currently the interior of the parapet of the minaret is cluttered with wires and speakers, causing it to look unkempt.

On the western facade, there were two stonemason's marks (theta-epsilon) and a bit too much cleaning was applied, so that the surface of that piece seems to have eroded. Also, the column standing on that piece which serves as a column base was replaced with a new one during the last restoration. The previous shanty unit was attached to that column, so it may have caused the original one to deteriorate. The replaced column is of gray veined marble, and does not seem to go well with the rest of the elements on the facade in colour and texture.

Finally it is important to make a few remarks on the nearby surroundings of the monument which is located in Süleymaniye World Heritage Site. The surrounding areas of the Kilise Camii look more like a post-conflict zone, rather than a UNESCO World Heritage Site in the photograph taken from its minaret balcony (Figure 20). There is a parking area for motor vehicles on every plot of any demolished structure. In such an environment it is not possible to expect that the Vefa Kilise Camii will be maintained, clean, and its preservation will be safeguarded. Further, it is located in a renewal zone that is capable of producing major changes in quantity within a short amount of time. Based on

Figure 19. The figures on the parapet slabs of the minaret balcony (Erdoğan, 1996 - Esmer, 2021).

these circumstances, Kilise Camii is continuously threatened by its environment, and is at risk.

Figure 20. The nearby surroundings of the Vefa Kilise Camii (2021)

5. Conclusion

Medieval structures are excellent historical documents, providing evidence of different styles, and periods. Over the centuries, they have been repaired many times, and additions have been made at different periods. Defining, repairing, and maintaining these structures requires multidisciplinary, multi-expert teams. After the repair of the Vefa Kilise Camii, it is clear that there were some points that could have been better handled.

By their nature and history (materials and assembly), architectural heritage structures present a number of challenges in diagnosing and restoring them that limit the application of modern building codes and standards, according to the Icomos Charter- Principles For Analyzing, Conserving And Restoring Architectural Heritage (ICOMOS, 2003). It is desirable and essential to provide recommendations that cover both rational methods of analysis and culturally appropriate methods of repair. Architectural heritage which requires a multidisciplinary approach for conservation, reinforcement, and restoration is not just about its appearance, but also about the integrity of all its components as a unique product of the specific building technology of its era. Furthermore, all its qualified additions are considered part of the monument. There is a need for a thorough understanding of the materials and structural characteristics. Information on the structure in its original and earlier states is essential.

Interventions should ensure safety and durability while preserving heritage values as much as possible. Within each small corner of the monument one can detect an important detail of its long past, building/repair technology, approach of the period and so on. For instance after the cleaning of the paint layers one can see the masons's toolmarks on one of the delicately carved column bases at Vefa Kilise Camii or a spoilated Ottoman slab used as a lintel at one of the openings on the main apsis on the eastern facade (Figure 21).

The choices of colors to be applied, the additions to be removed, the motifs to be added all require a thorough understanding of the structure's history, its periods, past repairs, building techniques used at the time it was built, including its qualified additions, as well as the knowledge of the current methods of conservation. Maintenance of the building after repair is also another concern. The inside of the balcony of the minaret is already cluttered with cables and speakers. Moreover, it looks like the architectural sculpture was laid down haphazardly in the garden without being properly secured against theft and/or damage.

Therefore, it is of utmost importance that these medieval structures have continual scientific committees that observe, and report any problems as they occur, so that precautions can be taken before they become too severe. Additionally, a protective zone should be established around them to prevent them from being affected by physical and social changes.

Besides being a protected area, and also a World Heritage Site, the Süleymaniye is a renewal area since 2006. World Heritage Site of Süleymaniye encompasses Vefa quarter and the Kilise Camii, and there is a sharp confict related to preservation, as the area is both a World Heritage Site, and a re-

Figure 21. The toolsmarks on the column base and an spoliated Ottoman slab (2021).

newal area. As recommended by the Valletta Principles (ICOMOS, 2012), a protected urban area is any part of a town that represents a historical period or stage of development of the town. It includes monuments and authentic urban fabric, in which buildings express the cultural values for which the place is protected. Therefore, it is unacceptable to approve the state of Süleymaniye as renewal area according to its requirements of preservation. Furthermore, as indicated in the charter, an accumulation of changes could have a negative effect on a historic town and its values. However, major quantitative and qualitative changes are enabled by the Renewal Law No. 5366 in renewal areas.

As a conclusion, a preservation strategy for a medieval monument needs to consider the urban scale, the surrounding environment, the building structure, and material conservation requirements. In the case of Vefa Killise Camii, it is hoped the institutions responsible will keep these requirements in mind for the future.

References

1. *Ayvansarayi, H. (2001), Hadikatü'l Cevami, İstanbul Camileri ve Diğer Dini-Sivil Mimari Yapilar, İşaret Yayinlari, İstanbul.*
2. *Ayverdi, E.H. (1953), Fatih Devri Mimarisi, İstanbul Fetih Cemiyeti, İstanbul.*
3. *Barkan, Ö.L. and Ayverdi, E.H. (1970), İstanbul Vakiflar Tahrir Defteri, no: 915, İstanbul Fetih Cemiyeti, İstanbul.*
4. *Brounoff, N. (1926), "Rapport sur un voyage a Constantinople", REG 39, Librairie Ernest Renoux, Paris, pp.1-30.*
5. *Brunov, N. (1930/31), "Über zwei byzantinische Baudenkmäler von Konstantinopel aus dem XI. J", Byzantinisch-Neugriechische Jahrbücher 9, pp.129-144.*
6. *Cezar, M. (1963), "Osmanli Devri'nde İstanbul Yapilarinda Tahribat Yapan Yanginlar ve Tabii Afetler", Türk Sanati Tarihi Araştirma ve İncelemeleri I, İstanbul, pp.327-414.*
7. *Ebersolt, J. (1979). Les Eglises de Constantinople, The Dorian Press, London.*

8. *Erdoğan, A. (1941), Şeyh Vefa: Hayati ve Eserleri, Ahmed İhsan Basimevi, İstanbul.*

9. *Erdoğan, E. G. (1996), "İstanbul'daki Osmanli Yapilarinda Kullanilan Devşirme Malzemenin Değerlendirilmesi", Unpublished Master Thesis, İstanbul University, İstanbul.*

10. *Esmer, M. (2020). "Transformation of the Urban Cultural Landscape through the Perspective of a Family Mansion: Mebus Münir Bey Mansion in Süleymaniye", Bailey, G., Defilippis, F., Korjenic, A., and Čaušević, A. (Ed.s), Cities and Cultural Landscapes: Recognition, Celebration, Preservation, and Experience, Newcastle upon Tyne: Cambridge Scholars Publishing, pp.298-315.*

11. *Esmer M., Kasmo, R., Dabanli, Ö., Kudumovic, L., and Cesur, S. (2023, forthcoming). "A critique of the scope, methodology, and impact of the urban renewal project at Tarlabasi in Istanbul". Proceedings of 6th Heritage Forum of Central Europe (16-18 Haziran, 2021), Krakow, Polland.*

12. *Eyice, S. (2006), Eski İstanbul'dan Notlar, Küre Yayinlari, İstanbul.*

13. *Eyice, S. (1995), "Toklu Dede Mescidi", Tekeli, İ. and Eyice S. (Ed.s), Dünden Bugüne İstanbul Ansiklopedisi, Tarih Vakfi ve Kültür Bakanliği Yayinlari, İstanbul, vol.7, p.375.*

14. *ICOMOS. (2003), "Charter- principles for the analysis, conservation and structural restoration of architectural heritage". Available: https://www.icomos.org/en/about-the-centre/179-articles-en-francais/ressources/charters-and-standards/165-icomos-charter-principles-for-the-analysis-conservation-and-structural-restoration-of-architectural-heritage (accessed 20 October 2022)*

15. *ICOMOS. (2012), "The Valletta Principles for the Safeguarding and Management of Historic Cities, Towns and Urban Areas". Available at: https://civvih.icomos.org/valletta-principles-english-french/ (accesed 23 November 2022)*

16. *Karaman, S., and Dağli, Y. (Ed.s). (2008). Günümüz Türkçesiyle Evliya Çelebi Seyahatnamesi: İstanbul, 2 vols., Yapi Kredi Yayinlari, İstanbul, pp. 278, 281, 278-286.*

17. *Kuban, D. (2000), İstanbul Bir Kent Tarihi, Bizantion, Konstantinopolis, Tarih Vakfi Yurt Yayinlari, İstanbul.*

18. *Kuban, D. (1998), Kent ve Mimarlik Üzerine İstanbul Yazilari, YEM Yayinlari, İstanbul.*

19. *Kuban, D. (2001). Türkiye'de Kentsel Koruma / Kent Tarihleri ve Koruma Yöntemleri, Tarih Vakfi Yurt Yayinlari, İstanbul.*

20. *Mango, C. (1965), "Constantinopolitana B: Kilise Camii", JDI 80, pp.323-330.*

21. *Mango, C. (1990), "The work of M. I. Nomidis in the Vefa Kilise Camii, Istanbul (1937-38)", (Μεσαιωνικά και Νέα Ελληνικά 3) Mesaionika kai Nea Ellinika 3, pp.421-429. Available at: http://www.academyofathens.gr/el/mes_and_nea_1990, (accesed 12 December 2022)*

22. *Müller-Wiener, W. (2007), İstanbul›un tarihsel topografyasi: 17. yüzyil başlarina kadar Byzanti-on-Konstantinopolis-İstanbul, YKY, İstanbul.*

23. *Nomidis, M. (1958). "Rapport Preliminaire des Travaux Executes dans une Eglise Byzantine (Kilise-Camii)", Notre Dame d'Ephese 2, vol.8, pp.14-19. Available at: https://katalog.ibb.gov.tr/yordam/?p=1&dil=1&q=&fq[]=kunyeBirliktelikKN_str:O/3541 (accessed 12 December 2022)*

24. *Nomidis, M. (1958). "Rapport Preliminaire des Travaux Executes dans une Eglise Byzantine (Kilise-Camii)", Notre Dame d'Ephese 2, vol. 11-12, pp. 36-40. Available at: https://katalog.ibb.gov.tr/yordam/?p=1&dil=1&q=&fq[]=kunyeBirliktelikKN_str:O/3541 (accessed 12 December 2022)*

25. *Ousterhout, R. (1987), The Architecture of the Kariye Camii in Istanbul, Dumbarton Oaks Studies 25, Washington D.C.*

26. *Paspatis, A.G. (1877), Bizantinai Meletai Topographikai kai Istorikai, Kontantinoupolei, Antoniou Koromila, İstanbul.*

27. *Theis, L. (2005), Die Flankenraeume in Mittelbyzantinischer Kirchenbau, Reihert Verlag, Wiesbaden.*

28. *Tümer, Ş. (1957), "İstanbul'da Vefa Kilise veya Molla Gürani Camii, Tarihçesi, Mimari Durumu, Mozaikleri", Unpublished Undergraduate Thesis, İstanbul University, İstanbul.*

Corresponding Author:
Mine Esmer,
Fatih Sultan Mehmet Vakıf University,
Istanbul,
Turkey,
E-mails: mesmer@fsm.edu.tr,
mineesmer@yahoo.com

The Regional and Local Influences on the Architecture of the Ottoman Mosques in Aleppo: Behram Pasha (al-Bahramiyya) Mosque as an Example

Ruba Kasmo

Faculty of Architecture and Design, Fatih Sultan Mehmet Vakif University, Istanbul, Turkey.

