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IoT Based Indoor Disinfection Coordinating System Against the New Coronavirus

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Abstract

In this study, a system solution for monitoring and coordinating indoor disinfection processes based on the Internet of Things technology is presented. Studies about COVID-19 shows that novel coronavirus is spreading through the virus-containing droplets exhaled by infected people on the surfaces; moreover, it is shown that the virus can remain stable up to 72 hours depending on the type of surface. Therefore, proper sterilization and disinfection routines in public areas play a major role in reducing the spread of coronavirus. In the proposed conceptual system, IoT nodes, consisting of single-board computer and camera, separate the human density in certain regions into various levels through image processing algorithms and write these densities in a cloud database. An Android application reads data from the cloud database periodically and locates the risky areas on the map. When the sterilization staff disinfects the specified spots, his/her location is determined in the android application via Bluetooth beacons located in the area, and the database is updated to show that disinfection is complete in these areas.

Keywords: "Internet of things, COVID-19, disinfection, bluetooth beacon, cloud database"

1. Introduction

Since December 2019, the new coronavirus which is named as 2019-nCoV by the World Health Organization (WHO), has rapidly spread from Wuhan, China's Hubei province to other parts of China, and then worldwide [1]. The disease caused by the 2019-nCoV virus, COVID-19, was identified as a pandemic on March 11 due to the spread and severity of the virus in 113 countries, except in China [2]. The number of known coronavirus infections around the world has been reached 6.5 million and more than 350 thousand people have died from the disease [3].

Countries have taken a series of measures to prevent the spreading of the virus; initial measures such as shutting down borders, curfews, halting domestic and international flights were followed by the cancellation of many events, including sports tournaments, concerts, and festivals. Every interaction between people increases the risk of spread; therefore, in many cities, malls, restaurants, coffee shops, and public parks and gardens have also been closed to minimize the interaction. Because the person-to-person transmission is primarily occurred through direct contact or by droplets that spread through the infected person's sneeze or cough [4-6].

After four months of the declaration of the COVID-19 epidemic as a public health emergency of international concern by WHO [7]; despite the significant number of patients and casualties, in many countries, governments have started or are planning to gradually relax restrictions because of the economic impacts of coronavirus. In the first place, shopping centers, restaurants, bars, cafes, hairdressers have been allowed to restart business considering low capacity and social distance. However, there is always the risk that the second wave, as in the case of Singapore, Japan, and Iran, in which new cases increase, may emerge after restrictions were loosened.

At this point, we need to make more use of technology to prevent possible second and third waves of the COVID-19 infection. The Internet of Things (IoT), defined as interconnected smart devices that are changing data without any human interaction at any level through a defined network, is one of the key technologies that can be used during the COVID-19 pandemic [8]. IoT based systems can present effective solutions to prevent, control, and monitor infectious diseases [9].

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In this study, we present a monitoring and coordinating system solution for disinfection processes at public enclosed areas that is based on the IoT to prevent the spreading of the 2019-nCoV virus. (See Figure 1) Effective and proper disinfection will be helpful in the fight against the spread of the virus. The parts of the paper are arranged as follows; section II presents a detailed literature survey about the transmission path of the new virus, prevention and inactivation methods, and also IoT-based studies against the virus. The proposed methodology is explained in section III. The conclusions and further discussions on this study are given in section IV.

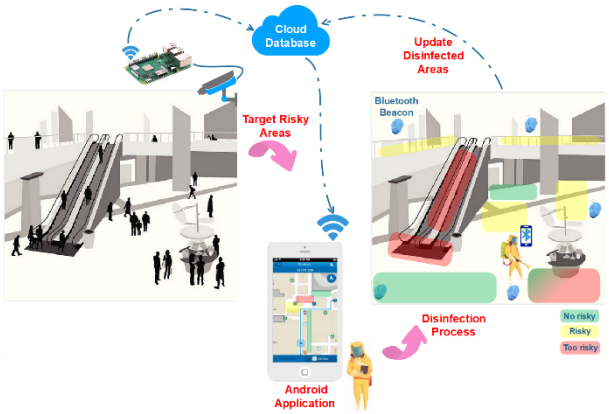

Figure 1.The proposed solution, an example application for shopping mall disinfection

2. Related Work

Preliminary information about the contamination of coronavirus is mentioned above. In this section, detailed information about the spreading of the virus, inactivation methods for the virus, and protective measures in the literature are mentioned; and then, studies based on the IoT technology are emphasized in the struggle with Covid-19.

2.1. About 2019-nCoV virus: transmission, prevention, and inactivation

The novel coronavirus which typically causes respiratory and gastrointestinal sickness has become a global health threat for humanity [10]. In order to stop this threat, it is necessary to understand clearly how the virus spreads. Unfortunately, the coronavirus is highly contagious, and there are still some uncertain spots about virus transmission.

The virus can spread via direct and indirect contact. As mentioned earlier, human-to-human transmission occurs mainly via droplets that spread through the patients' sneeze, cough, or even talk. These contagious droplets can reach up to 2m distance and remain infectious for up to 9 days [6, 11]. The droplets that contain the virus in most cases drop to the floor or a surface in a short time. However, some part of these droplets whose diameter are less than five microns can remain in the air for three hours; this finding indicates that being in the same room with an infected person increases the probability of aerosol transmission of the virus. The droplets containing viruses on different kinds of surfaces remain contagious for different durations; such as, on plastic surfaces for 72 hours, on stainless steel for 48 hours, on copper for 4 hours [12, 13]. Nevertheless, the persistence of the 2019-nCoV virus on inanimate surfaces reduces with the increasing temperature. For instance, at 4°C the virus is stable and remains viable up to 28 days, although, when the temperature rises to 70°C, the virus becomes inactive in 5 min. [11, 14]. The transmission due to the droplets on inanimate surfaces may occur if a person touches these infected surfaces, and then making direct contact with his/her nose, mouth, or even eyes with hands [15, 16].

The only way to stop the spreading of infection is to prevent contact with infected people. However, this is not a realistic solution when it is considered that there are asymptotic carriers of the virus and infected individuals during the incubation period who do not show any symptoms. Therefore, personal protection should be taken by wearing a mask, observing social distancing rules, paying attention to self-hygiene, and so on.

Environmental disinfection plays an important role in killing infectious agents such as viruses and bacteria. The new coronavirus can be inactivated with surface disinfection procedure by using 0.1% sodium hypochlorite, 0.5% hydrogen peroxide, or 62-71% ethanol for 1 min duration [17].

2.2. The Internet of Things: fight against pandemic

Application areas such as wearable devices, smart cities, smart healthcare, smart agriculture, etc., and market share of the Internet of Things technology are increasing day by day. During this pandemic, IoT based health monitoring systems, and wearable devices can be used efficiently against the COVID-19 with minor revisions. Unlike the rest of the world, China used IoT based solutions very effectively to stop spreading the virus; for example, location-based services and big data analytics were used to identify high-risk cases.

Due to health issues and restrictions worldwide, studies in the literature specifically about new coronavirus based on IoT mostly consisted of reviews (by the time I searched the web in May 2020). However, there are still some new approaches that could be found in the literature.

A system that operates on an edge computation platform using a thermal camera and Raspberry Pi camera can measure vital parameters of patients such as heart rate, respiratory effort and detect fever in the emergency department to decrease the triage durations, although the system needs to be optimized for real-life usage [18].

An integrated software and hardware platform which uses IoT based sensors to monitor patient physiologic conditions and mechanical ventilator operations was proposed [19]. The developed prototype device consists of Raspberry Pi that can be attached to the mechanical ventilator to collect the patient's ventilation data and another IoT device that collects patient blood oxygenation data. After collecting and storing data in a database, analytic algorithms are applied for diagnosis purposes.

An Internet of Medical Things enabled wrist-worn device was proposed to sense and track the same devices within its range [20]. The main idea is to warn people about the mildly and highly suspicious individuals in a nearby area, and also via LED lighting indicate the current condition of the wearer. The Bluetooth connection and Wi-Fi connection were used for inter-device communication and communication with the health authorities respectively.

3. Methodology and Design Example

The block diagram of the proposed IoT based monitoring and coordinating system for indoor disinfection is presented in Figure 2. The system consists of four main structures; IoT nodes, an Android application, a cloud database, and Bluetooth beacons.

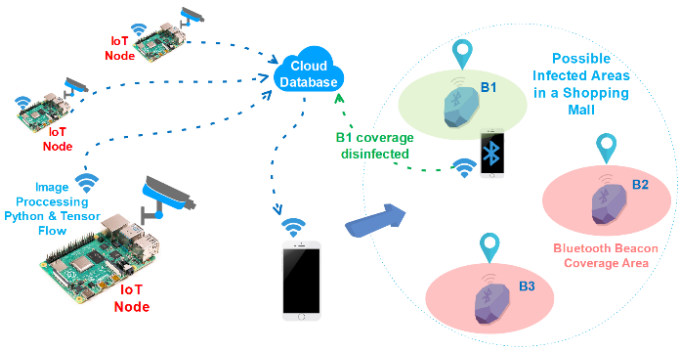

Figure 2. The block diagram of the proposed solution

A single IoT node that is consisting of a Raspberry Pi and a camera module detects and tracks people in the camera's field of view, and stores the data into the cloud database. Free open-source image processing library, OpenCV, is chosen with Python code. The frame in the camera's field of view is divided into sectors according to the Bluetooth beacons located inside of it. Raspberry Pi connects to the Internet over Wi-Fi. The screenshot of the human detection and tracking application performed on a sample video taken from a shopping center is shown in Figure 3.

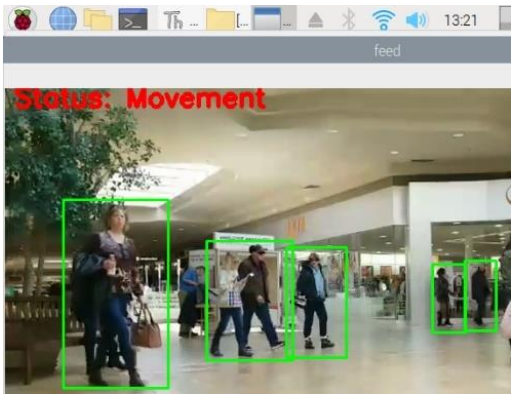

Figure 3. Sample application of human detection

The database can be updated by IoT nodes and Android application which runs on disinfection staffs' mobile phone. Each IoT node can increase the risk to higher levels for the sectors in the area according to crowd density; in contrast to the IoT nodes, the Android application works towards reducing risk to lower levels by updating the database whenever staff disinfects these sectors. The only components that are not mandatory to use in the proposed system are the IoT nodes. Because in many enclosed areas, images obtained from security cameras can be subjected to image processing on a PC at the server room or security room, and then the database can be updated; such a change also reduces the overall cost of the system.

The Android application periodically reads data from the database to show the risk levels on the map. When the sterilization staff goes to risky areas and spends enough time to perform disinfection processes, the application updates the database as reducing the risk level of that specific region. If the staff postpones the sterilization, he/she gets notifications via the application periodically.

The Bluetooth beacons use Bluetooth Low Energy (BLE) technology which is energy efficient and has lower costs than standard Bluetooth devices. The transmission ranges of BLE are very short typically several meters that make BLE a good choice for indoor localization applications [21-23]. By considering the shopping mall example; the IDs of the beacons already used by the stores in the shopping malls can be introduced to the system to determine indoor localization. If there are not enough beacons in the mall, the stores can be encouraged to buy these products, thus they can contribute to the determination of sterilization staff location as well as increase their sales by reaching their customers easily.

In addition to the components mentioned in the system, by using another Android application customers can scan a data matrix code at the entrance of a shopping mall and get information about risky places inside of the mall; thus they can avoid spending too much time at places where the disinfection process has not been completed.

There are also economic advantages of using that kind of IoT based disinfection monitoring system, such as; the municipalities that are responsible for carrying out disinfection of public areas allocate serious budgets; if they can achieve to use disinfectant products only in the required areas, they will contribute to the economy.

