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Original Article

Securing Data on Crisis Management from GIS of IDP in Iraq Using Steganography Technique

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Abstract - *Crisis management for Internally Displaced Persons (IDPs) in Iraq relies mainly on the secure transmission of data obtained from Geographic Information Systems (GIS), which contain sensitive information about camp locations, resource distribution methods, and population information. This study explores the use of steganography to hide sensitive data using contrast variation and embeds the data in digital media such as images. The proposed method adds secret data to pixels whose contrast difference is higher than a certain threshold while maintaining image quality. Steganography adds a higher level of security in addition to encryption. The proposed approach is suitable for securing vital and secure data in high-risk environments such as the subject of our study here. Security data is exchanged without attracting attention in an image that carries data imperceptibly. The high results prove the merit of the research within the criteria (PSNR = 90 dB) and (probability in chi-square = 1.7%), and there is a suitable environment for developing this study by adding techniques such as machine learning and adopting real-time.*

Keywords - *Steganography, Crisis management, Geographic Information Systems (GIS), Internally Displaced Persons (IDPs), Contrast variation.*

1. Introduction

Digital technology has witnessed rapid development, as well as systems that rely on digital data, so crisis management has become unprecedented in its capabilities, especially in areas witnessing a long conflict, such as Iraq. One of the most important sources of information for crisis management is Geographic Information Systems (GIS), considered vital data for making important decisions, which is dealt with in the IDP crisis in Iraq. This data may be a location or personal information, the disclosure of which raises concerns, as tampering with this information or changing it by unauthorized persons poses major threats to the safety of the displaced first and to national security second. Through the above, securing data related to crisis management is considered a priority. Steganography is a pioneering technology in the field of information security, which is the process of hiding sensitive, confidential information within digital media in a way that appears harmless and visible to people; unlike traditional methods of data security such as encryption, steganography is considered a layer of protection that cannot be discovered or challenged [1]. This study is based on the principle of enhancing the security of GIS data, which is the main source of information for managing the displacement crisis in Iraq through steganography. This is done by including the data in the digital image to ensure the confidentiality of sensitive data throughout the crisis until the response process [2]. This study participates in the process of improving data security in managing the displaced crisis and giving more flexibility to the system that supports it. One of the biggest crises caused by armed conflict and political and economic instability is the Internally Displaced Persons (IDPs) in Iraq. Many Iraqis live in dire conditions, approximately 1.5 million IDPs [3]. They live in temporary housing and camps that lack the most basic requirements for dignity. These include lack of health care, food, and poor housing [4]. Such a crisis requires great efforts to address it and good crisis management to ensure that assistance is provided to the displaced. The use of high-accurate Artificial Intelligence (AI) technologies to automate, analyze and study estimates of the number of internally displaced persons and to draw approximate maps of camp structures, especially in areas that are difficult to access for long periods [5]. Therefore, artificial intelligence can improve the service and efforts of humanitarian relief and save time and money. After 2006, groups of people began to be displaced to areas considered safe due to the civil war that passed through Iraq. Many people settled in informal camps, many of which were temporary, where humanitarian relief and protection were limited [6]. Accurate and up-to-date population data is essential for accurate programming, monitoring and analysis in order to

improve the situation of the displaced [7]. Population data is often inaccurate and unreliable for security and political reasons, as well as the difficulty of accessing camps in conflict areas and the field nature that represents a major challenge during population influx [8]. Inaccurate data that leads to failure to document and neglect by governments and relief agencies increases the suffering of the displaced [9]. The comprehensive, easy-to-use and readily available GPS information about the area to be studied is useful in the decision-making process, especially in emergency planning and crisis management. Thanks to the development of GPS systems, these processes have been accelerated, made easier and processed more simply. The purpose of this information is to solve problems and facilitate the provision of services to those displaced families.

