

# Performing Forensic Data Analyzes Using Data Visualization Library

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**Abstract**— We live in an age where knowledge is power. The phenomenon described as information is the processed and meaningful version of the data obtained from many devices and sensors today. As technology advances, processor and memory architectures also evolve. This development has increased the speed of data processing and has also increased the storage capacity of the data. It has become common for today's people who have many different technological devices to produce data and be exposed to this data. However, the increase in the number of devices in parallel with the new living conditions causes the data produced to reach an incredible size. The increase in the size of the data has exceeded the controllability level. For this reason, the processing of uncontrolled data and its transformation into meaningful information becomes very important today. Analysis of the data was tried to be made by using the field of statistics, but the field of statistics alone was insufficient for the large data we call "big data". It is necessary to gain different capabilities for information systems to draw meaningful conclusions by analyzing the data. The acquired abilities should also enable it to be easily understood by everyone, while at the same time transforming the data into information. Visual expression is the most effective way of communication. Because the most effective learning takes place with visual perception. Stripping data from its abstract structure and giving them visual identities will cause the data to be understood quickly. Within the scope of the thesis presented, using the python programming language, T.C. The data from the "Justice Statistics 2020" publication prepared by the Ministry of Justice, General Directorate of Criminal Records and Statistics, was analyzed and visualized.

**Index Terms**— Data analysis, data visualization, forensic data analysis, computer forensics, digital forensics,

## 1 INTRODUCTION

Today, the amount of data that can be produced and stored in machines that can process with the developing technology is increasing rapidly. The reason for this speed; It is the continuous data transfer within the network formed by the machines that can process and the development of the memory structure in which the data is stored. With this development, very large data sets, which can be expressed as "Big Data", have been stored in a controlled manner. However, the obtained data sets have started to cause data waste problems that are difficult to solve for computers. In this case, it is necessary to give the computer a skill in order to make the data processable and meaningful. Information systems; It is important in terms of storing and managing data, but today it comes to the fore with the transformation of data into meaningful information. It is not easy to transform large-scale data into meaningful and valuable information with traditional statistical methods. Therefore, advanced innovative techniques were needed to process data and generate output. "Data visualization" has emerged to meet this need [29].

The human perception system is limited to 3 dimensions. Data with larger dimensions exceeds the limit of human perception. While visualizing multidimensional data by reducing it to 2 or 3 dimensions with data visualization techniques, which are the foundations of artificial intelligence, the relationship between the data should also be preserved. There may be some loss from the dataset during the reduction. In order to prevent loss and make the data ready for visualization, data analysis should be performed before data visualization [7].

One of the methods used to analyze data is statistics. Statistics is the science of collecting data accurately and transform-

ing that data into information. Today, it is known that technological devices produce countless data. However, with classical statistical methods, a certain size of data can be analyzed. Data analysis in large structure should be done by coding thanks to programming languages. The process of transforming data into actionable and inferential information may differ. Data analysis, which is necessary to make a general statistical interpretation, can be performed with data visualization. At the same time, necessary precautions can be taken by making predictions with the analyzed data

In history, the concepts of crime and criminal emerged simultaneously with the formation of human societies. Before the state and administrative organs existed, the definition of crime and criminal were concepts that were put forward by the consensus of the societies. Today, the definition of crime and criminal made by states differs for each state and society. To give an example from the recent past, giving blood taken from black people living in the USA to white people without permission is included in the definition of crime. However, this definition of crime is not valid for Turkey. Although the definition of crime and criminal is different in every time period and in every geography, this definition is definitely made and is necessary for the existence of order.

Although the concepts of crime and criminal vary according to the countries, the rules of criminal procedure have started to be determined with the research of the evidence. Concrete research has begun to determine the crime and the criminal, and the rules of criminal procedure have been born to meet this need. Today, collecting, analyzing and concluding evidence is very important so that criminals can be uncovered. Analyzing, examining and presenting the evidence found in

the concrete research to the judicial authorities in the necessary forms has led to the formation of various sub-disciplines under the heading of criminal procedure law. Disciplines such as forensic science, forensic medicine, forensic psychology can be given as examples of these branches of science [26].

In the age that has become virtual day by day, the analysis processes of forensic cases, which are necessary for the detection of crime, have also changed. Because, with virtualization, data based on classical writings in the past are increasingly being replaced by digital data, and many fields of study are affected by this change in every sense. Along with the change, there have been some differences in the commission of the crime. While the crime is committed with a physical contact individually or organizationally, now the crime takes place in the virtual world. Political, economic, cultural etc. Societies that have been in many wars have included the cyber world as a new battlefield. With the aforementioned concepts, there should be specialized disciplines for the determination of the crime and the criminal. One of these disciplines, forensic informatics, constitutes a process that includes the acquisition, verification, analysis and reporting of physical or virtual data from the crime scene [19].

Computer forensics is an emerging research field that applies computer investigation and analysis techniques to help detect these crimes and collect digital evidence suitable for presentation in courts (Guo et al. 2010). It is also defined as a discipline that requires expertise in different fields to obtain digital data. In order for the data produced in many fields to be processed in the field of forensic information, it must be obtained by associating with forensic events. Artificial intelligence or "artificial intelligence" is needed in forensic studies in order to analyze data, help obtain legal results, produce results based on statistical science, create data pools and obtain new findings.

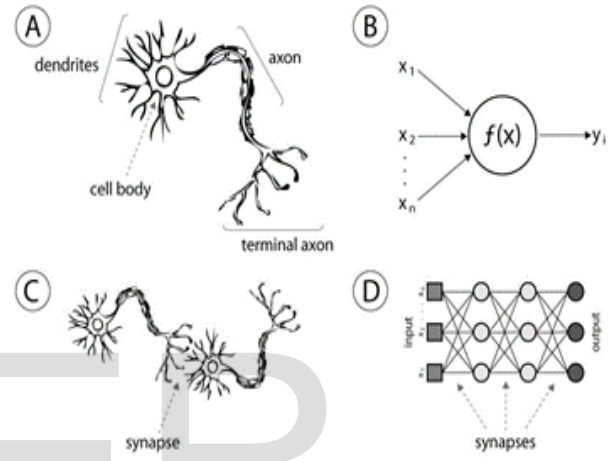
**1.2 Artificial Intelligence**

The hardware and software fields, which we call machines and which basically have two stages, were created by modeling the intelligent behavior of beings in nature. Intelligent software in technological fields; Techniques such as expert systems, genetic algorithms, fuzzy logic, virtual intelligence, artificial neural networks, machine learning are generally called artificial intelligence technologies. Artificial intelligence; They are computer systems that think like humans, act like humans, think rationally and act rationally, and have behaviors that are accepted as intelligent by living things

Studies to develop intelligent software, including artificial intelligence, have become a necessity today. Unintelligent software causes loss of efficiency by making users do unnecessary or repetitive work. Users prefer smart ones of the same type of software. For example, if the website that a person constantly visits is not designed with a virtual intelligence, the page that the person encounters at each site entrance will be the same as the previous one. However, in today's developed sites, we see dynamically structured web sites designed according to the demands of each user. This allows the user to spend more time on the page efficiently. In addition, abilities such as abstraction, learning and adapting to new situations

can be brought to systems. In general terms, artificial intelligence can be defined as intelligence in non-organic systems with these features [38].

