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CORRESPONDENCE and COMMUNICATION:

Istanbul Gelisim University Faculty of Engineering and Architecture
Cihangir Mah. Şehit P. Onb. Murat Şengöz Sk. No: 8
34315 Avcilar / Istanbul / TÜRKİYE
Phone: +90 212 4227000
Fax: +90 212 4227401
e-Mail: ijet@gelisim.edu.tr
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From the Editor

Dear Colleagues,

On behalf of the editorial board of International Journal of Engineering Technologies (IJET), I would like to share our happiness to publish the 35th issue of IJET. My special thanks are for members of Editorial Board, Publication Board, Editorial Team, Referees, Authors and other technical staff.

Please find the 35th issue of International Journal of Engineering Technologies at http://ijet.gelisim.edu.tr or https://dergipark.org.tr/en/pub/ijet. We invite you to review the Table of Contents by visiting our web site and review articles and items of interest. IJET will continue to publish high level scientific research papers in the field of Engineering Technologies as an international peer-reviewed scientific and academic journal of Istanbul Gelisim University.

Thanks for your continuing interest in our work,

Prof. Dr. Necmettin MARAŞLI
Istanbul Gelisim University
nmarasli@gelisim.edu.tr
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Table of Contents

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Shipping Containers as Temporary Shelters in Post-Disaster Scenarios: Flying Factories

Semih G. Yıldırım*, İlke Ciritci**, Meryem Müzeyyen Fındıkgil***, Hilay Atalay****

* Corresponding Author, Assist. Prof., Department of Architecture, Istanbul Gelisim University, Cihangir Mah. Petrol Ofisi Cad. No.5, 34310, Avcılar, Istanbul, Türkiye. E-mail: sgyildirim@gelisim.edu.tr ORCID: 0000-0002-7832-6575

** Assoc. Prof., Department of Architecture, Istanbul Gelisim University, Cihangir Mah. Petrol Ofisi Cad. No.5, 34310, Avcılar, Istanbul, Türkiye. E-mail: iciritci@gelisim.edu.tr ORCID: 0000-0002-1492-0727

*** Assist. Prof., Department of Architecture, Istanbul Gelisim University, Cihangir Mah. Petrol Ofisi Cad. No.5, 34310, Avcılar, Istanbul, Türkiye. E-mail: mmfindikgil@gelisim.edu.tr ORCID: 0009-0004-9810-0962

**** Assist. Prof., Department of Architecture, Istanbul Gelisim University, Cihangir Mah. Petrol Ofisi Cad. No.5, 34310, Avcılar, Istanbul, Türkiye. E-mail: hatalay@gelisim.edu.tr ORCID: 0000-0001-7976-2240

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Abstract: After the recent earthquakes in Turkey, there has been a significant demand for temporary shelter. Issues such as the availability of emergency shelters, designated emergency assembly areas, and the lack of social networks have come to the forefront. Due to the construction industry's inability to produce the necessary quantity of prefabricated temporary housing, the Ministry of Trade imposed a three-month ban on the export of prefabricated structures in 2023. The limited availability of emergency assembly areas renders low-density temporary settlements unfeasible. For disaster victims, leaving their homes does not provide a solution to overcoming the trauma they have experienced; in fact, it can exacerbate other economic, social, and security issues. Reusable shipping containers can partially address the problem of temporary shelter by utilizing the concept of flying factories. This research proposes a model that encompasses both technical and social phases, including the creation of technical documentation prior to a disaster and aiming for a participatory production model in the aftermath. The establishment of temporary logistics and production facilities is crucial and should be driven by volunteer participation under the guidance of professionals. Additionally, this model includes training and coordination activities before a disaster as part of the execution plan. Through this study, which incorporates both physical and social dimensions, an integrated solution is proposed based on the identification of challenges faced after recent disasters.

Keywords: Shipping container, temporary shelter, emergency assembly area, flying factory, social networking

1. Introduction

Addressing the temporary shelter needs of disaster victims is a crucial component of disaster management planning. Temporary settlements provide essential support and shelter for individuals who have been displaced from their homes due to damage or destruction, until they can transition to permanent housing. The demand for such temporary housing remains significant worldwide, particularly following natural disasters such as earthquakes, floods, and wildfires. This need arises in situations where communities are impacted by flooding due to the failure to implement urban planning decisions or due to poor planning practices, as well as from wildfires that encroach upon urban areas and threaten the built environment. Additionally, earthquakes often result from inadequate construction practices that do not adhere to zoning regulations, building codes, or the existing geological conditions of the area. When evaluating damaged and unusable building stock following disasters, it becomes evident that temporary housing is primarily needed after earthquakes. In light of the experiences following the Kahramanmaraş earthquakes on February 6, 2023 (7.8 Mw magnitude in the Pazarcık district and 7.5 Mw magnitude in the Ekinözü district) and the Hatay earthquakes on February 20, 2023 (6.3 Mw magnitude in the Defne district and 5.5 Mw magnitude in the Samandağ district), it is clear that the issue of temporary shelter after earthquakes remains a significant challenge in Turkey.

2. Literature Review

Shipping containers, known for their modularity and resistance to harsh weather conditions, are increasingly being repurposed as housing. This approach represents a more environmentally friendly and sustainable construction method, as it reduces construction time, waste, and the overall workload on-site [1]. Numerous studies have been conducted globally on the use of shipping containers for social housing

[2][3]. Furthermore, the sustainability of recycling shipping containers for living spaces has been extensively researched [4][5][6]. Within the framework of the skeleton and infill construction system, shipping containers can be regarded as the primary structural element of a building, with additional components serving as infill within this cellular system [7].

Certain standards for the design of temporary settlements have been established to address the needs of disaster victims, and definitions for temporary shelter design criteria have been formulated based on previous experiences with prefabricated buildings [8][9]. In terms of construction methodology, it has been observed that structural systems utilizing shipping containers exhibit adequate seismic response to earthquake loads [1]. A review of the literature indicates that various studies have been conducted on the use of shipping containers as emergency shelters and temporary housing following disasters, leading to the proposal of numerous prototypes and designs [10][11][12][13][14][15][16][17]. For instance, Akar (2012) developed a database model for container use in producing temporary housing, while Atamer (2010) focused on optimal pricing and production decisions in reusable container systems. Additionally, Avlar et al. (2023) introduced the CLT E-BOX as a post-earthquake temporary housing unit, and Beyatlı (2010) proposed a model for an emergency state container as a shelter. Kumaş (2022) explored the use of containers for temporary housing and the development of spatial solutions in Turkey. Furthermore, a variety of sustainable temporary housing proposals have been developed as shelters [18][19][20].

Analyses have demonstrated that social sustainability is equally important as technological sustainability [21][22]. The architectural adaptation of shipping containers for housing has been investigated for domestically displaced individuals in Nigeria. Two significant social and environmental issues were addressed: mass displacement leading to homelessness and the increasing number of empty shipping containers abandoned at ports [23]. Similarly, the housing challenges faced by Syrian refugees have been tackled through the use of shipping containers [24]. Based on experiences with temporary housing following major disasters worldwide, several critical social factors have been identified. These factors include issues related to ownership, reuse, resettlement arrangements, and pre-disaster planning by authorities, which depend on the characteristics of various types of disasters. Furthermore, it is essential to explore whether these social factors are equally applicable to all post-disaster scenarios [25].

Post-disaster reconstruction is evaluated from a comprehensive and interdisciplinary perspective, encompassing both technical and managerial aspects, and is treated as an integrated system. The coordinated operation of these two subsystems is crucial in the chaotic environment that typically follows a disaster. The managerial subsystem delineates roles and responsibilities in the post-disaster process [26]. Within the framework of disaster management and post-disaster preparedness, it has become increasingly important to establish guidelines for temporary shelters and define coordination strategies in advance to mitigate potential financial and time losses [27]. Disaster operations occur in a chaotic environment characterized by uncertainty and time constraints. Consequently, there is a pressing need to leverage information and communication technologies in decision-making processes [27][28]. In addition, it is believed that the participatory design method, which is typically applied in permanent housing, can also be utilized in temporary housing to positively influence the recovery period of victims. The primary objective should be to engage the end-users [29]. It is anticipated that involving those affected by the disaster as stakeholders in the procurement, design, and construction of temporary housing can foster a sense of social interaction following the disaster [27]. Furthermore, a decision support system has been developed to prioritize assistance among disaster victims during the post-disaster recovery phase [30]. Participatory design should be favored in the production of post-disaster housing. Given the nature of participation, post-disaster traumas can be addressed in a more manageable and controlled manner. Society must address post-disaster trauma through solidarity and unity. Effective participation can be achieved by fostering solidarity, communication, cooperation, trust, and a sense of belonging. Participatory design offers a viable solution to this pressing issue following a disaster [31]. Research has shown that temporary settlement areas, which do not align with the characteristics of the region in which they are established and are designed uniformly, fail to aid the recovery of disaster victims; instead, they create additional challenges for those affected [32]. The process of partially or completely abandoning the disaster-stricken area and relocating to a new, safer environment also presents significant challenges regarding individuals' adaptation to their new surroundings [33][34]. For instance, following the 2011 Christchurch earthquake, studies were conducted on the transformation of urban spaces and post-disaster reconstruction, examining how these efforts could enhance a city's resilience [35].

In the selection and identification of temporary settlement areas within urban centers, specific methods were employed to establish criteria [36]. The criteria for selecting temporary settlement areas can be summarized under the following categories: proximity to existing urban areas, access to water resources, connectivity to city infrastructure, area size, ownership status, topography, transportation accessibility, distance from disaster risk zones, classification as agricultural land, and the presence of surface obstacles, among others [8]. Studies conducted by various institutions over the years aimed at determining the location and size of post-disaster housing and emergency assembly areas in Izmir have been compiled. A related study examined whether the emergency assembly points and the areas designated for tent shelters in the Karşıyaka district met the necessary quality and size requirements. Additionally, their compliance with national and international standards was assessed [37]. In a study conducted in Istanbul, the shortest routes for citizens traveling from temporary emergency assembly point to temporary shelter areas using vehicles were analyzed. This analysis revealed districts that face challenges and require strengthening [38]. Post-disaster risk maps were created for the districts of Istanbul, identifying areas that need improvement [39]. Additionally, geographical surveys of temporary settlements designated by civil defense and local municipalities in eighteen districts on the European side of Istanbul were conducted for use following a potential disaster. The minimum standards for temporary settlements should be clearly defined by the International Red Cross, the Red Crescent Society, and

Non-Governmental Organizations (NGOs). This study examined these standards in detail. Data obtained from field surveys, digital topographical maps, geological maps, and the established minimum standards for temporary settlements were evaluated using Geographic Information System (GIS) methods [40]. Potential vacant spaces for temporary emergency assembly areas were analyzed through various case studies, including Kastamonu, Denizli, Malatya, and Çankırı, leading to specific recommendations. As a result of the risk analysis, suitable locations within built-up environments were investigated [41][42][43][44]. Through these studies, appropriate locations for temporary emergency assembly areas will be identified prior to an earthquake, enabling local authorities to enhance and rehabilitate these areas effectively [45].

3. Categorization of Emerging Problems in Dense-Urban Regions

When evaluating the post-disaster process in light of the experiences gained from recent disasters in Turkey, the emerging challenges can be categorized into three main areas. This study identifies these issues as follows: difficulties encountered in emergency assembly areas, a lack of social networks, and ineffective use of temporary shelters. After identifying these problems, the question arises: how can we contribute to addressing the issues of temporary housing and social assistance following a disaster? Depending on the definition of the problem, the solution emphasizes the post-disaster period, urban environments with high population density, temporary settlement and shelter design, and contributions to social life. Accordingly, the hypothesis of this study is articulated as follows: a partial contribution will be made to addressing the problem by developing a high-density, on-site temporary settlement and social network model following a disaster. Issues related to the hypothesis are presented in this section under the topics of temporary shelter, social networking, and emergency assembly areas (see Figure 1).

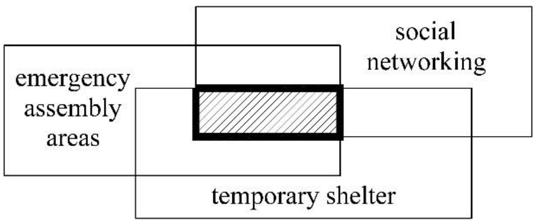

Figure 1: Problem definition

3.1 Temporary shelter

The need for post-disaster shelter is defined at various levels, with tents classified as "emergency shelters. The accommodations where disaster victims reside until they transition to permanent housing are referred to as "temporary shelters. Temporary shelters are typically established using prefabricated units and are expected to be constructed starting from the fifteenth day after the disaster and continuing until the second month. It can be stated that permanent housing is generally provided to disaster victims within twelve months following the event. Temporary shelter refers to the settlements where disaster victims reside from the second month following an earthquake until the twelfth month. Generally, prefabricated building technology is the predominant method used during this period. However, considering the impact area of the Kahramanmaraş earthquakes in 2023, it appears unlikely that prefabricated temporary shelters capable of meeting all needs can be established within the specified timeframe, even when accounting for all available resources in the country. Following the aforementioned earthquakes, the demand for prefabricated housing in earthquake-affected regions surged. Consequently, the Ministry of Trade issued a decision on February 15, 2023, to ban the export of prefabricated structures for three months [46]. Similarly, in the risk analysis of a potential Marmara earthquake, it is anticipated that a substantial population will require temporary shelter. It is evident that the needs of all individuals affected by the earthquake cannot be met simultaneously with prefabricated houses. In the context of emergency management, diversifying the range of solutions is deemed highly beneficial. Therefore, various alternatives should be proposed in addition to the production of prefabricated buildings for the establishment of temporary settlements.

At this stage, standard prefabrication production techniques are insufficient for rapid and on-site production, leading to the emergence of the innovative concept of the flying factory. Skanska defines modern flying factories as a strategy for off-site manufacturing and the industrialization of construction projects, which utilizes temporary and flexible factories while implementing lean principles in the manufacturing process [47][48]. The modern flying factory (MFF) involves the production of specific components or modules at temporary off-site or near-site locations, employing relatively simple technologies and processes that can be quickly set up and dismantled [49][50][51].

3.2 Social networking

It is often not immediately possible for disaster victims to leave their living environment for various reasons. Even if their building has become uninhabitable, disaster victims may not be able to leave the area due to physical, economic, and sociological factors. For instance, after an earthquake, live search and rescue operations can last up to fourteen days, while debris removal may take anywhere from two to six months. Consequently, disaster victims may be unable to leave the affected areas immediately, and first-degree relatives who come to the site during this time may also remain in the region for an extended period. In addition, first responders in charge of search and rescue operations also face challenges related to emergency shelter. The lack of a social network within the neighborhood following a disaster further complicates search, rescue, and support efforts. Therefore, there is a pressing need for a pre-established social network at the neighborhood level in the aftermath of a disaster. Evacuating the region or relocating disaster victims to large-scale temporary settlements outside the city center is often not a viable solution. Involving disaster survivors in recovery activities not only aids regional recovery but also significantly helps victims cope with the trauma they have experienced [52] [53] [54] [55]. At the neighborhood level, there is a need for volunteers to support on-site solutions.