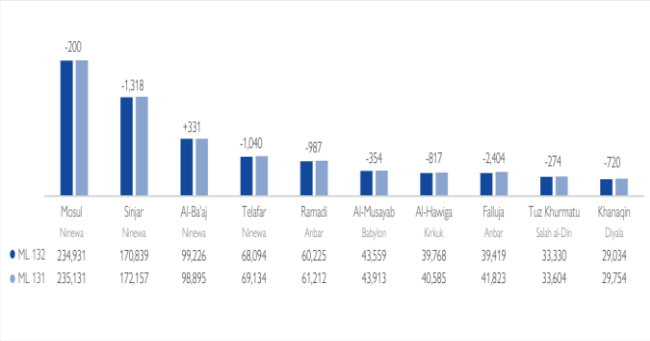


Fig. 1 Number of IDP districts of origin

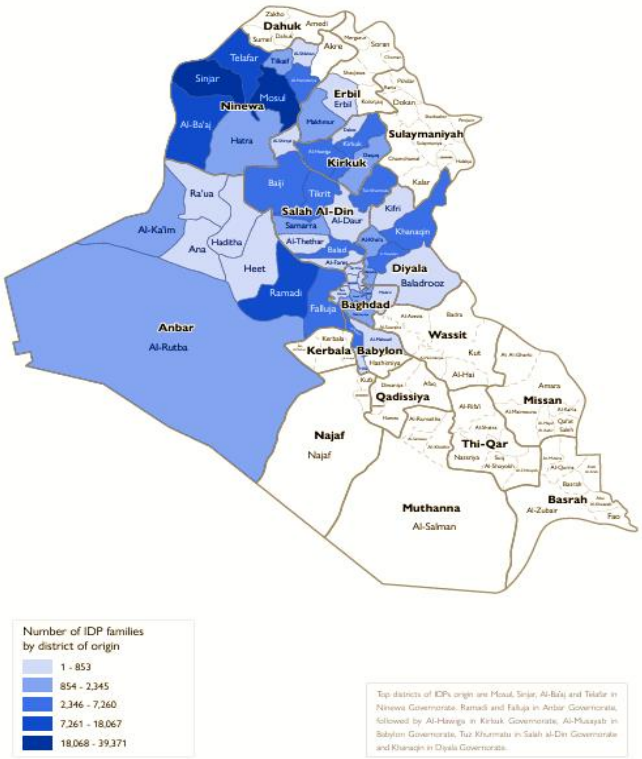


Fig. 2 Distribution of IDPs over Iraq governorates

More than half of the IDPs, or about (56%), are residents of Nineveh Governorate and from various districts and are also displaced from other governorates such as Anbar or Salah al-Din [10], as shown in Figure 1. There are many methods used to increase data security, the most famous of which is encryption, which is the process of changing the structure of the data that is to be sent to the other party in a way that is not understood except by the encryption key that rearranges the data to the original format. In this method, it is revealed to everyone that there is confidential information and is considered a clear challenge to anyone who can read the secret data. The other method is to hide the confidential data in a transmission medium, and the encrypted data is often in the form of digital data. Steganography is a method of hiding data in another digital medium in a way that is not visible to the public and is known only to the receiving party. In managing the data of the displacement crisis, the data in circulation is often textual, with digital records, correspondence, and text commands, so the data in digital format is hidden in a specific image using the steganography technique. Many of the displaced are distributed over large areas of the governorates in Iraq, and the displacement area is almost more than half of the area of Iraq. The displaced are concentrated in the northern and northwestern areas of Iraq [11], as is clear in Figure 2. Therefore, the transfer of data between the areas of the displaced, relief headquarters, and government headquarters is necessary to maintain the security of that data

There are many objectives that we aim to achieve in this study, including:

- Maintaining the security of crisis management data related to IDP and hiding it within a digital medium such as an image.
- Improve steganography by finding the large contrast between image pixels to embed secret data.
- Securing communication between government agencies, relief workers and humanitarian organizations and sharing data without raising suspicion.

We can state the problems and gaps related to this study as follows:

The humanitarian crisis in Iraq has displaced families from their homes to safer areas. For this reason, crisis management has created Internally Displaced Persons (IDPs). Therefore, the data provided by GIS is of paramount importance to aid relief efforts in alleviating the suffering of IDPs and tracking their movements. Such information about IDPs, camp locations, and their personal information is confidential and sensitive in nature, and if such information is leaked, it is vulnerable to malicious attacks and puts the lives of IDPs at risk. Traditional data protection methods have become common, so we need a second layer of protection to provide a security solution in such a high-risk environment. Securing such systems may open the door to promising solutions in this area.

2. Related Work

The number of internally displaced persons in Iraq has increased due to wars and internal conflicts, and it was necessary to find a management for these crises. Recently, there has been increasing attention between data security and crisis management for internally displaced persons [12]. The data generated by GIS is important, but the security of that data is equally important because key decisions are made based on accurate data. The importance comes from the sensitivity of the information and its relevance to the lives of the displaced. Accurate data analysis from GIS services helps improve services provided to displaced people and find solutions that serve displaced people and society in general [13]. Spatial data analysis is crucial in mapping crisis locations to varying degrees and according to priorities. A study on the use of GIS data to solve crises [14] confirmed the creation of a new model and a practical, applicable method for adopting geographic information to reduce risks, determine organizational priorities, and use external pressure and work professionals as an organizational factor for crisis management.