4. Conclusion

One of the best ways to stop the spread of the coronavirus is to isolate anyone who is infected by the virus. Unfortunately, this is not a practical solution since without testing it is not possible to know who is infected and who is not, especially considering that some of the infected people do not show symptoms. So, the best thing to do is people need to be more careful about cleaning than they always do. In addition to personal cleaning, the disinfection, and sterilization processes of public areas, particularly indoor locations should be done properly. The proposed IoT based monitoring and coordinating system solution for disinfection processes could provide better hygiene in enclosed areas. By using image processing the IoT nodes in the system categorize the enclosed areas according to the risk conditions and provide better hygiene by ensuring that the necessary locations are sterilized. The Bluetooth beacons placed in certain points are used to locate the disinfection staff position. Via the Android application, the risk situations of the disinfected areas are updated in the database. When the proposed system solution will be concluded, it will provide better cleaning as well as economical savings by ensuring the effective usage of disinfectant products.

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Mannheim Curves in 3-Dimensional Euclidean Space

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Abstract

In this paper, we consider the Mannheim curve and the slant helix together. We called this curve as a Mannheim slant helix shortly. First we calculate the (first) curvature $\boldsymbol{\kappa}(\boldsymbol{s})$, and the curvature of the tangent indicatrix of the Mannheim curve, in terms of the arc-lenght parameter of the curve. Also, we proved that if the Mannheim curve is also slant helix, i.e. if it is Mannheim slant helix, then the partner curve is general helix. Moreover, we show the striction curve of the ruled surface such that the base curve is Mannheim curve, and the rulings are the normal vector field of the Mannheim curve, is the Mannheim partner curve. Finally, we show the ruled surface such that the base curve is Mannheim curve, and the rulings are the normal vector field of the Mannheim curve is non-developable while the torsion of the Mannheim partner curve $\overline{\boldsymbol{\tau}}(\boldsymbol{s}) \neq \pm\infty$ for all s.

Keywords: "Mannheim curve, Slant helix, Ruled surface"

1. Introduction and Material-Method

The Mannheim curve is firstly investigated by French mathematician Amédéé Mannheim (1831-1906) in 1878. The Mannheim curve is a space curve such that the principal normal line of the curve coincides with binormal line of the another curve at the corresponding points of the curves. In general, the first curve is called as Mannheim curve and the second curve is called as Mannheim partner curve of the first one. All together they called as a Mannheim pair. It is well known that if $(\alpha, \overline{\alpha})$ is a Mannheim pair then, we can write

$$\alpha = \overline{\alpha} + \lambda\overrightarrow{\boldsymbol{N}}$$

where $\overrightarrow{\boldsymbol{N}}$ is the normal vector field of α and λ is constant.

Also, the curvatures of the Mannheim curve satisfy

$$\kappa(t) = \lambda\left(\kappa^2(t) + \tau^2(t)\right) \tag{1}$$

where κ is the curvature, τ is the torsion of the curve. We note that λ is the distance between the corresponding points of the Mannheim pair curve.

Even if the definitions and some basic properties of this curve is given in previous century, most of studies, especially in three dimensional spaces, are given in the recent times. Wang and Liu [1] studied this curve in three dimensional Euclidean and Minkowski space. They stated the first derivative of the torsion of the partner curve depending on the curvatures of the Mannheim curve. Then, Orbay and Kasap [2] gave the torsion of the partner curve in terms of the curvatures of the Mannheim curve by following:

$$\overline{\tau}(t) = \frac{\kappa(t)}{\lambda\tau(t)} \tag{2}$$

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Yaylı [3] investigated these curves in three dimensional Minkowski space in detail. Honda and Takahashi [4] stated the curvatures of the partner curve depending on the curvatures of the Mannheim curve as follows:

$$\overline{\kappa}(s) = \frac{\kappa(s)\big(\kappa(s)\tau'(s) - \kappa'(s)\tau(s)\big)}{|\lambda\tau(s)|\big(\kappa^2(s) + \tau^2(s)\big)^{\frac{3}{2}}}, \overline{\tau}(s) = \frac{\kappa^2(s) + \tau^2(s)}{\tau(s)} \tag{3}$$

The concept of the slant helix is firstly introduced by Izumiya and Takeuchi [5]. They defined the slant helix as a curve that its principal normal lines make a constant angle with a fixed direction and characterized the slant helices by following:

Proposition 1.1 *Let γ be a unit speed curve with $\kappa(s) \neq 0$. Then γ is a slant helix if and only if*

$$\sigma(s) = \left(\frac{\kappa^2}{(\kappa^2 + \tau^2)^{\frac{3}{2}}}\left(\frac{\tau}{\kappa}\right)'\right)(s) \tag{4}$$

is a constant function.

Let I be an interval of $\mathbb{R}$ and let $\gamma : I \to \mathbb{R}^3$ be a regular space curve, that is, $\gamma'(t) \neq 0$ for all $t \in I$, where $\gamma'(t) = (d\gamma/dt)(t)$.

We say that γ is nondegenerate, or γ satisfies the nondegenerate condition if $\gamma'(t) \times \gamma''(t) \neq 0$ for all $t \in I$.

The surface formed by moving lines along a space curve is called a ruled surface. The moving lines are called the rulings of the surface and the space curve is called the base curve.

Let α be the base curve and $\vec{\boldsymbol{\gamma}}$ be the rulings of the ruled surface. The parametrization of this surface is given by $\psi(s,u) = \alpha(s) + u\vec{\boldsymbol{\gamma}}(s)$.

The striction curve, and the distrubition parameter (drall) of the surface is given by

$$\beta(s) = \alpha(s) - \frac{\langle \alpha'(s), \vec{\boldsymbol{\gamma}}'(s)\rangle}{\langle \vec{\boldsymbol{\gamma}}'(s), \vec{\boldsymbol{\gamma}}'(s)\rangle}\vec{\boldsymbol{\gamma}}(s),$$

and

$$P_X = \frac{\det(\alpha'(s), \vec{\boldsymbol{\gamma}}(s), \vec{\boldsymbol{\gamma}}'(s))}{\langle \vec{\boldsymbol{\gamma}}'(s), \vec{\boldsymbol{\gamma}}'(s)\rangle},$$

respectively.

Throughout this paper, the curves will be considered as an nondegenerate, unless otherwise mentioned.

2. Results

In this section, we give our main results about the Mannheim curves and the ruled surfaces.

Theorem 2.1 *Let α be an non-degenerate unit speed Mannheim slant helix. The curvature of this curve is given by*

$$\kappa = \frac{1}{\lambda}\sec h^2\varphi$$

where φ is a linear function of arc-lenght parameter.

Proof. Let α be a Mannheim slant helix. From (1) and (4) we get

$$\sigma(s) = \pm\frac{\lambda}{2}\frac{\kappa'(s)}{\kappa(s)\sqrt{1 - \lambda\kappa(s)}}.$$

Since $\sigma(s)$ is constant, $\pm\frac{\lambda}{2}\frac{\kappa'(s)}{\kappa(s)\sqrt{1-\lambda\kappa(s)}}$ is also constant. So, we have the differential equation as follows:

$$\kappa'(s) - c\kappa(s)\sqrt{1-\lambda\kappa(s)} = 0 \tag{5}$$

where c is a constant. Solution of (5) gives the intended.

Theorem 2.2 *Let $(\alpha, \overline{\alpha})$ be a Mannheim pair curve. If α is a Mannheim slant helix then, the partner curve $\overline{\alpha}$ is general helix.*

Proof. If α is a Mannheim slant helix then, $\sigma(s)$ is constant and $\kappa(s) = \lambda(\kappa^2(s) + \tau^2(s))$. We note that s is not the arc-length parameter of $\overline{\alpha}$. Since $\sigma(s)$ is constant, it follows from (3) that

$$\overline{\kappa}(s) = a\frac{\kappa(s)}{\tau(s)};\ \overline{\tau}(s) = b\frac{\kappa(s)}{\tau(s)}$$

where a and b are constant. Hence, we have $\frac{\overline{\tau}(s)}{\overline{\kappa}(s)} = \frac{b}{a}$ is constant, and this completes the proof.

Theorem 2.3 *Let α be a Mannheim slant helix. The curvature of the tangent indicatrix of α is given by*

$$\kappa_T(s) = \pm cosh\varphi$$

where φ is a linear function of arc-lenght parameter of the curve.

Proof. It is well known that the curvature of the tangent indicatrix of the curve is as follows,

$$\kappa_T(s) = \frac{\sqrt{\kappa^2(s) + \tau^2(s)}}{\kappa(s)}$$

where $\kappa(s)$ and $\tau(s)$ are the curvature and the torsion of α, respectively. By Theorem 2.1, we get the intended.

Proposition 2.4 *Let γ be an unit speed Mannheim curve and $\overrightarrow{\boldsymbol{N}}$ be the normal vector field of γ in $\mathbb{R}^3$. The striction line of the ruled surface*

$$\psi(s,u) = \gamma(s) + u\overrightarrow{\boldsymbol{N}}(s)$$

is the Mannheim partner curve of γ.

Proof. The striction line of the ruled surface ψ is given by

$$\beta(s) = \gamma(s) - \frac{\langle \gamma'(s), \overrightarrow{\boldsymbol{N}'}(s)\rangle}{\langle \overrightarrow{\boldsymbol{N}'}(s), \overrightarrow{\boldsymbol{N}'}(s)\rangle}\overrightarrow{\boldsymbol{N}}(s).$$

Since $\kappa(s) = \lambda(\kappa^2(s) + \tau^2(s))$, we get $\beta(s) = \gamma(s) + \lambda\overrightarrow{\boldsymbol{N}}(\boldsymbol{s})$ which completes the proof.

If the distrubition parameter of a ruled surface is vanishing, that surface is said to be developable, otherwise it is said to be non-developable or skew. In the following theorem, we show that the ruled surface is non-developable, under the certain condition.

Theorem 2.5 *Let $\gamma: I \to \mathbb{R}^3$ be an unit speed Mannheim curve and $\overrightarrow{\boldsymbol{N}}$ be the normal vector field of γ. Suppose that the torsion of the Mannheim partner curve $\overline{\tau}(s) \neq \pm\infty$ for all s. Then, the ruled surface of*

$$\psi(s,u) = \gamma(s) + u\overrightarrow{\boldsymbol{N}}(s)$$

is non-developable.

Proof. By straightforward calculations, we get the distribution parameter of ψ as

$$P_X = \frac{\det(\gamma'(s), \overrightarrow{\boldsymbol{N}}(s), \overrightarrow{\boldsymbol{N}'}(s))}{\langle \overrightarrow{\boldsymbol{N}'}(s), \overrightarrow{\boldsymbol{N}'}(s)\rangle} = \frac{\tau(s)}{\kappa^2(s) + \tau^2(s)} \tag{6}$$

It follows from (1) and (2) that

$$\overline{\tau}(s) = \frac{\kappa(s)}{\lambda\tau(s)} = \frac{\kappa^2(s) + \tau^2(s)}{\tau(s)} \tag{7}$$

From (6) and (7) we get $P_X = \frac{1}{\overline{\tau}(s)}$. Since $\overline{\tau}(s) \neq \pm\infty$ for all s, $P_X \neq 0$ and ψ is non-developable.

3. Conclusion

In this study, we considered the some invariant properties of the Mannheim slant helix, for instance the curvature of the curve is calculated by its arc-lenght parameter. Also, we gave the curvature of the tangent indicatrix of the Mannheim curve by arc-lenght parameter similarly. Moreover, we showed that the striction curve of the the ruled surfaces such that the base curve is Mannheim curve and the rulings are the normal vector field of the Mannheim curve is the Mannheim partner curve. Finally, we proved that the ruled surface is non-developable if the torsion of the Mannheim partner curve $\overline{\tau}(s) \neq \pm\infty$ for all s.

For further studies, these curves will be considered and will be examined by different frames, and the ruled surfaces will be investigated by taking its base curve as a Mannheim curve in another space. As we did in this study, some curves will be considered together.