Abstract

Conforming to the established norms of the imperial architectural style, the congregational mosques of the 16th-century Ottoman complexes in Aleppo exhibited a radical break from the mosque architecture of the city with their centralized ground plans, hemispherical domes, and cylindrical minarets. However, they were not exact copies of those in the capital, instead, they were products of multi-leveled interactions among the center, the region, and the province. Through a historical and architectural analysis of Behram Pasha mosque, locally called al-Bahramiyya, this paper aims to clarify these influences and their deepness. It also presents the damages induced by the recent conflict in the city and the mosque's current conservation condition.

Key Words: *Syria, Aleppo, Built Heritage, Mosque, Ottoman, Architecture, Conservation*

1. Introduction

More than any other building type, the Ottoman congregational mosques imprinted an image on any cityscape in the Empire of proclaiming the power of the center. They were the monumental structures that towered over the other structures and defined the urban skyline. The influence of the central imperial style on every provincial mosque was a natural result of the organization of architectural activity in the Empire as the imperial architectural office was responsible for the design and execution of the buildings of the Sultanic family and the ruling elite in both the capital and the provinces. However, the varying levels at which the imperial ateliers took part in this process opened the door for local influence. For Sultanic constructions, court architects might be sent from the capital while buildings for lesser patrons were more likely to be entrusted to local architects and craftsmen, though they might be provided with drawings and sometimes written descriptions from the imperial atelier (Kafesçioğlu, 1999, pp.82-84). Necipoğlu (1986, p. 231) noted that, in such cases, there was a marked lack of drawn elevations. This was reflected in the greater central Ottoman feel of the plans in contrast to provincial elevations, where a greater variety and detachment from central Ottoman models is evident. Another factor that played a considerable role in this detachment was the rotation of governors among provinces (Necipoğlu, 2010, pp. 157-160) During their tenures, the governors had the chance to be familiar with local building techniques, and closer to the local masons and workshops. They later engaged them in their provincial building campaigns which enabled another set of interactions at a regional level.

This was the case with the 16th- century Ottoman mosques of Aleppo. The city came under Ottoman rule in 1516 and changed from a frontier city on the borders of the Islamic lands into an interior urban center well protected from outside aggression. The later expansion of the Ottoman Empire towards Iraq, North Africa, and Arabia created an enormous market where both individuals and products could circulate freely. As a commercial center located on the main trade routes, Aleppo benefited well from these interior currents in addition to the favorable changes in the international trade routes that had already started since the late 14th century. Regional and international trade flourished in the city which was reflected in economic, demographic, and urban growth throughout the 16th century.

The Ottoman building campaign during the 16th century was concentrated in the central commercial zone in order to meet the increasing demand

for commercial and production spaces. Large four complexes, of which three comprised congregational mosques, were established successively by Hüsrev Pasha in 1546, Dukakinzade Mehmed Pasha in 1556, Sokullu Mehmed Pasha in 1574, and Behram Pasha in 1583. Together with those established by the Mamluk governors in the late 15th century, the Ottoman complexes doubled the commercial zone and transformed it into an economic quarter called "el-Mdine" by their extensive size, their architectural quality, and the diversity of occupations they accommodate. Situated beside each other, these complexes connected the two major urban cores of the city; the citadel's perimeter and the Great Umayyad Mosque and the markets (suqs) around it. In addition, they pivoted back the commercial zone to its classical west-east orientation by reviving the main thoroughfare extending from the citadel in the east to the Antioch Gate in the west. (Figure 1)

While the commercial dependencies of these complexes considerably followed the local building conventions, their congregational mosques conformed more to the established norms of the imperial architectural style. With their centralized ground plans, hemispherical domes, and cylindrical minarets, they exhibited a radical break from the mosque architecture inherited from the precedent Islamic periods. However, the local influence was also apparent in the applied construction techniques, selected materials, and decorative features.

As the latest of the 16th-century Ottoman mosques in Aleppo, the mosque of Behram Pasha (al-Bahramiyya) constitutes a valuable case to examine the deepness of the central, regional, and local influences and understand the mechanism of their interaction. The mosque is typical to the Ottoman model, yet has extremely close affinities with local and regional examples so that it was claimed as "the beginning of a decentralization of influence" (David, 1991, p.183).

2. The Foundation of Behram Pasha in Aleppo

Behram Pasha, known as Halhalli (Bangled), was born in Gaza to Kara Şahin Mustafa Pasha, a Bosnian recruit, who served as governor of Gaza and of Yemen (1556-60) and then of Egypt (1560-64), with the honorary rank of vizier. [1] Behram himself held the governorship of several cities in Anatolia and the Arab lands including Diyarbakır, Yemen, Sivas, Erzurum and Aleppo. He also participated in

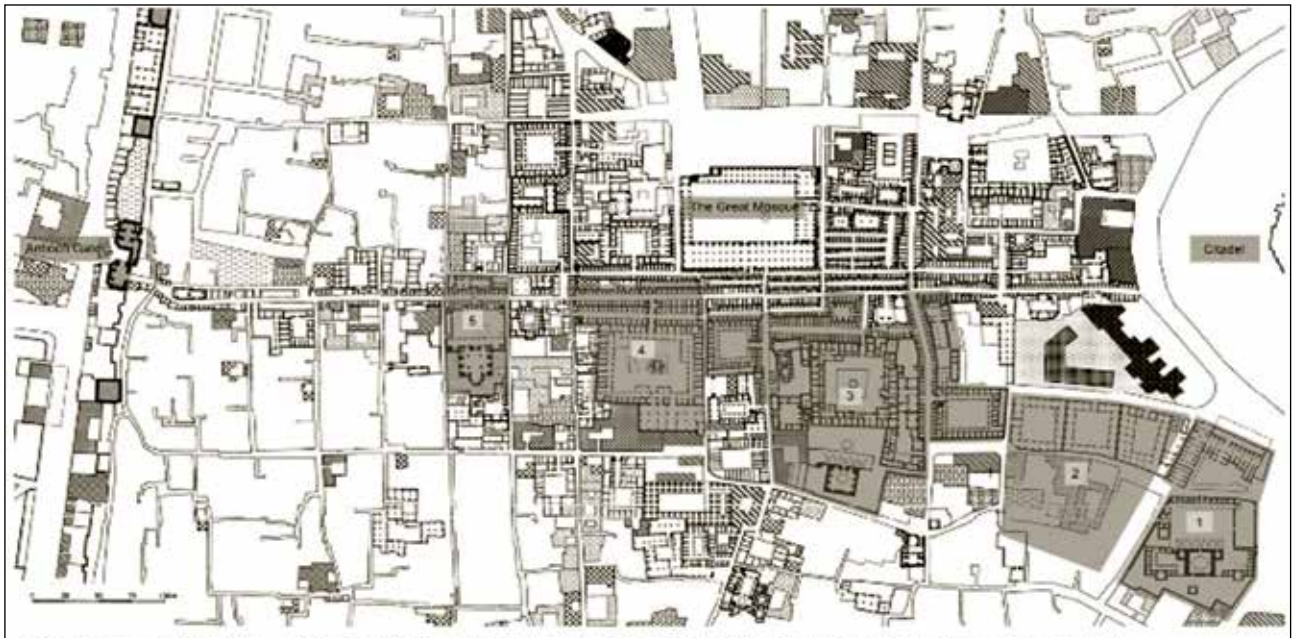

Figure 1. The 16th-century grand Ottoman complexes in the central commercial zone (based on the map of Gaube and Wirth, 1984)

military campaigns, including the Cyprus campaign of 1570-71 and the Safavid campaigns of 1578-79 and 1581-82. Behram Pasha died in 1585 and, as stipulated in his will, he was buried in Aleppo, in a mausoleum at the south side of his mosque. [2] In addition to his complex in Aleppo, Behram Pasha built charitable buildings in Diyarbakır and Urfa and supported them with numerous revenue-generating properties and lands (Necipoğlu, 2010, pp. 467-468). The patron's mosque in Diyarbakır, dated by inscription to 1572-73 and attributed to the Ottoman architect Sinan, is particularly relevant to the architectural study of al-Bahramiyya Mosque because of the close affinities between the two structurs.

The building campaign of Behram Pasha in Aleppo started in 1580, the year of his governorship of the city, and was completed and registered as a foundation (waqf) in 1583. [3] According to the trust deed of the foundation (waqfiyya), the beneficiary buildings of the foundation are the patron's mosque, public fountain (sabil), elementary school, and latrine. The revenue-generating properties include two markets (suqs) to the mosque's immediate north, a qaysariyya, and a coffee house. The second group of properties, a public bathhouse (hammam) and a qaysariyya, is located in the extramural neighborhood of al-Jdayde. [4] The distribution of Behram Pasha's buildings followed the Ottoman urban strategy in developing the central commercial zone. At the same time, it initiated a new trend in developing the northwestern suburbs, which were economically important but so far un-patronized in the Ottoman period. This decision was interpreted by some researchers to be a result of the large-scale building campaigns of the 16th century in the commercial zone where the available areas were diminishing and the property values were rising forcing the constructions out (Raymond, 1979, p. 116) However, the quarter of al-Jdayde had begun to flourish as a major center of industry, in particular silk and cloth-weaving industries, since the late 15th century, offering great potential for urban interventions.

3. Behram Pasha (al-Bahramiyya) Mosque

3.1 History

Throughout its history, the mosque has witnessed several damages and consequent interventions that altered some of its original features. These interventions are mentioned by the two famous Aleppine historians in the early 20th century, al-Ghazzi (1991, p. 44) and at-Tabbakh (1988, pp. 175-176). The earliest known intervention took place in 1699 when a new minaret was constructed instead of the original collapsed one according to the inscription above the minaret's door. [5] There is no description of the original minaret. However, it was praised by the Ottoman traveler Evliya Çelebi as "the most beautiful one in Aleppo" when he visited the city in 1671-72 (Çelebi, 1935, p. 375). When the minaret fell, it is possible that the western side of the mosque was severely affected. Al-Ghazzi mentions that the western entrance of the courtyard was blocked because the whole adjacent alley was inaccessible. The western portico of the courtyard and the latrine, mentioned in the deed as being opposite the entrance across the alley, are not extant today. The western bays of the portico preceding the prayer hall were also destroyed. They were rebuilt later, at an unknown date, in a system that is different from the original one that is observable in the eastern bays.