A study was conducted in Iran [15] on managing data from GIS for temporary relief organizations within 18 criteria to evaluate the optimal areas according to standard criteria, where incorrect management in the analysis leads to more catastrophic results than before and making a decision-making matrix according to the evaluation of the Preference Ordering Organization (PROMETHEE) for analysis and using the fuzzy triangle clustering method for weight and standard classification of the criteria for extracting the optimal areas with the integration of entropy and the multi-objective optimization Method Based on Ratio Analysis (MOORA) to prioritize places in the region. In the study [16], the distances were calculated for data transfer between relief centers and information transfer by traditional methods. Managing agricultural crises using GIS provides high accuracy and capabilities, especially in our time, as proven by the study [17], which adopted the method of monitoring and managing disasters that affect agricultural crops as a result of natural disasters and tracking rescue teams and managing the workflow according to priorities and predicting disasters with the aim of avoiding them as much as possible by drawing a map of the spatial situation and transferring information confidentially to preserve the sources. A study presented by [18] on the relationship of data confidentiality and its relationship with geographic information systems to mitigate natural disasters, remote sensing and data collection using drones to mitigate crises and manage them with modern technology. Data sent through many sites have been saved in smart ways, especially in medical disaster management [19], to alert health centres, save reports, classify reports and analyze data for correct prediction. A study on the Kingdom of Saudi Arabia to manage crises at airports during peak hours using a new integrated model of the Fuzzy Hierarchical Analysis Process and the affective Artificial Neural Network (FAHP-EANN) [20] They used a data security system to maintain the confidentiality of flights and prevent them from being tampered with from the outside. The Geo-AI approach was used with the help of satellites and geographic information systems to reduce flood disasters and displaced persons [21], and an approach was adopted to convert geographic information systems data into digital data to be processed through the Google Earth Engine (GEE) to identify flood patterns. Data integrity had a major impact on crisis management. In the study to recommend suitable sites for building dams to manage water shortage crises in India [22], data analysis technology and its security played an effective role. The study by the International Organization for Migration and Georgetown University examines the causes of displacement in Iraq and reaches permanent solutions to manage the displacement crisis and solve problems in disputed areas [23]. The analysis and study emphasized the role of relief organizations and ways to solve the displacement crises in Iraq by dividing the regions into sectors and taking GIS data, analyzing it, and projecting the information onto a map of Iraq in order to identify the governorates where the displaced are located and manage crises in them [24]. Forced displacement from Syria to Iraqi Kurdistan is considered one of the largest groups of displaced people in the Middle East, where data from GIS and statistical analysis were relied upon to prevent the displaced from remaining in difficult conditions with the unsafe situation in the areas through which they move [25]. After discussing previous studies related to GIS systems and securing data that work to manage displacement crises in general and in Iraq in particular, it is necessary to identify the method and importance of managing crises for the displaced, which we will explain in the next section.

2.1. Displacement Crisis Management

Displacement crisis management is concerned with supporting and caring for people forced to leave their homes due to conflict, natural disasters, or humanitarian crises. This management is a vital part of humanitarian response efforts. It aims to provide shelter, food, water, health services, and protection to displaced people and seek durable solutions to their situations.

The importance of displacement crisis management

1. The rights of the displaced are among the priorities of protecting the rights of the displaced, including decent living, safety and food aid. This can only be achieved through cooperation between organizations and local authorities.
2. Providing basic services: Crisis management requires providing basic services such as food, water, health care, and education. These services must be sustainable and meet the needs of displaced people in the short and long term.
3. Coordination between actors: Crisis management requires coordination between different actors, including local governments, international organizations, donors, and local communities. This coordination helps improve the

effectiveness of the response and avoid duplication or overlap between efforts.

4. Rapid and effective response: Crisis management needs to be able to respond quickly to emergencies through advance planning, resource allocation, and the ability to adapt to changing circumstances. This flexibility contributes to reducing suffering and increasing the effectiveness of humanitarian interventions.

2.2. Challenges Facing IDP Crisis Management

- The security of the data obtained from GIS and the process of its transfer between crisis management, government agencies and humanitarian organizations to prevent its leakage to unauthorized parties and avoid the exacerbation of crises.
- Lack of funding: Many crisis management efforts suffer from a lack of funding, which affects the ability of humanitarian organizations to provide the necessary assistance with the required speed and efficiency.
- Access to affected areas: Sometimes, conflicts or natural disasters hinder access to areas where IDPs live, making it more difficult to provide humanitarian support and assistance.
- Increasing and changing needs: The needs of IDPs are constantly changing, requiring crisis management actors to constantly adapt their strategies to meet these needs.
- Coordination and cooperation between partners: Although coordination is important, the multiplicity of actors and the diversity of their goals and interests can lead to complications and overlaps in the efforts being made.

2.3. Steganography as a Solution for Data Security

2.3.1. Definition of Steganography?

It is a technique for hiding digital data in a digital medium, such as an image, by embedding it within the data of the medium in a way that does not arouse suspicion [26]. It is not like encryption, which relies on the principle of mixing the data itself. Steganography works to hide secret data by embedding it in harmless data such as images [27]. In this case, the data is less susceptible to detection by intruders because the transfer file is not subject to doubt. The steganography structure consists of two sides: sender and receiver embedding occurs on the sender side while extracting on the receiver side, as shown in Figure 3.