3.3 Temporary settlements in emergency assembly areas

In Turkey, the medium to high density of urban development, zoning plans that do not align with soil geology, construction activities that fail to adhere to regulations, and the presence of construction defects—even when regulations are met—render the built environment particularly susceptible to earthquakes. The large number of people affected by earthquakes presents a significant challenge that must be addressed, both by learning from past earthquake experiences and by conducting future risk analyses in the context of disaster management. It is highly probable that we will encounter a phenomenon similar to the population density affected by the Kahramanmaraş earthquakes in future seismic events. In this context, various public institutions and universities have conducted risk analyses regarding the anticipated impact of the Marmara earthquake on Turkey's largest city. The population density that will be affected has been frequently discussed. In the case of Istanbul, it is evident that temporary settlements following a disaster cannot be dispersed over a large area due to the limited open spaces in the city center, which has a high population density. In addition, post-disaster emergency transportation routes and evacuation corridors are being developed in collaboration with various public institutions as part of disaster management efforts. However, ensuring self-sufficiency and coordination in disaster-affected areas in the event of potential transportation restrictions is also a critical concern. Temporary settlements established after a disaster should be designed to utilize existing small open spaces within urban areas. Furthermore, previous earthquake experiences have shown that relocating earthquake victims from their neighborhoods can have detrimental socio-psychological effects [56][57][58][59]. When the prefabricated temporary settlements constructed outside the city center were dismantled, it became evident that the concrete used for ground leveling had resulted in significant environmental issues. Furthermore, based on the risk analyses conducted for Istanbul, transferring such a large number of people outside the city and establishing extensive temporary accommodation areas does not appear to be a feasible solution. The establishment of large-scale prefabricated settlements outside the city center may also lead to additional economic and environmental challenges.

4. Aim and Scope of the Study

The proposed model can be tested as a prototype for Istanbul. Solutions are sought at the neighborhood level due to the dense urban pattern, the limitations of large emergency assembly areas following an earthquake, and the relatively small size of existing open spaces. Emergency assembly areas are determined by local municipalities and the state emergency management agency (AFAD). Within the scope of this proposed project, suitable locations among these emergency assembly areas will be selected as case studies, and temporary settlements will be defined for these sites.

Table 1: The extensive impact of the proposed model

Category	Impact
Social / Cultural	>Finding solutions to post-disaster shelter needs >The utilization of existing materials, such as shipping containers, through conversion. >Supporting local production >Increasing the social awareness through volunteering activities >Contributing to on-site solutions for post-disaster social issues
Academic	>The potential for prototype production following the successful completion of the project >Providing public training to volunteers who will respond to disasters through public institutions and NGOs >Determining production bases by selecting pilot regions within organized industrial zones and testing the system
Economic	>It is essential not to rely solely on the manufacturing facilities and capacities of prefabricated building manufacturers for the production of temporary housing following a disaster. >The ability of different companies to produce kitchen, bathroom, door, window, etc. independently from one another. >Corporatization of temporary manufacturing facilities following a disaster: contributions to the local economy and employment
Homeland Security	>Preventing migration from regions experiencing economic recession following disasters and discouraging the evacuation of these areas. >Retaining skilled labor in the region >Addressing social issues directly within communities and mitigating the potential rise in crime rates through the establishment of neighborhood social networks

The number of individuals affected in the disaster risk analyses for the anticipated Marmara earthquake is significant enough to complicate search and rescue operations. Therefore, the application of a participatory production model for post-disaster temporary shelters aims to enhance social life during the recovery period. Upon the successful completion of a case study, the proposed model can be implemented in different provinces.

The aim of this study is to develop a research model for "post-disaster temporary shelter in high-density settlements utilizing the concept of a flying factory. Sufficient number of temporary shelter that aligns with the existing urban density like in Istanbul is not feasible. If it were designed to match the same density, this project would either evolve into a permanent housing initiative or be classified as an earthquake-prioritized urban regeneration project. In this context, the term temporary settlement non-single-storey, compact spaces within the city center that are intended to be utilized to their maximum capacity. The anticipated impacts of the project, if successfully implemented, are categorized as social/cultural, academic, economic, and homeland security [60]. Based on these impact categories, the extensive effects of the proposed model are illustrated in Table 1.

The scope of the model proposal can be summarized as follows: preparation of temporary settlement alternatives, creation of a structural design and assembly guide for shelters, definition of a temporary manufacturing facility, and development of a social network and volunteer management program. Following the preparation of the temporary settlement alternatives, the technical and organizational phases of the proposed model are illustrated in Figure 2.

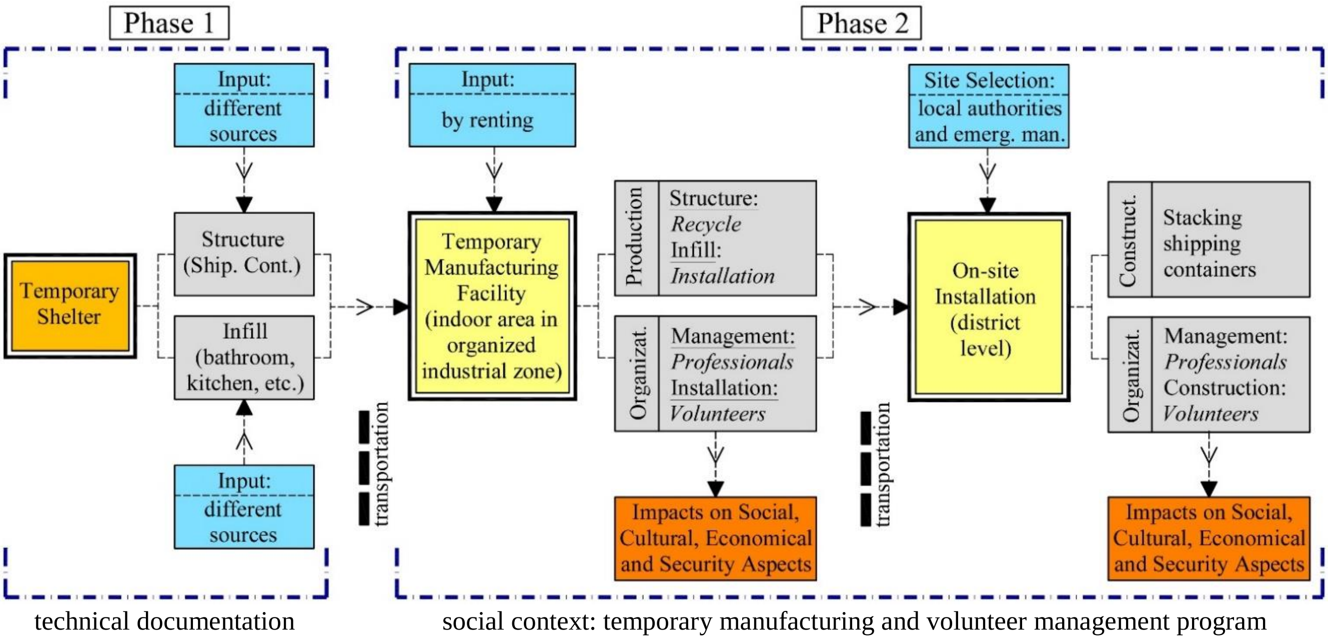

Figure 2: Technical and organizational phases of the proposed model

4.1 Temporary settlement and the structure

An existing shipping container will be converted into a shelter, with the dimensions of temporary shelters adhering to modular multiples of the container's specifications. Interior components, including doors, windows, bathrooms, and kitchens, will be manufactured separately. These components can be sourced from various suppliers in accordance with the established project procurement plan. Interior units can be assembled independently in a cellular form that fits inside a shipping container. This approach results in an assembly-intensive construction process on-site, rather than starting production from scratch. Individuals or organizations wishing to donate or support the production of temporary shelters can produce or procure these units, which have predefined dimensions and technical standards, and send them to on-site production centers, functioning as a flying factory. For instance, a kitchen unit or bathroom unit could be manufactured in other production facilities and shipped to the designated regional manufacturing center.

This study targets the establishment of a temporary manufacturing facility at the local or regional level as a production model. It is proposed to create an appropriately sized indoor space within an organized industrial zone near the disaster area. In this temporary facility, local and regional manufacturing will take place, with professional and volunteer teams assembling the temporary shelters. In the following sections, these production facilities will be referred to as "temporary local manufacturing facilities”. A limited example of this production model was implemented after the Kahramanmaraş and Hatay earthquakes at the TÜYAP fair and exhibition hall in Beylikdüzü, Istanbul (see Table 2). Unlike the aforementioned example, this proposal suggests locating the manufacturing facility closer to the disaster area, with the expectation that it will enhance social life through volunteer involvement [61] [62] [63]. Additionally, a key distinction is that rather than constructing a new structure, the focus is on rapidly transforming existing shipping containers by utilizing a production kit that follows a predefined work schedule.

It is anticipated that the proposed temporary settlement will be situated in high-density residential areas, with a structure comprising two or three stories due to the limited size of the emergency assembly areas. Consequently, the population of 30 units is expected to accommodate between 90 and 120 people. Based on this example, settlement alternatives will be developed according to increasing numbers in multiples. Examples of design features are presented in Table 3.

Table 2: Temporary manufacturing facility at TÜYAP fair and exhibition hall, Beylikdüzü, İstanbul [61] [62] [63]

Temporary Off-Site Manufacturing Phases for Core / Shell (Support) as Prefabrication			
a. structural frame (HSS hollow section) 	b. member connection 	c. exterior sheathing (OSB) 	d. interior finishing works 

Table 3: Samples of design features [64] [65] [66] [67] [68] [69] [70] [71] [72] [73]

Design features	
a. Urban context; - stacked structure - intricate design - different storey numbers	Housing / Dormitory / Commercial 
b. Building design; - small units like student dorm - optimum access to each unit by staircase	Housing / Dormitory 
c. Infill design; - modular kitchen pod - modular bathroom pod - doors & windows - MEP systems	Kitchen Pod / Bathroom Pod / Cabinets 

Although these samples pertain to permanent settlements, the design and construction management strategies outlined in this study provide methods for utilizing shipping containers as temporary shelters. Regarding infrastructure connections, the proposed project model will be integrated into the city's existing infrastructure network. Additionally, post-disaster infrastructure risk analyses previously conducted by the public sector will also be reviewed. Following this review, if deemed necessary, a study should be undertaken to assess self-sufficiency in an off-the-grid context.

Shipping containers are constructed from corten steel, which is highly resistant to weathering and corrosion. Additionally, the corrugated panels are welded to the frame, creating a sealed shell. For these reasons, internal insulation is often preferred. Typically, a secondary layer is formed using wooden or galvanized steel profiles on the interior wall surface, with the necessary thermal insulation applied between these frames. The second layer is finished with gypsum board on the inside.

4.2 Social networking; volunteer management program

This study proposes a model aimed at constructing a social network that supports disaster victims in maintaining their connection to their habitat. In this research proposal, the term refers specifically to disaster victims. The social network described here is fundamentally based on the participation of local individuals who are experiencing post-disaster trauma. As illustrated in Figure 2, the proposed model consists of two stages, and it is anticipated that the design process will be completed in advance. The social networking aspect highlighted in the second stage also emphasizes a participatory production model.

Efforts are being made to prevent earthquake-prone zones from becoming abandoned areas. A neighborhood-level solution will contribute to addressing regional security, workforce issues, and post-earthquake trauma. Prior to a disaster, public and relevant institutions should be informed about the temporary settlements to be established in predetermined areas for each neighborhood, as well as how these social networks will function. Each neighborhood is affected by disasters to varying degrees. The status of the evacuation corridors designed for neighborhoods impacted by the disaster should also be evaluated during this process. Therefore, in addition to constructing buildings in the proposed model, user prioritization can be implemented based on the victims' status affected by the disaster. Along with prioritization, a timeline may also need to be established. After a disaster, the daily transfer of first responders from the nearest suitable accommodation can result in them spending hours on the road. A temporary accommodation plan can be developed for these individuals, and the proposed model presented herein can also address their needs. Local volunteers, municipalities, the national emergency agency (AFAD), and NGOs are considered essential components of this social network. The organization of volunteers and professionals who will work at temporary local or regional manufacturing facilities and construction sites will be defined by a volunteer management program. This initiative particularly aims to prevent the qualified workforce from leaving the earthquake-affected areas.

The manufacturing facility" will help retain skilled labor in the disaster-affected area. The proposed social network lays the groundwork for transforming initial voluntary activities into professional endeavors over time, fostering a vision that will support the region's development following the disaster. The volunteer management program cycle has been extensively studied in social work, and valuable insights can be drawn from these experiences [74].

5. Execution Plan for the Proposed Model

In the project proposal aimed at developing a solution for post-disaster shelter, the project stakeholders will be identified. A due diligence study will be conducted to assess the locations where temporary settlements are planned to be established in high-density urban areas. Site selection will be analyzed, and the chosen sites will be evaluated based on criteria that include not only susceptibility to earthquakes but also risks related to flooding, wildfires, and transportation limitations.

Site evaluation will be followed by structural performance assessment. Since the temporary settlements will be designed as two or three stories rather than a single story, their structural performance against earthquake loads shall be assessed through simulation. Related risks, if any, will be identified. The execution plan for the model proposal is presented in Table 4, which corresponds to Phase 1 in Figure 2.

Table 4: Execution plan for pre-construction period by professionals / experts for Phase 1 depicted in Figure 2

Phases	Type	Notes
1. Project Stakeholders		
Public institutions and non-governmental organizations	O*	Definition of emergency assembly areas, scope of technical guide, boundary of social networking
University-led workshop		Establishment of a participatory production model, a temporary manufacturing facility operation plan, and integration strategies for production with the social network.
2. Design Process		
Design of temporary settlements	DE**	Determination of required land sizes, number of units and floors, and etc.
Design of temporary structure		Determination of sizes, storey usage characteristics, and other relevant factors.
Design of temporary infill		Determining the integration of kitchen, bathroom, and plumbing systems
3. Documentation		
Supply/shipping specification	DO***	Preparation of sanitary and transportation specifications for reusable containers
Production specification		Preparation of installation manuals defining production phases
Technical and social networking (volunteer management) guide		Establishing a comprehensive guide for preparation and training prior to a disaster, as well as for following established procedures in the aftermath.

* O=Organizational, ** DE=Design, *** DO=Documentation

After the proposed model is successfully implemented, a case study will be carried out in the chosen location. The technical documents to be produced (such as the user manual and volunteer management program) will be utilized in pre-disaster training conducted by public institutions and NGOs. Phase 1 of the pre-construction period is the primary focus of this execution plan, as Phase 2 is directly dependent on the work completed in Phase 1.

Conclusion

Following the recent earthquakes in Turkey, it has been determined that the demand for post-disaster temporary housing exceeds the production capacity of prefabricated structures. Temporary settlements located outside the city center present various challenges, highlighting a significant need for social connectivity. Based on these findings, the primary objective of the proposed model is to repurpose shipping containers to enhance the diversity of prefabricated housing options. This approach aims to enable facilities to address housing needs at the neighborhood level, rather than in peripheral areas, while also fostering a social network to support the aforementioned technical initiatives.