The earthquake of 1822 resulted also in severe damages. As the revenues of the foundation were not enough to cover the costs of repairs, the consequent interventions were gradual and lasted until the early 20th century. The dome of the prayer hall collapsed and was rebuilt after about 40 years in a totally new structural system. [6] In 1882, the original ablution pool in the middle of the courtyard was replaced by a modest square one provided with taps along its sides. In 1924, the mausoleum of Behram Pasha in the back garden was renovated. In the following year, a new block was built along the western side of the courtyard instead of the original portico. The block contains a prayer space (hijaziyya) and an ablution room that was provided with hot water. [7] The northern and eastern porticoes of the courtyard were not rebuilt. Finally, the mosque witnessed maintenance works under the supervision of the General Directorate of Islamic Foundations in the second half of the 2000s.

3.2 Urban Setting

The mosque lies south of the east-west main thoroughfare of the central commercial zone. It is

surrounded by the patron's suq to the north, two narrow alleys to the east and west and by the bimaristan (hospital) of Nur ad-Din, dating back to the 12th century, and other buildings to the south. (Figure 2)

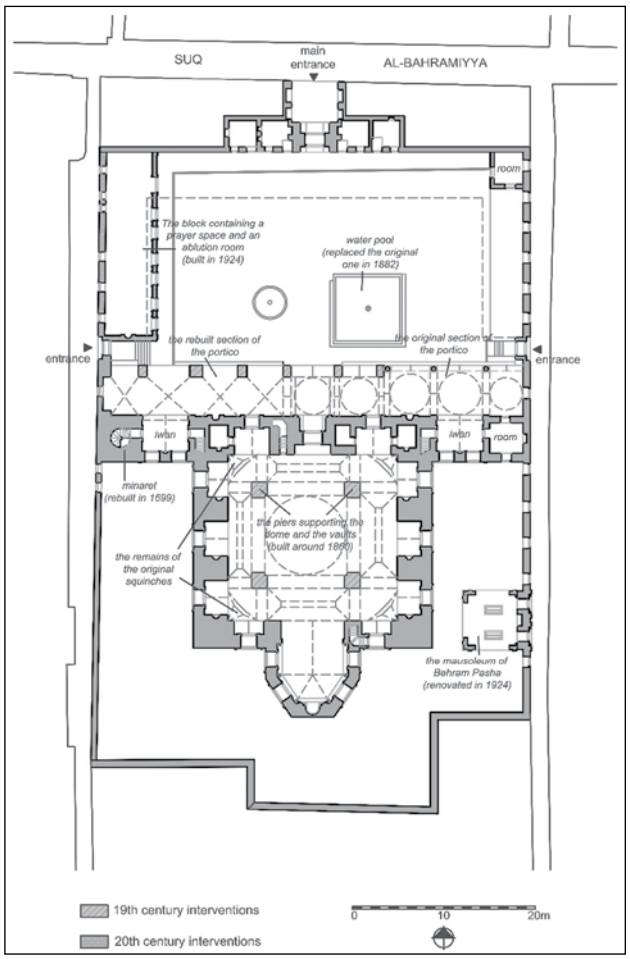

Figure 2. The plan of Al-Bahramiyya Mosque (2010)
Based on a survey conducted by the students of the Faculty of Architectural Engineering at Aleppo University in 1991

The mosque has three entrances leading directly to the courtyard. The main entrance, with the public fountain on its eastern side, is reached midway through the northern suq. In an arrangement that recalls the entrances of the major Ottoman khans rather than mosques, al-Bahramiyya's main entrance is signaled by three raised domes. The dome over the portal is characterized by its muqarnas pendentives. (Photo 1) The portal itself is richly decorated; built entirely with alternative courses of yellow and black stones (ablaq) and surrounded by a wide frame with carved geometrical ornaments. The doorway is topped with an elaborate crested segmental arch and set inside a niche ending with a pointed arch instead of the usual muqarnas hood. (Photo 2) The mosque's other two entrances are set at equivalent positions on the eastern and western sides. They are identically built and simpler than the main entrance. The doorways are built with polychrome masonry and set within pointed niches. (Photo 3)

Photo 1. The domes in front of the mosque's main entrance (2008)

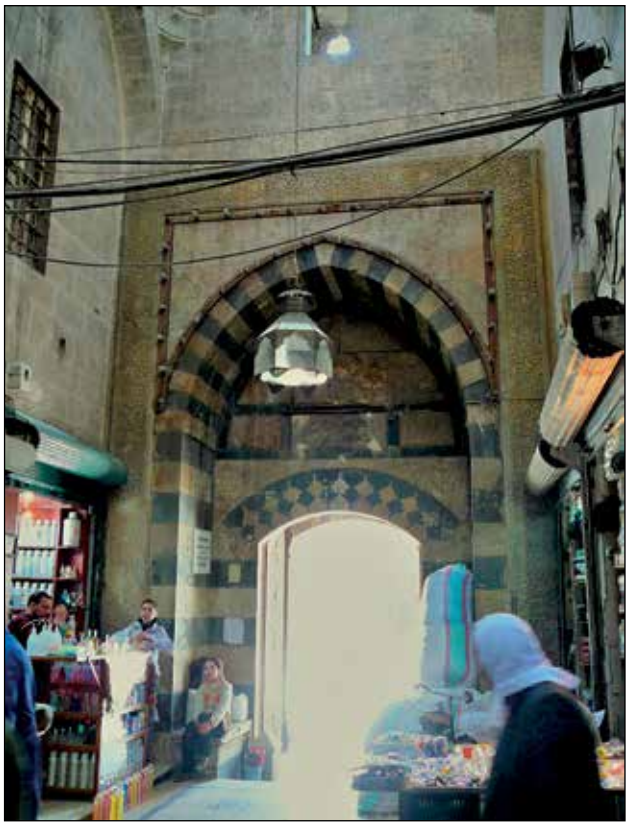

Photo 2. The mosque's main entrance (Knost, S. 2009)

Photo 3. The mosque's eastern entrance (2008)

3.3 Architecture

The entrances lead to a rectangular and spacious courtyard. (Photo 4) The prayer hall, preceded by a portico, occupies the southern side. The new block, built in 1924, extends along the western side. The remains of two column shafts are laid horizontally in front of the block. Along the eastern side, there is a raised platform ending with a small room, that seems like a later addition, at the northeastern corner. Five rectangular windows pierce the courtyard's wall overlooking the adjacent alley. The main entrance on the northern side is flanked by two rooms on each side opening directly towards the courtyard by a door and a window for each. The wall bears traces of a former preceding portico that comprised 11 bays. (Photo 5) Two ablution pools take place in the middle of the courtyard; the square one which was built in 1882 and another one which is circular and smaller in size.

The current condition of the courtyard presents little of its original appearance. Originally, three porticoes extended along the eastern, western, and northern sides. They were covered by brick domes and supported by columns. The original ablution fountain was covered by a brick dome with a wooden canopy and provided with iron grills. [8] Had the courtyard persevered its original features, it would have been the closest to the central idioms among the three 16th-century mosques in Aleppo with its regular shape, symmetrical composition, and axial layout in which the main entrance to the courtyard aligns precisely with the main entrance of the prayer hall, which in turn aligns with the mihrab centered on the qibla wall.

Photo 4. A general view of the courtyard (2007)

Photo 5. The traces of the former northern portico (2008)

The prayer hall is preceded by a noticeable long portico of 9 bays; of which only the three to the east have survived in their original form. (Photo 6) They are covered by small domes and supported by elegant columns with muqarnas capitals. Water spouts emerge just below the plain cornice in the middle of each spandrel. The new bays, however,

are covered with cross vaults and supported by rectangular stone piers. On the façade, their cornice is a little lower than the original one.

Photo 6. A general view of the prayer hall's portico (2011)

The reconstructed minaret rises from the western side of the portico. Conforming to the Ottoman style, the minaret has a square base and a cylindrical shaft, interrupted by a balcony with a cut stone balustrade and topped by a cone covered with lead tiles. The shaft is ornamented with a band of black joggled stones in the shape of crests just under the balcony. The transition between the square base and cylindrical shaft is created by using muqarnas units at the corners of the base. (Photo 7)

On both sides of the prayer hall, there is an iwan, which drops back to the garden wall. Each iwan is provided on its lower level with a mihrab and two windows overlooking the garden behind. Above, another small window gives further light to the space. (Photo 8) The western iwan gives access to the minaret and the western gallery, which overlooks the interior space of the prayer hall, while the eastern iwan gives access to the eastern gallery and to a small room, which is secluded in the eastern corner and detached from the prayer hall. This room may have been a guest room, perhaps for prestigious visitors. Since they have no earlier models, these two iwans have provoked some discussion. David (1991, p. 183) considered them a local "Aleppine feature" that was re-used only once in the 18th-century al-Madrasa al-Uthmaniyya in Aleppo.

Photo 7. A general view of the minaret (2008)

Watenpaugh (2004, p. 87) considered them a development of the two tabhane rooms flanking the prayer hall in T-type Ottoman mosques. The two closest examples in the region are the mosques of al-Khusrawiyya in Aleppo (1546) and Iskender Pasha in Diyarbakır (1551). Wolf (2005, 364-365) argued that these iwans may have been a derivation of a garden view in the context of the double-portico mosques where the outer portico wraps around the inner one and provides a view onto the rear garden. Several examples of double-portico mosques can be found in Syria and the region such as the mosque of Sultan Suleyman in Damascus (1558), al-Adiliyya mosque in Aleppo (1565), and Behram Pasha's mosque in Diyarbakır (1573). Whatever its origin is, it is evident that this peculiar feature of exterior iwans has developed in the regional and local context rather than imported from the center. Aesthetically, these iwans give a dynamic spatial quality under the portico. Functionally, they provide a kind of additional prayer space, as they are equipped with mihrabs.

Photo 8. The iwan on the eastern side of the prayer hall (Meinecke, M. 1984),

Apart from this specific feature, the layout of the prayer hall's façade conforms to the central Ottoman model. The portal in the middle is flanked by a window and a small mihrab on each side. (Photo 9)

Photo 9. A section of the prayer hall's northern facade (Meinecke, M. 1984),

The portal is built with polychrome masonry and recesses within a large niche topped by a pointed arch. Lacking the muqarnas hood, the portal came closer to the local idiom than those of the previous Ottoman mosques in the city. (Photo 10) The tympanum of the niche is covered by carved stone ornaments and muqarnas strips recalling the portal of the Mamluk Oghul Bek mosque (1480) in Aleppo. The windows of the prayer hall are also built with polychrome masonry and surmounted by relieving arches.