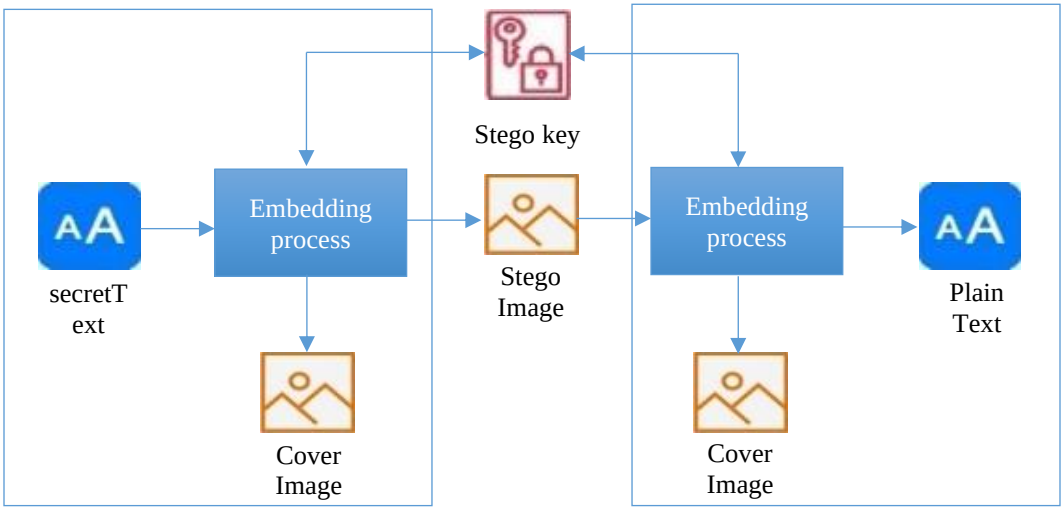


Fig. 3 Steganography structure

Steganography has types, including:

Images: It is more widespread, as confidential data is hidden within the components of the pixel image in a way that the human eye cannot notice.

Audio: The data is hidden in the modified sound wave in a way that cannot be distinguished from the original sound.

Text: The hidden data here is within certain patterns, such as spacing between letters or certain symbols within the same language.

Video: The video consists of a group of successive images that are embedded through those images, and discovering them is almost impossible.

2.4. Why do We Need Steganography in GIS Data?

Steganography is effective in securing GIS data in crisis management in order to:

1. Hide important and sensitive data in a way that does not arouse suspicion among adversaries, unlike encryption, which increases the possibility of attacks because it raises suspicion.
2. Integration with encryption so that steganography can be added as a second layer of security complementary to

encryption, so if the transmitting file is intercepted, it is difficult to hack it.
3. Reduced level of suspicion on the transmitted data, which reduces the possibility of suspicion of hidden data in images.
4. One of the advantages of good steganography is that no evidence or sign of the presence of confidential data appears.

In the following section, the proposed method will explain the reason for using steganography and how to secure information from GIS in crisis management to deal with it and find the best ways to enhance the security of displaced crises.

3. Proposed Method

In this section, we discuss the security of data from GIS, which is considered by the crisis management for internally displaced persons. Here, we use the steganography method to hide sensitive data, and we choose one of the media, which is images, as it is the most reliable and flexible. At the sending and receiving end of the data, the embedding process is done, and after sending it, the extraction process is done to separate the confidential data from the image; we have ensured the secure transmission of sensitive data.

3.1. First: Sensitive Data that Must be Hidden is Determined

The information obtained from GIS is numerous and of various types, most of which require confidentiality in movement and are considered sensitive. These types include:

1. Spatial data: These are geographical coordinates of internally displaced persons camps, which are very accurate, resource distribution points, covered areas, and evacuation routes.
2. Population data: These include statistics on the number of displaced people, their composition, and the obstacles within the camps.
3. Infrastructure data: These include data on health care, education, basic services, and sanitation for the displaced.
4. Logistics data: These are data related to scheduling aid, availability of supplies, and storage methods.

This data must be in a format that can be included effectively to not affect the quality of the transmission medium.

3.2. Second: Preparing the Carrier Media

The choice of the carrier medium is important here to be unobtrusive and to have the ability to transfer data easily. The following must be taken into account:

The carrier medium formats, as in our study, are images, and attention must be paid to the type of image (JPEG or PNG formats are widely used in maps and satellite images), its size, and its ability to be absorbed. The size of the file to be included must be compatible with the size of the carrier file to be absorbed. A high-resolution image is suitable for transferring a large amount of data. The file must be available without repeated compression and repeated editing in order to preserve the data it carries.

3.3. Third: Data Embedding

Embedding is done using steganography technology, which makes the data invisible to intruders. In the embedding process, the image is analyzed into its pixel components, and then the pixel value is analyzed into binary numbers consisting of 8 bits; the addition is often done in the Least Significant Bits (LSB) because the addition in this place has the least effect on the pixel value [28], which leads to an imperceptible change in the image as shown in Figure 4. The embedding process in steganography In the proposed method, the secret data (represented by the report and correspondence messages) is taken and converted to ASCII code and then converted to a series of binary bits.

