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ESTIMATION OF OCCUPATIONAL ACCIDENTS IN TURKEY UNTIL 2030

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Abstract

Today, as a result of the development of technology, the production power of companies and the increase in the competition between themselves have led to the emergence of dangers especially for occupational safety. The 21st century, in which industrialization and production techniques have come to the fore, has been a period in which deaths and disabilities have increased because of work accidents caused by machines. In this paper, the number of occupational accidents in Turkey until 2030 was estimated by using an artificial neural network on the Weka package program. While creating the model, the numbers of compulsory insured workers, workplace, work accident, death as a result of a work accident and permanent incapacity for work were used between 1970 and 2021. 30% of the data was used as test data and 70% as training data in the neural network. In the light of the result, the expected number of occupational accidents in 2030 is estimated as 642210.

Key words: *Artificial Neural Networks, Occupational Accident, Time Series, Turkey*

INTRODUCTION

With the development of technology in recent years, the production power of companies and the increase in competition between themselves have led to the emergence of hazards, especially for occupational safety. As a result of this, the concept of occupational health and safety has gained importance, which indicates the work done to protect the employees from negative factors that occur during work, to continue the production without any problems and to increase the efficiency. As a result of work accidents, deaths or injuries can occur [1]. Occupational accidents, which bring material and moral losses for the people of the country, require an important job security for the people who do the work. As the country's economy grows, the number of workplace and, accordingly, the number of employees increase [2]. These increases make today's occupational safety more important [3]. According to the Official Social Security Institution records in Turkey, 511084 work accidents occurred in 2021 and 1382 people died. Approximately 1703 occupational accidents occur in one day and 5 persons die. Considering that the values are obtained through the Social Security Institution but those who are employed without official registration or without insurance are not taken into account, it is inevitable that the resulting numbers may be much higher.

Developments in production systems make the measures that can be taken in occupational and workers' health more complex. New regulations need to be developed in order to prevent occupational accidents and protect workers' health. The International Labor Organization (ILO) and World Health Organization (WHO) define occupational health as keeping, maintaining, and improving the physical, mental, and social well-being of people working in different occupational groups at the highest level [4]. Occupational health and work safety have been revealed as a discipline with the combination of a workplace physician, lawyer, social scientist, technical staff and scientists from many different fields in the process that is included in the applications developed on occupational health [5].

In our country, the National Occupational Health and Safety Council have an important role in planning and determining policies in order to prevent work accidents and create a more productive and more reliable working environment [3]. Estimations of occupational health and possible accidents have also become a very important issue in terms of plans and policies. In particular, the method used and

statistical analysis emerge as a factor that directly affects the success level of the resulting estimation. There are studies in the literature about occupational accidents and workers' health, in which future predictions are made.

Yağımlı and Ergin [6], estimated the occupational accidents in Turkey with the exponential correction model. Using a fuzzy logic series, the number of work accidents that will occur in 2017 and the number of workers that will lose their lives as a result of work accidents are estimated with the data between 2005 and 2016. Ceylan and Avan [3], estimated the occupational accidents in Turkey until 2025 with using the artificial neural network method. Work accidents, the number of people who lost their lives as a result of work accidents and the number of permanent incapacity for work were estimated with three different scenarios. Among the used artificial neural network architectures, the 2-5-1 architecture has emerged as the most suitable neural network architecture. Yağımlı and İzci [7] estimated fatal work accidents in the fabricated metal products manufacturing sector excluding machinery and equipment in Turkey. In the study, which was carried out using the adaptive fuzzy time series and the least squares method, it was estimated that there would be 770 different occupational accidents in 2016 and 39 fatal occupational accidents would occur as a result of the estimation. Yağımlı and Hacıbektaşoğlu [8] in this study aimed to estimate the number of work accidents and fatal work accidents in the construction sector in Turkey. In the study, which used the exponential plane as the estimation method, the number of occupational accidents and fatal occupational accidents in 2016 was estimated. Shah et al., performed the analysis and forecasting of mining accidents in Pakistan [9]. The ARIMA model was used in the study to analyze the main factors affecting the safety management system, which indicates the number of accidents and fatalities in underground and surface mining. The results show that the ARIMA (2, 1, 0) model is a suitable model to predict accidents and worker deaths in mines. Efe et al. [10] using the Fuzzy Promethee Method analyzed the Error Types and Effects in Occupational Safety on the construction sector.

In this study, a prediction model has been created for work accidents in Turkey by using the artificial neural network method on the Weka package program. While creating the model, the number of workers with compulsory insurance, the number of workplaces, the number of work accidents, the number of people who died as a result of work accidents and the number of permanent incapacity for work were used as parameters and the data between 1970 and 2021 were used.