The article prepared for this research outlines a theoretical method for a project model. The primary objective of this research is to contribute to addressing the challenges associated with post-disaster shelter needs. The key steps to achieve this research goal, which encompasses both technical and social aspects, are illustrated in Figure 2 as follows:

- *Technical aspect:* A key objective is to develop a prototype that incorporates the features outlined in the article, utilizing a shipping container within an appropriate indoor facility to facilitate real-scale handling. Throughout the development of this prototype, it will be possible to create an application kit and engage in the process using the most realistic dimensions.

- *Social aspect:* Following the implementation kit, the content can be shared with relevant institutions and NGOs to achieve widespread impact. Another primary objective is to outline how to establish a participatory production model. In the context of defining social networking, it will be recognized as an academic platform for discussing the topic in various workshops and contributing to the post-disaster response plans of public authorities in Turkey.

In Table 4, an execution plan is proposed for Phase 1, as illustrated in Figure 2. Documentation for Phase 2 will be prepared during Phase 1. Cities located in earthquake-prone regions, particularly Istanbul, will be examined as case studies. Due to its dense population and limited emergency assembly areas in the city center, Istanbul faces challenges in establishing large-scale temporary settlements. The design for temporary settlements will focus on the emergency assembly areas identified as suitable. Unlike single-storey prefabricated temporary dwellings, the plan aims to maximize density within a limited area by incorporating two or three-story structures. It is anticipated that the production of "infill" elements, such as kitchens, bathrooms, doors, and windows, will be independent of the overall structure. The kitchen and bathroom are designed as separate modules, enabling manufacturers to produce these units independently and transport them to a temporary local manufacturing facility. In the context of a disaster, it is crucial to encourage local residents and disaster victims to engage in recovery activities, assisting them in overcoming the trauma they have experienced. Keeping them in their own environment will mitigate many sociological issues that may arise.

The proposed model has significant social, cultural, academic, economic, and national security implications. In addition to first aid and debris removal activities, residents of the region can also volunteer during the production phase. In this context, the establishment of a temporary manufacturing facility based-on the concept of flying factory falls within the scope of this project. This model, which is based on participatory production, is characterized as a social networking or volunteer management program in this study. Indoor spaces selected from organized industrial zones within or near the disaster area will be allocated or rented and used temporarily for structural production and transformation. This approach ensures that temporary shelters, supported by local and regional production, will not rely solely on existing prefabricated facilities in the construction industry, thereby eliminating dependency in production. The social networking initiative, designed to support the production phase, will also help prevent the evacuation of the region and mitigate potential domestic migration. Various public institutions and NGOs will participate in the shelter production process. Upon completion of the project, a user manual will be created to outline the work accomplished, along with a document that can be utilized in the aftermath of a disaster. This document will also serve as a resource for public institutions and NGOs for preparation and training purposes prior to a disaster. Following the successful completion of the model proposal as a technical document, a case study application will be implemented based on the selected location.

Conflict of Interest

The authors declare that they have no conflicts of interest.

References

[1] Chen, Z., Khan, K., Khan, A., Javed K. & Liu J., Exploring of the multidirectional stability and response of prefabricated volumetric modular steel structures, *Journal of constructional steel research,* 184, 1066826, 2021.

[2] Botes, A. W., A feasibility study of utilising shipping containers to address the housing backlog in South Africa, *MSc. Thesis*, Stellenbosch University, Faculty of Engineering, Civil Department, Construction Management Division, 2013.

[3] Balcha, L. T., The prospect and challenges of shipping container as residential unit: alternative housing solution for Ethiopia, *MSc. thesis*, St. Mary’s University, School of Graduate Studies of Business Administration, 2022.

[4] Dara, C., Hachem-Vermette, C. & Assefa, G., Life cycle assessment and life cycle costing of container-based single-family housing in Canada: A case study, *Building and environment*, 163, 106332, 2019.

[5] Radwan, A. H., Containers architecture reusing shipping containers in making creative architectural spaces, *International journal of scientific and engineering research*, vol. 6, issue 11, pp. 1562-1576, 2015.

[6] Taleb, H., Elsebaei, M., & El-Attar, M., Enhancing the sustainability of shipping container homes in a hot arid region: A case study of Aswan in Egypt, *Architectural engineering and design management*, vol 15(6), pp. 459-474, 2019.

[7] Cao, X., Li, X., Yan, Y., & Yuan, X., Skeleton and infill housing construction delivery process optimization based on the design structure matrix, *Sustainability*, vol. 10 (12), 4570, 2018.

[8] Dayanır, H., Geo-spatial analyses of after disaster dwelling sites and container town design for Seferihisar case, *MSc. thesis*, İzmir Katip Çelebi University, Institute of Science, 2019.

[9] Onur, İ. Ö., The analysis of temporary housing after disaster in Turkey - evaluation of temporary housing samples in İzmit and Yalova, *MSc. thesis*, Istanbul Technical University, Institute of Science, 2005.

[10] Akar, E., A database model for container use in producing temporary housing, *MSc. Thesis*, Istanbul Technical University, Institute of Social Sciences, 2017.

[11] Atamer, B., Optimal pricing and production decision in reusable container systems, *MSc. thesis*, Middle East Technical University, Graduate School of Natural and Applied Sciences, 2010.

[12] Avlar, E., Limoncu, S., & Tizman, D., Post-earthquake temporary housing unit: CLT E-BOX, *Journal of the Faculty of Engineering and Architecture of Gazi University*, vol. 38 (1), 2022.

[13] Beyatlı, C., Proposal of a model of an emergency state container as a shelter, *MSc. Thesis*, Trakya University, Institute of Science, 2010.

[14] Kumaş, B., Konteynerların geçici konut olarak kullanımı ve mekansal çözüm önerileri geliştirilmesi, *MSc. thesis*, İstanbul Kültür University, School of Graduate Studies, 2022.

[15] Messeidy, R., Adapting shipping containers as temporary shelters in terms of recycling, sustainability and green architecture; reuse as accomodatiıon in Egypt, *Engineering research journal*, vol. 160, December 2018 A33-A.

[16] Pena, J. & Schuzer, K., Design of reusable emergency relief housing units using general-purpose (GP) shipping containers, *International journal of engineering research and innovation*, vol. 4, no. 2, pp55-64, 2012.

[17] Tan, C. S. & Ling, P, C. H., Shipping container as shelter provision solution for post-disaster recontrcution, *E3S web of conferences* 65, 08007, ICCEE, 2018.

[18] Arslan, H., Research of planning / organisation, construction phases of temporary houses and re-use potential after usage 'case study of Düzce', *MSc. Thesis*, Gebze Technical University, Institute of Engineering and Science, 2004.

[19] Eren, Ö., A proposal for sustainable temporary housing applications in earthquake zones in turkey: Modular box system applications, *Gazi University journal of science*, vol. 25 (1), pp. 269-288, 2012.

[20] Kuittinen, M. & Takano, A., The energy efficiency and carbon footprint of temporary homes: a case study from Japan, *International journal of disaster resilience in the built environment*, vol. 8 (4), pp. 326-343, 2017.

[21] Alemdağ, E. & Aydın Ö., A study of shipping containers as a living space in context of sustainability. *ARTIUM, vol.* 3, no. 1, pp. 17-29, 2015.

[22] Zubaidi, L., The container as a sustainable housing unit: an analyses of social dimension, *MSc. Thesis*, Altınbaş University, School of Graduate Studies, 2022.

[23] Obia, A., Architectural adaptation of the shipping container for housing the internally displaced persons in South Nigeria, *International journal of architecture, engineering and construction*, vol.9, no.4, pp. 1-9, 2020.

[24] Rahman, S. A., Displaced Settlements, *MSc. Thesis*, The Victoria University of Wellington, School of Architecture, 2017.

[25] Zhang, G., Setunge, S. & Van Elmpt, S., Using shipping containers to provide temporary housing in post-disaster recovery: social case studies, *Procedia economics and finance*, vol. 18, pp. 618-625, 2014.

[26] Johnson, C., Lizarralde, G. & Davidson, C. H., A systems view of temporary housing projects in post-disaster reconstruction, *Construction management and economics*, vol. 24 (4), pp. 367-378, 2006.

[27] Abulnour, A. H., The post-disaster temporary dwelling: Fundamentals of provision, design and construction, *HBRC Journal*, vol. 10 (1), pp. 10–24, 2014.

[28] Çavdur, F., Sebatli-Saglam, A. & Kose-Kucuk, M., A scenario-based decision support system for allocating temporary-disaster-response facilities, *Journal of the faculty of engineering and architecture of Gazi University*, vol. 36 (3), pp. 1500-1514, 2021.

[29] Günal, N., The arrangement of temporary houses with participant focused design methods in the post-disaster awareness and healing period, *MSc. thesis*, Bahçeşehir University, Institute of Science, 2020.

[30] Öztaş, S., Solution approaches for post disaster recovery operations, *PhD dissertation*, Atatürk University, Institute of Science, (2019).

[31] Çelik, S. D., Participatory design process in post disaster housing production: The case of 30 October 2020 İzmir earthquake, *MSc. thesis*, Izmir Institute of Technology, (2022).

[32] Yaşar, S. B., The evaluation of post-disaster temporary settlements though concept of mass production, *MSc. thesis*, Hacettepe University, Institute of Fine Arts, (2021).

[33] Arslan, H., (2009). The evaluation of the post disaster reconstruction process in terms of place attachment, relocation and cognitive mapping concepts, *PhD dissertation*, Istanbul Technical University, Institute of Science.

[34] Genç, S., An integrated model proposal and an application for the determination of temporary shelter areas to be opened after the disaster and their allocation to the disaster victims, *MSc. thesis*, Kütahya Dumlupınar University, School of Graduate Studies, 2022.

[35] Brand, D. & Nicholson, H., Public space and recovery: learning from post-earthquake Christchurch, *Journal of Urban Design*, vol. 21 (2), pp. 159-176, 2016.

[36] Hazırcı, M., Selection of temporary shelter sites to be used after disaster; A case study Burdur-Isparta, *MSc. thesis*, Mehmet Akif Ersoy University, Institute of Social Science, 2017.

[37] Maral, H., Examining the allocation of post-disaster shelter areas: A case study in İzmir Karşıyaka district, *MSc. thesis*, Gediz University, Institute of Science, 2016.

[38] Kuru, G. N., Accessibility of disaster problems in İstanbul, *MSc. thesis*, Istanbul Technical University, Institute of Social Sciences, 2019.

[39] Üstün, A. K. & Anagün, A. S. , Determination of importance weights of Istanbul's districts using analytic hierarchy process, *Gazi University journal of engineering and architectural faculty*, vol. 31 (1), pp. 119-128, 2016.

[40] Özdemir, H., Geographical etude of temporary shelter areas after propable disaster at the European side of İstanbul İstanbul, *MSc. thesis*, Istanbul University, Institute of Social Science, 2002.

[41] Özel, S., The location of post-disaster gathering areas in urban open and green area systems - case of Kastamonu city, *MSc. thesis*, Kastamonu University, Institute of Science, 2019.

[42] Palazca, A., Analysis of gathering areas after the disaster: The case of Denizli city, *MSc. thesis*, Pamukkale University, Institute of Science, 2020.

[43] Şahin, İ. K., Post-disaster gathering areas in Malatya city center examination of the current situation, *MSc. Thesis*, İnönü University, Institute of Science, 2022.

[44] Taylan, S., Commenting on post-disaster emergency gathering and temporal shelter areas standarts (The case of Çankırı province), *MSc. Thesis*, Çanakkale Onsekiz Mart University, Institute of Educational Science, 2018.

[45] Rezaei, S., Development of a decision support model for the optimum shelter location following a disaster, *MSc. Thesis*, Istanbul Technical University, Institute of Science, 2014.

[46] TRT Haber, *Prefabrik yapı ve konteynerlerde KDV indirildi, ihracat yasaklandı,* Retrieved February 14, 2023, from https://www.trthaber.com/haber/ekonomi/prefabrik-yapi-ve-konteynerlerde-kdv-indirildi-ihracat-yasaklandi-746222.html

[47] Ofori-Kuragu, J.K. & Osei-Kyei, R., Mainstreaming pre-manufactured offsite processes in construction—Are we nearly there?, *Construction Innovation*, vol. 21, no. 4, pp. 743-760, 2021.

[48] WEF, Shaping the future of construction - A breakthrough in mindset and technology world economic forum in collaboration with the Boston consulting group Geneva", *Industry Agenda*, Retrieved February 17, 2023, from https://www.weforum.org/publications/shaping-the-future-of-construction-a-breakthrough-in-mindset-and-technology/, 2016.

[49] Gee, S & Brown, A., A mobile Ssystem for the on-site assembly of timber frame components: the development of an agile, low-cost alternative to offsite prefabrication, *Sustainability*, 14, 651, 2022.

[50] Haukka, S. & Lindqvist, M., Modern flying factories in the construction industry; a description of the concept and lessons for future development, *MSc. Thesis*, Lulea University of Technology, Department of Civil, Environmental and Natural Resources Engineering, 2015.

[51] Young, B., Harty, C., Lu, S. L & Davies, R., Developing temporary manufacturing facilities for residential building: a case of the modern flying factory, *31st Annual ARCOM Conference, London, UK*, September 7-9, 2015.

[52] Wilkin, J., EBiggs, E. &Tatem, A. J., Measurement of social networks for innovation within community disaster resilience, *Sustainability*, 11, 2019.

[53] Kawawaki, Y., Role of social networks in resisting disparities in post-disaster life recovery: Evidence from 2011 Great East Japan Earthquake, *International journal of disaster risk reduction*, 50, 101867, 2020.

[54] Varda, D. M., Forgette, R., Banks, D. & Noshir, C., Social network methodology in the study of disasters: issues and insights prompted by post-Katrina research, *Population Research and Policy Review*, 28, pp. 11–29, 2009.

[55] Guarnacci, U., Joining the dots; social networks and community resilience in post-conflict, post-disaster Indonesia, *International journal of disaster risk reduction*, 16, pp. 180-191, 2019.

[56] Chakrabarty, A., Rahman, M. & Ubaura, M., Assessment of emergency evacuation preparedness for seismic hazard in an urban area, *17th World Conference on Earthquake Engineering, Sendai, Japan* - September 13th to 18th 2020.

[57] Thompson, R. R, Garfin, D. R. & Silver, R. C., Evacuation from natural disasters: a systematic review of the literature, *Risk Analysis*, vol. 37, no. 4, pp. 812-839, 2017.

[58] Vorst, H. C. M., Evacuation models and disaster psychology, *Procedia engineering*, 3, pp.15–21, 2010.

[59] Hu, Z. H., Sheu, J. B. & Xiao, L., Post-disaster evacuation and temporary resettlement considering panic and panic spread, *Transportation research part B*, 69, pp.112–132, 2014.