Each bit of the secret data takes its position in one bit of the LSP of the image's pixel. In the traditional methods, the pixels of the image are selected in sequential order, and then the addition is made. This embedding is dangerous if the information is detected in the image; the secret data can be extracted easily. So, we choose a method of embedding that is difficult to detect, which is after randomly arranging the image pixels, we compare the variance in the scattered image pixels and whether they have a large variance (more than 50). We embed, but if not, we take the next pixel in the random sequence, repeat the process again, and so on. This method ensures that unauthorized people cannot extract data from the image. In this method, extracting data without the stego key is almost impossible. The general steps for the proposed method are illustrated in Figure 5. In order to enhance the effectiveness of steganography, some protocols must be followed, such as controlling access by only authorized specialists, especially GPS data. It is important to train a team on how to manage crises and regulate electronic data handling. It is important to monitor and audit the data and its output periodically to identify any weaknesses and strengthen them.

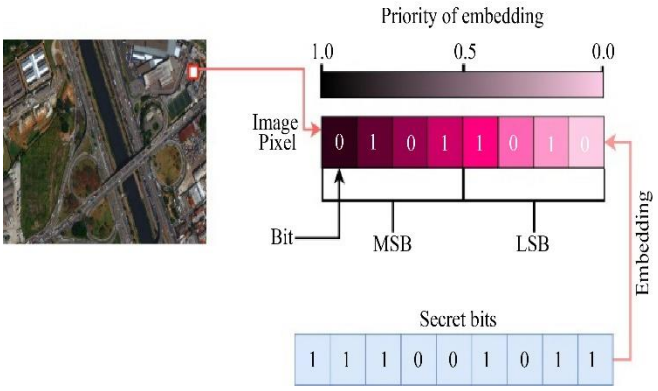


Fig. 4 Embedding in image pixel (LSB)