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Investigating the Relationship between the Opinions of Mothers with Infants in Intensive Care Unit on Human Milk Banking and their Religious Attitudes

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Abstract

The aim of this study is to determine the relationship between the opinions of mothers with newborns in intensive care unit on human milk banking and their religious attitudes. Designed in a descriptive and cross-sectional type (June–November 2015). The study was conducted on 200 mothers who agreed to participate in the study. The data were collected using the Religious Attitude Scale and an information form. It was determined that the mothers' 4% gave another mother's milk to their babies, and that 95% did not give their own milk to other babies. It was found that 32% of the mothers stated they would not be willing to donate milk if a milk bank opened, while 69% of this proportion did not favor the donation due to religious milk kinship. No statistically significant relation was found between parents' education, employment status, family type, number of children and scale scores ($p>.05$). It was concluded that the religious orientations of the mothers influenced their attitudes towards human milk banks, and that did not have a positive perspective on human milk banking. When the test results were examined, it was found that the only variable that was a significant predictor on the religious attitude was "obtaining milk from the bank when needed".

Keywords: "Donor milk, human milk bank, intensive care unit, milk kinship, religious attitude"

1. Introduction

In recent years, there has been an increase in the number of risky newborns all over the world and in our country. It has been reported that 5-13% of babies born in the US and European countries are premature Goldenberg et al. [5] and that with increased maternal age, this risk is increasing [1-4]. Some infants may not be breastfed due to some reasons such as separation of the mother and the baby because of the risks associated with the mother or the baby, inadequate social support, insufficiency of sucking reflex, nutritional intolerance and problems [6]. The Human Milk Bank (HMB) is an important source particularly for risky newborns, who cannot be breastfed for various reasons. It is recommended that a HMB should be established near (NICU), breast milk should be collected and stored here, and that hospitalized infants should be feed on their mother milk [7]. In many developed countries in the US and Europe, HMB has been used as part of the standard care in neonatal NICU for a long time [4].

In studies comparing the effects of donor milk and formula in premature infants, while it has been determined that feeding the infants on donor milk has reduced the risk of NEC development and shortened the length of hospitalization [4,8,9]. Although considerable effort is spent in Turkey to ensure the infants in the NICUs are fed with breast milk, there are no suitable HMBs in compliance with international standards. HMB was established in Turkey in 2013 and is expected to make legal arrangements for the expansion of the Ministry of HMB. Because most of the population in our country is Muslim (99%), most of the population may oppose HMB due to their religious attitudes. According to Muslim belief, in the case of a baby who is breastfed by another woman, although this baby is not a relative of blood, it is accepted as the brother of the children of the donor and cannot be married [10].

There are quite different opinions about breastfeeding in terms of medical and socio-cultural perspectives in our country. Especially in rural settlements, wet nursing is traditionally practiced in cases where the mother cannot breastfeed for any reason. Both sides need to know each other well for a wet nurse to be approved. Accordingly, it is thought that a maternal bond has formed between the infant and the donor and that the infant and the children of the donor are siblings thereafter. According to

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this traditional approach, children who have milk kinship cannot get married. This problem needs to be addressed with a culture-specific approach and a solution should be produced [12].

The traditional and cultural attitudes and beliefs of parents about baby nutrition with milk from milk banks should be investigated [11]. No research into the relationship between attitudes towards HMB and religious orientation was found for the Turkish setting. Therefore, this study aimed to investigate the relationship between the attitudes of mothers with infants in NICU on HMB and their religious orientations.

1.1. Material and Methods

The universe of this descriptive and cross-sectional study consisted of 1289 mothers who had infants in the NICU of a university hospital (N=691) and a state hospital (N=598) between June–November 2015. The sampling size was calculated to be about 196 subjects for a single sampling with 80% power, 5% error margin, and 6.1% effect size. The sampling, on the other hand, was made up of 200 mothers who met the sampling selection criteria and agreed to participate in the study.

The sampling inclusion criteria was that mothers would not have any mental or physical problems that would prevent them from understanding the questions correctly.

1.2. Data collection and data collection tools

The study used the Religious Attitude Scale and an information form questioning the socio-demographic characteristics designed by the researchers. The mothers were administered the data collection tools through face-to-face interviews.

The Information Form: This form consisted of 18 open-or closed-ended items questioning the gender and age of mothers and infants; descriptive features of the mothers such as education, employment status, and number of children; opinions and attitudes about breast milk banking such as donating breast milk to others' babies or giving the baby others' breast milk, and reasons for accepting/rejecting breast milk from a HMB.

Religious Attitude Scale (RAS): The "RAS" developed by Onay [13] was used to determine the religious attitude of the participating. The scale has been developed to quantify the extent to which religion has taken place in the lives of adults. Religious attitude is regarded as the level of the impact of individuals' religious beliefs, knowledge, and acceptance on their own feelings, thoughts, and behaviors. The scale is a four-point (never, sometimes, often, always) likert-type measure consisting of three dimensions (thoughts, behaviors, and emotions). It has a total of 18 items, 12 of which are positive structured and 6 of which were reversed. Increasing scores indicate rising religious attitudes, whereas decreasing scores mean falling religious attitude (the Cronbach Alpha: 0.95).

1.3. Ethical considerations

Necessary permission (Ethics board no: 15-KAEK-117) was obtained from the related hospital management and the ethics committee. The use of human cases in the study require the protection of individual rights, so the relevant ethical principles were strictly taken into consideration.

1.4. Data analysis

The data obtained at the end of the study were analyzed in SPSS 21.0 software package. In addition to descriptive statistical methods, student t test and Mann Whitney U test was used. Factors related to religious orientation were analyzed using simple linear regression. Factors related to religious orientation were analyzed using simple linear regression. Statistical significance of each analysis was determined at $p<0.05$.

1.5. Limitations

Responses from participants may not be representative of the target population being studied and the results cannot be generalized to other mothers and infants.

2. Results

Mothers in the study group were in 16-45 age range and the mean age was 27.68 ± 5.96. The infants of 66.5% (n=133) of the mothers were in the university hospital, while the newborns of 33.5% (n=67) were in the state hospital. Table 1 presents the

demographic and obstetric characteristics of the mothers in the study group. While 2.5% of the mothers were illiterate, 46% were primary school graduates, 30% were secondary school graduates, and 21.5% were university graduates. In addition, 62.0% of them had core family structure and 86.5% were housewives. 27.5% of the parents had at least one pregnancy while 28% had two pregnancies.

Table 1. Demographic and obstetric characteristics of the mothers in the study group (N:200)*

Characteristics	*N*	*%*
Mother's education		
Illiterate	5	2.5
Primary education	54	46.0
Secondary education	98	30.0
Higher education	43	21.5
Employment status of the mother		
Employed	27	13.5
Unemployed	173	86.5
Family structure		
Core family	124	62.0
Extended family	76	38.0
Number of pregnancies		
One	55	27.5
Two	56	28.0
Three	38	19.0
Four	27	13.5
Five and more	24	12.0

**Mean mother age: 27.68±5.96*

It was found that 96% (n=192) of the mothers did not feed their baby with another mother's breast milk, 4% (n=8) gave their baby another mother's breast milk, and that 95% (n=190) did not give their own breast milk to other babies. It was also determined that 95% of the mothers had heard about HMB previously and that 73% (n=146) wanted HMB in our country. In addition, 52.6% (n=106) of the mothers stated that they could get milk from a HMB when they failed to provide breast milk for their babies. 74.5% (n=79) recognized the benefit of breast milk. 25.5% (n=27) said they could get milk for the health and development of their babies. On the other hand, the mothers stated they wouldn't get breast milk from others they didn't know well and that they did not approve milk kinship from a religious perspective (%47,4) (n=94), they didn't want to get breast milk from others (53,2%;n=50), breast milk from others might not be hygienic (25,5%;n=24), diseases could transfer from others' milk (17,0%;n=16), and that they did not want to donate milk because their milk was sufficient (4,3%;n=4).

It was determined that 32% (n=64) of the mothers would not make breast milk donations if a milk bank was opened in our country. When the reason why they didn't want to donate was questioned, the following responses were obtained: "I do not want a religion based milk kinship", 69% (n=44); "my breast milk is inadequate", 25% (n=16); and "diseases can spread through breast milk, not hygienic, not healthy", 5% (n=3). When the responses and scale scores were compared, no significant relationship was found between them ($p>0,05$).

When the subscale scores of the RAS were compared to willing to get milk from the HMB, it was found that subscale scores and total scale scores of the RAS were found to be statistically significantly higher ($p<0.05$) (Table 2).

Table 2. Comparison between RAS and the variables such as getting milk from HMB, agreeing to donate breast milk to HMB, and giving breast milk to others' babies

Subscales of the Religious Attitudes Scale	***Getting milk from the Breast Milk Bank***	$\overline{x} \pm SS$	*t*;p*
Thoughts	Yes	29.55±2.19	-2.005
	No	30.13±1.85	.044
Behaviors	Yes	18.48±2.80	-2.673
	No	18.51±2.63	.000
Emotions	Yes	14.42±1.79	-3.259
	No	15.14±1.19	.000
Total score for the Religious Attitudes Scale	Yes	62.45±5.25	-3.460
	No	64.78±4.08	.001
	Making milk donations to the breast milk bank		
Thoughts	I would donate	29.71±2.13	-1.122
	I would not donate	30.05±1.87	.264
Behaviors	I would donate	18.71±2.71	-1.585
	I would not donate	19.50±2.82	.066
Emotions	I would donate	14.65±1.70	-1.475
	I would not donate	15.00±1.26	.142
Total score for the Religious Attitudes Scale	Yes	63.07±5.05	-2.011
	No	64.55±4.32	.046
	Giving breast milk to others' babies		
Thoughts	Yes	30.10±1.79	-1.585
	No	29.81±2.07	.066
Behaviors	Yes	21.10±2.72	-2.540
	No	18.85±2.73	.029
Emotions	Yes	15.00±1.24	.614
	No	14.75±1.60	.552
Total score for the Religious Attitudes Scale	Yes	66.20±2.93	2.180
	No	63.41±4.91	.016

* *t-test*

It was determined that 95% of the parents (n=190) did not want to give their breast milk to others' children and that behavior subscale scores and total scale score of the mothers who did not want to give their milk to others' babies were statistically significantly higher ($p<0.05$) (Table 2).

It was determined that there was no statistically significant difference between the RAS scores of mothers in terms of their education level, employment status, family type, age, occupation, number of pregnancies, planned pregnancy, number of children, and number of pregnancies ($p>0,05$).

According to the standardized regression coefficient (β), the order of the importance of the predictive variables on the religious orientation is as follows: mother's education; donating breast milk; hearing about HMB; family structure; mother's employment status; obtaining breast milk from the bank when needed; accepting milk from another mother; age; the rank of the pregnancy; milk donation to the HMB; and planned pregnancy (Table 3). When the test results were examined (In multiple regression analysis), it was found that the only variable that was a significant predictor on the religious attitude was "obtaining milk from the bank when needed".

Table 3. Factors related to religious attitudes (N:200)

Variables	***B***	***Standard Deviation***	***Beta ($R^{2)}$***	*t*	*p*	*r*	*Partial r*
Constant	6.026	5.786	-	11.41	0.000	-	-
Age range	0.069	0.075	0.86	0.927	0.35	0.582	1.719
Employment of the mother	-0.024	0.344	-0.006	-0.70	0.94	0.626	1.594
Education status	-0.466	0.338	-0.118	-1.376	0.170	0.660	1.50
Family type	-0.143	0.743	-0.015	-0.192	0.848	0.342	1.18
Number of pregnancies	0.112	0.452	-0.034	-0.247	0.805	0.258	3.98
Rank of the child	0.177	0.528	0.046	0.334	0.738	0.253	3.94
Planned pregnancy	0.236	0.981	0.018	0.238	0.812	0.874	1.14
Receiving husband support during pregnancy	-1.254	1.004	-0.092	-1.248	0.213	0.892	1.12
Donating milk to others' babies	-2.187	1.622	-0.098	-1.348	0.719	0.918	1.08
Accepting milk from others	0.810	1.869	0.033	0.433	0.665	0.855	1.16
Hearing about milk banking	-0.716	0.797	0.070	-0.898	0.370	0.811	1.23
Approving a milk bank in our country	-1.047	1.093	-0.096	-0.958	0.339	0.487	2.05
Making milk donations to a breast milk bank	0.295	1.073	0.28	0.275	0.783	0.458	2.18

3. Discussion

%4 of the mothers participating in this study stated that their infant had a wet-nurse. Despite the lack of data on how often wet-nursing is resorted to in our country, it was observed that wet-nursing was a still continuing traditional practice in our country. It was determined according to the reports of mothers (10.9%) in Ekşioğlu et al. [14]; 8.7 % in Ergin et al. [15]; and 14.7% in Can et al. [16] that at least one of the children in the family had a wet-nurse. When compared to these rates, it was observed that our rates were lower. This difference might have stemmed from the fact that the studies were carried out in different cities and sample groups.