Photo 10. A general view of the portal of the prayer hall (2008)

The prayer hall is a domed cube with a five-sided apse on its southern side. The original dome was resting on eight arches and four squinches. The remains of the squinches at the hall's corners have retained roundels and 3 rows of muqarnas corbelling. (Photo 11) The original dome covered an approximate area of 324 m2 which made it the largest among the other Ottoman domes in the city (David, 1991, p. 185). The rebuilt dome, however, was built raised on a drum pierced with 16 small windows. The drum itself is supported by four piers set directly into the hall with pendentives being used as transition elements. (Photo 12) The rest of the hall is covered by vaults.

On the four sides of the hall, there are deep recesses carved as window casements.

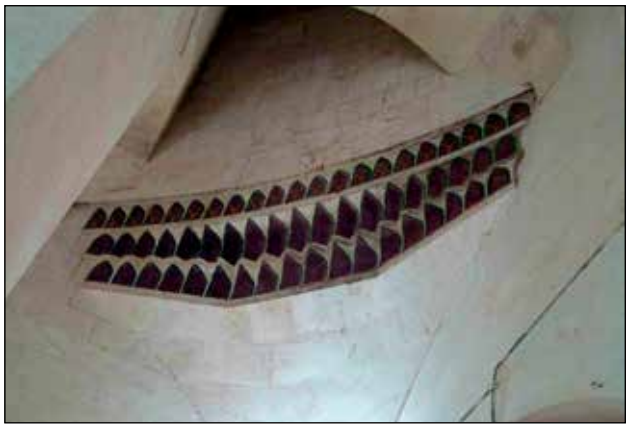

Photo 11. One of the original squinches at the corner of the prayer hall (2008)

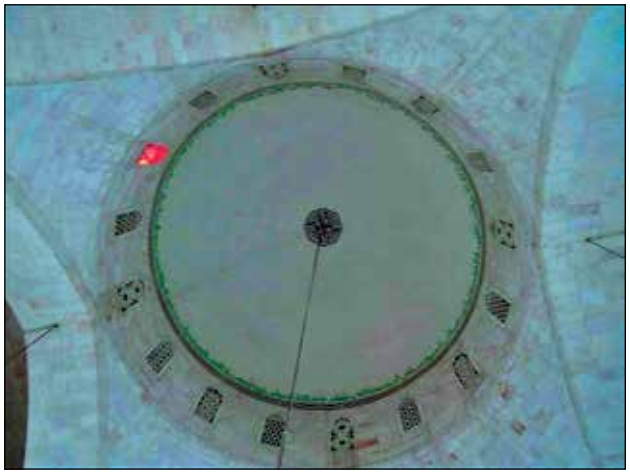

Photo 12. A general view of the dome built around 1860 (2008)

On the lateral sides, every recess accommodates a mihrab on its southern face. The recess-plan was a structural arrangement developed by the architect Sinan. The earliest example of this arrangement is Hadım Ibrahim Pasha's mosque at Silivrikapı in Istanbul (1551), while the two examples closely related to al-Bahramiyya, are al-Adiliyya mosque in Aleppo (1565) and Behram Pasha's mosque in Diyarbakır (1973). Similar also to these two mosques, there are upper galleries reached by staircases built into the walls. The facades of the galleries consist of double arcades set on thin columns, which provide a rich, dynamic articulation of the space. (Photo 13) Two small rooms are inserted into the northeast and northwest corners of the hall and can be accessed from the adjacent recesses. According to the deed, these rooms functioned as storage spaces for rugs, carpets, oil lamps, and candles.

Photo 13. The western upper galley inside the prayer hall (2008)

The projecting apse on the southern wall of the hall houses the mihrab niche on its southern end and four windows on the other sides. (Photo 14)

Photo 14. A general view of the southern apse from outside (2008)

Five arches, built with polychrome masonry, on columns at the corners frame the mihrab and windows. Above each arch, another window is opened below the thin cornice which defines the beginning of the covering vault. (Photo 15) The vault is not precisely a half-dome but is rather a

quintuple. Although the five-sided apses appeared in Ottoman architecture in the late 15th century, this feature was rarely used in Istanbul. One of the few examples is Davud Pasha Mosque (1485). On the other hand, Watenpaugh (2004, pp. 88-89) has notified that these apses constituted a building tradition in Diyarbakır even before the Ottoman conquest of the city and cited several examples such as the Aynı Minare mosque (1489), Hüsrev Pasha's mosque-madrasa (1521-28) and Hadım Ali Pasha's madrasa (1537-43). Therefore, the apse of al-Bahramiyya mosque is more likely a regional influence rather than a central one.

Photo 15. A general view of the southern apse from inside (2008)

The mihrab, minbar, and sudda are reminiscent of the Aleppine conventions of such architectural features. The splendid mihrab is made in yellow limestone and colored marble and features the general characteristics of Ayyubid style. This similarity is apparent when this mihrab is compared, for example, with the one of Madrasa al-Firdaws (1235-36). The niche consists of a fairly deep concavity flanked by inset colonnettes with muqarnas capitals and framed by a heavy continuous molding. The concavity itself is covered by alternating panels of light and dark marble. These panels are topped by small arches that give them the appearance of small niches. The hood of the niche is covered by elaborate muqarnas of five levels. The niche is topped by polychrome interlaced voussoirs. (Photo 16) The minbar is of yellow limestone and white marble and it features geometric marble mosaics on its sides. The sudda, not extant today, took place on the western side of the prayer hall's entrance raised on two columns with muqarnas capitals.

Photo 16. The mihrab inside the prayer hall (2008)

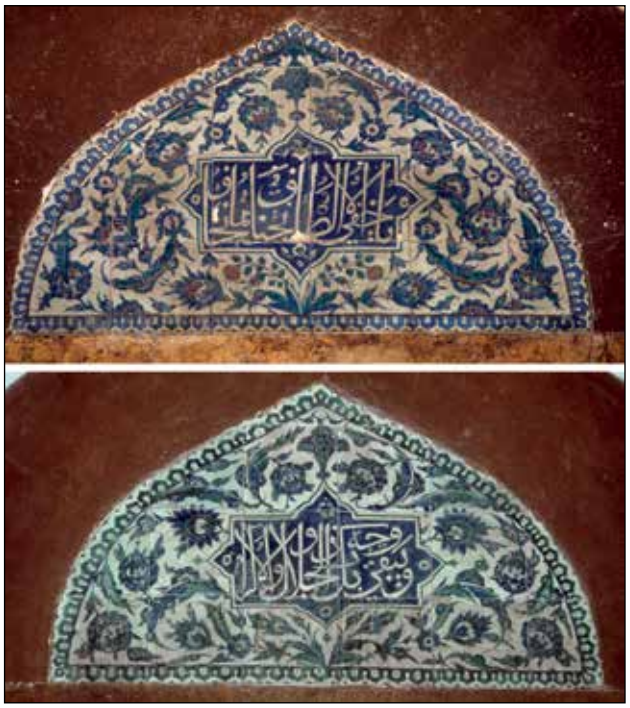

Photo 17. Above: One of the decorative panels inside the prayer hall
Below: One of the decorative panels that might be a later replacement
(Meinecke, M. 1971),

Compared to the other 16th-century Ottoman mosques in the city, the indoor atmosphere of the prayer hall is more austere with its walls built in finely-cut ashlars. The decorative elements are confined to the tympana of the windows which are covered by panels of under-glazed ceramic tiles. The tiles are in a typical Iznik palette with their saz-leaf and arabesque design and the use of red and turquoise. Therefore, the general consensus of scholars is that these tiles are imports from Iznik. There are also some panels that have a palette of blue, black, and turquoise which can be a later replacement (Millner, 2015, pp. 181-182). (Photo 17)

3.4 Current Conservation Condition

The central commercial zone of the old city of Aleppo was among the most affected locations during the recent armed conflict (2012-2016). Huge fires erupted in the covered suqs resulting in the collapse of many roofs and the complete destruction of some suqs. The urban fabric of the zone with its narrow and covered alleys encouraged street combat, causing all the facades of the historic buildings damaged by the traces of bullets and random shells. The escalation of the fight to take control over the Great Umayyad Mosque and the Citadel resulted in heavy damage to many monuments in the zone. Every single minaret, dome, or roof has been affected in one way or another by bombardments and shelling. The fight took its toll on the 16th-century Ottoman mosques discussed in the paper. Al-Khusrawiyya mosque was completely destroyed in 2014 (UNESCO and UNITAR, 2018, p. 72), while the dome of al-Adiliyya mosque collapsed together with a section of the preceding portico (UNESCO and UNITAR, 2018, p. 76).

The most serious structural damages in al-Bahramiyya mosque can be observed in the prayer hall and its preceding portico. The dome of the prayer hall together with some vaults is partially destroyed and there is a risk of their full collapse. (Photo 18) A similar condition is observable in two of the domes covering the preceding portico. (Photo 19) Holes of varied sizes can be seen in several points in the walls of the prayer hall, the walls of the courtyard, and the shaft of the minaret, together with the displacement of stone blocks, which can increase the threat of structural disintegration of the masonry. (Photo 20)

Photo 18. The structural damages in the prayer hall (2021)

Photo 19. One of the partially destroyed domes in the prayer hall's portico (2021)

The stone surfaces are affected at varying levels by bullets and shells. Unfortunately, this includes some carved details of the prayer hall's portal. However, the distinctive architectural elements inside the hall – the mihrab, and the minbar, together with the decorative elements are almost

intact. Except for some urgent interventions in that took place in 2017 to consolidate one of the portico's piers, no restoration works have been conducted yet and the mosque is still closed.

Photo 20. Varying damages in the walls of the prayer hall (2021)

4. Conclusion

The architectural importance of al-Bahramiyya mosque stems from the fact that it was the last example of a dynamic interaction among local, regional and central influences that shaped the Ottoman architecture in the city during the 16th century. Had the building campaign in Aleppo flourished at the same pace in the following century, this interaction would have produced more examples of distinguished provincial Ottoman architecture.

The analysis of the mosque shows the deep regional and local influences that go beyond the conventions of decor or building techniques to include new architectural elements applied for the first time in the city. This was clear from the usage of the unusual five-sided apse and the two large side iwans, features that researchers have argued originated locally and regionally rather than at the center. In decorative terms, the mosque exhibits a further step in the Ottoman appropriation of the city's architectural repertoire. In the earlier mosques of al-Khusrawiyya and al-Adiliyya, the usage of the local decorative elements was limited to the most recent period, which was the late Mamluk. In al-Bahramiyya mosque, however, elements from the early Mamluk and Ayyubid periods were used. The design of the portals, windows, and the mihrab reverted strongly to these local styles.