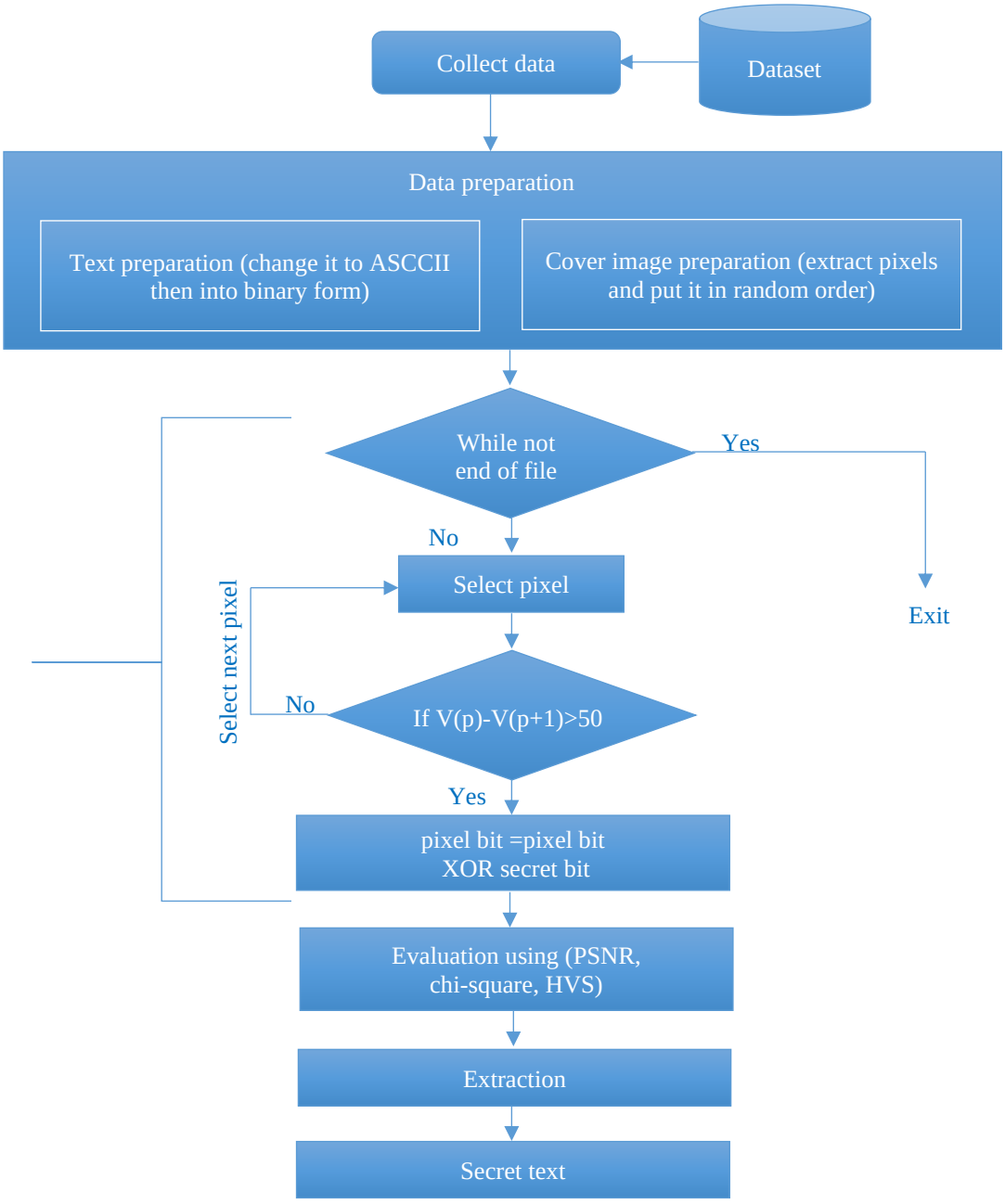


Fig. 5 General framework for embedding process within the proposed method

4. Result and Discussion

Crisis management data comes from GIS, and this data is mostly numbers and texts. After processing, it is transformed into reports and images sent between relief organizations and government centers. The research aims to hide sensitive secret data to ensure the safety of the displaced and prevent this data from being tampered with by unauthorized parties.

The sent image contains secret data, and preserving it is important and the image must be evaluated before sending it. The stego image can be evaluated according to several criteria, and these criteria will be mentioned in detail in this section.

The first criterion considered here is Peak Signal Noise Ratio (PSNR), which refers to the quality of the image after embedding data in it and can calculated as follows:

$$PSNR = 10.log_{10}\left(\frac{MAX_1^2}{MSE}\right) \quad (1)$$

Where MSE is Mean Square Error and can find it by:

$$MSE = \frac{1}{mn}\sum_{i=0}^{m-1}\sum_{j=0}^{n-1}[I(i,j) - K(i,j)]^2 \quad (2)$$

Where *MAX* is considered as the maximum pixel value of *m*, *n* dimensions image, *I* is an original image, *and K* is a noisy image.

PSNR value is negatively affected by MSE. When data is embedded in the image, the image starts to increase its PSNR value. The higher its value, the better, i.e., the image is of good quality even with the embedded secret data. Increasing the data loaded in the image leads to gradual image distortion, so traditional methods compete in the amount of data loaded into the image in multiple ways. The percentage of embedding varies from one method to another.

The percentage can be measured on a scale of 1/8. The method can be tested in multiple proportions and other ways, as in Table 1: The 6.25% ratio means the area of the image that will be exploited by the secret data, which is equal to 16384 bytes, so the PSNR increases as the embedding decreases and vice versa decreases with the increase in the amount of data embedded to the image because it increases the distortion of the image. As for the method followed has an effective effect, as the traditional methods that depend on LSB are easy to detect (79 dB) and expected by the PSNR equation. As for the increase in randomness in the distribution positively affects the value (90 dB), especially when applying the variable variance method, as the data is completely hidden. Therefore, the probability of inclusion plays an important role in changing the pixel value. This data was on a single image, so the image also plays an effective role in stating the result. The image with many changes in features is better than the image with the same color change. In common tests, you test on images from a standard dataset, and in this case, we have three types of embedding on four known standard images from a dataset called SEPI. The results were varied due to the change in the nature of the images. Figure 6 shows the test of the proposed algorithm in the different embedding ratios. The original image is exactly the same as the image (stego image) after the embedding, and this is the main purpose of stenography, as shown in Figure 7. When sending the image via any means of communication, its security cannot be guaranteed, especially in difficult circumstances such as the conditions of the displaced in Iraq; when the addition is made, a secure communication environment is very necessary. Through the proposed methodology, we can guarantee the required information without any device noticing that the sent image contains data.

Table 1. Imperceptibility of the proposed method using different payload capacities and different techniques

Capacity (Bytes)	Embedding Ratio	PSNR (dB)		
		Simple LSB Method	LSB with Random Distribution	The Proposed Method of Contrast Variation
16384	6.25%	76	79	90
32677	12.5%	63	71	83
49167	18.75%	60	65	76
65723	25%	51	59	62