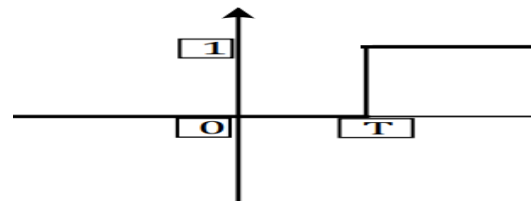
In Figure 1, the artificial neural cell model, which is inspired by the biological nerve cell (neuron) and enables the formation of intelligent systems, and the artificial neural network model, which is designed in association with the biological neural network, are shown. In this way, the neuron processor element/perceptron (Fig. 1a-b) corresponds to the dendrite collection function (Fig. 1a-b). Again in a nerve cell; cell body is designed for transfer function, axons for artificial neuron output and synapses for weights. The artificial neuron containing these three elements is shown in Figure 3 [31].



**Figure 1.** Comparative structure of biological and artificial neuron a) a neuron, b) perceptron (mathematical model of the cell) c) neural network system d) neural network design

**1.3 Signals and Artificial Intelligence Systems**

Data enters systems as signals. These input signals are interpreted with the machine language that is unique and different for each machine. The software is to work with the binary number system. Like the timed signals shown in Figure 2, these bits, expressed as 0 and 1 (each digit in the binary number system is one bit), correspond to the received signals. Signals are the factors that change according to the volt value and enable the systems to produce language. In spoken languages, it is like letters coming together to form words, and combining them to form sentences. Signals come together to form small data cells called bytes. 1 byte is 8 bits



**Figure 2.** Binary modeling graph

Artificial intelligence; It mimics the biological dendrite-cell body relationship by transferring the signals to the generated mathematical cell body. The input signals received here are defined in the cell body with the mathematical formula specified in Figure 2 and transferred to the appropriate output units. They act as synapses of a biological neural network. The system is expected to estimate by looking at the percentiles of the output values. Thus, the artificial design of the biological neural network is made. In Figure 3, the artificial neural model that enables the incoming data to be transferred to the relevant network during the data transfer process is shown.

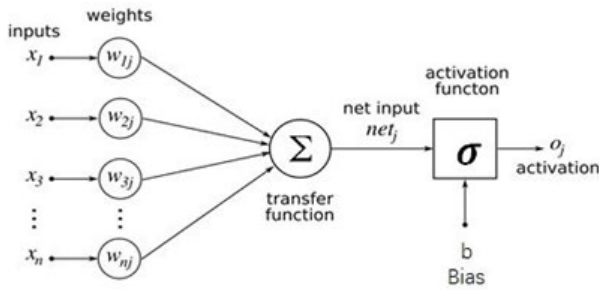


Figure 3. Structure of artificial neuron

Artificial intelligence has a layered structure to solve complex problems. A multi-layer neural network model is also seen in Figure 4. Thanks to the neural networks designed separately for each problem, many data can be analyzed and meaningful results can be drawn.

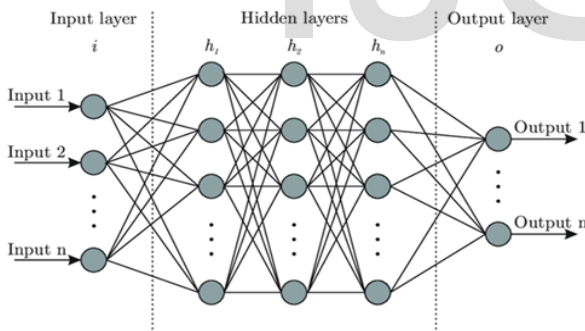


Figure 4. General structure of a multilayer artificial neural network

The basic units that make up the brain structure are nerve cells (neurons) and their extensions, axons and dendrites. Neurons, together with their extensions, enable the neural transmission (impulse) to occur through the contact points called synapses with another nerve cell. The greater the number of network patterns created by neurons, the stronger the information processing process. Figure 5 shows that the number of patterns correlates with age. Each neuron has many short extensions called dendrites and one long extension called axon. The connection between axon terminals and the dendrites or bodies of other neurons is called a synapse. All activities and memory in the nervous system are related to the

electrical current arising from neurons. Information travels between neurons as an electrical current. As mentioned earlier, the “artificial neural network” was made with the mathematical design of the electrical conduction pathway of the biological nervous system. In Figure 5, it is stated that the mathematical/artificial networks made by showing the age-related development of the nervous system should be constantly updated or self-development..

The coordination of all systems in advanced organisms is under the control of the Central Nervous System (CNS), and they perceive both external and internal stimuli with their sense organs and respond appropriately to these stimuli. The sense organs transmit the information that comes in the form of internal and external stimuli through neural networks to the brain and its associated spinal cord, which are the main parts of the CNS. A lot of information (109 bits/sec) is received from the environment with the sense organs. But very little of it (101-102 bits/sec) is consciously recorded. The rest is either subconsciously processed or not used at all. In other words, information important to consciousness (interesting/attention/motivation) is selected through the cerebral cortex (especially those that are noteworthy during seeing and listening). On the other hand, approximately 107 bits/sec of information is transmitted to the environment through speech and motor activities [24].

We know how much information the sense organs receive from the environment, what type of information it is and how much of it is recorded. Sense organs contribute to this innately coded ability we call learning. Today, the effect of sense organs on the learning process; 83% for vision, 11% for hearing, 3.5% for smell, 1.5% for touch and 1% for taste. When these ratios are considered, it is seen that sight and hearing are very important in the perception and learning process [2]. In particular, the ratio related to vision also expresses the need for visualization of big data.