5% of the mothers in our study group had done wet-nursing before. Similarly, the rate of mothers doing wet-nursing was determined to be 17% in Can et al. [16], 12.5% in Ergin et al. [15] and 8.2% in Ekşioğlu et al. [14].

It was determined that HMB was known in some previous studies (90.6-41.6% of the mothers) [14,15,17]. It was observed in our study group that more mothers (95%) had heard of HMB compared to the results of this investigators. The increase in the proportion of mothers who were aware of HMB can be explained by the increase in the sensitivity, interest and scientific studies related to the topic.

While 73% of the mothers in our study group wanted a HMB in our country, it was determined that only 32% of the mothers were willing to donate breast milk to the bank and that 47.4% would not get milk from the bank when they could not give milk to their babies. Similarly, Karadag et al. [18] found that 42.4% of the mothers in their study did not want to get milk from the HMB. Even if the mothers found the opening of HMB favorable, it is thought that about half of them had concerns about using the bank for their own baby.

Similar to the mother in other studies, the mothers in our study group did not want to get milk donations because they wanted to know the donor well, they did not approve a milk kinship, the milk might transfer diseases, and they were jealous of the donor mother [14,15,17] . Approximately half of the mothers (47.4%) stated that they would not give the breast milk of any mother to their babies without necessarily knowing the identity. This result shows that mothers prefer donor human milk when they know the family.

It was determined that the mothers with high religious orientation did not want to accept milk from the bank and neither did they want to make milk donations ($p<0.05$) (Table 2). In countries where the majority of the population is Muslim, attitudes

towards HMB is different from those of European region. The most important reason for opposing HMB in Muslim countries is that marriage between people having a milk kinship is not considered appropriate due to the religious reasons.

Children who are breastfed by a donor mother are siblings with the children of the donor mother and cannot get married. However, some contemporary Islamic law scientists claim that milk banks can be established if a solution to this problem can be found. In our country, the Presidency of Religious Affairs states that human milk banks can be founded in the country provided that necessary measures are taken. However, there are no HMB in Turkey as legal arrangements haven't been made yet [10].

It was observed that the most important reason why mothers were unwilling to make milk donations to others' babies was "milk kinship". Although the mothers with babies in NICU found breast milk beneficial for the health and development of their babies and they said they would accept breast milk from others, the results of the study indicated that mothers were hesitant and that they rejected it due to religious and disease transmission reasons.

Majority of the mothers are confronted with the dilemma of "milk kinship" and the "need of their babies"[10,11]. Despite all these teachings, it was observed that majority of the mothers (95%) did not want to donate their breast milk to others' babies, however, that religious orientation level of the mothers who wanted to donate milk was high ($p < 0.05$) (Table 2).

While this suggests that mothers' concerns and their religious orientations were influential on their milk donations, the issue still needs to be investigated on different groups.

In multiple regression analysis, "obtaining milk from the bank when necessary" was found to be an important predictor on religious orientation. Donor milk can be provided by removing the obstacles preventing breastfeeding, introducing donor and recipient mothers, giving the donated milk to a single child without mixing it with other donations, supplying the sides with donor and recipient information, establishing HMB on voluntary base, and informing the public.

4. Conclusion

According to the findings of the study, it was determined that the religious attitudes influenced mothers' attitudes towards HMB. It is important that healthcare workers, especially midwives, nurses, gynecologists, and pediatricians should provide information to donors and potential recipients. Involving HMB and donation issues in education should raise awareness of mothers.

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Conflict of Interest

The authors declare no conflict of interest.

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Modeling of 2D Functionally Graded Circular Plates with Artificial Neural Network

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Abstract

The thermo-mechanical properties of the functionally graded material (FGM) depend on the volumetric distribution that determines the material character, which is very important in order to overcome different operating conditions and stress levels. Three different training algorithms are used in an Artificial Neural Network (ANN) to determine the equivalent stress levels of a hollow disc that is functionally graded in two directions. The data set was created by choosing the most important four different equivalent stress values (σ_(eqv max max) ,σ_(eqv max min) ,σ_(eqv min max) ,σ_(eqv min min)) that determine the material structure in thermo-mechanical analysis. Performance estimation was performed in three different training algorithms (Gradient Descent Backpropagation, Gradient Descent with Momentum Backpropagation, BFGS Quasi-Newton Backpropagation Algorithm). In this study, termomechanical behaviour was numerically determined by using finite difference method at different compositional gradient upper values to train ANN.

Keywords: "Two-directional functionally graded circular plates, finite difference method, thermal stress analysis , artificial neural network, training algorithms"

1. Giriş

Malzeme teknolojisinde temel elementlerden alaşım, seramik ve kompozitler gibi konsolide malzeme geliştirilmesi ile klasik mekanikten daha karmaşık 3 boyutta ağır koşullarda çalışan sistemlere geçişte mekanik ve termal malzeme mukavemeti sağlanmıştır. Günümüzde bilgisayar teknolojisi ve analiz yöntemlerinin gelişmesi ile istenilen çalışma aralığı, tolerans değeri ve hassasiyette makro-mikro-nano yapıda makine malzemesi üretilerek maksimum verimlilik sağlanmıştır. Bilgisayar bilimleri ve yapay zeka uygulamalarının ilerlemesi ile kestirimsel malzeme davranışları ve ileri teknoloji malzeme kompozisyonunun belirlenmesi mümkün olmuştur. Bu teknolojik malzemelerden biri de özellikle yüksek sıcaklık uygulamalarında kullanılan bir tarafı metal diğer tarafı seramik, metalden seramiğe geçişi belirli bir hacimsel fonksiyona göre belirlenen fonksiyonel kademeli malzemeler (FKM) dir. FKM ile metal ve seramik malzemeler birleşim yerlerinde ara yüzey çatlakları ve artık gerilmeler engellenmiştir [1-4].

Literatürde yapılan çalışmalarda termo-mekanik karakteri ve belirli sınır şartları altında malzeme çalışma koşullarını belirleyen kompozisyonel gradyant üst değerinin tayin edilmesine odaklanılmıştır. Koşullara ayak uyduracak optimum malzeme dağılımını bulmak için sayısal analiz yöntemlerini kullanarak Sürü Optimizasyonları, Genetik Algoritmalar ve YSA gibi sezgisel optimizasyon yöntemlerinde farklı tasarım modelleri denenmiştir. Literatürde yer alan bazı çalışmalar aşağıda detaylandırılmıştır.

Wang ve arkadaşları [5] statik yüklemeye karşı fonksiyonel olarak kademelendirilmiş çerçeve yapısı için yeni bir makine öğrenimi tabanlı yapısal güvenilirlik analizi yöntemi geliştirdiler. Önerilen yarı simülatif yöntemin yapısal tasarım ve değerlendirmelerde uygulanabilir ve verimli olduğunu belirttiler. Do ve arkadaşları [6], 3-D fonksiyonel kademelendirilmiş malzemenin serbest titreşimi ve burkulmayı amaç fonksiyonu kabul ederek Derin Sinir Ağı ve İzogeometrik Çok Zamanlı Tasarım ile malzeme optimizasyonu üzerine çalıştılar. Bulunan değerlerin literatürde yer alan diğer çalışmalara yakın olduğunu belirterek daha karmaşık mühendislik problemlerinde kullanılabileceğini belirttiler. Ghatage ve arkadaşları [7], geniş bir literatür çalışması yaparak FKM'lerin çok yönlü gelişmeye açık bir malzeme olduğunu, doğru modelleme ve analiz ile gereksinimleri karşılayacağını belirtmiştir. İnsan sağlığı için önem arz eden özellikle medikal uygulamalar için gerekli olan FKM'lerin lineer

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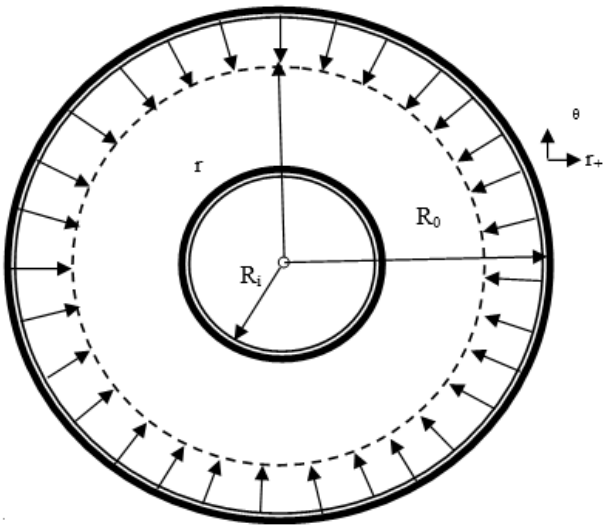
olmayan yüklemeler altındaki davranış analizlerinin sınırlı olduğuna değinmiştir. Karsh ve arkadaşları [8], sonlu elemanlar yöntemini kullanarak FKM'lerin YSA 'da stokastik dinamik analizini yaptılar. Sonlu elemanlar yöntemiyle kurulan modelin Monte Carlo simülasyonuna göre doğrulamasını yaparak YSA tabanlı algoritmanın, sonuçları doğru hesapladığını belirttiler. Dikici ve Tuntas [9], bir Al / TiC FKM'nin zamanla sertleşme ve korozyon davranışını giriş parametreleri kompozit katmanların TiC hacim fraksiyonu, kompozitin yaşlanma süreleri, çevresel koşullar ve korozyon testleri sırasında uygulanan yük ve çıkış değeri yoğunluk ve mikro sertlik olacak şekilde YSA'da araştırdılar. Sonuçların deneyselde yapılan çalışmalarla yakınsadığını belirttiler. Mantari ve Monge [10] fonksiyonel kademelendirilmiş sandviç plakalarda mekanik yüklemede malzemenin serbest titreşim ve burkulma davranışının gözlemlediler. FKM'lerin burkulma analizini kalınlık yönünden değerlendirerek optmizasyon yöntemi kurdular. Yöntemin yüksek doğrulukta sonuca ulaştığını belirttiler. Nazari ve arkadaşları [11] FKM'lerin çekirdek ve kalınlık üzerindeki doğal frekansını gerçek değerlere yakın bir şekilde Meshless Local Petrov-Galerkin (MLPG) yöntemi ile uygulayarak YSA yönteminde optimum değeri araştırdılar. Jodaei ve arkadaşları[12] 3-D fonksiyonel kademelendirilmiş halka malzemenin sayısal analizi için state-space based differential quadrature metodunda (SSDQM) yapay sinir ağı (YSA) algoritmasını kullandılar. YSA da Fonksiyonel kademelendirilmiş halka plakalar için yeni bir tasarım modeli oluşturdular. Cho ve Ha [13] fonksiyonel kademelendirilmiş malzemenin termo-elastik davranışını, sonlu farklar metodunu kullanarak analiz ettiler. Farklı sınır şartları için 2-D hacimsel dağılımın optimum değerini araştırdılar. Ara yüzeylerdeki en yüksek gerilmeyi minimize etmek için yapay sinir ağı (YSA) kullandılar. Na ve Kim [14] 3-D fonksiyonel kademelendirilmiş malzemelerde termo-mekanik burkulma analizi için kompozisyonel gradyant üst değerini araştırarak sonlu elemanlar metodu ile malzemede oluşan gerilme dağılımını optimum yapacak en uygun hacimsel dağılımı ifade ettiler. Cho ve Shin [15] YSA'yı kullanarak termal dayanımlı malzeme bileşiminin optimizasyonu üzerine çalıştılar. İç ceza fonksiyonu ve altın oran yöntemini optimizasyonda kullandılar. Sayısal deneyler sonucunda, YSA'nın malzeme optimizasyonunda optimum tasarıma ulaşmada etkin olduğunu sundular.