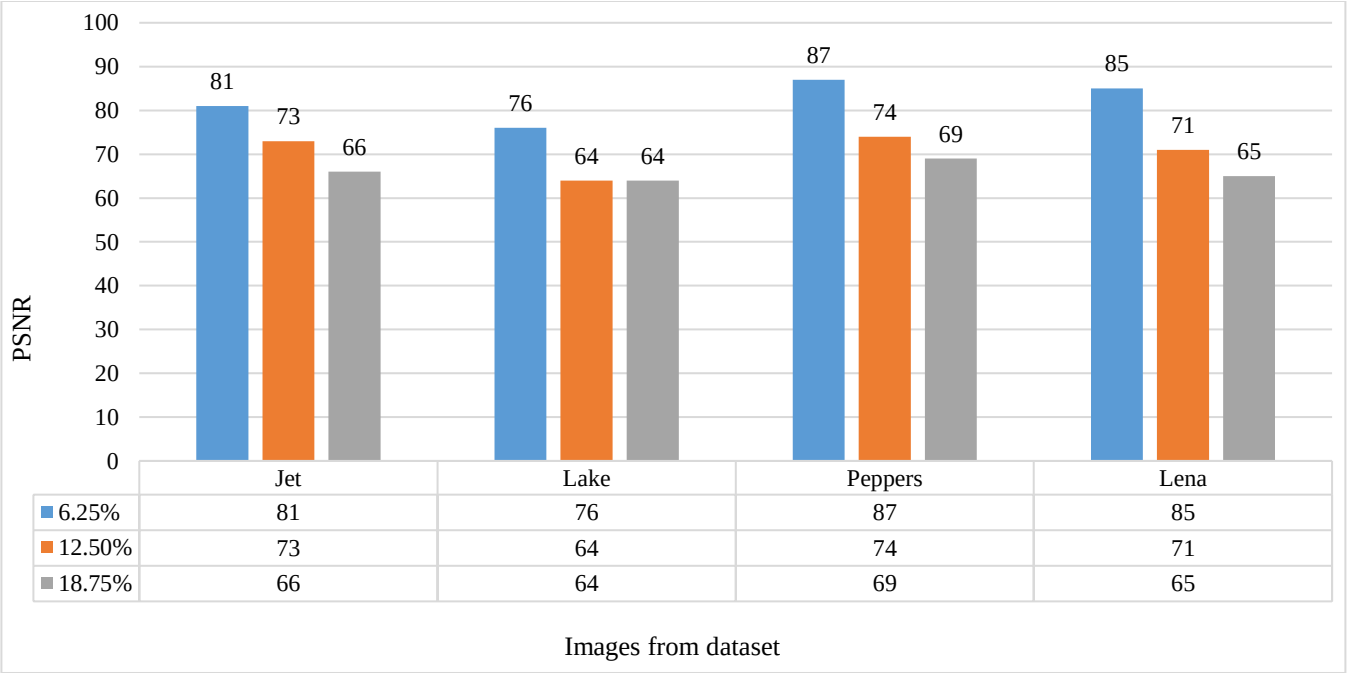


Fig. 6 Proposed method to test for different embedding ratios of different images from standard dataset.

Fig. 7 Original images vs. Stego images

4.1. Chi-Square Attack

Chi-square is a type of attack on data security transmitted through various media. It detects the probability of data inclusion in the image by checking the data frequencies in the LSB of the image pixels. In Figure 8, an image shows the original image before embedding, where the x-axis represents the percentage of the entire image, while the y-axis represents the probability of data inclusion in the image. We notice at the beginning of the image there is a probability of data addition, knowing that it is an original image that cannot include data because the pixels have similar frequencies in the language at the beginning of the letters, but when completing the rest of the letters represented by the pixel, the probability is completely correct. The embedding probability should not exceed 25% of the image; otherwise, the addition is exposed, and there is data, which is vulnerable to attack. The proposed method has proven its worth through the chi-square attack, as shown in Figure 9.