One of the most valued concepts of the modern age is “data”. From personal data to data on a global scale, the production and consumption of data is necessary to sustain modern life. However, the important thing in this heavy data traffic flow is that the data obtained is quickly and easily understood for everyone. For this reason, there is a need to train designers who have analytical thinking skills, can analyze, create hierarchical structures, and use graphics and visuals effectively [39]. The brain can process visual information 60,000 times faster than textual information. 90% of the information transferred to the brain is visual and 65% of people are visual learners.

## 2 MATERIAL AND METHOD

### 2.1 Data Visualization

The 21st century is called the information age and data production is quite high. Therefore, storing data securely becomes a problem. The reason for the problem is the abundance of data that cannot be captured, managed and processed. However, the real problem is the process of transforming the surplus processed, analyzable data into understandable information [25]. The most effective and universal method that can be used for this process is the

methods that include visual expression. The use of visualizations to analyze complex information and translate it into understandable form is a very functional method in today's communication age. Visualization enables complex data to be analyzed much more effectively and to be understood by large audiences [39].

In general, a successful visualization product should start with a view design that is widely recognized and familiar to users. In addition, the visualization system should provide a set of interactive tools that allow the user to modify the presentation of the view to his satisfaction. While in simple data a basic visualization view can be used to present all the information about the data, in complex data multiple views need to be visualized and even new views need to be invented to present the information contained in the data effectively [18].

After determining the mapping of data visualization elements, the design of views and interactions, another major challenge for data visualization design is that the designer must decide the amount of information to include in the visualization view. A good visualization should show the right amount of information, not more. However, for an unsuccessful visualization, it can be defined that shows too little or too much information about the data at the two ends [36].

Color is one of the most impressive elements of visual language and the importance of color in visual communication design should not be ignored during the design process. Due to the physiological characteristics of human beings, morphological analyzes can be made in response to color. For this reason, the effect of color comes before graphics and text in terms of visual effects [37].

**2.2 Development Environment - Kaggle**

Although there are many different development environments in the studies in the field of data visualization, the applications we have made were carried out on the kaggle.com platform and pandas and numpy libraries were used for data analysis. It has been worked with seaborn and plotly as data visualization library. When we look at the studies in the field of artificial intelligence today, it is seen that many libraries have been developed in Python [28].

**3 RESEARCH FINDINGS**

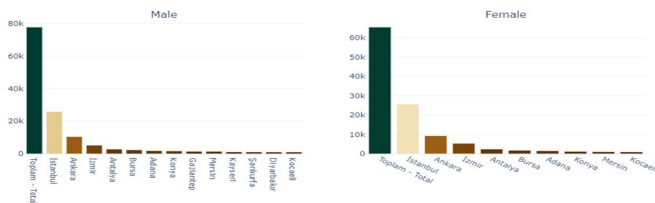


Figure 5. Number of lawyers at the place of the bar association in provinces with bar associations

While analyzing the data, it is seen that the visualization of Figure 5 has only two features, "gender" and "the highest

number of lawyers by cities", and the remaining feature of "total number of lawyers registered in the bar association in provinces" is made with Figure 6.

Figure 5 Comparative analysis of male and female lawyers registered to the bar association was made in the provinces with bar associations. A visualization is a "conditional" visualization. Provinces with more than 1000 female and male lawyers were selected "conditionally" and the viewing area was narrowed.

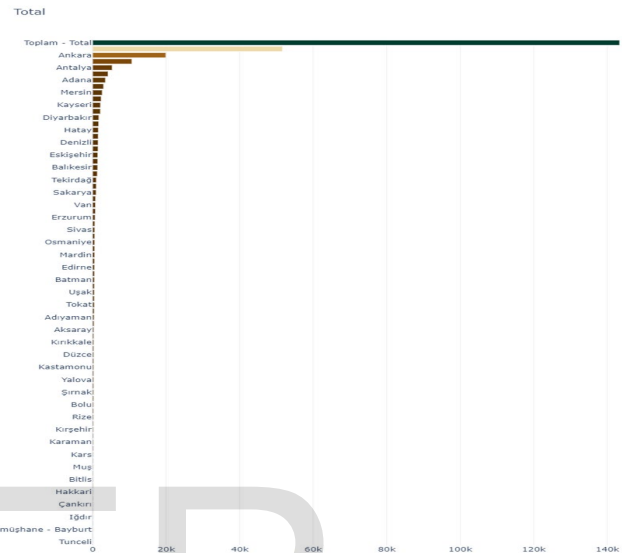


Figure 6. The total number of lawyers admitted to the bar in provinces with bar associations

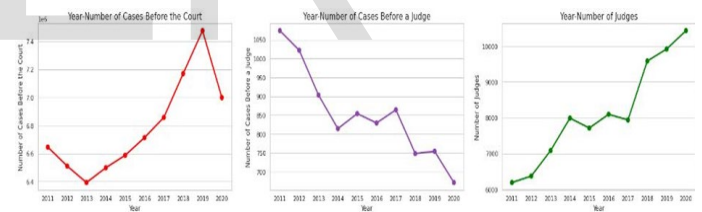


Figure 7. Number of judges in courts, number of cases before courts, and per judge

Data on the number of judges in criminal, civil and administrative courts, and the number of cases pertaining to one judge between the years 2011-2022 are given. Considering Figure 7, we can say that despite the increase in the number of cases coming to the court, the decrease in the number of cases per judge varies in proportion to the increase in the number of judges

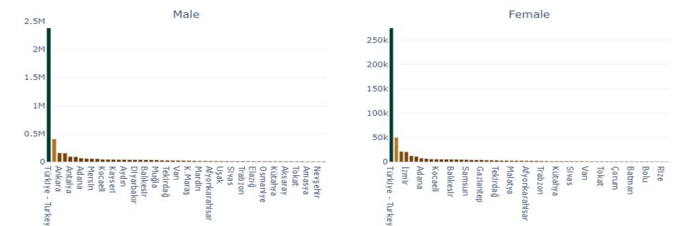


Figure 8. Number of crimes in criminal courts, Male & Female

The data are plotted with the go.Bar() function using the plotly.graph\_objects as go library. The plotly library is not an inactive library. In this way, the area to be examined on the visualization can be activated