Literatürde fonksiyonel kademelendirilmiş malzemelerin malzeme kompozisyonunu belirleyen kompozisyonel gradyant üst değerinin optimizasyonu veya tahmini için pek çok çalışma yapılmaktadır. Kompozisyonel gradyant üst değerinin optimizasyonu ile arzu edilen malzeme davranışı sağlanabilmektedir. YSA ve GP gibi literatürde sıkça yer alan yöntemlerin yanı sıra farklı efektif optimizasyon yöntemleri ile yüksek nitelikli FKM tasarım çalışmaları devam etmektedir [16-20].

2. Materyal ve Metot

2.1. Fonksiyonel Kademelendirilmiş Malzemeler ve Dairesel Plaka

Günümüz statik/dinamik sistemlerinde termal dayanımı yüksek malzeme üretimi sistemlerin güvenliği için oldukça önem kazanmıştır. Gelişen bilgisayar bilimleri ve analiz yöntemleri ile mevcut malzemelerde iyileştirme ve geliştirme olanakları artmış böylelikle özgün malzemeler üretilmiştir. Geliştirilmiş bu özel malzemelerden biri de fonksiyonel kademeli malzemelerdir. FKM'ler birden fazla malzemenin bir hacim fonksiyonuna bağlı olarak malzeme geçişleri kademeli olacak şekilde birleştirilmesi ile elde edilir. Kademeli malzeme geçişi ile standart üretilmiş malzemelerden farklı olarak malzemenin geçiş bölgesindeki süreksizlikler ve buna bağlı olarak meydana gelen yapısal kusurlar ve ara yüzey çatlakları minimum düzeye indirgenebilmiştir. İstenilen özelliklerin sağlanması için en uygun hacimsel dağılımı belirlerken verimlilik, performans ve iyileştirilmiş termo-mekanik özellikler göz önünde tutulmalıdır. Bu özellikler optimum hacimsel dağılım ve dolayısıyla kompozisyonel gradyant üst değerinin belirlenmesi ile olur.



Şekil 1. Fonksiyonel kademelendirilmiş dairesel plaka [21]

Şekil 1'de Fonksiyonel kademelendirilmiş dairesel plakanın radyal yönde kademelendirilmesi gösterilmiştir. Bu kademelendirilme ise aşağıdaki Seramik malzemenin hacimsel dağılımını gösteren formül ile gerçekleştirilmiştir.

$$V_s^{\,r}(\bar{r}) = \left(\frac{\bar{r}}{l_R}\right)^n \tag{1}$$

$$V_s^{\theta}(\theta) = (|\sin(p\theta)|)^m \tag{2}$$

R_o ve R_i sırasıyla plakanın dış ve iç yarıçapı olup $\bar{r} = r - R_i$, l_R=R_o-R_i'dir ve Vs, seramik hacim oranını vermektedir. Plakadaki radyal yöndeki seramik hacimsel oranı denklem 1'de ve teğetsel yöndeki seramik hacimsel oran denklem 2'de vermektedir. $\mathbf{V_m}$ metal hacimsel dağılımını gösteren denklem 4'te ulaşılmaktadır [27];

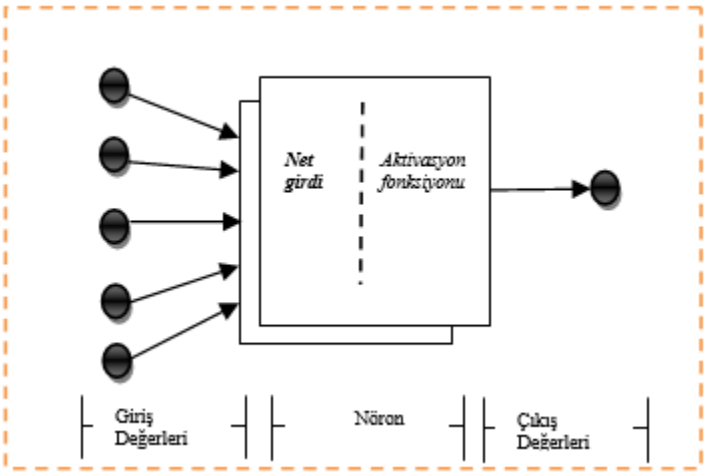
$$V_s(\bar{r},\theta) = V_s^r(\bar{r}).V_s^{\theta}(\theta) \tag{3}$$

$$V_m(\bar{r},\theta) = 1 - V_s(\bar{r},\theta)$$

Plakanın hacim oranlarına bağlı olarak termal ve mekanik özellikleri Mori-Tanaka [26] şeması esas alınarak belirlenmiştir. Daha önceki çalışmalarımızda formülasyonlar vardır [21,23-25].

2.1. Yapay Sinir Ağı Algoritması

Optimizasyon yöntemleri doğadaki canlıların yaşayış ve işleyiş şekillerinden uyarlanarak tasarlanmıştır. Yönetimsel süreçler göz önünde tutularak bunların en iyi araması ve en uygun sonuca ulaşması gözlemlenmiştir. Bunların sonucunda insan beyninin çalışma prensipleri, bilgiyi iletme şekli ve tercih etme süreçlerinin aşamaları düşünülerek yapay sinir ağı modelleri ortaya çıkmıştır. Bu işleyiş sürecinde bilgilerin alınması, değerlendirilmesi, durumun kaydedilmesi ve sonuca ulaşması aşamaları bulunmaktadır.



Şekil 2. YSA'nın basit bir nöron işleyiş modeli

Bir veya birden fazla giriş ve çıkış değeri olan lineer ya da non-lineer problem çözümlerinde aktif olarak kullanılmaktadır. YSA'nın kuruluş mantığına göre giriş değerleri, nöron ve çıkış değerleri arasındaki işlemlerle modeller kurulur. Şekil 2'de YSA'daki basit bir nöronun işleyiş durumu gösterilmiştir. Nöronlara gelen giriş değerleri denklem 4'de belirtilen kümülatif toplam fonksiyonunda kullanılarak net girdi oluşturulur ve denklem 5'de yer alan aktivasyon fonksiyonuna gönderilir. Aktivasyon fonksiyonu non-lineer fonksiyon olarak tercih edilir çalışmamızda bunların arasında yaygın olarak kullanılan sigmoid fonksiyonu tercih edilmiştir. Denklem 4'de x giriş, w ağırlık ve b eşik değerini simgelemektedir.

$$net\ girdi = \sum_{m=1}^{m} (x_i * w_i + b_i) \tag{4}$$

$$f(net\ girdi) = \frac{1}{1 + e^{-net\ girdi}} \tag{5}$$

Bu işlemlerin sonucunda tahmini çıktı değerlerine ulaşılır. Tahmini değerler ile gerçek değerler arasındaki yakınsamayı ölçmek için bir hata değeri hesaplama fonksiyonu belirlenir. Denklem 6'da ortalama karesel hata fonksiyonu ile hata değerleri gösterilmiştir. Denklem 6'da y_d tahmini ve y de gerçek değerleridir.

$$e = \frac{1}{2}\sum_{m=1}^{m}(y_d - y)^2 \tag{6}$$

Problemimizin aşağıda belirtilen 3 farklı eğitim algoritması ile modelleri kurulmuş ve değerlendirilmiştir.

Geriye Yayılım Algoritması (Gradient Descent Backpropagation) Geriye Yayılım, yapay sinir ağının çoğunlukla kullandığı bir öğrenme algoritmasıdır. Öğrenme sürecinde her nöronda gradyant azaltma tekniğini uygular. Rumelhart ile McClelland tarafından önerilen ve ilk olarak Werbos tarafında geliştirilen yöntem, çıkış değerlerinden giriş değerlerine doğru hata değerlerini azaltma işlemi yaptığı için geriye yayılım algoritması denmiştir [28]. Doğrusal olmayan programda hata oranları ve ağırlıklar kısmı türevleri üzerinden gerçekleşir tahmini değerlerin gerçeğe yakınsaması beklenir. Bu algoritma, kuruluş mantığına göre ilk koşullara duyarlıdır, yakınsama hızı yavaş ve yerel minimuma takılma olasılığı vardır. Eğer ilk atanan ağırlık vektörleri hata düzeyine yakınsa öğrenme durumu hızlı olacaktır. Fakat tam tersi durum da olabilir. Öğrenme katsayısı ''n'' olup 0.1-0.9 arasında bir değer verilir [29-30]. Geriye yayılım algoritması denklem 7'de gösterilmiştir.

$$w_{ij} = w_{ij-1} + n\left(\frac{\partial e_{ij}}{\partial w_{ij-1}}\right) \tag{7}$$

Momentum Katsayılı Geriye Yayılım Algoritması (Gradient Descent with Momentum Backpropagation) Geriye Yayılım Algoritması'nın ilk koşullara takılmasını önlemek için Rumelthart tarafından momentum kat sayısı eklenerek geliştirilmiştir ve güncellenen fonksiyon denklem 8'de gösterilmektedir. Burada α momentum katsayısıdır [31].

$$w_t = w_{t-1} + n\left(\frac{\partial E_t}{\partial w_{t-1}}\right) + \alpha\Delta w_{t-1} \tag{8}$$

Quasi-Newton Algoritması (BFGS Quasi-Newton Backpropagation) 'nda hatanın, ağırlıklara göre ikinci derecede türeviyle oluşan Hessian matrisi kullanılarak işlem yapılır. Denklem 9 'da olan Hessian matrisi ağırlık uzayının farklı doğrultuda gradyant değişimini gösterir. Eşleşmeli gradyant algoritmalarına göre daha hızlıdır. Ağırlık güncelleme işlemi denklem 10 'da gösterilmektedir [32].

$$H_t = \frac{\partial^2 E_t}{\partial {w_{t-1}}^2} \tag{9}$$

$$w_t = w_{t-1} + \eta {H_t}^{-1}\frac{\partial E_t}{\partial w_{t-1}} \tag{10}$$

3. Problem Tarifi ve YSA ile Modelleme

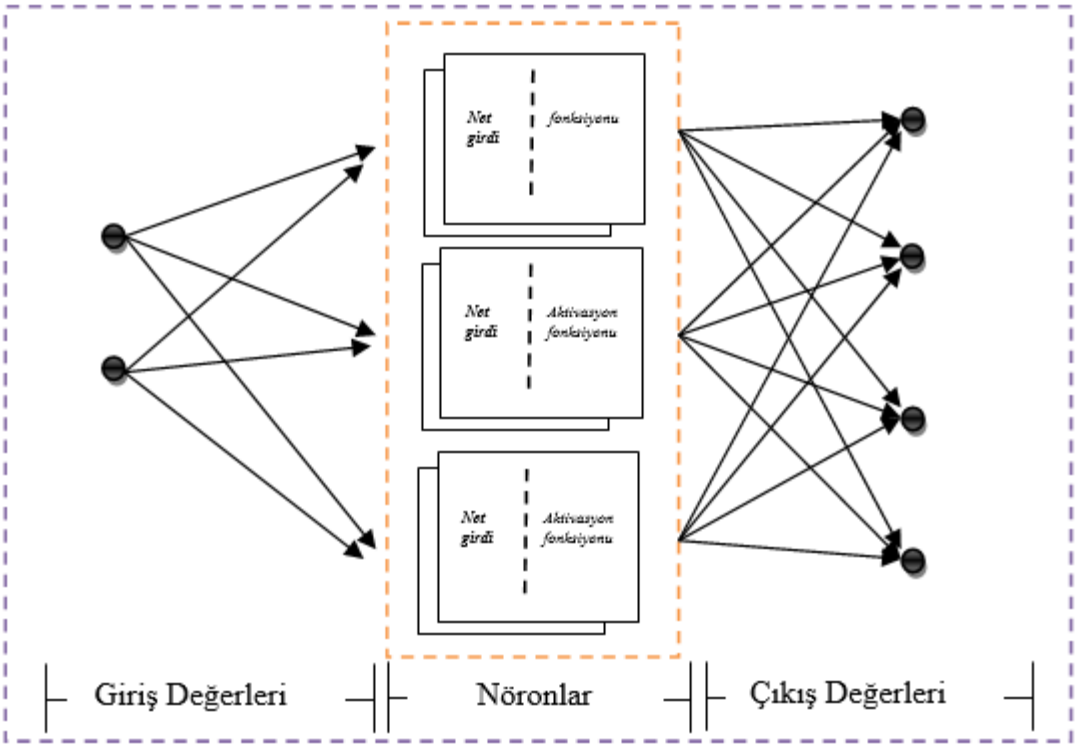
3.1. Problemin Tarifi

Dairesel plakanın dış kenarı boyunca düzlem içi sabit 200 KW/m2 ısı akısında maruz bırakılıp iç ve dış kenarı sabit tutularak termal gerilme analizleri sonlu fark denklemleri ile Elastisite Teorisi kullanılarak yapılmıştır. Plakamızın kalınlığı belirlediğimiz boyutlara göre ihmal edilebilecek seviyede olduğu için Elastisite Teorisi denklemleri iki boyutlu olarak çözülmüştür. İki yönde kademelendirilen dairesel plakanın bileşenleri seramik (ZrO2) ve metal (Ti-6Al-4V) olarak tercih edilmiştir. Dairesel plakanın Termo mekanik davranışını belirleyen eş değer gerilme seviyeleri esas alınarak YSA modelleri değerlendirilmiştir. Eşdeğer gerilme değerleri arasında en önemli olan en büyük değerinin en büyüğü, en büyük değerinin en küçüğü, en küçük değerinin en büyüğü ve en küçük değerinin en küçüğü seçilerek farklı kompozisyonel gradyant üst değerleri için YSA modelleri kurulmuştur.