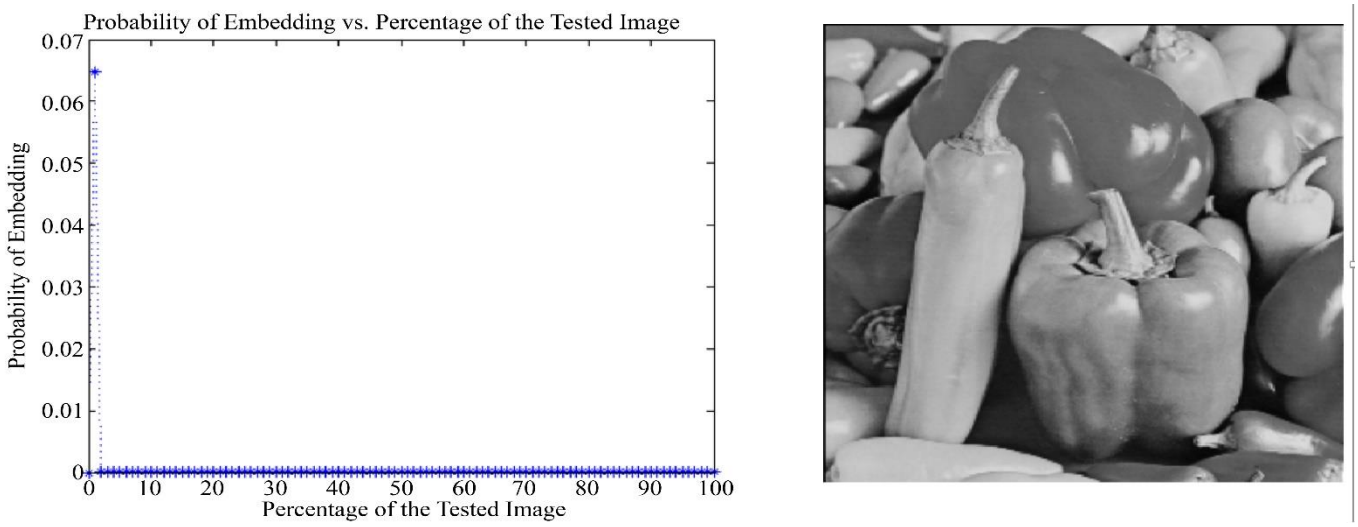
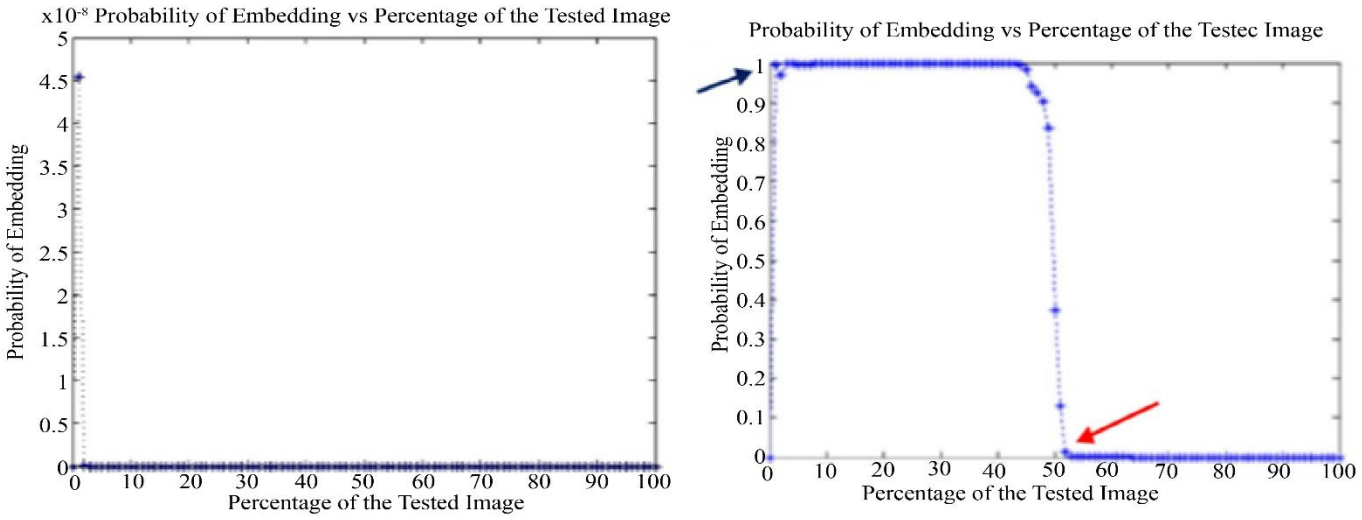


Fig. 8 Chi-square attached to the original image (peppers)



(a) **(b)**

Fig. 9 Chi-square attached on (a) Stego image with the proposed method, and (b) Simple LSB method.

With the proposed Figure 9(a), the embedding probability looks like the original image, contributing to the good method. With the simple LSB method, Figure 9(b), the embedding probability is very high, and clearly, the image has a secret.

5. Conclusion

Securing vital data is a priority in managing the crisis related to internally displaced persons in Iraq. This is done by protecting sensitive data obtained from GIS, especially in conflict-prone areas. Steganography technique via contrast-variation is used as a powerful solution to embed secret data within the image in an imperceptible way to the human eye. It works based on the contrast difference in density between adjacent pixels in the image to a certain extent that can be embedded without tampering with the external appearance of the image. The proposed methodology ensures that even if the transmitted data is intercepted and inspected, it is impossible to detect it, providing a high level of security beyond traditional encryption processes.

Important information such as the locations of displaced persons, population data, and resource distribution methods can be transmitted without raising any suspicion. Preventing cyber-attacks ensures the continuity and security of the crisis management process. The process of selecting pixels in the image and checking their data-carrying capacity increased the robustness and reliability of the system, and thus, the results obtained (PSNR = 90 dB) and (Chi-square probability < 1.7%) proved the worthiness of the proposed methodology.

5.1. Future work

Using contrast variation steganography to secure GIS data for crisis management in Iraq presents promising opportunities, but several areas warrant further exploration. First, the steganography algorithm can be developed using machine learning techniques to select the appropriate pixels for embedding.

The real-time data hiding can be worked on to manage the IDP crisis and be directly integrated with the GIS data. Adding blockchain technology can have an effective impact on increasing the security level of the data. The data resulting from managing the IDP crisis can be used for prediction using artificial intelligence, thus facilitating data security in advance, as it will be integrated with the GIS data.

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