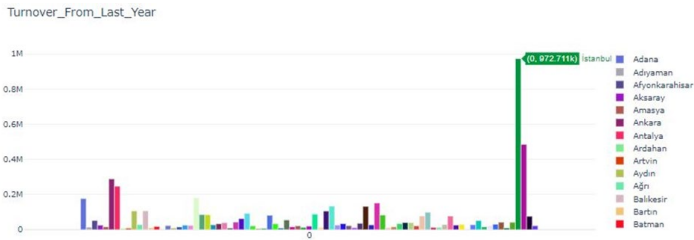


Figure 9. Prosecutor General's Offices - Turnover from last year

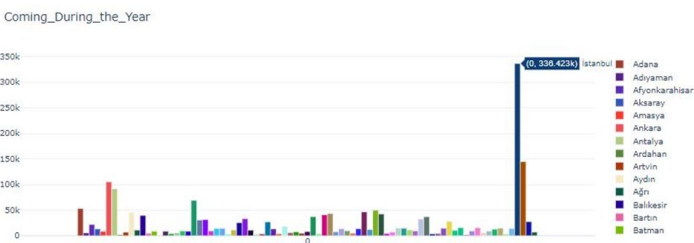


Figure 10. Prosecutor General's Offices - Coming during the year



Figure 11. Prosecutor General's Offices - Carry over to next year

In the visualization of the Plotly library, the coloring process was designed as random in Figure 9-11. Each time the system runs, the colors will be presented differently from the previous one. The main reason for doing this is to exhibit the features of the Plotly library. Plotly library can work actively with many libraries. It is not correct to limit the designs or leave them in a static structure while visualizing.

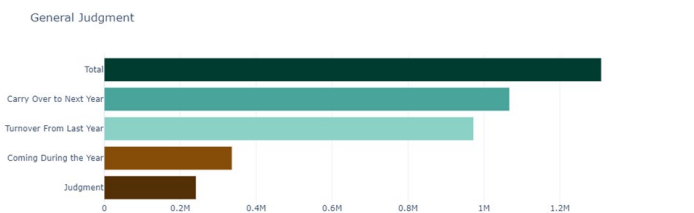


Figure 12. Judgment General works

A general analysis was made by taking the first lines of the data. In order to do this, the data properties (columns) must behave like data belonging to a property. Such operations are

frequently performed in the field of data visualization. In short, in this process, rows should behave like columns and columns.



Figure 13. Cases received between 2011-2020, were settled and transferred by the next route - Plotly library

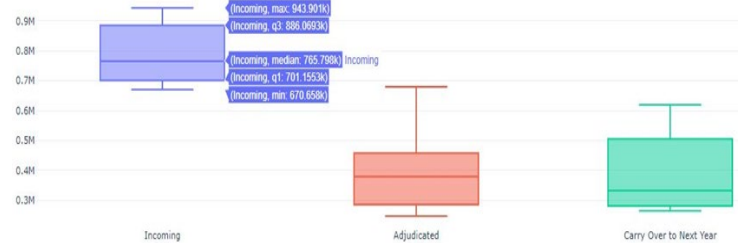


Figure 14. Cases received, settled, and transferred to the next year between 2011-2020 - Plotly Library/Box Plot

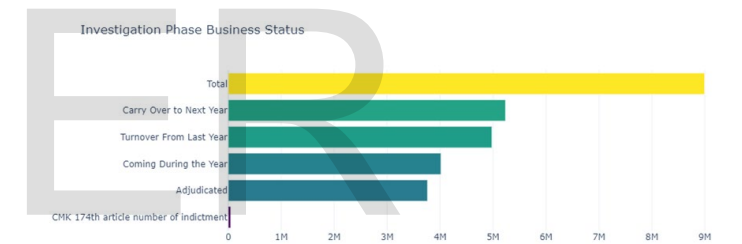


Figure 15. Investigation phase general business situation

Statistical visualization of the data was made.

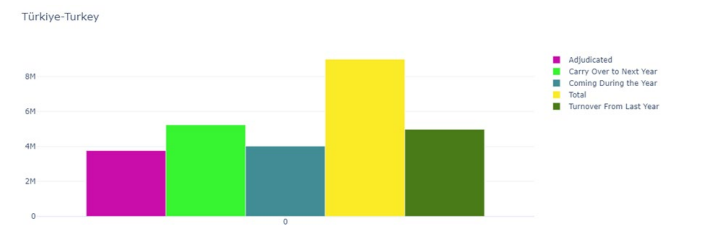


Figure 16. Investigation phase business situation by province - Turkey

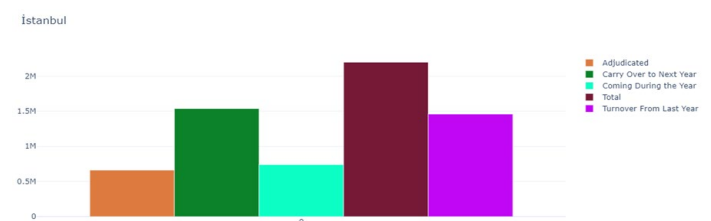


Figure 17. Investigation phase business situation by province - Istanbul

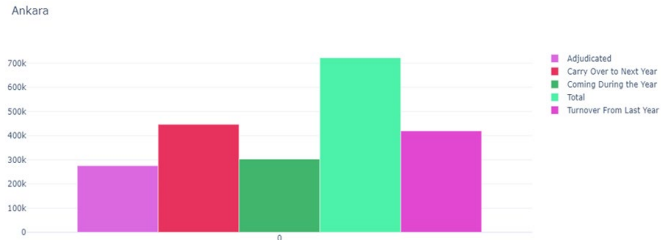


Figure 18. Investigation phase business situation by province - Ankara

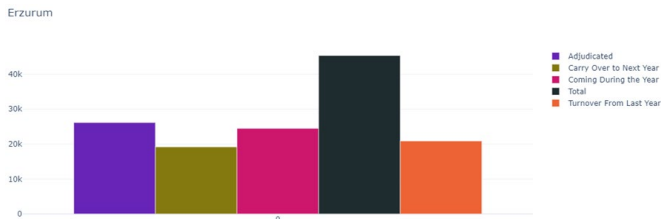


Figure 19. Investigation phase business situation by province - Erzurum

It is understood that the general visualization of Turkey found in Figure 16 is very similar to the visualization of Ankara province found in Figure 18. It is seen that the least adjudicated case is Istanbul with Figure 17. In addition, it can be analyzed by looking at the visualizations that the number of cases that have been decided the most among these four provinces is Erzurum with Figure 19, and that the cases transferred from the last year to the next year are the least.