The numerous similarities such as the recess-plan and the upper galleries put the mosque within the context of its close local and regional examples, al-Adiliyya and the patron's mosque in Diyarbakır, as they all show the development of a common typology. This sheds light on the architectural interactions between the two main centers; Aleppo and Diyarbakır, and suggests a steady and rapid transfer of ideas, and perhaps architects in the region. The role of patronage in this aspect is evident as two of Aleppo's main 16th-century patrons, Hüsrev Pasha and Behram Pasha, governed Diyarbakır and established complexes there. Although further research is needed, Necipoğlu has already cited two examples of regional transfer of architects and masons. The first was in Sokollu Mehmet Pasha's complex in Payas (the 1580s), where architects and masons from Aleppo had participated in the construction (Necipoğlu, 2010, p. 360). The second case was when Behram Pasha himself, wanting to replicate the elegant baths he had seen in the Arab lands, imported skilled builders and marble cutters from Gaza, his birthplace, and from Jerusalem. She also suggested that Behram Pasha may have seen al-Adiliyya Mosque in Aleppo and asked Sinan to design one like it in Diyarbakır (Necipoğlu, 2010, p. 468). We can say that later some of the architectural solutions returned to Aleppo through his mosque, al-Bahramiyya, yet in a more developed way.

With its history and unique architecture, al-Bahramiyya mosque is among the monuments that represent the evolution of architectural, urban, and social practice in Aleppo. Similar to the other mosques located in the commercial zone, it was a place where people met and interacted on a daily basis. Thus, it is an indispensable part of their collective memory. The recovery process of Aleppo is facing today major challenges to meet

the amount and the quality of needed work to restore these monuments. There is a hope that al-Bahramiyya mosque will be carefully restored in a way that respects its historic layers, enhances its presentation, and fully brings back the mosque to its religious and social role in the city.

Endnotes

[1] The trust deed and the Aleppine sources give Mustafa Pasha's name as -- Mustafa Basha ibn 'Abd al-Mu'in. At-Tabbakh (1988, p. 175), al-Ghazzi (1992, p. 41). More information on Mustafa Pasha's life and career can be found in Blackburn (2009, p. 720).

[2] For more biographical information on Behram Pasha see Necipoğlu (2010, p. 467), and Watenpaugh (2004, p. 84). Behram Pasha's older brother, Radwan Pasha, was also buried next to him in 1586, after serving as the governor of the city for one year.

[3] The deed was composed in Arabic by the Aleppine legal scholar Taj ad-Din al-Korani. For the purpose of this article, three copies of the deed were studied. The copies are identical in content, however, there are slight differences in the description of the courtyard and the prayer hall. The first copy is preserved in the Ottoman Archives (*Başbakanlık Osmanlı Arşivi*) in Istanbul. The second copy is a hand-copied version preserved in the Archives of the General Directorate of Foundations (*Vakıflar Genel Müdürlüğü Arşivi*) in Ankara. The third one is the summary published in 1926 by al-Ghazzi (1992, pp. 41-45).

[4] Some dependencies were added to the foundation in 1890: a coffee house and several shops to the west of the bath-qaysariyya complex in al-Jdayde neighbourhood, according to al-Ghazzi (1992, p. 44). In addition to the properties in Aleppo, the deed also refers to a number of mills outside of Aleppo, a public bath, a coffee house, a stable and shops in Cairo and several orchards near Gaza.

[5] The reconstruction of the minaret was celebrated with an inscription composed by the poet Yahya al-Halabi al-Akkad. For the complete text of the inscription see ʿUthman (2010, p. 62).

[6] According to At-Tabbakh, the structure stood in ruins for about forty years until the foundation's administrator sold the lead which had covered the original dome to raise funds for a new one.

[7] There are several inscriptions dating the interventions of the early 20th century. For the complete text of the inscriptions inside the mausoleum see ʿUthman (2010, pp. 63-64).

[8] The copy of the deed preserved in Istanbul doesn't mention any of the porticos surrounding the courtyard and refers to only one covered ablution fountain, while the copy preserved in Ankara describes the northern and western porticos and refers to two ablution fountains in the courtyard, one is reserved for the Hanefis' and the other for the Shafi's.

Acknowledgment

The author would like to thank the Museum for Islamic Art in Berlin for permission to consult the digitalized photographic collection of al-Bahramiyya Mosque in Aleppo and use some of the relevant images.

References

1. *Blackburn, J. R. (2009), "Mustafa Pasha, Kara Shahin", Bearman, P., Bianquis, Th., Bosworth, C.E., Van Donzel, E. and Heinrichs, W.P. (Eds.), Encyclopedia of Islam, Second Edition, Brill, Leiden, Vol. 7, pp. 720-722. Available at: http://dx.doi.org/10.1163/1573-3912_islam_SIM_5614 (accessed 12 December 2022)*

2. *Behram Paşa Vakfiyesi, (991/1583), Başbakanlık Osmanlı Arşivi, BOA.EV.VKF.4.11, Istanbul*

3. *Çelebi, E. (1935), Evliya Çelebi Seyahatnamesi, 10 vols, vol 9, Devlet Matbaası, Istanbul.*

4. *David, J. C. (1991), "Domaines et Limites de l'architecture d'empire dans une capitale provinciale", Revue du Monde Musulman et de la Mediterranee, Vol. 62 No. 4, pp. 169-194. Available at: https://www.persee.fr/doc/remmm_0997-1327_1991_num_62_1_1531 (accessed 12 December 2022)*

5. *Gaube, H. and Wirth, E. (1984), Aleppo: historische und geographische Beiträge zur baulichen Gestaltung, zur sozialen Organisation und zur wirtschaftlichen Dynamik einer vorderasiatischen Fernhandelsmetropole. Ludwig Reichert, Wiesbaden.*

6. *Al-Ghazzi, K. (1992), Nahr adh-Dhahab fi Tårikh Halab, 3 vols, vol 2, Dar al-Qalam al-ʿArabi, Aleppo.*

7. *Goodwin, G. (1971), A History of Ottoman Architecture, Thames and Hudson, London.*

8. *Kafesçioglu, Ç. (1999), "In the Image of Rum: Ottoman Architectural Patronage in Sixteenth Century Aleppo and Damascus", Muqarnas: An Annual on the Visual Culture of the Islamic World , No. 16, pp. 70-96. DOI: 10.1163/22118993-90000384*

9. *Necipoğlu, G. (1986), "Plans and Models in 15th and 16th Century Ottoman Architectural Practice", Journal of the Society of Architectural Historians, Vol. 45 No. 3, pp. 224-243. DOI: 10.2307/990160*

10. *Necipoğlu, G. (2010), The Age of Sinan: Architectural Culture in the Ottoman Empire, Reaktion Books, London.*

11. *Raymond, A. (1979), "Les grands waqfs et l'organisation de l'espace urbain à Alep et au Caire à l'époque ottomane (XVIe-XVIIe siècles)", Bulletin d'Études Orientales, No. 31, pp. 113–132. Available at: https://www.jstor.org/stable/41604663 (accessed 12 December 2022)*

12. *At-Tabbakh, M. R. (1988), Iʿlam al-Nubalå bi-Tarikh Halab al-Shahbå, 8 vols, vol 3, Dar al-Qalam al-ʿArabi, Aleppo.*

13. *UNESCO and UNITAR. (2018), Five Years of Conflict: The State of Cultural Heritage in the Ancient City of Aleppo, UNESCO and UNITAR Publications, Paris and Geneva. Available at: https://unesdoc.unesco.org/ark:/48223/pf0000265826 (accessed 12 December 2022)*

14. *Behram Paşa Vakfiyesi, (991/1583), Defter 588, Vakıflar Genel Müdürlüğü Arşivi, pp. 139-146, Ankara*

15. *ʿUthman, N. (2010), Dirasat Naqåish al-ʿAhd al-ʿUthmani fi Muhafazat Halab: Al-Mabani wa Shawahid al-Qubur, Mudiriyyat Awqaf Halab, Aleppo.*

16. *Vakıflar Genel Müdürlüğü Arşivi, Behram Paşa Vakfiyesi, Defter 588, pp. 139-146, Ankara*

17. *Watenpaugh, H. Z. (2004), The Image of An Ottoman City: Imperial Architecture and Urban Experience in Aleppo in the 16th and 17th Centuries, Brill, Leiden. DOI: 10.1163/9789047404224*

18. *Wolf, S. (2005), "The Construction of Ottoman Aleppo: Modes and Meanings of Urban (Re)-organization", unpublished Ph.D. dissertation, Harvard University, Cambridge.*

Corresponding Author
Ruba Kasmo,
Faculty of Architecture and Design,
Fatih Sultan Mehmet Vakif University,
Istanbul,
Turkey,
E-mail: rubakasmo@gmail.com

Frequency Decomposition in Predictive Error Compensating Wavelet Neural Network

Ajla Kulaglic

Istanbul Technical University, Istanbul, Turkey

Abstract

This paper presents an extended study of the previously proposed Predictive Error Compensation Neural Network (PECNET) model. Different frequencies are used as input, in addition with the use of the Butterworth filter and the model performances are compared. The results show that the PECNET with frequency decomposition and Butterworth filter applied to input data provides significantly more accurate predictions for stock price prediction problem with respect to previous studies and conventional machine learning and time series prediction methods without changing any hyperparameter or the structure. In addition, the time and space complexity of the PECNET model is less than all other compared machine learning methods.

Key Words: *predictive error compensated neural network, Butterworth filter, frequency decomposition, wavelet transform, stock price forecasting*

1. Introduction

In the time of global financial changes, forecasting financial time series data is a significant challenge that even trading robots can hardly predict. 80% of the stock markets nowadays are controlled by machines, and according to Forbes (Kindig, 2020), robots will replace 200,00 banking businesses in the next ten years. High-Frequency trading technologies are a type of algorithmic trading that uses machine learning algorithms to implement investment strategies in brief time intervals. Stock market prediction is essential when making the proper decision (Fama, 1993). However, evaluating input data and their appropriate frequencies is critical regarding machine learning problems. For this purpose, more relevant frequencies have been determined that can be used to improve the forecasting performance without causing overfitting problems or increasing the complexity of the proposed algorithm. On the other hand, stock price data are disposed to frequent changes that cannot be derived from the historical trend. Changes are influenced by real-world factors, such as political, social, and environmental factors (Novak *et al.*, 2016). In addition, the noise-to-signal ratio is very high in such conditions, and it is difficult to analyze and forecast future data. The use of econometric models is convenient for describing and evaluating the relationships between variables using statistical inference, with some limitations. These limitations can be seen in the inability to capture the nonlinear nature of stock prices. In addition, (Abu-Mostafa and Atiya, 1996) in their study assumed constant variance while the financial time series are boisterous and have time-varying volatility.