MATERIAL AND METHODS

Time Series Analysis

Time series analysis is the process of obtaining a significant result for the future time zone by analyzing and processing the existing data source found at a certain time. In order to establish a good time series model, the level of competence of the data, the level of significance of the data, and the degree of compliance of the model are important criteria. In time series works, parameters must be meaningful with each other. When the data that is meaningful with each other is used, the success rate of the model may also vary.

Artificial Neural Networks

The structure of the human brain convinced scientists to work on the human brain. Scientists inspired the neuro-physical structure of the brain and tried to create a mathematical model. Various artificial cell and network models have been developed in order to completely examine the movements of the brain [11]. Neurons are based on an artificial neural network architecture. In general, neurons are included in the logical groups called layers [12]. Some basic functions of artificial neural networks are shown below.

- Prediction and estimation
- Classification
- Control

In addition, it can also be used for data merging, conceptualization, and filtering. An artificial neural network architecture mainly consists of three main layers: input layer, hidden layer, and output layer. The sample structure of an artificial neural network is shown in Figure 1.

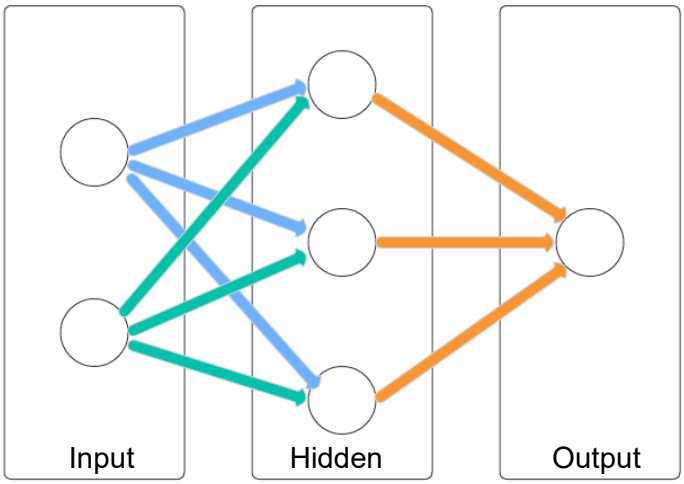

Figure 1. Structure of an artificial neural network

The input values of the neuron in the artificial neural network are xi, weight values wi, collection function (Σ), activation function (f) and output (y). x1, x2,... x3 values are the input values of the cell in Figure 2. Input values are multiplied by weight values and net inputs occur. Activation functions also perform operations on net inputs. Activation functions are a function used to make the output to be obtained into the desired intervals. İt is an imitation of the adaptation of a biological neuron. If an artificial network structure is created without the activation function, the resulting structure is similar to a simple linear regression. The most widely used activation functions are ReLU activation function, sigmoid activation function, and hyperbolic tangent activation function.

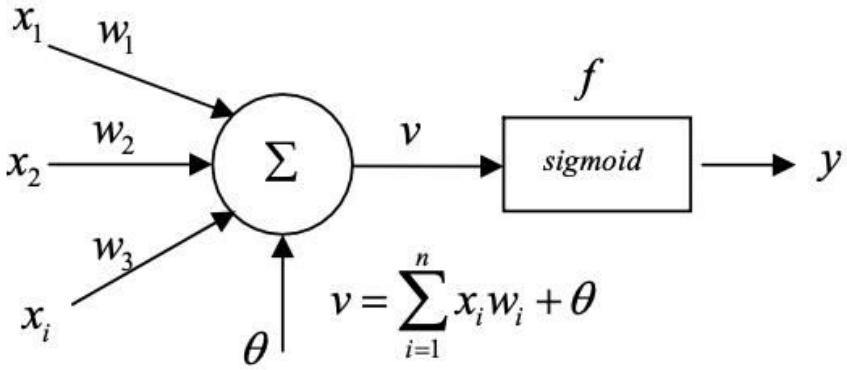

Figure 2. Basic Neural Network Cell

Work Accidents and Artificial Neural Network

Occupational accidents are caused by careless behaviors of employees, physical and mental fatigue, lifting excessive loads, inadequate safety measures in the work area, employing less than necessary personnel, irregular working environment, and inadequate use of devices in the workplaces. There may be many reasons such as not placing the necessary warnings and signs. However, it is not always possible to collect the specified parameters on a single model. Therefore, the model to be used is expected not to be complex. For the created artificial neural network model, the number of compulsory insured workers, workplaces, work accidents, deaths as a result of work accidents, permanent incapacity for work were used as parameters and the number of work accidents was estimated. The values of the parameters used between 1970 and 2021 are shown in Table 1.