In cases where the divorced woman, who divorced the most from the statute of limitations and entitlement process, to use her husband's surname, most in cases of adoption due to lack of jurisdiction, cases of remuneration due to lack of jurisdiction, most cases of foreign exchange due to lack of evidence, cases of geographical indication due to waiver most Decisions are mostly made in cases of permission to marry because of the absence of a condition, in cases of property sharing in divorce cases, in cases of partial refusal, in cases of removal of the surname of the husband of the divorced woman, in cases of partial acceptance, settlement, division of property in divorce cases, and in other cases of cancellation of checks. has been connected

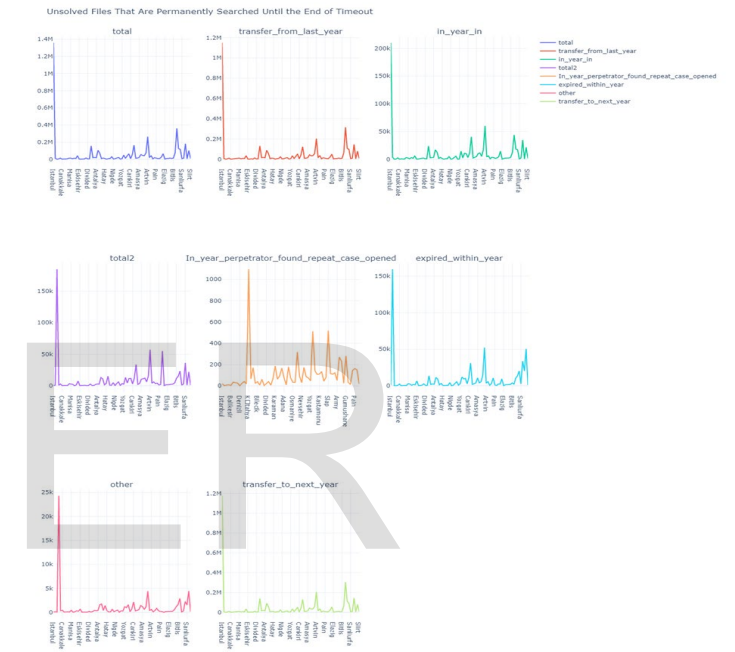


Figure 21. Unsolved files according to provinces are constantly searched until the end of the statute of limitations

The visualization was made using the Plotly library scatter plot in the section where the unsolved perpetrator in the Chief Public Prosecutor's Offices was examined, and the files, which were constantly searched until the end of time, were examined. The same visualization techniques were used as it was similar to the previous data structures.

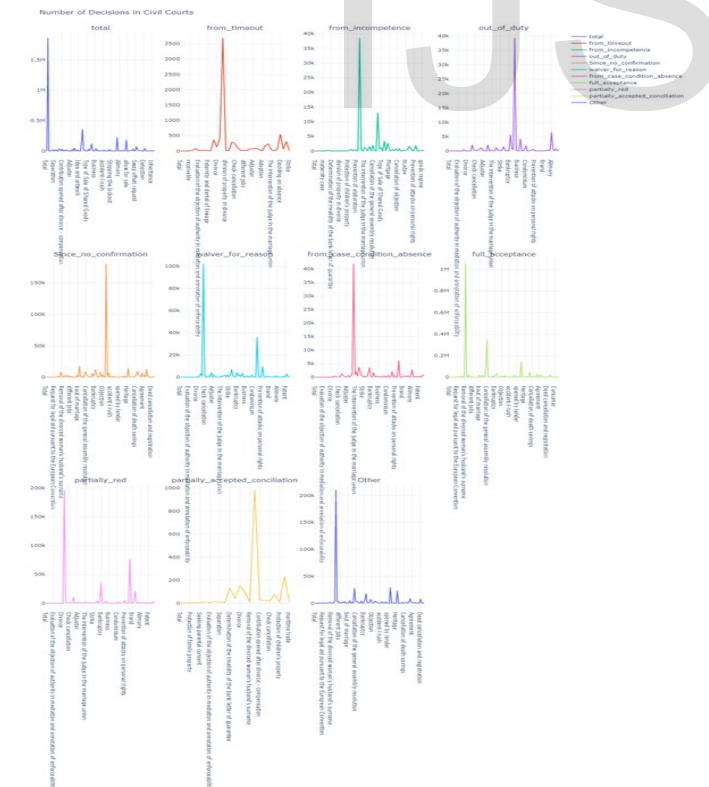


Figure 20. Number of decisions in civil courts

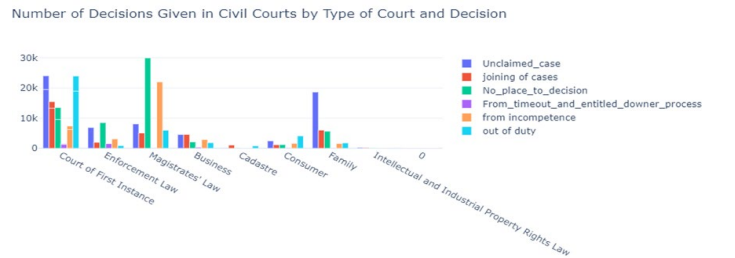


Figure 22. Number of decisions by decision type

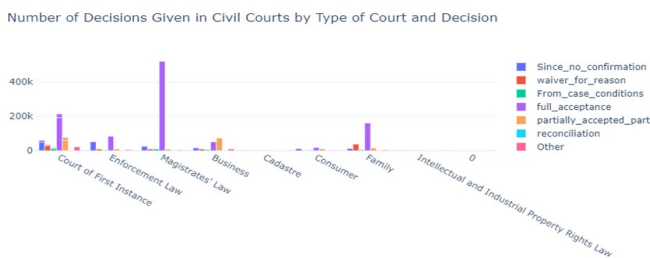


Figure 23. Number of decisions by decision type - continued

The bar plot of the Plotly library was drawn. The drawn bar plots were grouped with the command given above.

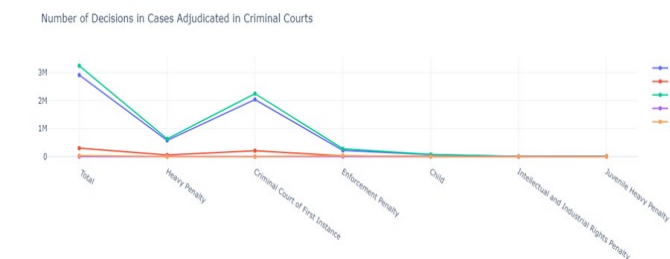


Figure 24. Number of decisions in cases decided in criminal courts

When Figure 24 is examined, it is seen that as the type of court, criminal courts of first instance are the most concentrated, and heavy penal and enforcement courts come after the first instance. With visualization, it can be concluded that juvenile heavy penal courts are the least dense in terms of density.