3.2. YSA ile modelleme

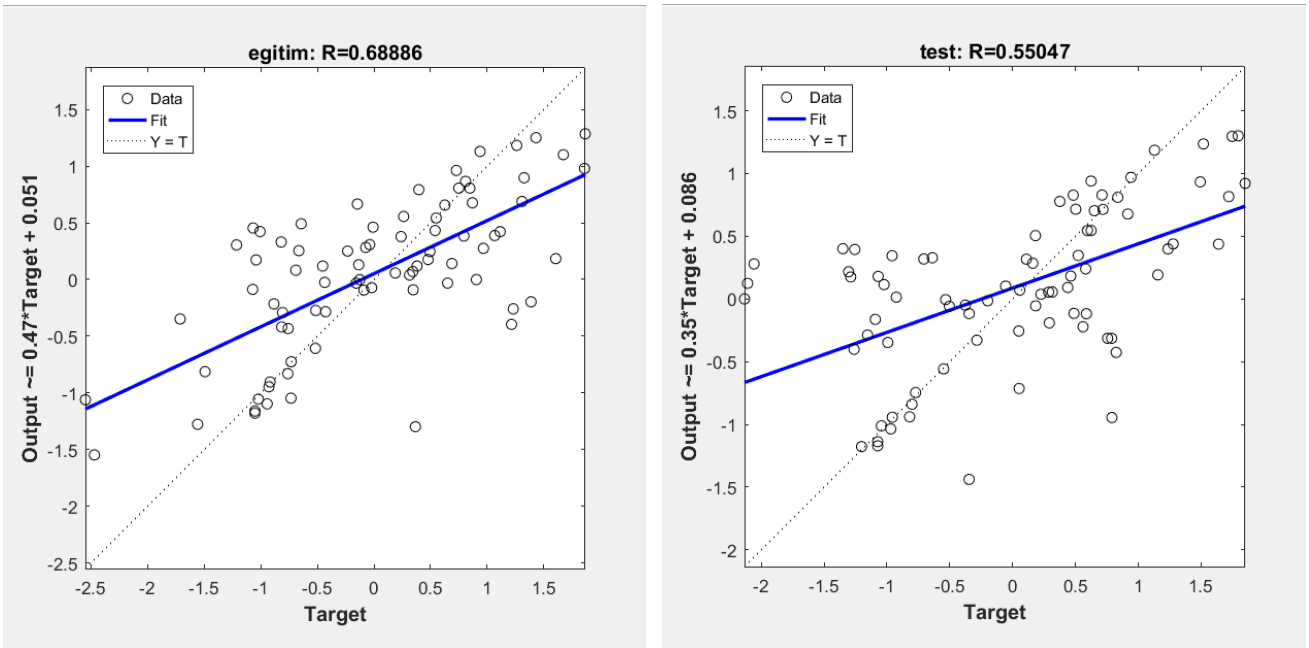
Sonlu farklar metodu ile yaptığımız analiz çalışmaları sonucunda 40 farklı kompozisyonel gradyant üst değerlerine ulaşılmıştır. Kompozisyonel gradyant üst değerleri yani n ve m değeri [0.1-1] aralığında sınırlandırılmıştır. Bu verileri YSA'da kullanmak üzere iki giriş ve dört çıkışlı olacak şekilde $V_{40,6}$'lık bir matris oluşturularak veri seti yapılmıştır. Bu matrisin ilk iki

sütunu giriş verileri, son dört sütunu ise çıkış verileri olarak Matlab [22]'da kurduğumuz koda tanıtılmıştır. Rassal dağılacak bir şekilde oluşturulan veri seti %50 eğitim ,%50 test verisi olarak bölünmüştür. Programımızın durdurma kriteri verilerdeki doğrulama oranının %10 olması ve maksimum çevrim sayısının 1000 olması olarak belirlenmiştir. Şekil 3.' de görüldüğü gibi YSA modelimizde 3 farklı eğitim algoritması kullanılarak iki giriş, dört çıkış ve üç nörondan oluşan tek katmanlı algılayıcı model oluşturulmuştur.

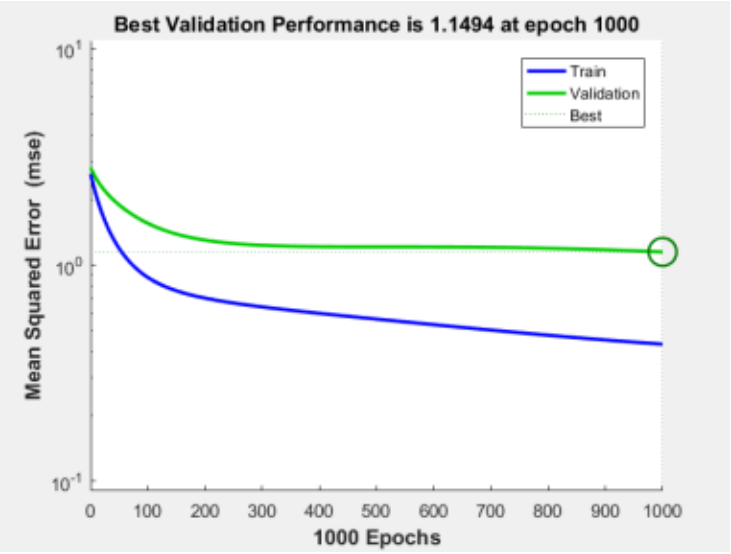


Şekil 3. Tek katmanlı yapay sinir ağı modeli

Geriye Yayılım algoritmasında eğitilmiş model incelendiğinde eğitim aşamasında çıkan tahmini değerlerin gerçek değerlere yaklaşık %70 oranında bir doğrulukta çözdüğü görülmektedir. Dahası eğitilmiş modelin test değerlerleri ile yaptığı analizde ise bu oran %55'e gerilemiştir. Programın grafiksel çıktısı şekil 4'de görülmektedir.

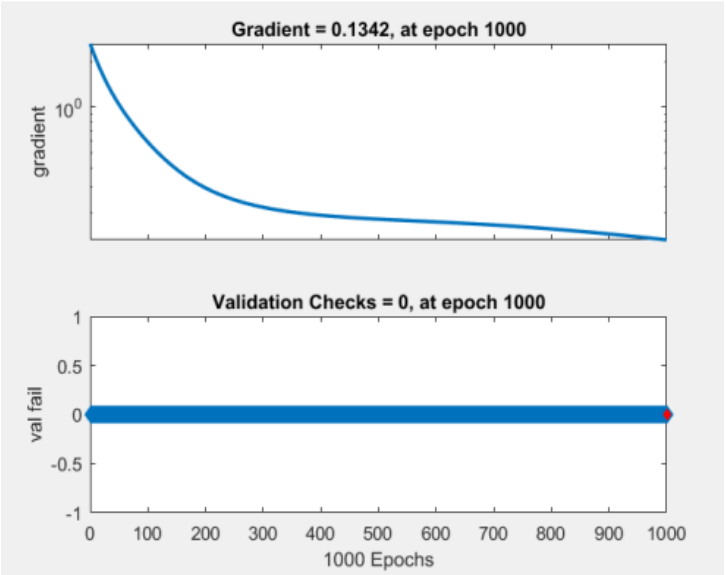


Şekil 4. Geriye Yayılım algoritmasının eğitilen model için tahmin değerleri



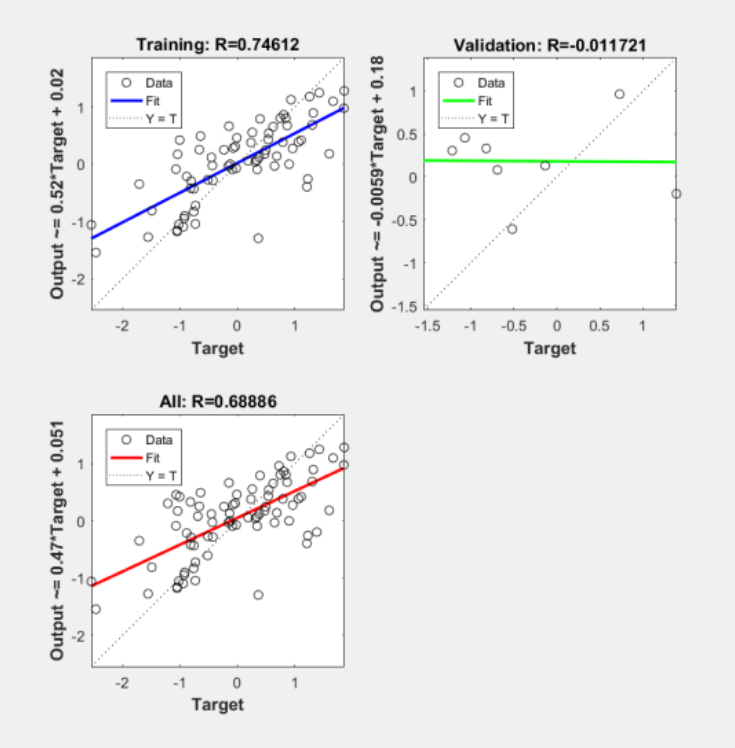
Şekil 5. Geriye Yayılım algoritmasının eğitilen model için doğrulama performansı

Şekil 5'te YSA'da Geriye Yayılım algoritmasında eğitilmiş modelin en küçük kareler (MSE) yönteminde hesaplanmış minimum hata değerini göstermektedir. Burada çevrim sayısı arttıkça eğitim ile doğrulama tahmininin hata değeri arasındaki fark artmaktadır. En iyi doğrulama performansı ise 1000 çevrim için 1.1494' tür.



