



JOURNAL
OF SOFTWARE
ENGINEERING AND
APPLIED SCIENCES

Table 1.

Analysis of tools for detecting unauthorized changes to multimedia data based on the Markov chain model

Rustambek Melikuziev orcid: 0009-0004-4786-7928 e-mail: rustam.timur4323@gmail.com

Murodbek Melikuziev orcid: 0009-0004-4786-7928 e-mail: melikuziyevmurodbek7@gmail.com

¹University of Tashkent for Applied Sciences, Tashkent University of Humanities,
Tashkent, 100149, Uzbekistan

²Tashkent University of Information Technologies named after Muhammad al-Khwarizmi,
Tashkent, 100095, Uzbekistan

https://doi.org/10.5281/zenodo.15177219

Abstract: This article analyzes methods for detecting unauthorized changes to multimedia data based on the Markov chain model and related problems. The article discusses the application of the Markov chain model for determining manipulations with multimedia materials, especially with images and videos. It analyzes how the Markov chain model's capabilities are particularly effective in detecting unauthorized changes in images, developing its algorithms, and detecting manipulations using them. The article will also discuss the main difficulties and problems that arise in the analysis of multimedia data, as well as the advantages and limitations of tools for fast and effective analysis of various volumes of material. This article focuses on the application of the Markov chain model and its importance in the field of digital vocabulary in detecting manipulation of multimedia materials.

Keywords: Markov chain model, multimedia data, unauthorized modification, manipulation detection, digital vocabulary, image manipulation, video analysis, document analysis, statistical analysis, analysis algorithms, signal analysis, network tools, network sharing, cybersecurity, analysis methods, multimedia analysis tools, deep fake technologies, cyber fraud, network security, security management, image and video editing, manipulation detection, document storage, multimedia analysis tools.

1 Introduction

Digital forensics and multimedia data manipulation have become a serious threat and threat in recent years[1]. The increase in the number of crimes related to image manipulation between 2020 and 2024 shows that the number of crimes related to image manipulation is increasing from year to year. This has further increased the need and need for this area(table 1).

Image manipulation is not only a technical problem, but also causes social and legal problems. These types of crimes often involve personal rights violations, reputational damage, and even fraud. Altered images, false information and their illegal distribution can lead to attacks on the privacy of citizens, which will lead to serious material and moral damage.

Digital forensic field manipulation of multimedia data associated with crime statistics.

Years	image manipulation , the number of crimes associated with	the mobile device, the manipulation of the number of crimes related to	online scams , the number of crimes related to the
2020	1500	3000	5000
2021	1800	3500	6000
2022	2000	4000	7000
2023	2300	4500	7500
2024	2500	5000	8000

This problem requires the development of special software tools for detecting and investigating digital forms, especially image manipulation. For example, tools such as EnCase Forensic, FTK (Forensic Toolkit), X1

Social Discovery, and PhotoDNA can effectively help you analyze digital evidence. Programs like PhotoDNA are most effective at detecting image manipulation, providing a high level of accuracy when quickly detecting manipulated images.

Along with the increase in the number of crimes, the size of their economic and social damage also increases[2]. In 2020, approximately US \$ 500,000 in damages were incurred as a result of crimes related to image manipulation, and by 2024, this damage reached US \$ 800,000(Figure 1). This indicates the need for knowledge and resources in the areas of numbers, image manipulation, and digital forensics. Thus, the effective fight against manipulation of digital and multimedia information, as well as the introduction of advanced technologies to prevent and investigate such crimes, are urgent problems. To reduce threats to data security and personal rights, Forensic analysis methods should be further developed(Figure 1).

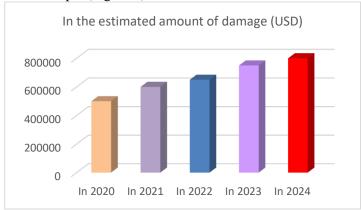


Figure 1. Diagram of the amount of damage caused by crimes committed by manipulating multimedia data.

2 Identifying Image Manipulation in Markov Chain Models

In the field of digital forensics, there are several software tools for detecting image manipulation, analyzing documents, and performing other formal analyses in the Markov chain model. The following software tools are widely used in forensic science and digital science:

1. EnCase Forensic is a very popular and widely used program in the digital economy. It is mainly useful for analyzing digital evidence, recovering files stored on a computer, examining the file system, and analyzing images. EnCase also helps you detect manipulations, such as changes to file systems, and recovery of deleted or hidden files. Another useful feature of EnCase is the ability to automatically analyze documents and images, which helps Forensic professionals quickly view large amounts of data. This digital data processing application is considered an ideal tool for storing, analyzing, and detecting errors in documents (Figure 2).

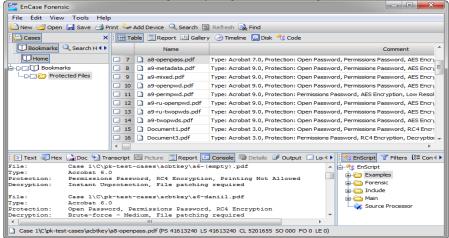


Figure 2. Overview of the EnCase Forensic software tool used for analyzing multimedia documents and images.