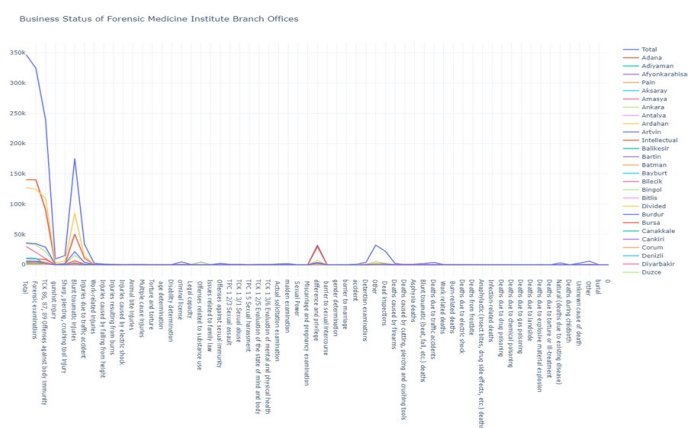


Figure 25. Business status of Forensic Medicine Institute branch offices - Plotly

Visualization of inspection types belonging to provinces is given in Figure 25. Forensic examinations, TPC 86, 87, 89 crimes against bodily immunity, blunt traumatic injuries, court cases belonging to the type of jurisdiction and disqualification are seen respectively. At the provincial level, Istanbul and Bursa are in the first place.

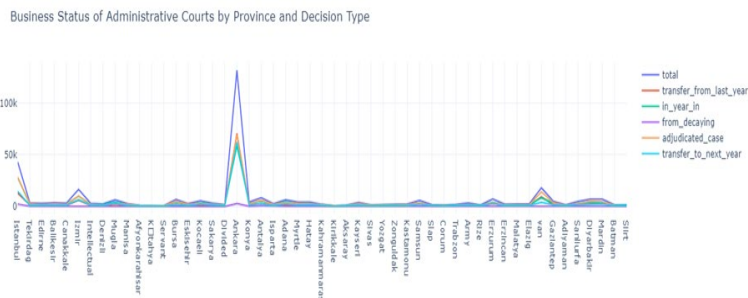


Figure 26. Business status of administrative courts by province and type of decision

The business situation and processes of the administrative courts in Ankara, Istanbul, Izmir, Van, Erzurum and Bursa, respectively, are given in detail in Figure 40. The relativizations of the data were made in an animated way using the Plotly library.

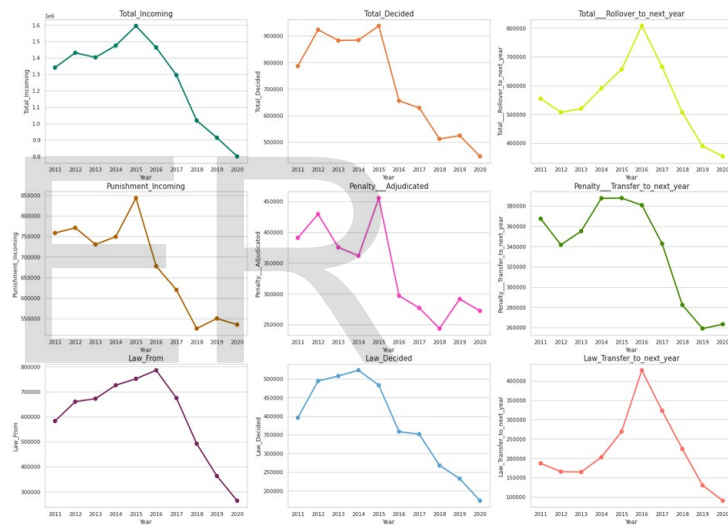


Figure 27. Supreme Court general assemblies and litigation chambers business situation - Seaborn

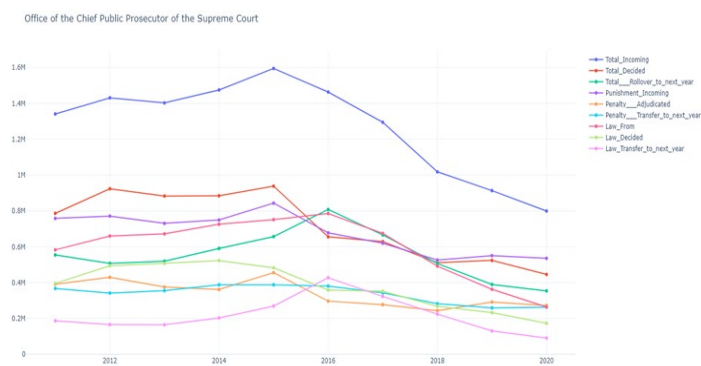
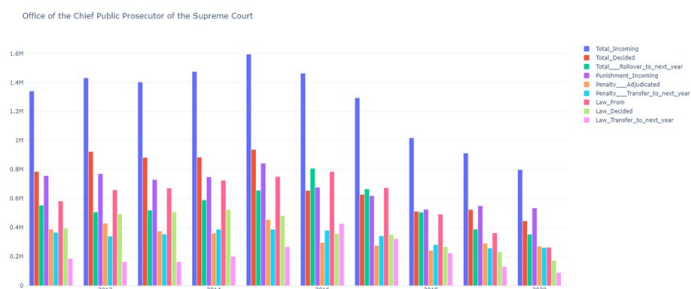


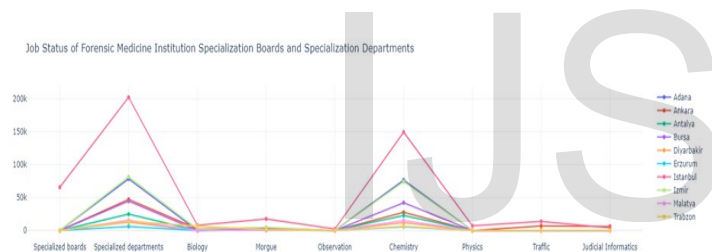
Figure 28. The business situation of the general assemblies and litigation chambers of the Supreme Court - Plotly



**Figure 29.** Supreme Court general assemblies and litigation chambers business situation - Plotly/Bar Plot



**Figure 30.** Job-status of forensic medicine institution specialization boards and specialization departments by province



**Figure 31.** Job-status of forensic medicine institution specialization boards and specialization departments by province

**RESULT**

The continuous increase in digital memory capacities with technological innovations and the widespread use of these devices by everyone in daily life have increased the amount of data produced and stored by these devices in an uncontrolled manner. In addition to this problem, software developed in different fields, especially in the field of forensic information, is insufficient in the analysis of large amounts of data. For this reason, the time spent by forensic experts for analysis is more than necessary. The analysis process of the rapidly increasing data over time becomes more difficult. With all the innovations created in the field of artificial intelligence, it has become easier to solve such difficulties by using more advanced software languages and developed libraries of interpretations based on statistical science.