[60] Tübitak 1002A, (n.d.) *Hızlı destek modülü.* Retrieved August 03, 2023, from https://tubitak.gov.tr/tr/icerik-1002-a-hizli-destek-modulu

[61] Kaya, D., *Mimarlardan depremzede konutu: tiny house*. Sabah, Retrieved February 15 2023, from https://www.sabah.com.tr/yasam/mimarlardan-depremzede-konutu-tiny-house-6360017

[62] Fuar Listesi, *Gönüllü mimarların depremzedeler için oluşturduğu "Tiny House" Taşınabilir Afet Evleri projesine yoğun ilgi*, Retrieved February 17, 2023, from https://fuarlistesi.com.tr/gonulluler-depremzedeler-icin-tiny-house-yapti/

[63] Yılmaz, Ç., (2023, March 18). *Depremzedelere ekolojik köy! Tiny house'lar yola çıktı,* Milliyet, Retrieved February 17 2023, from https://www.milliyet.com.tr/gundem/depremzedelere-ekolojik-koy-6918879

[64] McNamee, M. S., *A homeless family will be housed in this shipping container in time for Christmas*, The Journal, Retrieved November 23, 2014, from https://www.thejournal.ie/shipping-container-home-christmas-1792018-Nov2014/

[65] Arquitectura Ideal, (n.d.). *Common Ground, el centro comercial más grande del mundo hecho con contenedores*, Retrieved August 03, 2023, from https://arquitecturaideal.com/common-ground-centro-comercial-mas-grande-del-mundo-hecho-contenedores/

[66] Container Home Hub, (n.d.). *The Oscar container apartment-204*, Retrieved August 03, 2023, from https://containerhomehub.com/the-oscar-container-apartment-204/

[67] Architonic. (n.d.). *Urban post disaster housing prototype*, Retrieved May 01, 2023, from https://www.architonic.com/en/project/garrison-architects-urban-post-disaster-housing-prototype/5102498

[68] Aigner, S., *Flüchtlingsunterkunft: Fünf Jahre im Container?* Regensburg, Retrieved December 08, 2014, from https://www.regensburg-digital.de/fuenf-jahre-im-container/08122014/

[69] Vbenzeri. *Konteyner düzen,* Retrieved July 18, 2020, from https://www.vbenzeri.com/mimari/konteyner-duzen

[70] Walker Modular, (n.d.). *Steel kitchen pods*, Retrieved August 04, 2023, from https://www.walkermodular.com/bathroom-pods/steel-kitchen-pods

[71] Construible, *Se abre la nueva fábrica de baños industrializados de Lignum Tech para obra nueva y rehabilitación,* Retrieved April 18 2022, from https://www.construible.es/2022/04/18/abre-nueva-fabrica-banos-industrializados-lignum-tech-obra-nueva-rehabilitacion

[72] Bathroom Pod, (n.d.) *Prefab modular bathroom pod*, Retrieved August 04, 2023, from https://www.alibaba.com/product-detail/2017-customized-hotel-home-trailerhouse-use_60661297925.html

[73] Seabox, (n.d.). *20' x 8' dry freight iso container with 28 cabinets,* Retrieved August 04, 2023, from https://www.seabox.com/products/detail/SB861.0.4A-4B.NFELC-20ft-dry-freight-with-cabinets1

[74] Brudney, J. L., & Meijs, L. C.P.M., Models of volunteer management: professional volunteer program management in social work, *Human service organizations: management, leadership & governance*, vol. 38 (3), pp. 297-309, 2014.

Mathematical Optimization of Monte Carlo Simulation Parameters for Predicting Stock Prices

Sajedeh Norozpour*‡

*Department of Civil Engineering, İstanbul Gelişim University. Istanbul, Türkiye.

(snorozpour@gelisim.edu.tr)

‡ Corresponding Author; İstanbul Gelişim University, Istanbul, Türkiye.
Tel: +90 212 4227000 E-mail: snorozpour@gelisim.edu.tr

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Abstract- Stock price prediction holds paramount significance for individual investors, guiding crucial decisions in financial planning and investment strategies. This research delves into the methodology of Monte Carlo simulation, a versatile tool in financial modeling, to assess its advantages and disadvantages in the context of predicting stock prices. The study employs Python code to demonstrate the step-by-step implementation of Monte Carlo simulations, emphasizing the mathematical optimization of parameters for enhanced accuracy. Results showcase a characteristic bell curve, offering a probabilistic perspective on potential outcomes. Comparative analyses with other forecasting models, such as graphic analysis, underscore the superior reliability of Monte Carlo simulation in evaluating risks and rewards. Furthermore, the paper explores the application of Monte Carlo simulation in real-world scenarios, such as portfolio optimization and retirement planning, highlighting its pragmatic value for individual investors navigating the complexities of the stock market. The research concludes by acknowledging the limitations of the approach and advocating for a comprehensive consideration of all relevant factors in financial decision-making. This exploration serves as a valuable resource for individual investors seeking informed insights into probabilistic forecasting methods for effective stock price predictions.

Keywords: Stock price, Monte Carlo simulation, mathematical method

1. Introduction

Stock price prediction is a critical aspect of financial planning and investment decision-making, particularly for individual investors seeking to navigate the complexities of the stock market. The ability to anticipate price movements allows investors to formulate informed strategies, manage risks effectively, and optimize their investment portfolios. Among the various methodologies employed in financial modeling, Monte Carlo simulation emerges as a versatile and powerful tool, providing a probabilistic perspective on potential outcomes. The foundation of this research is built upon a comprehensive review of existing literature that underscores the significance of stock price prediction and the role of Monte Carlo simulation in this domain. Empirical studies by Mandelbrot and Fama laid the groundwork for understanding the complexities of stock price movements and the challenges in predicting them accurately [1], [2]. The Efficient Market Hypothesis introduced the notion that stock prices reflect all available information, challenging the feasibility of consistently outperforming the market [3].

Monte Carlo simulation, rooted in probability theory, has gained prominence in financial modeling due to its ability to incorporate uncertainty and provide a comprehensive view of potential outcomes [4]. The application of Monte Carlo simulation in stock price prediction has been explored by numerous researchers. Boyle et al. were among the early contributors, demonstrating its utility in option pricing [5]. More recent studies, such as those by Ghalanos and Theussl and Long et al. have extended its application to various financial scenarios, emphasizing its flexibility and adaptability [6] and [7].

Furthermore, the research delves into the mathematical optimization of Monte Carlo simulation parameters, aligning with the work of Clewlow and Strickland on options pricing and stochastic calculus [8]. The comparison of Monte Carlo simulation with other forecasting models, such as graphic analysis, draws on the insights from Lo and MacKinlay [9] and Murphy [10], highlighting the unique strengths of Monte Carlo simulation in handling complex financial scenarios.

In addition to its theoretical underpinnings, this research aims to bridge the gap between academic concepts and real-world applications. The work of Lapan and Rezende [11] and Chen et al. [12] exemplifies the practical implementation of Monte Carlo simulation in financial modeling, offering valuable insights for individual investors seeking actionable strategies.

Further advancements in Monte Carlo simulation techniques were introduced by Andersen and Piterbarg , who developed the Longstaff-Schwartz method for pricing American options [13]. This method addressed computational challenges and extended the scope of Monte Carlo simulation to a broader array of derivative instruments, emphasizing its adaptability in handling complex financial scenarios.

While the advantages of Monte Carlo simulation are evident, it is crucial to acknowledge its challenges and limitations. The efficient market hypothesis, as expounded by Malkiel , questions the predictability of stock prices and poses challenges for any forecasting methodology, including Monte Carlo simulation [14]. Additionally, the work of McNeil et al. emphasized the computational intensity and potential for overfitting in Monte Carlo simulations, cautioning researchers and practitioners about the nuances of its implementation [15].

By synthesizing insights from these foundational studies, this research seeks to contribute to the ongoing discourse on probabilistic forecasting methods, with a particular emphasis on Monte Carlo simulation, as a practical and effective tool for individual investors in the dynamic landscape of stock market investments. The subsequent sections will elaborate on the methodology, results, and implications, providing a comprehensive understanding of the role of Monte Carlo simulation in stock price prediction for individual investors.

2. Advantages and disadvantages of Monte Carlo simulation

Monte Carlo simulation is a versatile tool for modeling complex systems and assessing risk by incorporating uncertainty. It provides a comprehensive view of possible outcomes, making it valuable in fields like finance. However, it demands substantial computational resources, relies on input data quality and assumptions, and may not yield clear predictions but rather probabilistic insights. Understanding and interpreting its results can be challenging, and it's most effective when used alongside other analytical methods while being mindful of its computational intensity and potential for overfitting.

3. Monte Carlo Analysis

You can employ software like Microsoft Excel or its equivalents to craft a Monte Carlo simulation, a powerful tool for approximating potential price fluctuations in stocks and various assets. In this study, the graphs and results were obtained by implementing Python code, and the inputs were extracted from an Excel spreadsheet. An asset's price behavior can be dissected into two fundamental elements: first, there is the drift, signifying its consistent directional trend, and second, there is the random input, emblematic of market volatility. Through a meticulous analysis of historical pricing data, it is possible to deduce the asset's drift, standard deviation, variance, and mean price shifts. These pivotal metrics serve as the foundational elements for constructing a Monte Carlo simulation. Below are the sequential procedures for implementing a Monte Carlo simulation.

The initial step involves utilizing historical price data of the asset to create a sequence of daily returns (DR) at regular intervals, achieved by applying the natural logarithm as follows;

$$DR = \ln(\frac{p_i}{p_{i-1}})$$

Where p_i represents the stock price on the current day, while p_{i-1} corresponds to the price on the previous day. It is important to note that the prices used for this calculation are the closing prices at the end of each trading day on the stock exchange.

Proceed by employing the AVERAGE, STDEV.P, and VAR.P functions across the entire derived series to calculate the mean daily return, standard deviation (sd), and variance parameters. The drift is determined as follows:

$$D = ADR - \frac{VAR}{2}$$

Where ADR represents the previously calculated average of daily returns.

To simulate the price for future days, it is essential to factor in an approximation error, which is computed as follows:

$$\varepsilon = V * Z$$

Where V is the Volatility, stands for market volatility and Z is a random variable following a standard normal distribution.

Then we can express the equation for the following day's price as:

$$p_{i+1} = p_i * e^{\varepsilon}$$

Through the generation of a multitude of simulations, you can evaluate the likelihood that a security's price will conform to a specified trajectory.

4. Result of Monte Carlo Simulation

The results of this simulation exhibit a characteristic bell curve, forming a normal distribution of various outcomes. Positioned at the center of this curve is the most likely return, representing an expected value. Notably, there is an equal chance that the actual return will either surpass or fall short of this expected value. The probabilities associated with the actual return are as follows: there is a 68% chance that it will fall within one standard deviation of the expected rate, a 95% probability of it falling within two standard deviations, and a 99.7% likelihood of it being within three standard deviations.

It is important to emphasize that there is no guarantee that the anticipated outcome will materialize, and actual movements may deviate significantly from the most conservative projections.

Furthermore, a Monte Carlo simulation simplifies the model by disregarding external factors not directly tied to price movement, including macroeconomic trends, company leadership, market sentiment, and cyclical influences. This implies an assumption of market efficiency within the model.

5. Case Study: Simulating Future Stock Prices

We create a fictitious stock named " X " and generate daily historical price data for 30 days in Figure 1.

Using the given formula, we calculate the daily returns for each day. Then, we calculate the mean daily return (ADR), standard deviation (sd), and variance (VAR) of the daily returns over the 30 days,

ADR(Average Daily Return) = (0.0198+0.02899+…..+0.00837)/30

SD(Standard Deviation) = STDEV.P(DR) and VAR (Variance) = VAR.P(DR), Then we calculate the drift (D) as D = ADR - VAR / 2.

To simulate the price for the next day, we need to factor in an approximation error using the volatility (V) and a random variable Z following a standard normal distribution.

Fir this data we have ADR = 0.00629, SD = 0.02 and VAR = 0.0004 (VAR = SD^2).

We can use a random number generator to generate Z, which follows a standard normal distribution with a mean of 0 and a standard deviation of 1.

Let's assume that we generate Z = 0.5 for this example. Then, we can calculate the approximation error (ε) as,

ε = V * Z   ε = 0.02 * 0.5 = 0.01

Finally, we can use the formula to simulate the price for the next day,

$$p_{31} = \$120 * e^{0.01} \qquad p_{31} \approx \$121.21$$

DAY	STOCK PRICE AT THE END OF THE DAY $	RETURN
1	100	
2	102	0,0198
3	105	0,02899
4	100	-0,0488
5	98	-0,0202
6	100	0,0202
7	99	-0,0101
8	105	0,05884
9	105	0
10	107	0,01887
11	103	-0,0381
12	105	0,01923
13	108	0,02817
14	109	0,00922
15	111	0,01818
16	111	0
17	111,5	0,00449
18	113	0,01336
19	114	0,00881
20	116	0,01739
21	118	0,01709
22	115	-0,0258
23	118	0,02575
24	116	-0,0171
25	113	-0,0262
26	116	0,0262
27	118	0,01709
28	118,5	0,00423
29	119	0,00421
30	120	0,00837
		0,00629

Fig. 1: Daily Historical Price and Return

In the context of big data and predicting stock prices, the process typically involves leveraging a large volume of historical stock price data from various sources, such as financial websites, stock exchanges, or financial databases. Python libraries like pandas_datareader, yfinance, or financial APIs can be used for this purpose (Figure 2). The use of big data allows for more comprehensive analysis and the development of more sophisticated predictive models. leveraging big data allows for more extensive and accurate analysis, and the use of Python and machine learning techniques enhances the ability to predict stock prices. The combination of data collection, preprocessing, model training, and simulation techniques can provide valuable insights for making informed investment decisions.

The Python code below is a simplified example of a Monte Carlo simulation to estimate the next day's stock price based on the given historical data. To handle big data and build more sophisticated models, you may consider extending and enhancing the code in several ways.

```python
import numpy as np

ADR = 0.025
sd = 0.02
VAR = 0.0004
current_price = 120

historical_prices = np.array([100, 102, 105, 100, 98, 100, 99, 105, 105, 107, 103,
                              105, 108, 109, 111, 111, 111.5, 113, 114, 116, 118,
                              115, 118, 116, 113, 116, 118, 118.5, 119, 120])

daily_returns = np.log(historical_prices[1:] / historical_prices[:-1])
ADR_calculated = np.mean(daily_returns)
sd_calculated = np.std(daily_returns)
VAR_calculated = np.var(daily_returns)
D = ADR_calculated - VAR_calculated / 2
num_simulations = 1000
random_numbers = np random.normal(0, 1, num_simulations)
epsilon = sd * random_numbers
simulated_prices = current_price * np.exp(D + epsilon)
mean_simulated_price = np.mean(simulated_prices)
std_dev_simulated_price = np.std(simulated_prices)

print(f"Mean Simulated Price for the Next Day: ${mean_simulated_price:.2f}")
print(f"Standard Deviation of Simulated Prices: ${std_dev_simulated_price:.2f}")
```

Fig. 2: The Monte Carlo Simulation, Python Code

The code in Figure 2. first, calculates the daily returns based on the provided historical prices and then performs the Monte Carlo simulation using the specified parameters.

6. Monte Carlo Graphic Analysis

Graphic analysis has been used since the late 1800s to assess stock performance and risk. It relies on the idea that past stock price movements can be used to predict future ones. Graphic analysis is advantageous because it can swiftly identify trends and changes in stock performance. Furthermore, it can be used to identify long-term trends and potential risks in the stock market. Additionally, graphic analysis can assess correlations among different stock instruments, allowing investors to develop strategies that account for differences in stock prices. It can also be used to accurately predict future stock prices. Lastly, it can be used to identify undervalued or overvalued stocks. In this way, graphic analysis offers investors a wide array of benefits in terms of stock performance and risk analysis.