Statistical methods such as Autoregressive Moving Average (ARMA), Autoregressive Integrated Moving Average (ARIMA), and vector autoregression have generally achieved reasonable predictive results based on the results found in the literature (Box, 2013) and (Reddy, 2019). However, according to the statistical models, Artificial Neural Networks (ANNs) are one of the most accurate prediction models (Khashei and Bijari, 2010). According to (Hornik *et al.*, 1989), ANNs with a given sufficient amount of data can approximate any finite and continuous function based on the universal approximation theorem. The first significant study of a neural network model to predict stock price returns were made by (White, 1988), where he introduced a prediction model based on IBM's daily common stock and achieved promising results. Various hybrid systems using ANN have been proposed to increase prediction performance, the Hidden Markov Model (HMM), (Hassan *et al.*, 2007), exponential smoothing, and ARIMA (Wang *et al.*, 2012), and ANN with exponentially generalized autoregressive conditional heteroscedasticity model (Hajizadeh *et al.*, 2012). The two most popular deep-learning architectures for stock market forecasting in recent years are the Long Short-Term Memory (LSTM) model and the Gated Recurrent

Unit (GRU) model with its hybridization (Shahi *et al.*, 2020). LSTM models are appropriately structured to learn temporal patterns and overperform the conventional recurrent neural networks (RNNs). LSTM and GRU deep-learning architectures are proposed and performances of these two models are compared for stock market predictions in (Shahi *et al.*, 2020). In their study, they compared the performance of the LSTM and GRU models under the same conditions. Also, they showed that the predicting model could be significantly improved by including contextual information such as financial news sentiments and stock market features. Bao *et al.* (Bao *et al.*, 2017) used the LSTM for stock price forecasting using different types of sequential data. Using the sentiment features, Li *et al.* (Li *et al.*, 2017) have shown that LSTMs surpass benchmark models of SVM and improve the accuracy of next-day opening price predictions. In prediction models, the problem of overfitting and getting stuck in local optima are additional issues that must be considered. The problem is due to the limited amount of data and appropriate model configuration. The financial time series data yearly obtain approximately 252 data points. However, this is insufficient for the Deep Neural Networks (DNN) models compared to the number of model parameters (Goodfellow *et al.*, 2016). Sufficient data is needed as the number of model parameters increases as the number of features used is enlarged. Although NN models achieve better generalization, they are prone to overfitting due to their high capacity. Regularization techniques can prevent overfitting, but they cannot improve generalization performance. Hence, data augmentation is a method used in order to avoid overfitting while improving generalization accuracy. However, regarding financial time series, the data augmentation distorts the original data. Consequently, in recent times, signal processing techniques have recently been used to transform data into a format that reveals certain characteristics. The results showed that the extracted features could achieve more accurate predictions than the data without feature extraction. In this study, the proposed studies in (Ustundag and Kulaglic, 2020), (Kulaglic and Ustundag, 2021), and (Kulaglic and Ustundag, November 2021) are extended by using different frequencies as input to the Predictive Error Compensation Neural Network (PECNET) model. In addition, the use of the Butterworth filter on the input data is tested, and the model performances are compared. The rest of this chapter is organized as follows. Section 2 describes the differences between the proposed model. The Butterworth filter is a signal processing technique with a frequency response as flat as mathematically possible in the bandwidth. Experimental results with discussion are given in section 3. Conclusions and proposed remarks on future work are given in section 4.

2. Predictive Error Compensated Neural Network Model with Butterworth Filter

The Predictive Error Compensating Neural Network (PECNET) model presented in this section is an extension of the previously proposed model. The model utilized in this study also consists of four separately trained neural networks, as demonstrated in Figure 1.

The main discrepancy is manifested in the first network, wherein place of the average filtering that was previously applied, the Butterworth filter (BF) is used. Butterworth filters have the sharpest roll-off possible without inducing a peak in the Bode plot, and because of that, they are called maximally flat filters (Ellis, 2012). The general formula for BF depends on the order of the applied filter. For continuous-time Butterworth filters, the poles associated with the squares of the frequency response magnitude are equally distributed in the angle on the circle in the s-plane, concentric with the origin and radius equal to the cut-off frequency. The poles that characterize the system function are readily obtained when the cutoff frequency and filter order are specified. Once the poles are specified, getting the differential equation characterizes the filter is straightforward. The response of the Butterworth filter is given in Equation (1):

$$| B(j\cdot\omega)|^2 = 1/(1+(j\cdot\omega/ j\cdot\omega_c)^2) \quad \text{..... (1)}$$

Where the constant is the 68 400 sample frequency (one day is 68 400 seconds). It is easy to show that the first derivative of $B(j\cdot\omega)^2$ at ω is equal to zero ($\omega = 0$). For this reason, Butterworth's response is maximally flat at $\omega = 0$.

Later, the current input of each parameter is shifted to the previous values using the unit time delay

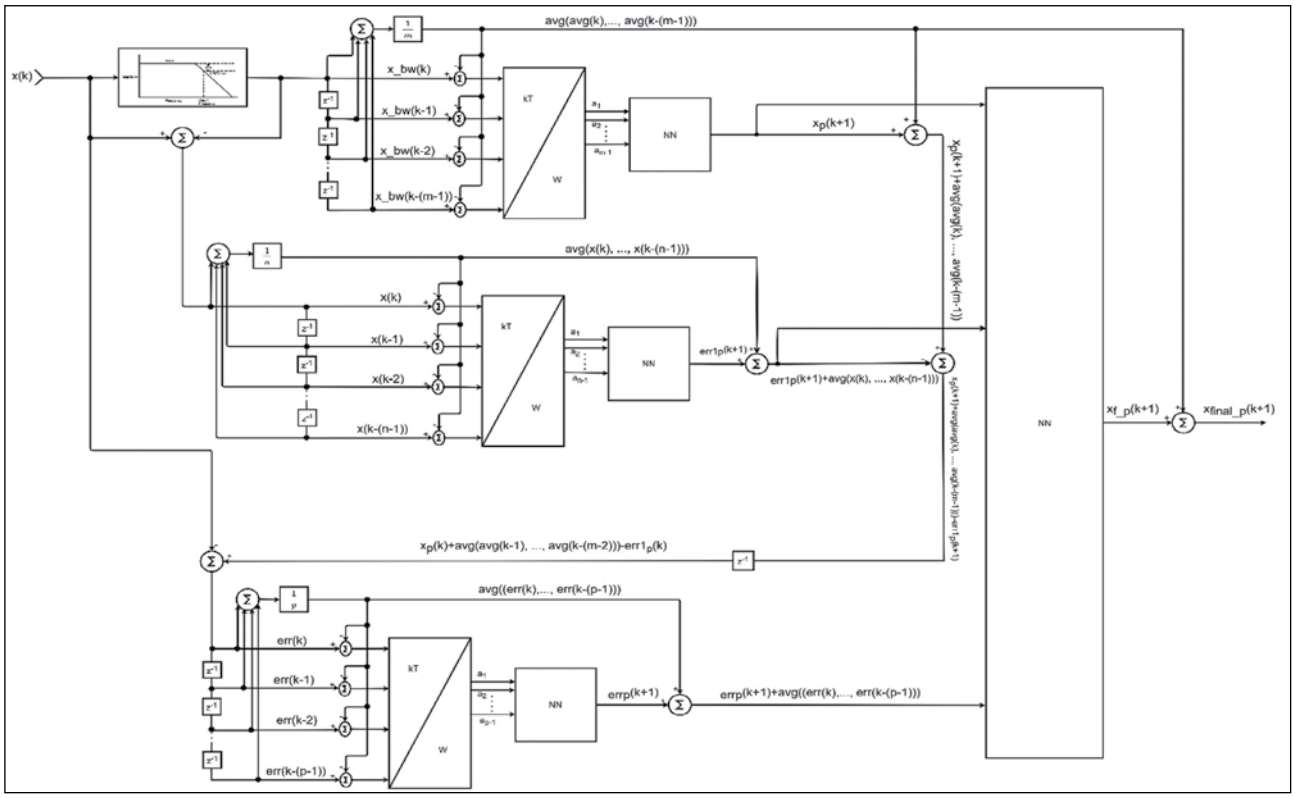

Figure 1 The predictive error compensated neural network model with Butterworth filtering

operator z^{-1} as in previous studies. The error pattern obtained in the main network is applied as the output of the second network, where the difference between the primary data and the BF filtered data is used as input. Additional and separately trained NN with error data patterns of previously trained network have been used. The final neural network merges the outputs of the neural networks in a cascaded part. The average subtraction normalization used as a normalization technique due to the problems in traditional normalization approaches has been proposed and discussed in (Kulaglic and Ustundag, 2021). Normalization of the average subtraction allows us to build a normalization method representing differed volatilities and preserving the original time series properties inside the input sequence. The normalized time series data are preprocessed by discrete wavelet transform (DWT), where the obtained coefficients are used as input to the NNs. The decomposed signal y[n] consists of high- and low-frequency components, as shown in Equation (2). The input signal is presented with x[n]. The low- and high-pass filters are represented by h[n] and g[n], respectively. The Haar wavelet filters have been used as they significantly reduce distortion rate during signal decomposition and reconstruction, and also considerably reducing processing and computational time (Ustundag and Kulaglic, 2020).

$$y[n] = y_{high}[n-1] + y_{low}[n-1] \quad \text{..... (2)}$$

The low-pass outputs recursively pass through an identical group of filter banks in order to use different resolutions in each phase. The filtering process is mathematically expressed using Equations (3) and (4). Equations (3) and (4) provide an approximation and detailed signal, respectively.

$$y_{high}[n-1] = \Sigma\, g[k].x[2n-k] \quad \text{..... (3)}$$

$$y_{low}[n-1] = \Sigma\, h[k].x[2n-k] \quad \text{..... (4)}$$

The neural network configuration consists of input, hidden, and output layers for predicting n-step-ahead time series data. Employed networks have the same network configurations. Regarding different formulas found in the literature (Goodfellow, 2016), (Moshiri and Cameron, 2000) and (Patterson, 1996), the number of neurons in the hidden layers are selected using (Patterson, 1996). The activation function used for these networks is Rectified Linear Unit (ReLU). In comparison with sigmoid and hyperbolic tangent activation functions, the linear activation

function ReLU notably improves the achievement of feed-forward networks (Goodfellow, 2016). The learning rate and momentum of the Stochastic Gradient Descent (SGD) optimization algorithm are 0.05 and 0.75, respectively. In addition to the effect of different filtering methods, the impact of frequency decomposition on the presented model has been investigated. In this regard, high, medium, and low frequencies have been applied to the financial data and ways to improve model performance without compromising model accuracy or causing overfitting have been explored. In order to obtain the spatial resolution, we also included the additional parameters to see the performance of the proposed model. An additional network with supplementary data is added to the proposed model. In order not to increase complexity or cause the overfitting rate by applying the supplementary data to the same NN, we added new parameters into the additional network.