In order to combat cybercrimes and crimes committed through IT more effectively, digital evidence, which is defined as data and information that has the quality of evidence transmitted or recorded on electronic or magnetic media, at least as much as physical evidence, in the process of clarifying

the crimes and handing over the criminals to the judicial authorities. is needed. In order to find and reveal these digital evidences, all devices with storage feature are examined by cyber security teams (Ateş 2020). However, artificial intelligence fields should be used to try to concretize the resulting data by supporting the predictions and probabilities with statistical data.

As an important discipline in computer science, data visualization is a relatively young field. Data visualization is a concept that develops and expands with the visual and aesthetic changes of people. The methodological techniques behind it, image processing, user interfaces, animation effects, etc. It allows visual interpretation of data using The techniques covered by data visualization are much broader than the methods and techniques specific to mathematical modeling. Data visualization is basically communicating information efficiently and clearly with the help of graph-like tools and making it better understood. is about communicating (Liu and Wang 2018). Data visualization is one of the fields of artificial intelligence and is accepted as an effective and rapid progress method for many units that work in isolation from each other.

Excel and SPSS, which are data visualization programs that are common in the field of statistics, were not used within the scope of the thesis. The limited data obtained from the "Justice Statistics 2020" publication have been visualized by considering them as unlimited data with a deeper structure. Nowadays, when visualization has strategic importance, it is important to understand the techniques of using new and rapidly developing visualization libraries and to have information about how many processes, especially data analysis, are carried out with various algorithms.

In the data visualization phase, the characteristics of the data used are very important. Information about the dimensions of the data, which will carry a visual identity, affects the visualization process. Having a limited number of data or data that does not have many variables allows for easier visualization than other scenarios considered. Because many programs can easily visualize the information hidden among the data. However, it is not possible to visualize large and constantly changing data with conventional methods. A lot of data needs to be used for the development of artificial intelligence fields. These data used for training systems are constantly changing. Data content, dynamic or static, size, etc., especially the sectors in which the data is created. Many factors also affect the processing of data. For the limited number of data obtained and visualized in the forensic field, the techniques used during the process have the same design as the techniques used for the visualization of enhanced big data.

In this respect, in our opinion, "data in different fields that may be valuable, especially in the forensic field, should be included in this process". Regarding the subject, we should say that "there is no data bank other than the Blood Data Bank in our country, but there may be a need for data banks such as DNA and tooth structure in the future". This will bring with it a lot of data that needs to be controlled. The analysis of the data to be obtained from data banks such as DNA and tooth structure by the experts of the subject, then the development of artificial intelligence techniques, the algorithms used for the



solution of events, and making them understandable and interpretable by everyone will be possible with "Data Visualization".

The presented thesis includes the processing and visualization of many recorded data. Especially from the forensic field