Table 1. Used parameters and data

Years	Number of Compulsory Insured	Number of Workplaces	Number of Work Accidents	Number of Deaths	Number of Permanent Incapacity for Work
1970	1313500	109391	144483	679	2480
1971	1404816	154821	148822	583	2574
1972	1525012	174344	160585	682	2359
1973	1649079	184427	176993	822	2372
1974	1799998	195929	180375	983	2643
1975	1823338	205441	182601	855	2560
1976	2017875	216941	196341	947	2659
1977	2191251	229198	199961	1135	3123
1978	2206056	231130	193998	975	2841
1979	2152411	239225	186089	1050	2053
1980	2204807	241580	159600	1014	2406
1981	2228439	259589	165101	938	2300
1982	2264788	273226	147118	831	1881
1983	2327245	281627	145296	1070	2592
1984	2439016	294284	152650	885	2453
1985	2607865	326996	148027	877	2549
1986	2815230	365514	150821	1108	2282
1987	2878925	387452	158836	838	2483
1988	3140071	451662	171769	1163	2170
1989	3271013	474318	159463	1150	2394
1990	3446502	514390	155857	1292	2778
1991	3598315	536098	130278	1189	3334
1992	3796702	559184	139464	1583	3044
1993	3976202	610129	109563	1064	2522
1994	4202616	691023	92087	1034	2791
1995	4410744	724427	87960	798	2188
1996	4624330	759342	86807	1296	2249
1997	4830056	781911	98318	1282	3445
1998	5299533	813010	91895	1094	2677
1999	5005403	769674	77955	1165	2697
2000	5254125	753275	74847	731	1493
2001	4886881	723503	72367	1002	1866
2002	5223283	727409	72344	872	1820
2003	5615238	777177	76668	810	1451
2004	6181251	850928	83830	841	1421
2005	6918605	944984	73923	1072	1374
2006	7818642	1036328	79027	1592	1953
2007	8505390	1116638	80602	1043	1550
2008	8802989	1170248	72963	865	1452
2009	9030202	1216308	64316	1171	1668
2010	10030810	1325749	62903	1444	1976
2011	11547134	1435879	69227	1700	2093
2012	12527337	1538006	74871	745	2036
2013	13136339	1611292	191389	1360	1586
2014	13967837	1679990	221366	1626	1421
2015	14802222	1740187	241547	1252	3433
2016	15355158	1749240	286068	1405	4447
2017	16369073	1874682	359653	1633	3987
2018	16054759	1879771	430985	1541	3773

2019	16010002	1891512	422463	1147	4121
2020	17358140	1960911	384262	1231	3347
2021	18399864	2087692	511084	1382	4867

RESULTS AND DISCUSSION

The artificial neural network architecture used in the Weka program is the 5-10-1 artificial neural network architecture. Each variable was used as an input in the model and the number of occupational accidents was obtained as an output. The sigmoid function was used as the activation function in the first and second layers. An example of the neural network architecture used in the model is shown in Figure 3.

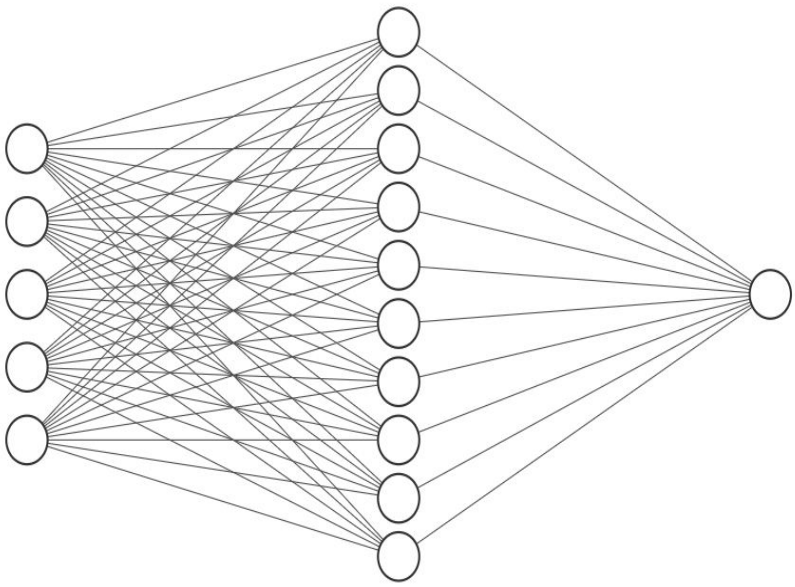

Figure 3. 5-10-1 Artificial neural network architecture

After the data is loaded into the Weka program, it is divided into training and test values before future value estimation is made with artificial neural networks. 70% of the data used was reserved as test data, while 30 was reserved as train data. After the data were divided into two as test and train, predictions were made for the next 10 years with the artificial neural networks in the Weka program. The future value obtained for the variables is shown in Table 2.