Şekil 6. Geriye Yayılım algoritmasının eğitilen model için gradyant ve başarısız doğrulamanın çevrim sayısına bağlı değişimi

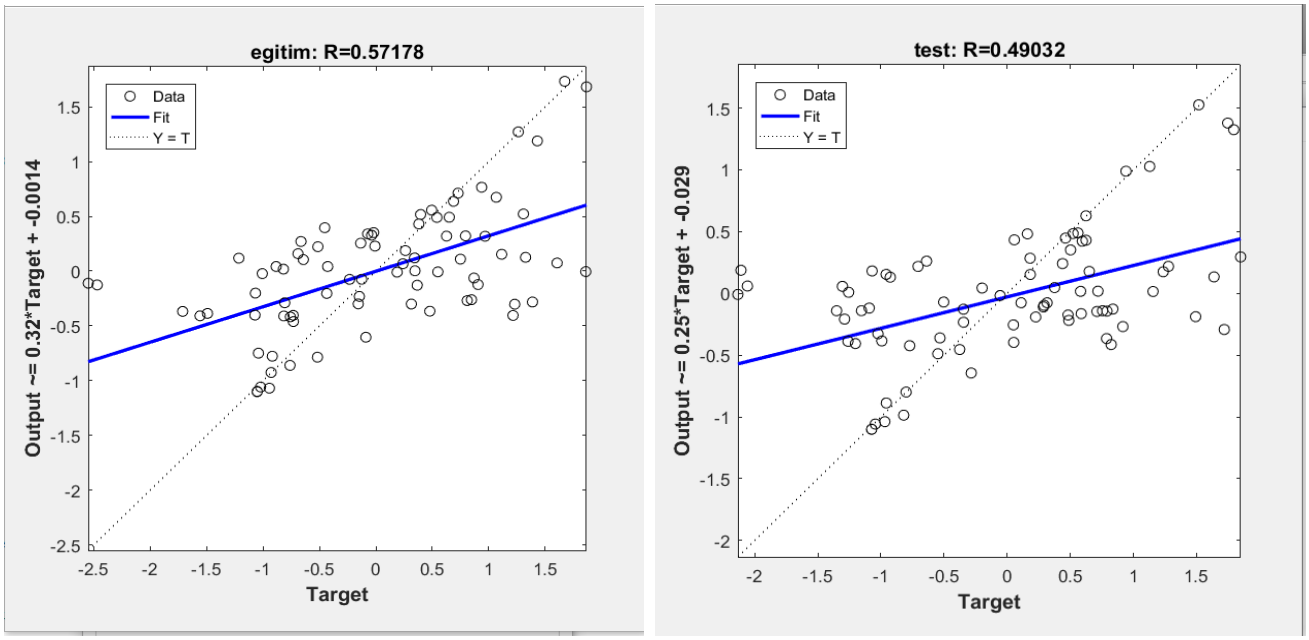
Şekil 6'da Geriye Yayılım algoritması ile eğitilen model için gradyant ve başarısız doğrulamanın çevrim sayısına bağlı değişimini göstermektedir. Burada maksimum çevrim sayısı 1000 olmak üzere gradyant 0,1342 ve başarısız doğrulama 0'dır.



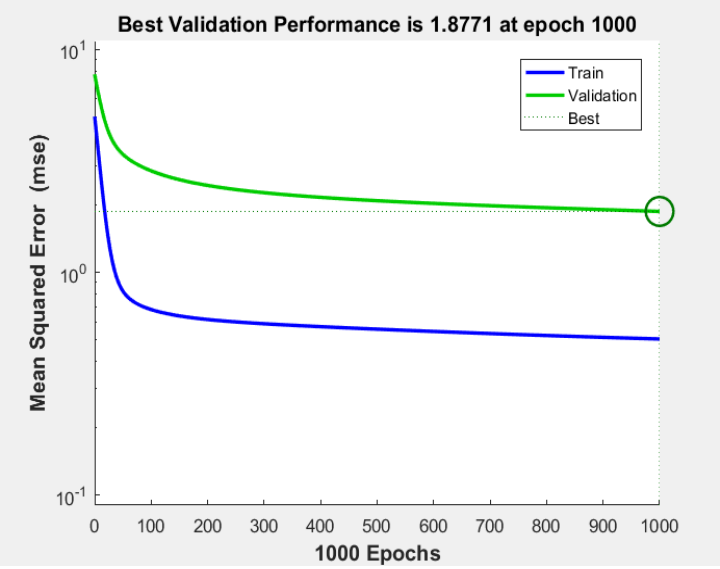
Şekil 7. Geriye Yayılım algoritmasının eğitilen model için tüm tahmin değerleri

Şekil 7'de Geriye Yayılım algoritması ile eğitilen yapay sinir ağının modelinin tahmin değerlerini gösterilmektedir. Burada eğitim için tahmin değeri 0.74612, doğrulama için tahmin değeri 0.011721 ve toplam tahmin değeri 0.68886 olup eğitilmiş modelin performansı arzu edilen seviyeye ulaşamamıştır.

İkinci eğitim algoritmamız olan Momentum Katsayılı Geriye Yayılım algoritması kullanılarak oluşturduğumuz modelin eğitim aşamasında oluşturduğu tahmini değerleri yaklaşık %57 ve modelin test aşamasındaki performansı ise %49 olmuştur. Şekil 8'de modelin eğitim ve test değerlerinin performansları gösterilmektedir.

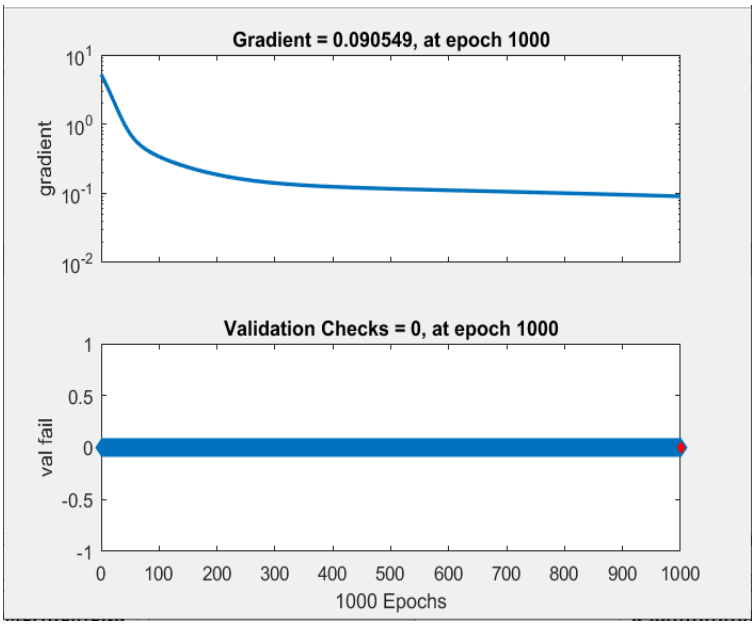


Şekil 8. Momentum Katsayılı Geriye Yayılım algoritmasının eğitilen model için tahmin değerleri



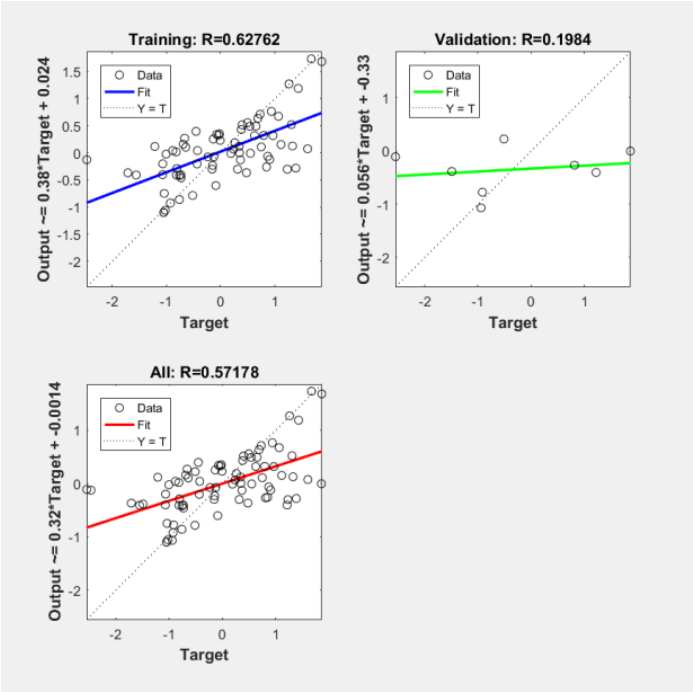
Şekil 9. Momentum Katsayılı Geriye Yayılım algoritmasının eğitilen model için doğrulama performansı

Şekil 9' da Momentum Katsayılı Geriye Yayılım algoritması ile eğitilen yapay sinir ağının en küçük kareler (MSE) yönteminde hesaplanmış minimum hata değeri gösterilmektedir. Çevrim sayısı arttıkça eğitim ve doğrulama tahminlerinin hata oranı aynı olmaktadır. En iyi doğrulama performansı ise 1000 çevrim için 1.8771' dir.



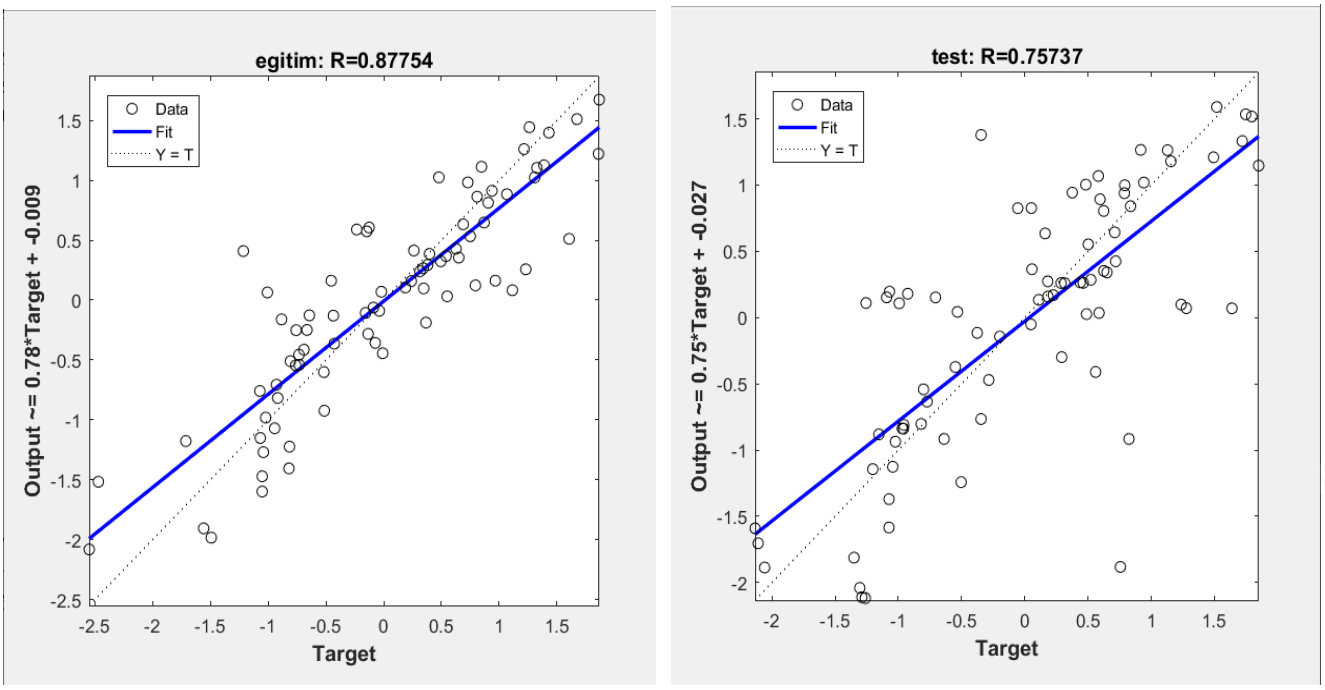
Şekil 10. Momentum Katsayılı Geriye Yayılım algoritmasının eğitilen model için gradyant ve başarısız doğrulamanın çevrim sayısına bağlı değişimi

Şekil 10'da görüldüğü gibi gradyant, maksimum çevrim sayısı 1000 için 0.090549 olmaktadır. Başarısız doğrulama ise 0'dır.



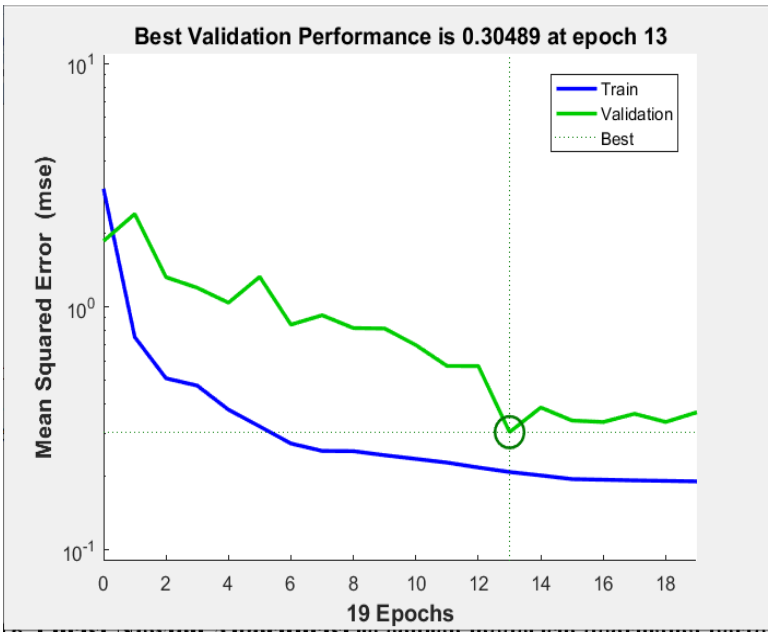
Şekil 11. Momentum Katsayılı Geriye Yayılım algoritmasının eğitilen model için tüm tahmin değerleri

Şekil 11'de Momentum Katsayılı Geriye Yayılım algoritması ile eğitilen model için tüm tahmin değerlerini göstermektedir ve çıkış verilerimizin tahmininde en iyi hedeflenen eğitim değeri 0.62762, doğrulama tahmin değeri 0.1984'tür. Eğitilmiş modelin istenilen seviyede olmadığı görülmüştür.