## REFERENCES

- [1] Seri, G. Corrielli, D. Lago-Rivera, and Lenhard Osellame and Mazzer, 2018. Laser-written integrated platform for quantum storage of heralded single photons, *Optica*, vol. 5, no. 8, pp. 934-941.
- [2] Akpınar, B. ve Ersözlü, Z.N., 2008. Sosyal Bilimler Araştırmaları Dergisi, 2, 42-53.
- [3] Alpan, G., 2008. Görsel okuryazarlık ve öğretim teknolojisi. *Van Yüzüncü Yıl Üniversitesi Eğitim Fakültesi Dergisi*, 5(2), 74-102.
- [4] Ateş, E. C., 2020. Adli Bilişim, Dijital Deliller ve Bilişim Suçları Kavramlarının İncelenmesi.
- [5] Lee, E. K. Choe, P. Isenberg, K. Marriott and J. Stasko., 1 March-April 2020. Reaching Broader Audiences With Data Visualization, in *IEEE Computer Graphics and Applications*, vol. 40, no. 2, pp. 82-90, doi: 10.1109/MCG.2020.2968244.
- [6] Bezerra, R.F., Jalloh, S. and Stevenson, J. 1998. Formulating Hypotheses Graphically in Social Research, *Quality and Quantity*, 32 (1), 327-353.
- [7] Bilgin, T. T., ve Çamurcu, A. Y., 2008. Çok Boyutlu Veri Görselleştirme Teknikleri.
- [8] Akademik Bilişim, 30, 107-112.
- [9] Çelik, S., ve Akdamar, E., 2018. Büyük veri ve veri görselleştirme. *Akademik Bakış Uluslararası Hakemli Sosyal Bilimler Dergisi*, (65), 253-264.
- [10] Çetin, S., 2022. Büyük Veri (Big Data) [Çevrimiçi forum yorumu]. <https://teknocak.com/buyuk-veri-big-data/36>
- [11] Dilber, İ., ve Çetin, A., 2021. Adli Bilişim İncelenme Süreçlerinde Yapay Zeka Kullanımı: VGG16 ile Görüntü Sınıflandırma. *Düzce Üniversitesi Bilim ve Teknoloji Dergisi*, 9(5), 1695-1706.
- [12] Dilek, S., Çakır, H. ve Aydın, M., 2015. Siber suçlarla mücadelede yapay zeka tekniklerinin uygulamaları: Bir inceleme. *arXiv ön baskı arXiv:1502.03552*.
- [13] Durukan, E., ve Alkan, Ö. G. B., 2022. Sosyal ve Beşerî Bilimlerde Güncel Araştırmalar-II. Franke, K., and Srihari, S. N., 2008, August. *Computational forensics: An overview*. In
- [14] *International Workshop on Computational Forensics* (pp. 1-10). Springer, Berlin, Heidelberg.
- [15] Friendly, M., 2008. Milestones in the history of thematic cartography, statistical graphics, and data visualization. <http://www.math.yorku.ca/SCS/Gallery/milestone/milestone.pdf>
- [16] Guo, H., Jin, B., and Huang, D., 2010, November. Research and review on computer forensics. In *International Conference on Forensics in Telecommunications, Information, and Multimedia* (pp. 224-233). Springer, Berlin, Heidelberg.
- [17] Gürler, A., Yılmaz, A. S., ve Tekerek, M., 2018. Veri görselleştirme ve infografikler. *Kahramanmaraş Sütçü İmam Üniversitesi Mühendislik Bilimleri Dergisi*, 21(2), 131-148.
- [18] H. Liu and X. Wang., March 2018. Study on the application of big data in accurate marketing of cross-border e-commerce in China, in *Proceedings of the IEEE 3rd International Conference on Big Data Analysis (ICBDA)*, pp. 24-27, IEEE, Shanghai, China.
- [19] Henkoğlu, T., 2020. Adli bilişim: Dijital delillerin elde edilmesi ve analizi. *Pusula*.
- [20] Jarrett, A., and Choo, K. K. R., 2021. The impact of automation and artificial intelligence on digital forensics. *Wiley Interdisciplinary Reviews: Forensic Science*, 3(6), e1418.
- [21] Karakuş, S., ve Kaya, M., 2018. Derin öğrenme yöntemleri kullanarak dijital deliller üzerinde adli bilişim incelemesi, *Doctoral dissertation, Yüksek Lisans tezi, Fen Bilimleri Enstitüsü, Fırat Üniversitesi, Elazığ, Türkiye*.
- [22] Kellner, D., 2001. *New Technologies/New Literacies: Reconstructing education for the millennium*. *International Journal of Technology and Design Education* 11, 67- 81, Kluwer Academic Publisher. Printed in the Netherlands.
- [23] Korkmaz, Ö., ve Mahiroğlu, A., 2007. Beyin, bellek ve öğrenme. *Kastamonu Eğitim Dergisi*, 15(1), 93-104.
- [24] Meng, X., 2022. Construction of E-Commerce Economic Management Platform Based on Data Visualization Technology. *Mathematical Problems in Engineering*.
- [25] Muharrem, Ö. Z. E. N., ve Özocak, G., 2015. Adli Bilişim, Elektronik Deliller ve Bilgisayarlarda Arama ve El Koyma Tedbirinin Hukuki Rejimi (CMK M. 134). *Ankara Barosu Dergisi*, (1).
- [26] Orakçı, M., Cıylan, B., Kök, İ., ve Sevri, M., 2019. Suç Analizinde Veri Madenciliği Teknikleri Ve Makine Öğrenmesi Algoritmalarının Kullanılması.
- [27] Ozturk, M., 2022. Python Kütüphaneleri ve Özellikleri [Çevrimiçi forum yorumu]. <https://miracozturk.com/python-kutuphaneleri-ve-ozellikleri/>
- [28] Özkan, Y., 2013. Veri madenciliği yöntemleri (İkinci Baskı). İstanbul: Papatya Yayıncılık. Özköse, H., 2020. Büyük Veri Kavramı ile İlgili Akademik Yayınların Metin Madenciliği
- [29] Yöntemi ile Analizi. *Veri Bilimi*, 3(1), 11-20.
- [30] Öztürk, K., ve Şahin, M. E., 2018. Yapay sinir ağları ve yapay zekâ'ya genel bir bakış.
- [31] *Takvim-i Vekayi*, 6(2), 25-36.
- [32] Qin, X., Luo, Y., Tang, N. et al., 2020. Making data visualization more efficient and effective: a survey. *The VLDB Journal* 29, 93-117 <https://doi.org/10.1007/s00778-019-00588-3>
- [33] Reda, K., Febretti, A., Knoll, A., Aurisano, J., Leigh, J., Johnson, A., ... and Hereld, M., 2013. Visualizing large, heterogeneous data in hybrid-reality environments. *IEEE Computer Graphics and Applications*, 33(4), 38-48.
- [34] Rughani, P. H., 2017. Artificial Intelligence Based Digital Forensics Framework. *International Journal of Advanced Research in Computer Science*, 8(8).
- [35] S. Hirve and C. H. Pradeep Reddy., 2019. A survey on visualization techniques used for big data analytics, *Advances in Intelligent Systems and Computing*, Springer, Singapore, pp. 447-459.
- [36] Seveli, O., 2019. Göğüs kanseri teşhisinde farklı makine öğrenmesi tekniklerinin performans karşılaştırması. *Avrupa Bilim ve Teknoloji Dergisi*, (16), 176-185.
- [37] Uğur, A., ve Kınacı, A. C., 2006. Yapay zeka teknikleri ve yapay sinir ağları kullanılarak web sayfalarının sınıflandırılması. *XI. Türkiye'de İnternet Konferansı (inet-tr'06)*, Ankara, 1(4).
- [38] Uyan Dur, B. İ., 2014. Görsel İletişim tasarımı eğitiminde veri görselleştirme ve infografik.

- [39] Journal of Arts and Humanities, 3(5), 1-16.
- [40] Uzun, E., 2022. Görselleştirme Kütüphaneleri [Çevrimiçi forum yorumu]. <https://erdincuzun.com/python-third-party-libraries/02-gorsellestirme-kutuphaneleri/>
- [41]
- [42] X. Du, B. Liu, and J. Zhang., 2019 Application of business intelligence based on big data in E-commerce data analysis, Journal of Physics: Conference Series, vol. 1395, no. 1, Article ID 012011.
- [43] Yavuz, S., 2020. Çok Boyutlu Veri Görselleştirme Yöntemlerinden Chernoff Yüzleri Yöntemi Kullanılarak Üniversitelerin İstatistik Bölümlerinin Kpss Başarı Puanlarının Karşılaştırılması . Erzincan University Journal of Science and Technology , 13 (1) , 152-161 . DOI: 10.18185/erzifbed.640732.
- [44] Yıldırım, E. ve Erkurt, E., 2020. Büyük Veri Görselleştirme: Emlak Sektörüne İlişkin Bir Uygulama . Ankara Hacı Bayram Veli Üniversitesi İktisadi ve İdari Bilimler Fakültesi Dergisi , 20th International Symposium on Econometrics, Operations Research and Statistics EYI 2020 Special Issue , 38-57 . Retrieved from <https://dergipark.org.tr/en/pub/ahbvuibfd/issue/55755/694026>.

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