3. Model evaluation

The experimental setup uses the stock price data obtained from the Istanbul Stock exchange, Borsa Istanbul. For this purpose, data from the banking sector and the stock exchange index are used, Is Bank, Garanti Bank, AK Bank, and BIST30 (index of 30 companies). Data were collected using web services Investing (investing.com) for daily closing prices and Matriks (Information Distribution services Matrix) for hourly data. The experimental results are measured with the root-mean-square error (RMSE) and root-mean-square percentage error (RMSPE) (Equations (5) and (6)). Mathematical formulations are given below, where Pi is accurate, and Oi is estimated values in time i. The number of data samples is given by n.

$$RMSE = \sqrt{[\ \Sigma(Pi - Oi)^2 / n\ ]} \quad \text{..... (5)}$$

$$RMSPE=100/n\ *\Sigma|(Pi-Oi)/Pi \quad \text{..... (6)}$$

The RMSPE (Table 1) and RMSE (Table 2) errors for disseminated frequencies are presented. First, the results for the average filtering used in the primary network are shown. Secondly, the results of the improvements done by applying different frequencies to the PECNET model are presented. The frequency decomposition is done using weekly, daily, and hourly data.

Table 1. The RMSPE (%) average filtering results for PECNET.

W/D	AK	IS	GARANTI	BIST30
1NN	2.420932	1.684884	1.929106	1.581213
2NN	1.884708	1.735879	1.673334	1.247089
3NN	1.831507	1.621118	1.658614	1.168715
4NN	1.615228	1.117738	1.634853	0.842569

Table 2. The RMSE (TL) average filtering results for PECNET.

W/D	AK	IS	GARANTI	BIST30
1NN	0.131046	0.090225	0.176524	0.247961
2NN	0.09956	0.07617	0.240385	0.191119
3NN	0.098091	0.066546	0.242836	0.170376
4NN	0.089519	0.059838	0.150628	0.130173

The results are presented in Table 3, (RMSPE) and in Table 4 (RMSE). The improvements in forecasting performances can be seen by increasing the frequencies in the proposed model comparing the results where only weekly and daily data are used.

Table 3. The RMSPE results for increasing frequency applied to the PECNET.

W/D/H	AK	IS	GARANTI	BIST30
1NN	2.422607	1.581548	1.925032	1.587106
2NN	1.750624	1.229699	1.679927	1.266596
3NN	1.710756	1.220028	1.662537	0.960022
4NN	1.311037	1.07663	1.556721	0.860772
5NN	1.263475	1.070055	1.219931	0.797137

Table 4. The RMSE results for increasing frequency applied to the PECNET.

W/D/H	AK	IS	GARANTI	BIST30
1NN	0.131534	0.08455	0.176067	0.24241
2NN	0.09478	0.065632	0.191322	0.194238
3NN	0.092534	0.065115	0.170537	0.147811
4NN	0.069717	0.057155	0.143131	0.131245
5NN	0.062936	0.057059	0.112433	0.128643

If the frequencies are reduced, and the amount of information and data used increases, the model performances are significantly reduced (Tables 5 and 6).

Table 5. The RMSPE results for decreasing frequency applied to the PECNET.

H/D/W	AK	IS	GARANTI	BIST30
1NN	2.962316	2.228355	2.779509	2.085103
2NN	1.496557	1.489793	1.578333	0.918139
3NN	1.309792	1.438456	1.502039	0.747594
4NN	1.276866	1.368016	1.313222	0.811673
5NN	1.205566	1.238978	1.30025	0.737473

Improvements in performance results are also noticed when the Butterworth filter is applied. First, the appropriate frequencies were selected.

The sampling frequency, since daily data are used was 1/days (in seconds). One day has 86 400 seconds, so the sampling frequency is 1/86 400. The cut-off frequency 1/n· days(in seconds) where n is selected as 4. The lowest error is obtained when the ninth order of the BF filter is applied.

Table 6. The RMSE results for decreasing frequency applied to the PECNET.

H/D/W	AK	IS	GARANTI	BIST30
1NN	0.163362	0.121518	0.25242	0.333386
2NN	0.082705	0.080917	0.245359	0.246327
3NN	0.07862	0.077063	0.239065	0.216419
4NN	0.083928	0.074037	0.221789	0.19813
5NN	0.080243	0.067509	0.210701	0.181385

Table 7. The RMSPE results for when the Butterworth filter is applied to the input signal.

D	AK	IS	GARANTI	BIST30
1NN	3.716282	2.55976	3.189103	2.760657
2NN	2.607084	2.077328	2.519306	2.009513
3NN	1.541605	1.02821	1.576386	0.91528
4NN	1.520222	0.998691	1.57281	0.774124

Table 8. The RMSE results for when the Butterworth filter is applied to the input signal.

D	AK	IS	GARANTI	BIST30
1NN	0.202757	0.137869	0.286422	0.436493
2NN	0.144097	0.113562	0.229782	0.318334
3NN	0.078491	0.05527	0.146178	0.200641
4NN	0.072492	0.053673	0.143009	0.140798

The results indicated that applying BF filter to the input data set can further improve the model performances (Table 7 and Table 8).

Table 9. The correlation between Far-eastern stock indices to the BIST30 index.

	N225	HIS	ASX	BIST30
N225	1			
HIS	0.525851	1		
ASX	0.779896	0.404533	1	
BIST30	0.861042	0.652458	0.718566	1

Last but not least, the spatial dimension is included in the proposed model. The spatial dimension is obtained using the different indices from stock exchanges that close before the stock market in Turkey. For this purpose, a parameter that contains information from Far Eastern stock market indices has been constructed. This idea is based on the correlation between Far East market indices and the Istanbul stock market index (BIST30). Only a few Far Eastern indices are used at this stage, such as the Nikkei index (N225), the Tokyo Stock Exchange index, Hang Seng Index (HSI), the stock market index in Hong Kong, and the Australian Securities Exchange index (AXS), and its correlation with the BIST30 index is given in Table 9. The new parameter is constructed from the average normalized values of Far Eastern indices. The constructed parameter is used as an input to the proposed model. Performance improvement is noticed by applying new parameters (Table 10 and Table 11) and together with BF filtering (Table 12 and Table 13).

Table 10. The RMSPE results when the Far-eastern index is used.

Far-eastern index	AK	IS	GARANTI	BIST30
1NN	2.523778	1.563303	1.743394	1.535997
2NN	2.102215	1.272339	1.935211	1.089865
3NN	2.024797	1.271858	1.88175	1.265789
4NN	1.577906	1.101763	1.699738	0.993911
5NN	1.369125	1.088723	1.361959	0.802536

Table 11. The RMSE results when the Far-eastern index is used.

Far-eastern index	AK	IS	GARANTI	BIST30
1NN	0.139754	0.084788	0.161343	0.252468
2NN	0.097526	0.067915	0.181596	0.155434
3NN	0.102322	0.072752	0.195592	0.16116
4NN	0.070979	0.058526	0.163982	0.158479
5NN	0.069592	0.054038	0.155418	0.147533

Table 12. The RMSPE results when the Far-eastern index is used with the Butterworth filter.

Far-eastern index+BW	AK	IS	GARANTI	BIST30
1NN	3.556565	2.436843	3.092161	2.686676
2NN	2.68649	2.299159	2.397482	2.276949
3NN	2.599607	2.501083	2.322024	2.262921
4NN	1.362777	0.83993	2.16978	0.900213
5NN	1.281084	0.71907	1.359017	0.762704

Table 13. The RMSE results when the Far-eastern index is used with the Butterworth filter.

Far-eastern index+BW	AK	IS	GARANTI	BIST30
1NN	0.195383	0.131386	0.277857	0.426849
2NN	0.14941	0.125319	0.216807	0.363872
3NN	0.144235	0.135966	0.237084	0.361765
4NN	0.068886	0.044471	0.197342	0.139435
5NN	0.060181	0.038127	0.168986	0.117781

4. Conclusion

This work introduces an improved PECNET machine learning algorithm that yields reliable and improved prediction performance for the closing stock price prediction model. The model has been enhanced by including the Butterworth filter in the proposed model. In addition, the spatial dimension has been included in the proposed model by constructing additional parameters. The constructed parameter contains the average normalized values

of selected Far Eastern indices. Performance improvement of the proposed PECNET model is noticed by applying different filtering methods as well as including the additional parameters to the model.

References

1. *Kindig, B. (2020), "New age of stock market volatility driven by machines". Available at: https://www.forbes.com/sites/bethkindig/2020/04/10/new-age-of-stock-market-volatility-driven-by-machines/?sh=a53ca66dda21 (accessed 19 December 2022)*
2. *Fama, E.F. and French, K.R. (1993), "Common risk factors in the returns on stocks and bonds". Journal of financial economics, Vol. 33 No. 1, pp.3-56. Available at: https://doi.org/10.1016/0304-405X(93)90023-5 (accessed 19 December 2022)*
3. *Gorenc, N.M. and Velušček, D. (2016), "Prediction of stock price movement based on daily high prices". Quantitative Finance, Vol. 16 No.5, pp. 793-826. DOI: 10.1080/14697688.2015.1070960*
4. *Abu-Mostafa, Y.S. and Atiya, A.F. (1996), Introduction to financial forecasting. Applied intelligence, Vol. 6 No.3, pp.205-213. Available at: https://doi.org/10.1007/BF00126626 (accessed 19 December 2022)*
5. *Box, G., (2013), "Box and Jenkins: time series analysis, forecasting and control". In A Very British Affair. Palgrave Macmillan, London, pp.161-215.*
6. *Reddy, C.V. (2019), Predicting the stock market index using stochastic time series ARIMA modelling: the sample of BSE and NSE. Ind J Finance, Vol. 13 No.8, pp.7-25. Available at: http://dx.doi.org/10.2139/ssrn.3451677 (accessed 19 December 2022)*
7. *Khashei, M. and Bijari, M. (2010), An artificial neural network (p, d, q) model for timeseries forecasting. Expert Systems with applications, Vol. 37 No.1, pp.479-489. Available at: https://doi.org/10.1016/j.eswa.2009.05.044 (accessed 19 December 2022)*
8. *Hornik, K., Stinchcombe, M. and White, H. (1989), Multilayer feedforward networks are universal approximators. Neural networks, Vol. 2 No.5, pp.359-366. Available at: https://doi.org/10.1016/0893-6080(89)90020-8 (accessed 19 December 2022)*
9. *White, H. (1988), July. Economic prediction using neural networks: The case of IBM daily stock returns. ICNN Vol. 2, pp. 451-458. DOI: 10.1109/ICNN.1988.23959.*
10. *Hassan, M.R., Nath, B. and Kirley, M. (2007), A fusion model of HMM, ANN and GA for stock market forecasting. Expert systems with Applications, Vol.33 No.1, pp.171-180. Available at: https://doi.org/10.1016/j.eswa.2006.04.007 (accessed 19 December 2022)*
11. *Wang, J.J., Wang, J.Z., Zhang, Z.G. and Guo, S.P. (2012), Stock index forecasting based on a hybrid model. Omega, Vol. 40 No.6, pp.758-766. Available at: https://doi.org/10.1016/j.omega.2011.07.008 (accessed 19 December 2022)*
12. *Hajizadeh, E., Seifi, A., Zarandi, M.F. and Turksen, I.B. (2012), A hybrid modeling approach for forecasting the volatility of S&P 500 index return. Expert Systems with Applications, Vol. 39 No.1, pp.431-436. Available at: https://doi.org/10.1016/j.eswa.2011.07.033 (accessed 19 December 2022)*
13. *Shahi, T.B., Shrestha, A., Neupane, A. and Guo, W. (2020), Stock price forecasting with deep learning: A comparative study. Mathematics, Vol. 8 No.9, p.1441. Available at: https://doi.org/10.3390/math8091441 (accessed 19 December 2022)*
14. *Bao, W., Yue, J. and Rao, Y. (2017), A deep learning framework for financial time series using stacked autoencoders and long-short term memory. PloS one, Vol.12 No.7, p.e0180944. Available at: https://doi.org/10.1371/journal.pone.0180944 (accessed 19 December 2022)*
15. *Li, J., Bu, H. and Wu, J. (2017), June. Sentiment-aware stock market prediction: A deep learning method. 2017 international conference on service systems and service management. IEEE, pp. 1-6. DOI: 10.1109/ICSSSM.2017.7996306.*
16. *Goodfellow, I., Bengio, Y. and Courville, A. (2016), Deep learning. MIT press.*
17. *Ustundag, B.B. and Kulaglic, A. (2020), High-performance time series prediction with predictive error compensated wavelet neural networks. IEEE Access, Vol. 8, pp. 210532-210541. DOI: 10.1109/ACCESS.2020.3038724*
18. *Kulaglic, A. and Ustundag, B.B. (2021), "Stock price prediction using predictive error compensation wavelet neural networks". Comput. Mater. Continua, Vol. 68 No.3, pp. 3577-3593. DOI:10.32604/cmc.2021.014768.*
19. *Kulaglic, A. and Ustundag, B.B. (2021), "Predictive Error Compensating Wavelet Neural Network Model for Multivariable Time Series Prediction". TEM Journal, Vol.10 No.4. DOI: 10.18421/TEM104-61.*
20. *Ellis, G. (2012), Control system design guide: using your computer to understand and diagnose feedback controllers. Butterworth-Heinemann.*
21. *Moshiri, S. and Cameron, N. (2000), Neural network versus econometric models in forecasting inflation. Journal of forecasting, Vol.19 No.3, pp.201-217.*
22. *Patterson, D.W. (1996), Artificial Neural Networks: Theory and Applications, Prentice Hall.*