Graphic analysis is another technique used to assess the risks and rewards of an investment. It visually displays collected data and provides an easily understandable overview of the results. By analyzing data and creating graphs, investors and advisors can gain more insights into the risks and returns of an investment. However, while graphic analysis is a good way to visualize data, it doesn't objectively assess an investment's estimated risk and return. In contrast, Monte Carlo simulation is a more reliable and accurate tool for evaluating risk. The simulation generates multiple outputs that can be used to determine an investment's potential success or failure. Additionally, Monte Carlo simulation can account for a wide range of variables such as market volatility, economic conditions, and interest rates. It's also an excellent way to simulate future scenarios to assess an investment's potential risks and rewards. This makes Monte Carlo simulation a superior choice for evaluating the risk and reward of an investment compared to graphic analysis.

Here is an extended version of the code that includes plotting the Monte Carlo simulations along with the mean and standard deviation for the example provided. The augmented code includes the integration of Monte Carlo simulations, accompanied by visual representations of both the mean and standard deviation. This analysis is applied to the dataset exemplified in Figure 3. The outcomes of this investigation are elucidated in Figure 4.

```python
import numpy as np
import matplotlib.pyplot as plt

ADR = 0.025
sd = 0.02
VAR = 0.0004
current_price = 120

num_simulations = 1000
random_numbers = np.random.normal(0, 1, (num_simulations, 1))
epsilon = sd * random_numbers
D = ADR - VAR / 2
simulated_prices = current_price * np.exp(D + epsilon)
mean_simulated_price = np.mean(simulated_prices)
std_dev_simulated_price = np.std(simulated_prices)

plt.figure(figsize=(10, 6))

for i in range(num_simulations):
    plt.plot([current_price, simulated_prices[i]], color='gray', alpha=0.1)

plt.plot([current_price, mean_simulated_price], label='Mean Simulated Price', linestyle='--', color='red')
plt.plot([current_price, mean_simulated_price + std_dev_simulated_price], label='Upper Bound (1 SD)',
linestyle='--', color='green')
plt.plot([current_price, mean_simulated_price - std_dev_simulated_price], label='Lower Bound (1 SD)',
linestyle='--', color='blue')

plt.title('Monte Carlo Simulation of Stock Price for the Next Day')
plt.xlabel('Simulation')
plt.ylabel('Stock Price')
plt.legend()
plt.grid(True)
plt.show()
```

Fig. 3: The Monte Carlo Simulations

This code generates 1000 simulations and plots each individual simulation, along with the mean and one standard deviation bounds. The mean is represented by a red dashed line, the upper bound by a green dashed line, and the lower bound by a blue dashed line.

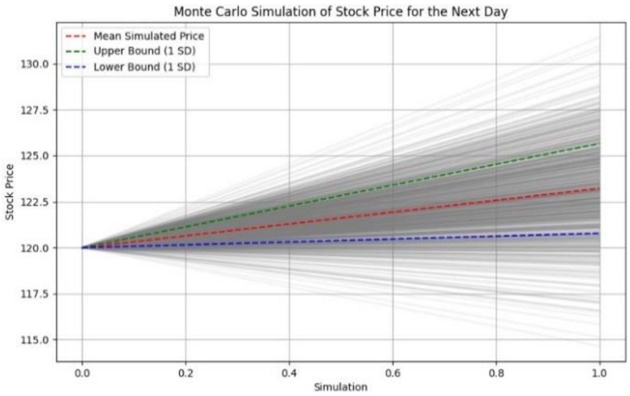

Fig.4: Monte Carlo Simulation of Stick Price for the Next Day

The graph resulting from the Monte Carlo simulation provides valuable insights into the potential outcomes for the next day's stock price. The individual gray lines represent different simulations, capturing the inherent uncertainty and variability in the predicted prices. The red dashed line represents the mean of these simulations, serving as an estimate for the most likely outcome. The green and blue dashed lines, representing one standard deviation above and below the mean, indicate the spread or volatility in the simulated prices. This spread offers a measure of the potential risk or uncertainty associated with the predictions. Assessing the distance between these bounds allows for a quantitative understanding of the range of possible outcomes. The graph aids in risk management, decision-making under uncertainty, and scenario analysis, providing a probabilistic perspective that can inform strategies and decisions based on a comprehensive assessment of potential price movements. It's important to note that the Monte Carlo simulation offers a range of possibilities rather than a deterministic prediction, making it a valuable tool for navigating financial uncertainties.

7. Conclusion

It is imperative to acknowledge that stock prices are influenced by a myriad of factors, including economic indicators, geopolitical events, market sentiment, and company-specific news. While the Monte Carlo simulation method presented in this study offers a valuable tool for probabilistic forecasting, it inherently simplifies the intricate nature of the stock market by focusing primarily on historical price data and certain statistical parameters. Therefore, market participants need to recognize the limitations of this approach and complement it with a comprehensive analysis of all relevant factors. The study serves as a foundation for understanding potential outcomes, yet prudent decision-making requires a holistic consideration of the broader financial landscape.

In conclusion, the application of Monte Carlo simulations in predicting stock prices has been demonstrated through the extended code and accompanying visualizations. The incorporation of individual simulations, mean estimates and standard deviation bounds provides a nuanced understanding of potential outcomes and associated uncertainties. This study contributes to the broader exploration of probabilistic methods in financial modeling, offering insights into decision-making under uncertain market conditions. The interpretive analysis of the Monte Carlo results facilitates risk assessment, scenario analysis, and strategic decision-making for investors and financial analysts. The academic-style representation aligns with the rigor expected in financial research, emphasizing the significance of probabilistic approaches in navigating the complexities of the stock market.

References

[1] B. Mandelbrot, “The variation of certain speculative prices”, The Journal of Business, 1963.36(4), 394-419.
[2] E.F. Fama, “Efficient capital markets: A review of theory and empirical work”, The Journal of Finance, 1970. 25(2), 383-417.
[3] E.F. Fama, “The behavior of stock-market prices”, The Journal of Business,1965. 38(1), 34-105.
[4] P. Glasserman, “Monte Carlo Methods in Financial Engineering”, Springer Publication. 2003
[5] P.P. Boyle, D.C. Emanuel, and V.E. Sandorf, “Options on the maximum or minimum of several assets”, Journal of Financial Economics,1977. 5(2), 267-288.
[6] A, Ghalanos, and S. Theussl, “Simulations for Monte Carlo Methods Using simecol”, Journal of Statistical Software, 51(5), 1-31.2012.
[7] J. B. Long, A. A.Lyubushin, and E. Perduofeva, “Financial Modeling Using Monte Carlo Simulation”, R. John Wiley & Sons Publication, 2014.
[8] L. Clewlow, and C. Strickland, “Implementing Derivatives Models”, R. John Wiley & Sons Publication, 1999
[9] A. Lo, and A. MacKinlay, “Stock market prices do not follow random walks: Evidence from a simple specification test”, Review of Financial Studies,1988. 1(1), 41-66.
[10] J. Murphy, “Technical Analysis of the Financial Markets: A Comprehensive Guide to Trading Methods and Applications”, Penguin Publication, 1999.
[11] A. Lapan, and S. Rezende, “Financial Modeling with Python” Packt Publishing, 2015.
[12] L. Chen, C. Zhu, and Y. Xie, “Financial Modeling and Simulation of Big Data”, Information, 2020. 11(5), 235.
[13] L. Andersen, and V. Piterbarg, “Interest Rate Modeling”, Atlantic Financial Press, 2010.
[14] B. Malkiel, “The Efficient Market Hypothesis and Its Critics”, Journal of Economic Perspectives, 2003. 17(1), 59-82.
[15] A. McNeil, R. Frey, and P. Embrechts, “Quantitative Risk Management: Concepts, Techniques, and Tools”, Princeton University Press, 2005.

The Impact of Irrationals on the Range of Arctan Activation Function for Deep Learning Models

Talya Tümer Sivri*, Nergis Pervan Akman**, Ali Berkol***

* Middle East Technical University, Ankara, Türkiye, E-mail: talyatumer@gmail.com

ORCID: 0000-0003-1813-5539

** BITES Defence & Aerospace, BITES-ASELSAN, Ankara, Türkiye, E-mail: nergis.pervan@bites.com.tr

ORCID: 0000-0003-3241-6812

*** Dr., BITES Defence & Aerospace, BITES-ASELSAN, Ankara, Türkiye, E-mail: ali.berkol@bites.com.tr

ORCID: 0000-0002-3056-1226

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Abstract- Deep learning has been applied in numerous areas, significantly impacting applications that address real-life challenges. Its success across a wide range of domains is partly attributed to activation functions, which introduce non-linearity into neural networks, enabling them to effectively model complex relationships in data. Activation functions remain a key area of focus for artificial intelligence researchers aiming to enhance neural network performance. This paper comprehensively explains and compares various activation functions, particularly emphasizing the arc tangent and its specific variations. The primary focus is on evaluating the impact of these activation functions in two different contexts: a multiclass classification problem applied to the Reuters Newswire dataset and a time-series prediction problem involving the energy trade value of Türkiye. Experimental results demonstrate that variations of the arc tangent function, leveraging irrational numbers such as π (pi), the golden ratio (ϕ), Euler number (e), and a self-arctan formulation, yield promising outcomes. The findings suggest that different variations perform optimally for specific tasks: arctan ϕ achieves superior results in multiclass classification problems, while arctan e is more effective in time-series prediction challenges.

Keywords: Deep neural networks, Activation functions, Multiclass classification, Time-Series prediction, Reuters data, Energy trade value data

Derin Öğrenme Modelleri için İrrasyonellerin Arctan Aktivasyon Fonksiyonunun Aralığı Üzerindeki Etkisi

Öz- Gerçek hayattaki çözümü zorlu uygulamalarda, derin öğrenme modelleri birçok alanda önemli başarı sergilemiştir. Bu başarının önemli bir kısmını, sinir ağlarındaki doğrusal olmayan yapılar aracılığı ile verideki karmaşık ilişkileri etkili bir şekilde modellemelerini sağlayan aktivasyon fonksiyonlarına dayanmaktadır. Aktivasyon fonksiyonları, sinir ağlarının performansını artırmayı hedefleyen yapay zeka araştırmacıları için hala önemli bir odak alanıdır. Bu makale, özellikle arktanjant ve onun belirli varyasyonlarına vurgu yaparak çeşitli aktivasyon fonksiyonlarını kapsamlı bir şekilde açıklamakta ve karşılaştırmaktadır. Ana odak noktası, bu aktivasyon fonksiyonlarının iki farklı bağlamdaki etkilerinin değerlendirilmesidir: Reuters Newswire veri kümesine uygulanan çok sınıflı sınıflandırma problemi ve Türkiye'nin enerji ticaret değerini içeren bir zaman serisi tahmini problemidir. Deneysel sonuçlar, π (pi), altın oran (ϕ), Euler sayısı (e) gibi irrasyonel sayıları ve yeni formüle edilmiş kendine ark tanjant formülasyonunu kullanan arktanjant fonksiyonu varyasyonlarının dikkate değer sonuçlar verdiğini göstermektedir.

Bulgular, farklı varyasyonların belirli görevler için en iyi performansı sergilediğini öne sürmektedir: arctan ϕ çok sınıflı sınıflandırma problemlerinde üstün sonuçlar elde ederken, arctan e zaman serisi tahmini problemlerinde daha etkili olmaktadır.

Anahtar Kelimeler: Derin sinir ağları, Aktivasyon fonksiyonları, Çok sınıflı sınıflandırma, Zaman serisi tahmini, Reuters verisi, Enerji ticaret değeri verisi

1. Introduction

Deep learning is a powerful and versatile methodology that has a wide range of applications in various fields, such as healthcare [8], natural language processing applications [7], drug discovery [5], autonomous vehicles [6], finance [9], cyber security [2], and many others. It belongs to a category of machine learning algorithms that go beyond traditional methods, such as multilayer neural networks with many hidden units, to learn complex predictive models [20]. When attempting to model complex problems, activation functions are pivotal as they introduce nonlinearity, which is essential for many tasks. Some examples of activation functions include sigmoid, ReLU, and tanh, which have been widely used in deep learning due to their ability to model complex and nonlinear relationships between input and output data [19]. Overall, deep learning has become a promising approach for solving many real-world problems thanks to activation functions.

By the adaptations made to the universal approximation theorem for neural networks, under certain conditions on the activation function, a single hidden layer neural network can approximate any continuous function arbitrarily well [12, 13, 14, 15, 16]. This means that, given enough data and suitable network architecture, a neural network can learn to approximate complex functions and make accurate predictions for a wide range of tasks. However, the effectiveness and performance of a neural network can vary depending on the specific problem and the characteristics of the data, as well as the choice of the activation function [18]. For example, some activation functions may be more effective for certain tasks or data types, while others may perform better for other tasks or data. Therefore, selecting the appropriate activation function is an important aspect of neural network design and can significantly impact the accuracy and efficiency of the model. In our work, we experimented with time series prediction and multiclass classification problems to find out how activation functions range affects the training time and success of models. Different ranges were obtained by dividing irrational numbers like the Euler number, the golden ratio, and pi, specifically applied to the arctan function. As a result of the experiments, we observed remarkable results.

2. Related Work

While developing more optimized algorithms, many researchers are focusing on activation functions. It is a common research problem that develops optimized models with the help of activation functions. There is a wide range of research that presents the efficiency of activation functions on different datasets and problems. Firstly, we proposed variations of the arctan function with irrational numbers such as the golden ratio and pi and the self-arctan function applied to the multiclass classification problem with the Reuters news wire classification dataset [1]. Skoundrianos and Tzafestas (2004) [24] developed a sigmoidal activation function for modeling dynamic, discrete-time systems. Efe (2008) [23] proposed activation functions which are sinc and cosc experimented on eight different datasets.

An activation function was developed by Liew et al. (2016) [22] which sets a boundary from the positive side of the ReLU applied on the MNIST handwritten digit dataset. Sharma (2019) [21] proposed an activation function that is a combination of the sigmoid and ReLU (Rectified Linear Unit) applied to the ionosphere dataset which is a radar system dataset with continuous values. Misra et al. (2020) [17] proposed a non-monotonic self-regularized activation function which is a composition of tanh and softplus functions and a multiplication of input values. It experimented on CIFAR-10, ImageNet-1k, and MS-COCO Object Detection. The recent research made by Jin et al. (2022) [28] focuses on solving the Time-varying Sylvester equation using Zeroing Neural Network based on the Versatile Activation Function (VAF) variations which include exponential convergence characteristics and adjustable parameters. Another recent work proposed a function called Smish by Wang et al. (2022) [29]. It was experimented on the CIFAR-10 dataset with the EfficientNetB3 network, the MNIST dataset with the EfficientNetB5 network, and the SVHN dataset with the EfficientNetB7 network. Furthermore, Shui-Long et al. (2022) [25] developed an activation function, named tanhLU which uses the symmetry feature of tanh and the unbounded feature of ReLU. It experimented on seven different benchmark datasets which are MNIST, CASIA-webface, Penn Treebank Dataset (PTB), LFW, CIFAR-10, CIFAR-100, datasets and neural network architectures like Fully Connected Neural Network (FCNN), Long Short-Term Memory (LSTM), and Convolutional Neural Network (CNN).