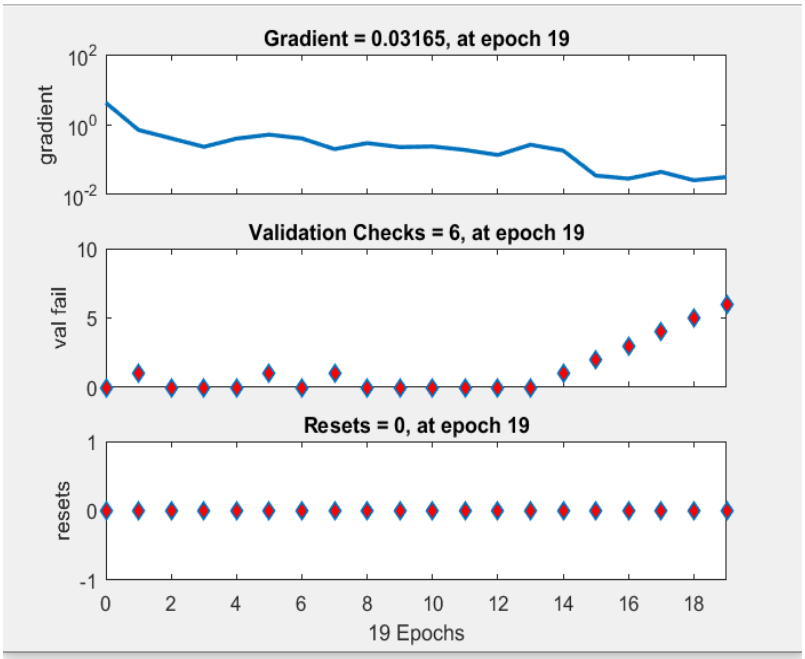
Şekil 12. Quasi-Newton Algoritmasının eğitilen model için tahmin değerleri

Üçüncü eğitim algoritmamız olan Quasi-Newton algoritması kullanılarak oluşturduğumuz model için Şekil 12'de ağın tahmin değerleri gösterilmektedir. Bu çalışmadaki çıkış verilerimizin en iyi eğitim tahmin değeri 0.87754 ve test tahmin değeri 0.75737 olarak hesaplanmıştır.



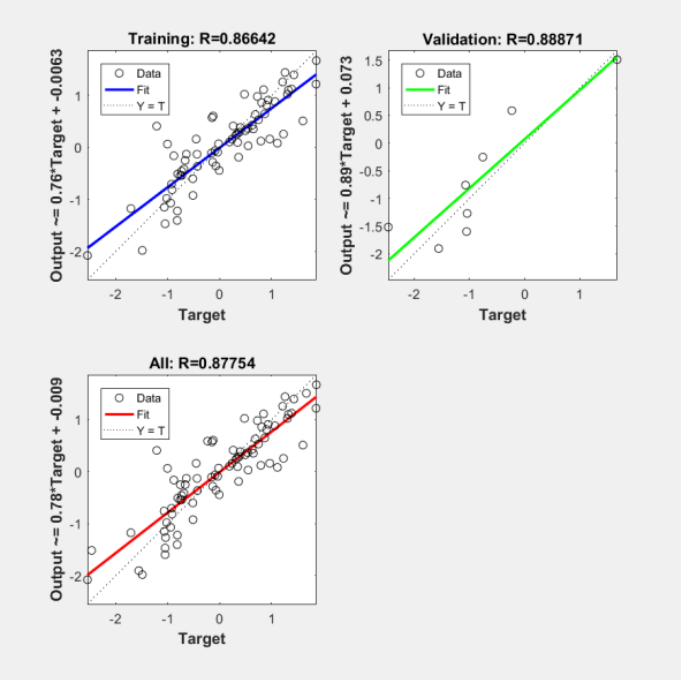
Şekil 13. Quasi-Newton Algoritmasının eğitilen model için doğrulama performansı

Şekil 13' de Adaptif Geriye Yayılım algoritması ile eğitim modeli için en küçük kareler yöntemi ile hesaplanmış minimum hata değerleri gösterilmektedir. Çevrim sayısı arttıkça eğitim ve doğrulama tahmin değerleri için hata oranları arasındaki fark azalmaktadır. En iyi doğrulama performansı ise 13 çevrim için 0,03609' dur.



Şekil 14. Quasi-Newton Algoritması algoritmasının eğitilen model için gradyant, başarısız doğrulama ve sıfırlama katsayısının çevrim sayısına bağlı değişimi

Şekil 14 Quasi-Newton Algoritması ile eğitilen model için gradyant, başarısız doğrulama ve öğrenme katsayısının çevrim sayısına bağlı değişimini göstermektedir. Şekilde görüldüğü gibi eğitilen modelin çevrim sayısı 19 olmak üzere gradyant 0.03165, başarısız doğrulama sayısı 6 ve sıfırlama katsayısı 0 olmaktadır.



Şekil 15. Quasi-Newton Algoritmasının eğitilen model için tüm tahmin değerleri

Şekil 15'de Quasi-Newton Algoritması ile eğitilen model için tüm tahmin değerlerini göstermektedir. Bu model için çıkış verilerimizin en iyi eğitim tahmini 0.86642 ve en iyi doğrulama tahmin değeri 0,87754 olmaktadır. Quasi-Newton Algoritması ile eğitilen model de toplam tahmin değeri 0. 87754'dür.

Tablo 1. Eğitim Algoritmaları İçin Çevrim Sayısı

	Çevrim Sayısı
Geriye Yayılım algoritması (GY)	1000
Momentum Katsayılı Geriye Yayılım algoritması(MGY)	1000
Quasi-Newton Algoritması(QN)	19

Tablo 1' de eğitim algoritmalarının maksimum çevrim sayısı gösterilmektedir. Tablo incelendiğinde en az çevrim değerinde olan Quasi-Newton Algoritmasıdır. Eğitim algoritmalarından çıkan sonuçlar ile sayısal çözümlemeden elde edilen gerçek değerler ile tahmini değerler arasındaki hata değerlerinin minimumu, maksimumu ve ortama mutlak değerleri Tablo 2, Tablo 3, Tablo 4'de karşılaştırılmıştır.

Eşdeğer Gerilme Değerinin En Büyüğünün En Büyüğü olan değerin YSA'daki eğitilmiş modellerimiz olan Geriye Yayılım (GY), Momentumlu Geriye Yayılım (MGY), Quasi-Newton (QN) Algoritmalarının ürettikleri tahmini değerlerin gerçek değerlere ne kadar yakınsadığının bulmak açısından Tablo 2'de değerlendirilmiştir. Sonlu faklar metodunda ürettiğimiz 40 farklı kompozisyonel gradyant üst değeri eğitilmiş modele sunularak bu değerler arasındaki minimum hata, maksimum hata ve tüm hata değerlerini kapsaması açısından Ortalama Mutlak Hata (MAE) fonksiyonunda değerlendirilmiştir. Bu değerlere bakıldığında minimum hata değerinin Quasi-Newton Algoritması'nın (QN) 1.408117 değerinde, maksimum hata değerinin Geriye Yayılım Algoritması'nın (GY) 459.1461 değerinde ve en iyi Ortalama Mutlak Hata (MAE) Quasi-Newton Algoritması'nın (QN) 48.80017 değerinde olduğu görülmektedir.

Tablo 2. Eşdeğer Gerilme Değerinin En Büyüğünün En Büyüğü Minimum Hata, Maksimum Hata ve Ortama Mutlak Hata Değerleri

$\sigma_{eqv\ max\ max}$			
	GY	MGY	QN
MİN	2.764089	5.152502	1.408117
MAX	459.1461	449.9309	137.918
MAE	103.2441	129.0702	48.80017

Tablo 3'de Eşdeğer Gerilme Değerinin En Büyüğünün En Küçüğü olan değerin eğitilmiş modellerdeki durumları incelenmiştir. Değerlere bakıldığında minimum hata değerinin Quasi-Newton Algoritması'nın (QN) 0.000014 değerinde, maksimum hata değerinin Momentum Geriye Yayılım Algoritması'nın (MGY) 0.493172 değerinde ve en iyi Ortalama Mutlak Hata (MAE) Quasi-Newton Algoritması'nın (QN) 0.095004 değerinde olduğu görülmektedir.

Tablo 3. Eşdeğer Gerilme Değerinin En Büyüğünün En Küçüğü Minimum Hata, Maksimum Hata ve Ortama Mutlak Hata Değerleri

$\sigma_{eqv\ max\ min}$			
	GY	MGY	QN
MİN	0.000759	0.017464	0.000014
MAX	0.435858	0.493172	0.235007
MAE	0.165866	0.184669	0.095004

Eşdeğer Gerilme Değerinin En Küçüğünün En Küçüğü olan değerin eğitilmiş modellerdeki analiz değerleri Tablo 4'de gösterilmektedir. Değerlere bakıldığında minimum hata değerinin Geriye Yayılım Algoritması'nın (GY) 0.000001 değerinde, maksimum hata değerinin Geriye Yayılım Algoritması'nın (GY) 0.003548 değerinde ve en iyi Ortalama Mutlak Hata (MAE) Momentumlu Geriye Yayılım Algoritması'nın (MGY) 0.000787 değerinde olduğu görülmektedir.

Tablo 4. Eşdeğer Gerilme Değerinin En Küçüğünün En Küçüğü Minimum Hata, Maksimum Hata ve Ortama Mutlak Hata Değerleri

$\sigma_{eqv\ min\ min}$			
	GY	MGY	QN
MİN	0.000001	0.000043	0.000029
MAX	0.003548	0.002685	0.003124
MAE	0.000948	0.000787	0.000866

4. Sonuçlar

YSA yöntemi ile FKM'de termo-mekanik davranışın en önemli kriteri olan eş değer gerilme değerinin, mevcut sınır koşulları altında, en iyi tahmin değerlerine ulaşılmaya çalışılmıştır. Yapılan çalışmada MATLAB [22] programlama dilinde 3 farklı nöronlu tek katmanlı algılayıcı model oluşturulan ve üç farklı eğitim algoritması için analizler gerçekleştirilmiştir. Ortalama Mutlak Hata (MAE), minimum hata, maksimum hata değerleri açısından modellerin eğitim ve test performansına bakıldığında genel olarak Quasi-Newton Algoritması diğer algoritmalara göre daha iyi sonuç çıkarmıştır. Geriye Yayılım ile Momentumlu Geriye Yayılım Algoritması'nda ise çalışma mantıkları benzer olduğu için değerler birbirine yakın çıkmıştır. Bu algoritmaların problemimizi analiz etme sürecinde performansları düşük kalmıştır. Dairesel plakanın radyal yapısından dolayı en büyüğünün en küçüğü olan eşdeğer gerilme değeri hep aynı çıktığından ve tüm eğitim algoritmaları doğru sonuca ulaştığından dolayı grafiklerde gösterilmemiştir. Kurulan modellerde CPU sürelerini azaltmak ve doğru veriye ulaşmak amaçlanmıştır. Termal gerilme probleminin Sonlu farklar metodu ile çözümü bir n ve m değerine yaklaşık 302400 saniye sürerken, model kurulduktan sonra bu değere 1 saniyeden kısa sürede ulaşılmaktadır.

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