Table 2. 10 years prediction results

Years	Number of Compulsory Insured	Number of Workplaces	Number of Work Accidents	Number of Deaths	Number of Permanent Incapacity for Work
2022	19026288	2158816	524162	959	4093
2023	19015953	2183675	523193	857	2592
2024	19439529	2183450	549049	889	3893
2025	19427333	2149766	569098	744	4857
2026	19623081	2203353	616778	392	5672
2027	19815477	2218288	613186	816	3619
2028	20071491	2222361	579182	857	3035
2029	19812482	2176930	611969	686	3965
2030	19160915	1958765	642120	432	5266

As a result of the estimation process carried out using the artificial neural networks method in the Weka program and the data about occupational accidents until 2030, the data is shown graphically in Figure 4.

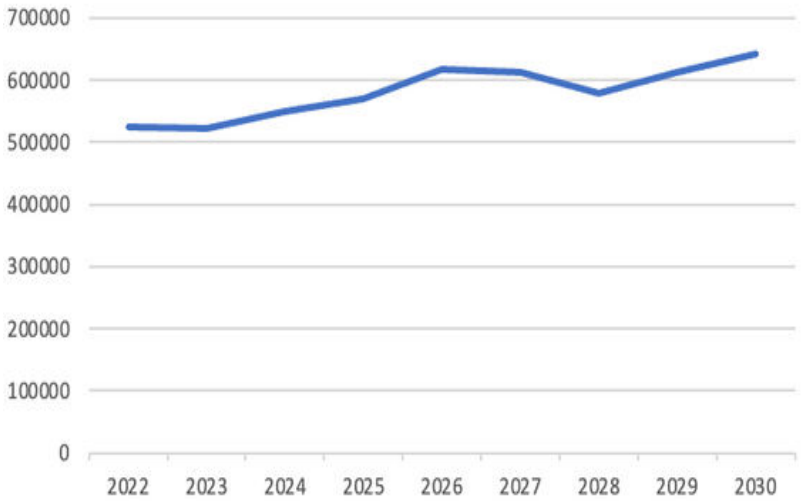

Figure 4. Graphical display of occupational accident estimates

To measure the performance of the model, mean absolute error (MAE), mean absolute percentage error (MAPE), root mean squared error (RMSE), and mean squared error (MSE) are given in Table 3.

Table 3. Obtained error values

Error Type	Number of Compulsory Insured	Number of Workplaces	Number of Work Accidents	Number of Deaths	Number of Permanent Incapacity for Work
MAE	6453644	618843	101379	831	3080
MAPE	459477	369672	319671	64615	1045758
RMSE	7140544	677947	148058	984	3623
MSE	5098737021608	459612669353	21921176952	969564	13130143

When the obtained error values were evaluated in terms of the number of occupational accidents, it was seen that the artificial neural network model was appropriate.

CONCLUSION

In this paper, a time series analysis was performed on the Weka program by using the artificial neural networks model, which is one of the machine learning techniques. As a data set, the number of compulsory insured workers, the number of workplaces, the number of work accidents, the number of people who died as a result of work accidents, the number of permanent incapacity for work between the years 1970-2021 were used. In the implementation, with the applied artificial neural network model, the estimation of work accident data until 2030 has been made.

In the study, using 5-10-1 artificial neural network architecture, the number of occupational accidents in 2030 was estimated as 642120. As a result of this value, it is seen that the number of occupational accidents will increase. In order to prevent bad results, it is necessary to implement better occupational safety policies in workplaces.

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ПРОЦЕНКА НА ПРОФЕСИОНАЛНИ НЕСРЕЌИ ВО ТУРЦИЈА ДО 2030 ГОДИНА

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Резиме

Денес, како резултат на развојот на технологијата, производната моќ на компаниите и зголемувањето на конкуренцијата помеѓу нив, доведе до појава на опасност, особено по безедноста и здравјето при работа. 21 век, во кој индустријализацијата и производствените техники дојдоа до израз, беше период во кој смртните случаи и инвалидитет се зголемија како резултат на несреќи при работа предизвикани од машини. Во овој труд, е проценет бројот на професионални несреќи во Турција до 2030 година со употреба на вештачка невронска мрежа на програмскиот пакет Weka. При креирањето на моделот, во периодот од 1970 до 2021 година се користени бројките на задолжително осигурени работници, работно место, работна несреќа, смрт како резултат на работна несреќа и трајна неспособност за работа. 30% од податоците се користени како податоци за тестирање, а 70% како податоци за обука во невронската мрежа. Врз основа на резултатот, очекуваниот број на професионални несреќи во 2030 година се проценува на 642210.

Клучни зборови: *Вештачки невронски мрежи, професионална несреќа, временски серии, Турција*