In this article, we present a novel approach that focuses on using variations of the arctan function, specifically those that are based on the combination of input and tanh function and the irrational numbers pi, the golden ratio, and the Euler number. Our experiments demonstrate that this approach can significantly improve training time compared to the topic classification problem. Furthermore, experiments show that promised activation functions produced better and closer results for both problems. Overall, our results indicate that this new approach has great potential for improving the performance of machine learning models.

3. Activation Functions

Activation functions are used in artificial neural networks to determine whether a neuron should be activated or not. These functions take the input from the previous layer of the neural network, sum the weighted input, and then transform it into an output that will be passed to the next layer of the network. Activation functions are often referred to as transfer functions in deep learning because they help to transfer the input to the next layer of the network [26]. Put differently, they serve as a mathematical barrier regulating the flow of information between the input and the neuron at hand, allowing the network to decide which information is relevant and should be passed on to the next layer. Overall, the activation function plays a crucial role in the process of deep learning, as it determines which information is important and should be used to make predictions or decisions.

The activation function is a key component of a neural network. Its primary role is to introduce non-linearity into the network [19], which is necessary for the network to be able to learn complex tasks. Without non-linearity, the network would only be able to perform linear transformations and would not be able to tackle more complicated problems. Non-linearity allows the network to make decisions based on conditional relationships, rather than just relying on a linear function to solve all problems. In addition to adding non-linearity, the activation function must also be differentiable [11]. This property is important because it allows the network to use gradient-based optimization algorithms, which are essential for training the network. Differentiability also enables the network to learn by making small adjustments to the weights and biases of the network, rather than having to start from scratch every time. Overall, the activation function plays a critical role in enabling neural networks to learn and make decisions in a way that is flexible and adaptable to different types of tasks. It allows the network to process and analyze complex data, and to find solutions that are numerically close to the original function, even if the exact function is unknown.

There are three types of activation functions used in Deep Neural Networks (DNN): binary step functions [4], linear activation functions, and nonlinear activation functions. First of all, binary step functions are not useful for solving deep learning problems because they only output a single value (either 0 or 1). They also have a zero gradient, which can cause problems when using backpropagation to update the weights in the network. The second is linear activation functions. They are not effective at approximating complex, nonlinear relationships. This is because their derivative is constant, meaning that they will not learn any new information during training. Lastly, nonlinear activation functions, on the other hand, are able to approximate a wide range of complex, nonlinear relationships and can be used for multiclass classification and regression tasks. Some examples of nonlinear activation functions include sigmoid, tanh, and ReLU. Each function has its pros and cons according to the problem it considers. The objective of this study is to compare the arctangent function and its variations with other functions, elucidating their efficacy while manipulating the range of the arctangent function. In the following sections, activation functions and experiments are explained in detail.

3.1. Rectified Linear Unit (ReLU)

Rectified Linear Unit (ReLU) [4] is a widely used activation function in deep learning models. It is defined in Table 1. In other words, the output of the ReLU function is the maximum of 0, and the input value is x. If x is greater than 0, the output is equal to x. If x is less than or equal to 0, the output is 0. The ReLU function has a simple, piecewise linear form and has several desirable properties for use in neural networks. It and its gradient, see Table 1, are computationally efficient because they do not require any expensive operations such as exponentiation or logarithms, and ReLU has a fast convergence rate during training. It also does not saturate for large input values, which can lead to vanishing gradients and slow training. ReLU is often used as an activation function in hidden layers of deep neural networks and has been found to work well in a wide range of applications. However, it can sometimes produce outputs that are "dead" (i.e., the output is always 0) if the network is not properly initialized or trained, or if the input data is not properly normalized. Variations like Leaky ReLU, Exponential Linear Unit (ELU), Scaled Exponential Linear Unit (SELU), parametric ReLU, etc. can be a solution to the vanishing gradient problem depending on the problem.

3.2. Leaky ReLu

Leaky ReLU [4] is a variant of the standard ReLU activation function that has a small, non-zero slope for negative input values. This helps address the issue of "dying ReLUs," which is a problem that can occur when using the standard ReLU function in neural networks. In other words, neurons that have negative weights will be updated unlike ReLU, and it allows a small, non-zero gradient for negative input values, see Table 1. For positive input values, leaky ReLU behaves like the standard ReLU function, mapping the input to itself. For negative input values, leaky ReLU maps the input to a small, non-zero value determined by the constant α, see Table 1. Leaky ReLU has been shown to improve the performance of neural networks in certain tasks and is often used as an alternative to the standard ReLU function. However, it is important to carefully tune the value of the constant a to ensure that the model is not overfitting the training data.

3.3. Sigmoid

The sigmoid function [4] is a mathematical function that maps values from an input space to a range between 0 and 1. It is often used as an activation function in neural networks, particularly in binary classification tasks, where the output of the network is interpreted as a probability. The sigmoid function is defined as in Table 1, where x is the input value and e is the base of the natural logarithm. It has an S-shaped curve, with an output of 0.5 when the input is 0. One of the main advantages of the sigmoid function is that its output is always bounded between 0 and 1, which makes it well-suited for modeling probabilities. However, the sigmoid function can also suffer from some limitations. For example, the output of the sigmoid function is not zero-centered, which can make it difficult to model certain types of relationships. In addition, the derivative of the sigmoid function (see Table 1) becomes very small for large positive or negative input values, which can make it difficult to train deep neural networks using the sigmoid function. Despite these limitations, the sigmoid function remains a popular choice for activation functions in neural networks and is often used in conjunction with other activation functions to achieve good performance on a wide range of tasks.

3.4. Hyperbolic Tangent (tanh)

The hyperbolic tangent (tanh) function [4], shown in Table 1, is a mathematical function that maps values from an input space to a range between -1 and 1. It is often used as an activation function in neural networks, particularly in tasks where the output of the network needs to be interpreted as a continuous value. One of the main advantages of the tanh function is that its output is zero-centered, which makes it well-suited for modeling certain types of relationships. In addition, the derivative of the tanh function, see Table 1, is relatively large for most input values, which can make it easier to train deep neural networks using the tanh function. However, the tanh function can also suffer from some limitations. For example, the output of the tanh function is not bounded, which can make it difficult to model probabilities. In addition, the tanh function can saturate for very large positive or negative input values, which can slow down the training process.

3.5. Swish

Swish [4] is a modified sigmoid function introduced by Google researchers, see Table 1. It has no upper limit but a lower limit. It is smooth and continuously differentiable, which can make it easier to optimize the model using gradient-based methods, see Table 1. Moreover, it captures negative values and prevents significant negative values from influencing the pattern, introducing a sense of sparsity. However, it can saturate and produce very small gradients when the input is very large or very small, which can slow down the training process. It provides sparsity.

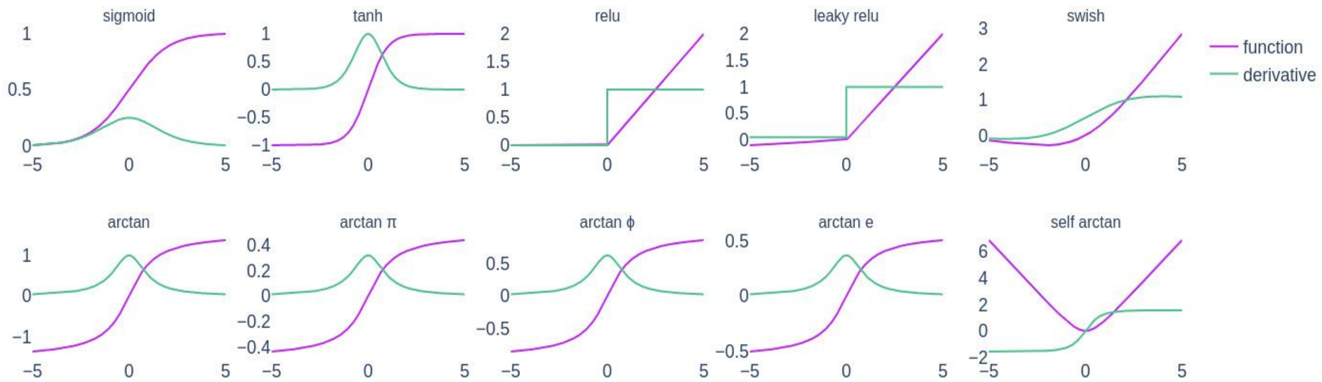


Fig. 1 Illustration of activation functions and derivatives are shown separately.

3.6. Arctanh

The arctan function [3], also known as the inverse tangent function, is a mathematical function that takes a value as input and returns the angle in radians that has a tangent equal to that value, see Table 1. It is also an S-shaped function like the sigmoid; however range of arctan is wider, i.e., $(-\frac{\pi}{2}, \frac{\pi}{2})$. Additionally, a convex error surface is provided by its monotonicity (faster backpropagation).

4. Promised Activation Functions

Activation functions are powerful gates for solving a problem with deep learning models. In this section, we provide the promised activation functions in detail. Specifically, the variations of the arctangent function are explained. These functions use irrational numbers like the golden ratio, the Euler number, and pi. Also, we defined a self-arctan function that uses the input directly in computations. Promised activation functions are designed to show the effect of range of functions manipulation with irrational numbers and the power of symmetry. Variations of arctan functions and their derivatives can be observed in Figure 2(a) and 2(b) respectively.

The variations of the arctan function leverage the unique properties of irrational numbers to adjust the range and behavior of the base arctan function. For example, the division of arctan by π, the golden ratio (ϕ), or Euler number (e) is designed to compress or shift the output range in ways that exploit the symmetry and distribution properties of these constants. This manipulation ensures that the resulting functions maintain smoothness while introducing subtle changes to the gradient flow, which can positively impact training dynamics. Similarly, the self-arctan function adds an innovative approach by directly multiplying the input with the arctan function, leveraging its symmetry around the y-axis to prevent the loss of negative weights—an issue seen in functions like ReLU—and to provide a differentiable, smooth alternative with polynomial-like behavior near the origin. These mathematical properties are not arbitrary but are grounded in the intention to address specific challenges in deep learning, such as vanishing gradients, non-linearity, and weight symmetry. Exploring these derivations and their implications in greater depth helps to clarify the design rationale and solidify the theoretical foundation of the proposed activation functions.

4.1. Arctanπ

Arctan π is a variation of arctan where arctan is divided with π, see Table 1. With purpose is to give a narrower range to arctan using the irrationality of π. So, the range becomes $(-\frac{1}{2}, \frac{1}{2})$. Other properties are the same as the arctan function.

4.2. Arctan Golden Ratio (ϕ)

Arctan with golden ratio is a variation of arctan where arctan is divided with $\frac{1+\sqrt{5}}{2}$, see Table 1. In this activation function, a narrower range is the purpose according to arctan using the irrationality of the golden ratio. Thus, the range becomes $(-\frac{\pi}{1+\sqrt{5}}, \frac{\pi}{1+\sqrt{5}})$. Other properties are the same as the arctan function.

4.3. Arctan Euler

Arctan with Euler number is another variation that we used to experiment with how the Euler number affects the range of arctan to train a neural network architecture, see Table 1 for details of it. Dividing the arctan function with Euler number stacks the range between $(-\frac{\pi}{2e}, \frac{\pi}{2e})$. Other properties are the same as the arctan function.

4.4. Self Arctan

The input itself with arctan is used to obtain symmetry according to the y-axis, see Table 1. Thus, negative and positive outputs will be treated similarly. Also, negative weights will not be lost like ReLU. Furthermore, it is smooth, i.e., differentiable at every point. It acts like a second-degree polynomial around zero.

5. Experiment

As we mentioned in the previous sections, deep learning can be used for solving different problems. While training the models, the effectiveness of activation functions can be different according to the problem and the data. To see the impacts of promised activation functions, we experimented with two different problems which are topic classification and time series prediction. While solving the problem we implemented two different models for each problem. The details are explained in the following sections. For both models, the hyperparameters are chosen using the Keras Tuner library. Specifically, this includes optimizing parameters such as the number of hidden layers, the number of neurons in each hidden layer, dropout probability, and the learning rate.

5.1. Topic Classification

Topic classification is a widely used problem in machine learning. Reuters news wire classification dataset was used in the experiments. It is a multiclass dataset with 46 different topics. It contains 11.228 news-wires from Reuters. The dataset was generated by preprocessing and parsing the classic Reuters-21578 dataset. Furthermore, it is an unbalanced dataset, i.e., the class example numbers are not close. For example, there are approximately 4000 samples for one label and approximately 20 samples for more than one label.

Data Preprocessing: Data preprocessing is an essential step in the data analysis and modeling processes as it ensures that the data is in the computable format for the model to analyze. This is particularly important for text data, which can be highly unstructured and contain noise such as emotions, punctuation, and misspellings. To address this, various natural language processing techniques can be applied, such as stemming, tokenization, lemmatization, removal of stop words, punctuation, extra spaces, and letter lowering. The specific techniques used will depend on the nature of the data and the problem being addressed. The Reuters Newswire Classification dataset [10] was used to perform a solution to the topic classification problem. Since the dataset was generated from the Reuters-21578 dataset, tokenization was applied only as a preprocessing step. After that list of sequences was converted to the array.

Models: There are two main components for training high-performance models which are data and hyperparameters. Preparing data for the model is explained in section 5.2. Regarding the performance of the model, fine-tuning hyperparameters is a critical stage for achieving an optimal fit. The selection of hyperparameters to be tuned should be done judiciously, taking into account the specific characteristics of the problem and the data at hand.

In this experiment, two deep learning models were trained for the classification problem for observing the effects of activation functions. The first model (Model 1) is a deep neural network that has two hidden layers with 64 neurons. The second model (Model 2) is also a deep neural network that has one hidden layer with 512 neurons. As the experiments detailed in the paper focus on the efficacy of activation functions, the remaining hyperparameters were kept constant.