Corresponding Author
Ajla Kulaglic,
Istanbul Technical University,
Istanbul,
Turkey,
E-mail: kulaglic@itu.edu.tr

Preparing the Camera Ready Paper for TTEM Journal

First Author [1], Second Author [2], Third Author [3]

[1] First affiliation, City, Country,
[2] Second affiliation, City, Country,
[3] Third affiliation, City, Country.

Abstract

In this paper are given the instructions for preparing camera ready paper for the TTEM Journal. The recommended, but not limited text processor is Microsoft Word (docx). Insert an abstract of 150-200 words, giving a brief account of the most relevant aspects of the paper. It is recommended to use up to 5 keywords. The Keyword should appear on the new line following the last line of the abstract, without a line space, set in Times New Roman 10pt.

Keywords: *Article, ready paper, TTEM Journal.*

1. Introduction

In order to affect high quality of the papers, the authors are requested to follow instructions given in this sample paper.

Title page - Every article has to have a title page with a title of no more than 10 words: name (s), last and first of the author (s), name of the institution the author(s) belongs to, abstract, keywords, introduction, etc.

The paper has to be typed on a standard size paper (format A4). All materials, including tables and references, have to be typed single-spaced. Main text should be set in 11 pt Times Roman, not in bold. All of the text should be printed as a double column and JUSTIFIED throughout.

Regular length of the papers up to 12 pages, (preferred text length is between 5000-7000 words). Footnote-comments, explanations, etc., cannot be used in the paper. Where cannot be avoid end noted should be used after conclusion with given numbers in a squared bracket [1].

2. Instructions for the authors

Main text body - Times New Roman 12 point's font should be used for the text. The manuscript has to be prepared in two columns separated by 5 mm. The margins for A4 (210×297 mm2) paper are given in Table 1.

Regular paper may be divided in a number of sections. Section titles (including references and acknowledgements) should be typed using 11 pt fonts with **bold** option.

Sections can be split in subsections, which should be typed in 10 pt *Italic* options. Figures should be one column wide. If it is impossible to place the figure in one column, two column width figure is allowed. Each figure must have a caption under the figure. For the figure captions 10 pt font should be used.

2.1. Tables and Pictures

Tables have to be numbered and shown by their order, so they can be understood without having to read the paper. Pictures also have to be numbered as they appear in text. All illustrations (pictures, drawings, diagrams, photos, figures etc.) have to be original. Authors are obligated to take Copyright permission, and any misunderstanding or conflict of interest will be responsibility solely of Author. Preferably the picture format is TIF, quality 300 DPI.

Table 1. Page layout description

Paper size	A4
Top margin	20 mm
Bottom margin	20 mm
Left margin	20 mm
Right margin	18 mm
Column Spacing	5 mm

If they have been prepared or taken by Author than only year can be added Figure 1.

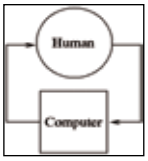

Figure 1. Text here (2018)

If they have been prepared or taken by someone else see Figure 2.

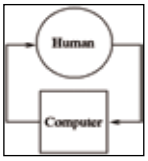

Figure 2. Text here (Esmer, 2018)

If they have been taken from any source than use them same as for the text as given in the Figure 3.

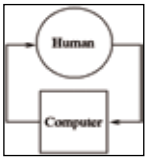

Figure 3. Text here (Nomidis, 1958, p.39)

3. Use of abbreviations

Use of abbreviations has to be reduced to mini- mum. Conventional units can be used without their definitions.

4. Conclusion

Be brief and state the most important conclusions from your paper. Do not use equations and figures here.

Endonotes

[1] Only where can not be avoided. The Endnotes headings are in bold but have no numbers.

Acknowledgements (If any)

Acknowledgements are to state about research supporting institution and title of the project (if any and where necessary), otherwise should not be written.

References

The Reference headings are in bold but have no numbers. Format references in the APA style.

References inside text body should be written as follows:

Single author: (Stewart, 2022)

Two authors: (Stewart and Adams, 2022)

Three or more authors: (Kudumovic et al., 2022) When referring to pages in a publication, use

'p. (page number)' e.g. p.75 for a single page or 'pp. (page numbers)' to indicate a page range. e.g. pp.175-179.

(Kudumovic et al., 2022, p. 5) or (Kudumovic et al., 2022, pp. 5-18)

- For books

Surname, initials (year), title of book, publisher, place of publication.

e.g. Kudumovic, Dž. (2009), Nauka o čvrstoći I, Univezitet u Tuzli, Tuzla, Bosna i Hercegovina.

For book chapters: Surname, initials (year), "chapter title", editor's surname, initials (Ed.), title of book, publisher, place of publication, page numbers.

e.g. Kudumovic, L. (2018), "20th Century's Heritage of Bosnia and Herzegovina as an Integrat- ed Part of Cultural Routes-Authentic Bosnia and Herzegovina Case Study: Mining town Banovici ", Pasic, A., Juvanec, B. and Moro, J.L. (Ed.s), The Importance of Place Values and Building Practice in the Historic Urban Landscape, Cambridge Scholars Publishing, UK, pp.91-105.

- For journals

Surname, initials (year), "title of article", journal name, volume issue, page numbers.

e.g. Kudumovic, Dz., Cosic, S., Trakic, E. and Kudumovic, L. (2008). "Modelation And Optimisation Of Self Operating Pump Parameters", Technics Technologies Education Management, Vol.3 No. 2, pp. 51-56.

-For published conference proceedings

Surname, initials (year of publication), "title of paper",

in editor's surname, initials (Ed.), title of published proceeding which may include place and date(s) held, publisher, place of publication, page numbers.

e.g. Wilde, S. and Cox, C. (2008), "Principal fac- tors contributing to the competitiveness of tourism destinations at varying stages of development", in Richardson, S., Fredline, L., Patiar A. and Ternel, M. (Ed.s), CAUTHE 2008: Where the 'bloody hell' are we?, Griffith University, Gold Coast, Qld, pp.115-118.

-Adding http and DOI

Where possible add after reference http or DOI For any http add also accessed date. Eg.

Zhu, G. and Yu, G. (2020), "Apine apple flavor imitation by the not method", Food Science and Technology, Vol. 40 No.4, pp. 924-928. Available at: https://doi.org/10.1590/fst.26019 (accessed 20 October 2022)

Zhu, G. and Xiao, Z. (2017), "Creation and imitation of a milk flavour", Food & Function, Vol. 8, pp. 1080-1084. DOI: 10.1039/c7fo00034k

- For encyclopedia entries (with no author or editor)

Title of encyclopedia (year), "title of entry", volume, edition, title of encyclopaedia, publisher, place of publication, page numbers.

e.g. Encyclopedia Britannica (1926), "Psychology of culture contact", Vol. 1, 13th ed., Encyclopedia Britannica, London and New York, NY, pp.765-771.

- For archival or other unpublished sources

Surname, initials (year), "title of document", unpublished manuscript, collection name, inventory record, name of archive, location of archive.

e.g. Erdoğan, E. G. (1996), „Istanbul'daki Osmanli Yapilarinda Kullanilan Devşirme Malzemenin Değerlendirilmesi", Unpublished Master Thesis, Istanbul, University, Istanbul.

- For electronic sources

If available online, the full URL should be supplied at the end of the reference, as well as the date that the resource was accessed.

Surname, initials (year), "title of electronic source". Available at: persistent URL (accessed date month year).

e.g. Zhou, Y. and Xiao, Z. (2007), Preparation Technology of Flavors, China Textile and Apparel Press, Beijing. Available at: https://book.douban. com/ subject/2256624/ (accessed 20 June 2018)

e.g. Campbell, A. and Kahn, R.L. (2015), American National Election Study, 1948, ICPSR07218- v4, Interuniversity Consortium for Political and Social Research (distributor), Ann Arbor, MI. Available at: https://doi.org/10.3886/ICPSR07218. v4 (accessed 20 June 2018)

Gorenc Novak, M. and Velušček, D. (2016). Prediction of stock price movement based on daily high prices. Quantitative Finance, Vol. 16 No.5, pp. 793- 826. DOI: 10.1080/14697688.2015.1070960

Corresponding Author
Name Surname
Affiliation
City, Country
E-mail:

The article is published with Open Access at https://www.ttem.ba/