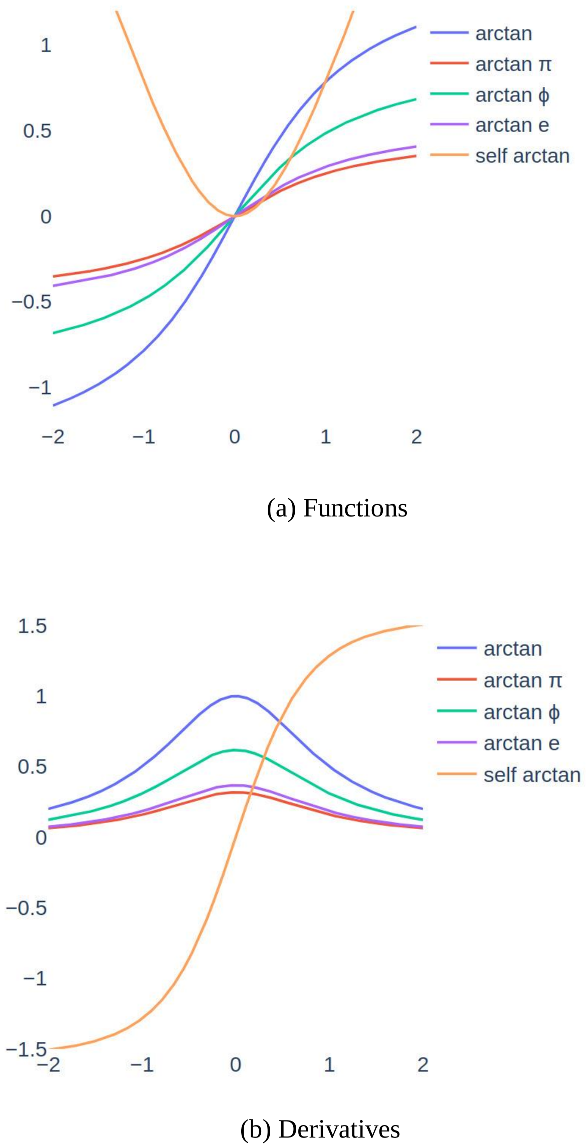


Fig. 2 Graphs of functions and derivatives of arctan and its variations. Figure 2(a) shows the function graphs, and Figure 2(b) shows the function derivatives. These graphs enable us to compare the ranges of variation

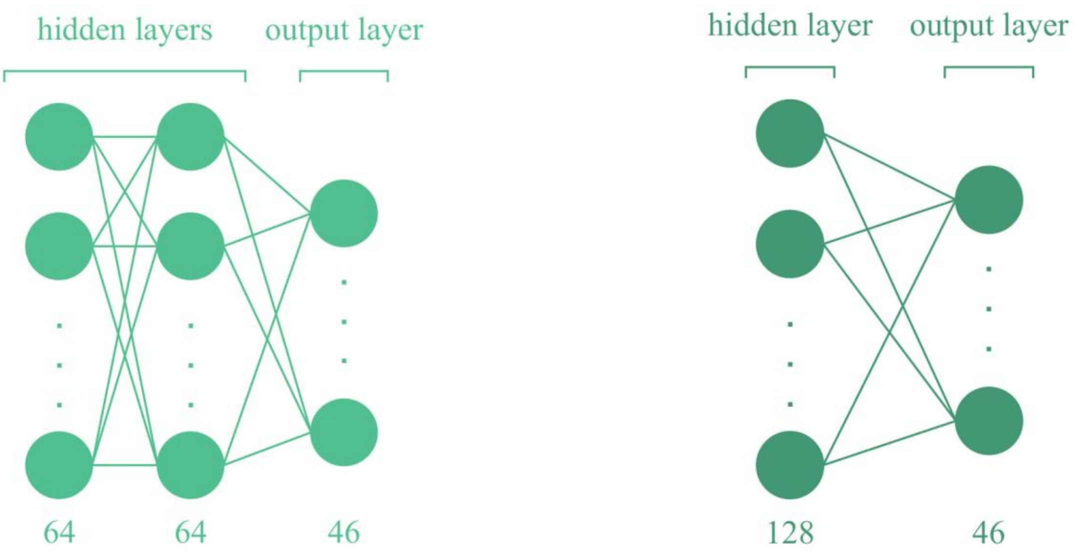
Moreover, since the problem itself is a multiclass classification, the activation function of the output layer was set to softmax. Some important hyperparameters used in the Model 1 are batch size is 512, and dropout probability is 0.4. In Model 2, the batch size is 32, and the dropout probability is 0.5. Both models have early stopping and also learning rates. The primary distinction between the models lies in the size of the layers and neurons. In Model 1, the neural network is narrower compared to Model 2. Employing early stopping is crucial as it serves to prevent the model from over-fitting.

Table 1 This table summarizes activation functions with their mathematical definitions, derivatives, and ranges.

Function Name	Function	Derivative	Range
ReLU	$max(0, x)$	$1\ if\ x \geq 0$ $0\ if\ x < 0$	$[0, \infty)$
leaky ReLU	$max(\alpha x, x), \alpha \in (0, 1)$	$1\ if\ x \geq 0$ $\alpha\ if\ x < 0, \alpha \in (0,1)$	$(-\infty, \infty)$
sigmoid	$\frac{1}{1+e^{-x}}$	$\frac{e^{-x}}{(1+e^{-x})^2}$	$(0,1)$
tanh	$\frac{(e^x - e^{-x})}{(e^x + e^{-x})}$	$\frac{4e^{2x}}{(e^{2x}+1)^2}$	$(-1,1)$
swish	$x \cdot sigmoid(x)$	$tanh(x) + x \cdot sech^2(x)$	$(-0.2, \infty)$
arctan	$tan^{-1}(x)$	$\frac{1}{x^2+1}$	$(-\frac{\pi}{2}, \frac{\pi}{2})$
arctan π	$\frac{tan^{-1}(x)}{\pi}$	$\frac{1}{\pi(x^2+1)}$	$(-\frac{1}{2}, \frac{1}{2})$
arctan ϕ	$\frac{tan^{-1}(x)}{\frac{1+\sqrt{5}}{2}}$	$\frac{1}{\frac{1+\sqrt{5}}{2} x(x^2+1)}$	$(-\frac{\pi}{1+\sqrt{5}}, \frac{\pi}{1+\sqrt{5}})$
arctan e	$\frac{tan^{-1}(x)}{e}$	$\frac{1}{e \cdot (x^2+1)}$	$(-\frac{\pi}{2e}, \frac{\pi}{2e})$
self arctan	$x \cdot tan^{-1}(x)$	$\frac{x}{x^2+1} + tan^{-1}(x)$	$[0, \infty)$

5.2. Time Series Prediction

Time series prediction is an important problem for researchers and sector employees. Since modeling the time series is useful for future planning, budget planning, etc. In this work, we used day ahead market/trade value [30] in Türkiye, where the data is available at the EXIST Transparency Platform. The dataset has an hourly frequency and its range is starting on October 1st, 2022 00:00, and ending on 12th December 2022 23:00. To sum up, the problem we consider here is the time-dependent univariate series. Before moving on to the model, the dataset needs to be preprocessed for the prediction problem since the features depend on the time and seasonality.



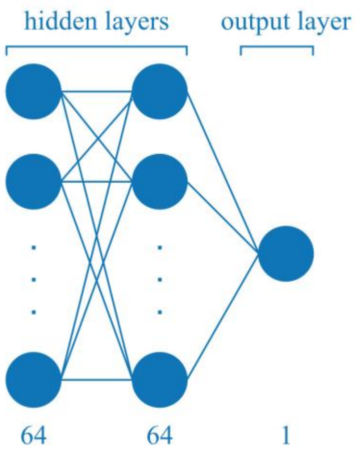
(a) Model 1 (b) Model 2

Fig. 3 Two different models for topic classification are presented. 3(a) shows the architecture of Model 1 and 3(b) shows the architecture of Model 2.

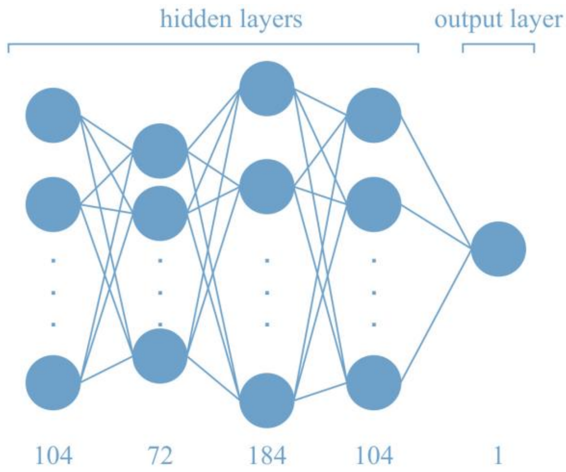
Data Preprocessing: Univariate time series problems generally need to extract features such as date-time, lags, etc. In our problem, we need to extract serial dependence and time-dependent properties. Serial dependence properties are obtained using the past values of the target variable. PACF and ACF plots are useful for understanding consecutive relationships between variables. It is observable that the data have a 24-hour cyclic pattern at the ACF plot. Also, we observe that the variable of time t+1 is highly correlated with the variable of time t. Moreover, one of the main feature extraction is lagging which is shifting values forward one or more time steps. Lagging is applied 36 times to the trade value to capture and learn hidden patterns. Another main feature extraction is time-dependent variables. Hour, month, year, day, week, and dayofweek independent variables are extracted from corresponding datetime information. Thus, 42 features were obtained. Since all features cannot be a helper for predictive models, feature selection is needed. Boruta, a feature selection library, was used for dimensionality reduction and feature selection. A Random Forest regression model was built with 100 estimators, and depth is 5 for the selection of features. As a result of 100 iterations, 19 features were confirmed, 3 were tentative and 20 were rejected. Features found important by Boruta are as follows: lags are 1, 2, 3, 4, 5, 7, 8, 9, 18, 21, 22, 23, 24, 26, 27, 28, 30, and time-dependent features are hour and day of the week. Finally, the MinMax scaling is applied to the dataset which is the version of the selected features since the problem we consider is a regression problem, i.e., scaling is vital. To sum up, time and serial-dependent features are extracted and selected for a univariate time series prediction.

Models: Time series prediction problems are based on AutoRegressive (AR) models. AR, ARMA (Auto Regressive Moving Average), ARIMA (Auto Regressive Integrated Moving Average), and MA (Moving Average) are some examples. In our case, we modeled the problem using DNN architecture to show that our promising activation functions are applicable to time series prediction problems.

In the previous section, data preprocessing steps were explained in detail. In this section, we will give details of prediction models. We applied two different models. Firstly, the dataset was divided into the train, validation, and test sets. The train set has approximately 55% set of attributes, and validation and test sets have approximately 22% of a set of attributes. The first model is designed as two hidden layers with 0.2 dropout probability and 64 neurons in each and an output layer with one neuron DNN model, see Fig. 4(a). It trained with a 0.01 learning rate. The second model has 4 hidden layers with 104, 72, 184, and 104 neurons and 0.1, 0.2, 0.5, and 0.3 dropout probabilities respectively and one output layer with 1 neuron, see Fig. 4(b). It trained with a 0.005 learning rate. Adam as an optimizer and mean squared error as a loss function were used for both models. Also, early stopping with 5 patience was used in both models.



(a) Model 1



(b) Model 2

Fig. 4 Two different models for trade value prediction are presented. 4(a) shows the architecture of Model 1 and 4(b) shows the architecture of Model 2

6. Results

In this section, we will discuss the results of our experimentation with various activation functions applied to two different problems, including their impact on model training time, model performance, and the trade-offs between them.

First of all, evaluating training time is important for deep learning problems since less training time is preferable in terms of optimized solutions and energy requirements. In the topic classification problem, all promised variations of arctan are faster than sigmoid for both models, see Fig. 5. For Model 1, the best epoch size occurs for self-arctan which is faster than sigmoid, the same with tanh, and slower than the other existing activation functions. On the other hand, promised activation functions, other than self-arctan, are slower than the existing ones. For Model 2, arctan π and arctan e are the slowest after sigmoid. However, arctan ϕ and self-arctan have the same epoch size as ReLU, swish, and arctan. Next, in the time series prediction problem, the slowest one is arctan π for both models. For Model 1, self-arctan is the fastest between promised activation functions and it is faster than leaky ReLU and sigmoid. For Model 2, arctan ϕ is the fastest between promised ones and it is faster than only sigmoid.

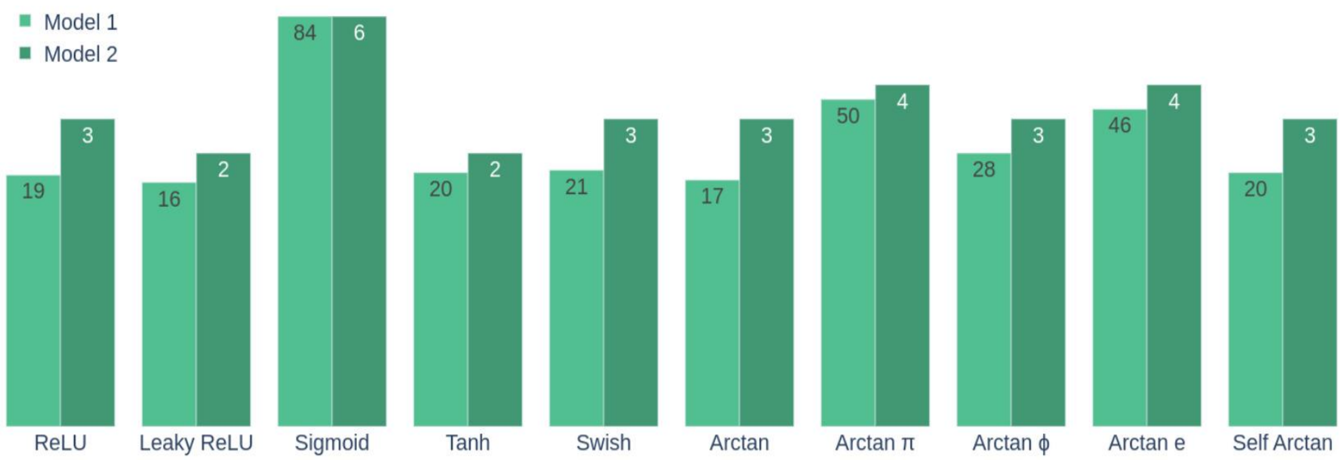


Fig. 5 Epoch sizes of topic classification models are summarized.

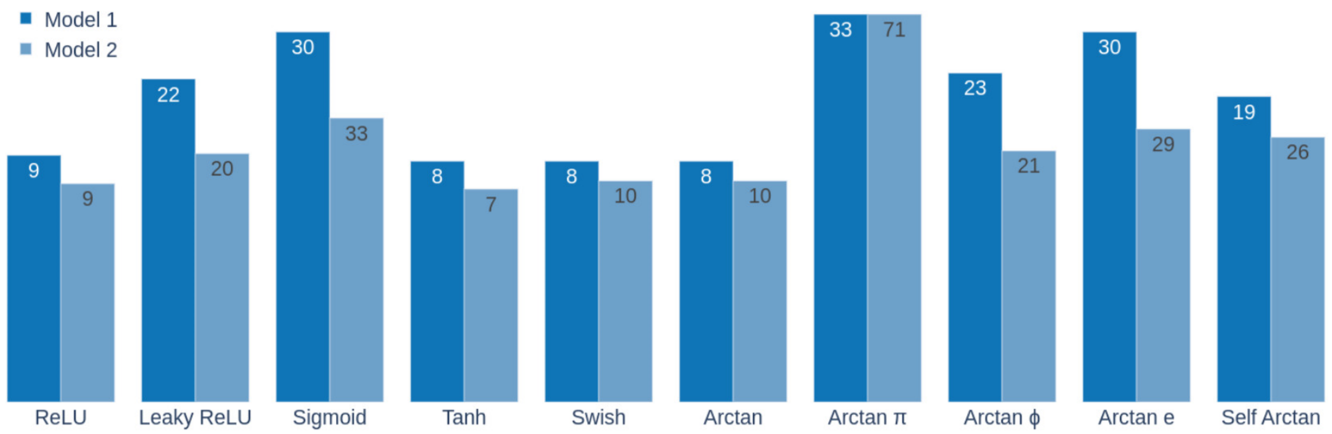


Fig. 6 Epoch sizes of energy trade value models are summarized.

Secondly, model performances are evaluated. For the first problem, topic classification, macro, and weighted average scoring methods were considered. Weighted and macro averages are considered separately since the dataset used in the problem has an unbalanced structure. For both models, promised activation functions to perform that they can compete with widely used activation functions. More specifically, in Table 2 and Table 3 precision, recall, and F1 scores are shown. For Model 1, it can be observed that arctan ϕ is the most competitive among the promised functions. It shares the best score in weighted recall with the evaluation according to two decimal truncation. However, arctan π is the worst among them and it is better than only sigmoid. For Model 2, arctan e has the best precision according to the macro average, arctan ϕ has the best recall, and F1 score according to the macro average, and precision and recall according to the weighted average. Furthermore, promised activation functions are mostly better than sigmoid. As a second problem, we trained the energy trade value and evaluated them according to RMSE, MSE, and R2 score; Table 4 and Table 5. Similarly, with the first problem, we obtained competitive results. For Model 1, arctan e is the most successful among the promising activation functions. Also, it performed better than sigmoid, tanh, ReLU, and arctan for all evaluation metrics except for arctan in MSE, where they are equal at the second decimal. For Model 2, similar results were obtained, which is arctan e is the best between arctan variations.

Table 2 Topic classification Model 1 results are summarized. *: Macro average. ': Micro average.

Evaluation Metrics	sigmoid	tanh	relu	leaky relu	swish	arctan	arctan π	arctan ϕ	arctan e	self arctan
Precision*	0.29	0.65	0.41	0.61	0.62	0.67	0.36	0.61	0.48	0.40
Recall*	0.25	0.45	0.32	0.42	0.43	0.45	0.31	0.44	0.38	0.29
F1Score*	0.25	0.50	0.35	0.46	0.47	0.50	0.31	0.48	0.40	0.31
Precision'	0.71	0.78	0.74	0.77	0.78	0.78	0.73	0.77	0.75	0.74
Recall'	0.76	0.79	0.77	0.78	0.79	0.79	0.76	0.79	0.78	0.77
F1Score'	0.72	0.77	0.75	0.77	0.77	0.78	0.74	0.77	0.76	0.77

Table 3 Topic classification Model 2 results are summarized. *: Macro average. ‘: Micro average.

Evaluation Metrics	sigmoid	tanh	relu	leaky relu	swish	arctan	arctan π	arctan ϕ	arctan e	self arctan
Precision*	0.72	0.71	0.71	0.72	0.71	0.69	0.74	0.72	0.75	0.71
Recall*	0.49	0.54	0.54	0.52	0.55	0.55	0.53	0.56	0.53	0.53
F1Score*	0.55	0.58	0.57	0.58	0.59	0.59	0.59	0.60	0.58	0.57
Precision’	0.79	0.80	0.80	0.79	0.80	0.80	0.80	0.81	0.80	0.80
Recall’	0.79	0.80	0.80	0.80	0.81	0.80	0.80	0.81	0.80	0.80
F1Score’	0.78	0.79	0.78	0.79	0.80	0.79	0.79	0.80	0.79	0.79

Table 4 Time series prediction Model 1 results are summarized.

Evaluation Metrics	sigmoid	tanh	relu	leaky relu	swish	arctan	arctan π	arctan ϕ	arctan e	self arctan
RMSE	0.17	0.19	0.18	0.12	0.12	0.17	0.43	0.25	0.14	0.39
MSE	0.03	0.03	0.03	0.01	0.01	0.02	0.19	0.06	0.02	0.15
R2 Score	0.63	0.54	0.61	0.82	0.82	0.66	-1.20	0.22	0.74	-0.76

Table 5 Time series prediction Model 2 results are summarized.

Evaluation Metrics	sigmoid	tanh	relu	leaky relu	swish	arctan	arctan π	arctan ϕ	arctan e	self arctan
RMSE	0.18	0.20	0.23	0.13	0.12	0.17	0.42	0.27	0.14	0.38
MSE	0.03	0.04	0.05	0.01	0.01	0.02	0.18	0.07	0.02	0.15
R2 Score	0.61	0.50	0.34	0.79	0.80	0.65	-1.12	0.14	0.76	-0.74

Overall, we can conclude that:

- At least one of the promised activation functions beat the sigmoid in every case;
- It is significant to gain attention to the range of functions for solving problems with deep learning;
- Arctan ϕ is the best for the multiclass classification problem;
- Arctan e is the best for the time series prediction problem;
- Promising activation functions are shown that they can learn stably with different neuron numbers and model depths.

7. Discussion and Limitations

The field of neural networks has seen many advancements in the last decade, one of which is the introduction of new activation functions. These functions play a crucial role in determining the output of a neuron, and as such, have a significant impact on the performance of a neural network. Many studies have focused on developing activation functions by applying different strategies like a combination of multiple functions. In this work, we mainly focused on a unique strategy which is changing the range of arctan functions with irrationals, pi, the golden ratio, the Euler number, and multiplying input with the arctan function. Furthermore, two different datasets and two different models in each are taken into consideration. One of them is the REUTERS Newswire classification dataset and the other is the Türkiye energy trade market value. Each problem has its challenges in terms of training and data preprocessing steps. Promised activation functions are experimented on wider and narrower DNNs to see how the results are affected by the range of functions. As a result, it is observed that promised activation functions showed stable results. Arctan ϕ shows the most promising results on the topic classification problem and arctan e shows on the time series prediction problem. Additionally, we can mention that although there is a small difference between the ranges of arctan π and e, arctan e is preferable for time series prediction. Also, arctan π which has a wider range according to variations and a narrower range according to arctan itself is more successful for topic classification.

However, this study has several limitations. The first limitation is that the experiments were restricted to only two datasets, limiting the generalizability of the results. The effectiveness of these activation functions in deeper networks or large-scale applications was not explored. Additionally, the underlying mathematical reasons for their success in specific tasks still need to be clarified and require further theoretical analysis. Finally, computational efficiency and convergence rates were not systematically studied, which is important for real-world scalability.

To sum up, these new activation functions have shown promising results and have the potential to improve the performance of neural networks. Further research and experimentation are needed to fully understand their advantages and limitations, as well as to determine their suitability for various tasks.

8. Conclusion and Future Work

In this study, we explored the impact of various activation functions, with a particular emphasis on arctangent variations, in addressing multiclass classification and time-series prediction problems. By adapting irrationals such as pi, the golden ratio, the Euler number, and a self-arctan formulation, we demonstrated the potential of these variations to enhance neural network performance in different contexts. Our experimental results indicate that arctan ϕ is particularly effective for multiclass classification tasks, while arctan e is successful in prediction problem. These findings emphasize the importance of modification of activation functions to the specific requirements of the problem, offering new insights into activation function design and optimization.

For future work, several paths can be taken in advance of this research. Firstly, additional experiments could be conducted across a wide range of datasets and different domains to validate the generalizability of the proposed arctangent variations. Secondly, combining these activation functions with advanced neural network architectures, such as transformers or graph neural networks, could provide deeper insides. Furthermore, the mathematical properties and optimization behaviors of these activation functions can be analyzed to better understand their underlying mechanisms. Finally, exploring new activation functions derived from other irrational numbers or mathematical constants could reveal further promising candidates for improving neural network performance across diverse applications.

Acknowledgements

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References

[1] T.T. Sivri, N.P. Akman, A. Berkol, "A.: Multiclass Classification Using Arctangent Activation Function and Its Variations.", 2022 14th International Conference on Electronics, Computers and Artificial Intelligence (ECAI), Ploiesti, pp. 1-6, 30 June 2022 - 01 July 2022.

[2] T.T. Sivri, N.P. Akman, A. Berkol, C. Peker, "Web Intrusion Detection Using Character Level Machine Learning Approaches with Upsampled Data", Annals of Computer Science and Information Systems, DOI: http://dx.doi.org/10.15439/2022F147, Vol. 32, pp. 269–274.

[3] J. Kamruzzaman, "Arctangent Activation Function to Accelerate Backpropagation Learning", IEICE TRANSACTIONS on Fundamentals of Electronics, Communications and Computer Sciences, Vol. E85-A, pp. 2373–2376, October 2002.

[4] S. Sharma, S. Sharma, A. Athaiya, "Activation Functions In Neural Networks", International Journal of Engineering Applied Sciences and Technology, Vol. 4, pp. 310–316, April 2020.

[5] D. Paul, G. Sanap, S. Shenoy, D. Kalyane, K. Kalia, R.K. Tekade, "Artificial intelligence in drug discovery and development", Drug Discovery Today, DOI: 10.1016/j.drudis.2020.10.010, Vol. 26, No. 1, pp. 80–93.

[6] B. Kisačanin, "Deep Learning for Autonomous Vehicles", 2017 IEEE 47th International Symposium on Multiple-Valued Logic (ISMVL), Novi Sad, pp. 142, 22-24 May 2017.

[7] D.W. Otter; J.R. Medina; J.K. Kalita, "A Survey of the Usages of Deep Learning for Natural Language Processing", IEEE Transactions on Neural Networks and

Learning Systems, DOI: 10.1109/TNNLS.2020.2979670, Vol. 32, No. 2, pp. 604–624.

[8] R. Miotto, F. Wang, S. Wang, X. Jiang, J.T. Dudley, “Deep learning for healthcare: review, opportunities and challenges”, Briefings in Bioinformatics, Vol. 19, pp. 1236–1246, November 2018.

[9] S. I. Lee, S. J. Yoo, “Multimodal deep learning for finance: integrating and forecasting international stock markets”, The Journal of Supercomputing, DOI: https://doi.org/10.1007/s11227-019-03101-3, Vol. 76, pp. 8294–8312.

[10] Team, K.: Keras Documentation: Reuters Newswire Classification Dataset. Keras. Retrieved December 2022, from https://keras.io/api/datasets/reuters/

[11] T. Kim, T. Adali, “Complex backpropagation neural network using elementary transcendental activation functions”, 2001 IEEE International Conference on Acoustics, Speech, and Signal Processing Proceedings, Utah, pp. 1281–1284, 07-11 May 2001.

[12] G. Cybenko, “Approximation by superpositions of a sigmoidal function.”, Mathematics of Control, Signals and Systems, DOI: https://doi.org/10.1007/BF02551274, Vol. 2, No. 4, pp. 303–314.

[13] K. Hornik, M. Stinchcombe, H. White, “Multilayer feedforward networks are universal approximators”, Neural Networks, Vol. 2, pp. 359–366, 1989.

[14] K.-I. Funahashi, “On the approximate realization of continuous mappings by neural networks”, Neural Networks, Vol. 2, pp. 183–192, 1989.

[15] A.R. Barron, “Universal approximation bounds for superpositions of a sigmoidal function”, IEEE Transactions on Information Theory, DOI: 10.1109/18.256500, Vol. 39, No. 3, pp. 930–945.

[16] M. Leshno, V.Y. Lin, A. Pinkus, S. Schocken, “Multilayer feedforward networks with a nonpolynomial activation function can approximate any function”, Neural Networks, Vol. 6, pp. 861–867, 1993.

[17] D. Misra, “Mish: A Self Regularized Non-Monotonic Activation Function”, British Machine Vision Conference, 7–10 September 2020.

[18] R. Parhi, R.D. Nowak, “The Role of Neural Network Activation Functions”, IEEE Signal Processing Letters, DOI: 10.1109/LSP.2020.3027517, Vol. 27, pp. 1779–1783.

[19] N. Kulathunga, N. R. Ranasinghe, D. Vrinceanu, Z. Kinsman, L. Huang, Y. Wang, “Effects of the Nonlinearity in Activation Functions on the Performance of Deep Learning Models”, CoRR, 2020.

[20] Y. LeCun; B. Boser, J.S. Denker, D. Henderson, R.E. Howard, W. Hubbard, L.D. Jackel, “Backpropagation applied to handwritten zip code recognition”, Neural Computation, DOI: 10.1162/neco.1989.1.4.541, Vol. 1, No. 4, pp. 541–551.

[21] O. Sharma, “A new activation function for deep neural network”, 2019 International Conference on Machine Learning, Big Data, Cloud and Parallel Computing (COMITCon), Faridabad, pp. 84 – 86, 14 – 16 February 2019.

[22] S.S. Liew, M. Khalil-Hani, R. Bakhteri, “Bounded activation functions for enhanced training stability of deep neural networks on visual pattern recognition problems”, Neurocomputing, Vol. 216, pp. 718–734, December 2016.

[23] M.Ö. Efe, “Novel neuronal activation functions for Feedforward Neural Networks”, Neural Processing Letters, DOI: https://doi.org/10.1007/s11063-008-9082-0, Vol. 28, No. 2, pp. 63–79.

[24] E.N. Skoundrianos, S.G. Tzafestas, “Modelling and FDI of Dynamic Discrete Time Systems Using a MLP with a New Sigmoidal Activation Function”, Journal of Intelligent and Robotic Systems, DOI: https://doi.org/10.1023/B:JINT.0000049175.78893.2f, Vol. 41, No. 1, pp. 19–36.

[25] S.-L. Shen, N. Zhang, A. Zhou, Z.-Y. Yin “Enhancement of neural networks with an alternative activation function tanhLU”, Expert Systems with Applications, Vol. 199, pp. 117181, August 2022.

[26] M.F. Augusteijn, T.P. Harrington, “Evolving transfer functions for artificial neural networks”, Neural Computing & Applications, DOI: https://doi.org/10.1007/s00521-003-0393-9, Vol. 13, No. 1, pp. 38–46.

[27] J.M. Benitez, J.L. Castro, I. Requena, “Are artificial neural networks black boxes?”, IEEE Transactions on Neural Networks, DOI: 10.1109/72.623216, Vol. 8, No. 5, pp. 1156–1164.

[28] J. Jin, J. Zhu, J. Gong, W. Chen, “Novel activation functions-based ZNN models for fixed-time solving dynamic Sylvester equation”, Neural Computing and Applications, DOI: https://doi.org/10.1007/s00521-022-06905-2, Vol. 34, No. 17, pp. 14297–14315.

[29] X. Wang, H. Ren, A. Wang, “Smish: A Novel Activation Function for Deep Learning Methods”, Electronics, Vol. 11, pp. 540, February 2022.

[30] Trade Value - Day Ahead Market - Electricity Markets| EPIAS Transparency Platform. (n.d.). Retrieved December 20, 2022, from https://seffaflik.epias.com.tr/transparency/piyasalar/gop/islem-hacmi.xhtml

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[2] Y. Yorozu, M. Hirano, K. Oka, and Y. Tagawa, “Electron spectroscopy studies on magneto-optical media and plastic substrate interface”, *IEEE Transl. J. Magn. Japan*, vol. 2, pp. 740-741, August 1987.

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$$C = a + b \tag{1}$$

Section titles should be written in bold style while sub section titles are italic.

3. Figures and Tables

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Figure 1. Engineering technologies.

Table captions should be written in the same format as figure captions; for example, “Table 1. Appearance styles.”. Tables should be referenced in the text unabbreviated as “Table 1.”

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Acknowledgements

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