2. FTK (Forensic Toolkit) is another important tool widely used in Forensic digital analysis. The FTC mainly works effectively for disk analysis, file recovery, and detection of manipulated or hidden data. This program is especially useful for creating detailed reports on the analyzed data and quickly scanning a large number of files. FTK allows users to recover deleted files, especially data in various formats such as images and documents. It alsoworks as a powerful tool for detecting changes and manipulations performed on files, which

plays an important role in Forensic research. The FTK interface is also intuitive and allows users to quickly analyze data(Figure 3).

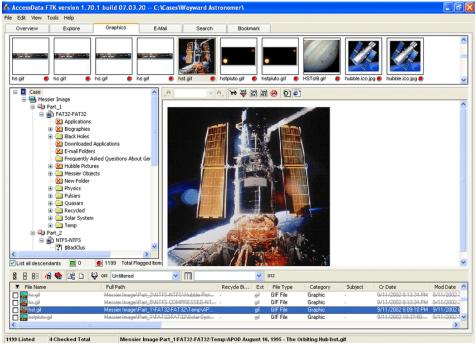


Figure 3. Overview of the FTK (Forensic Toolkit) software tool used to detect manipulated or hidden information.

3. X1 Social Discovery - is a software tool designed to collect and analyze information from social networks and web pages. It is also used incriminology, including the study of images and documents. The app allows you to track and analyze all social media activity, including changed or deleted messages, messages, and user profiles. The software, in particular, is used by law enforcement agencies and digital specialists to identify facts related to user actions and information in social networks. In addition, X1 Social Discovery allows you to quickly and efficiently index files, detect changes, search through posts and messages, and create reports on collected data. This program is known for its high efficiency and accurate results when analyzing social networks and online resources(Figure 4).

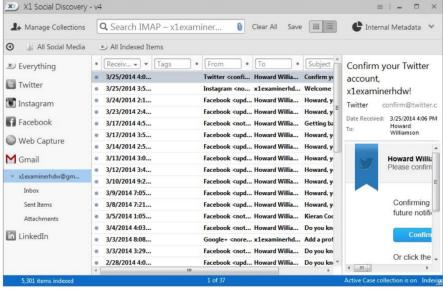


Figure 4. Overview of the X1 Social Discovery software tool used to detect social networks and data changes in online resources.

4. Cellebrite UFED (Universal Forensic Extraction Device) is a powerful Forensic tool widely used for extracting and analyzing data from mobile devices and other digital devices. This app is specifically designed to recover and analyze data from mobile devices (smartphones, tablets, SIM cards, SD cards, and other mobile devices). With Cellbrite UFED, you can restore and analyze images, messages, calls, contacts, geolocation data, and various other data stored on your phones. It also allows you to access data by restoring deleted data, locking security on devices, or cracking passwords (if possible). These features are particularly important for law

enforcement agencies and digital security professionals. Cellbrite UFED provides the ability to get complete and detailed information from mobile devices, helping to identify not only images and messages, but also other important information stored on devices(Figure 5).



Figure 5. Overview of the cellbrite UFED hardware and software tool used for checking images, messages, and other mobile data.

5. PhotoDNA — is a special software tool designed for image identification and manipulation detection. It was originally developed by Microsoft and is currently used by social media, police, and other law enforcement agencies. The main goal is to identify crimes related to child exploitation or pornography, as well as to check cases of manipulation or modification of images and videos[8]. PhotoDNA compares images with a digital "signature". This signature takes into account the features of the image (such as colors, textures, and shapes) and assigns each image a unique identification number. PhotoDNA then compares this number with a global image database and quickly identifies similar images. This software tool is also effective for detecting manipulated or altered images, which means that if the original image identification number has changed, the image shows that it has been manipulated. This tool is mainly useful for detecting content associated with a file exploit and for combating the distribution or retention of such images[9]. PhotoDNA is used by many online platforms and law enforcement agencies because it scans large images very efficiently and quickly to help identify violations. In addition, PhotoDNA provides personal information and personal security, since it only works with images and their digital "signatures", which means that the original images will not be changed or personal data will not be damaged(Figure 6).



Figure 6. Mechanism of operation of the PhotoDNA software tool.

3 Analysis of tools for video and image manipulation detection

The software tools used in forensics and digital science cover a wide range of needs, from detecting image manipulation to extracting data from mobile devices and analyzing documents. These tools are effectively used to investigate crimes, examine digital evidence, and detect manipulated images.

An analysis of the capabilities and effectiveness of the above tools is given in Table 2 [10,11]:

Table 2.

Analysis of tools for detecting unauthorized changes to multimedia data based on the Markov chain model

Software tool	usage scale	speed	efficiency
---------------	----------------	-------	------------

EnCase Forensic	more than	95% fast and efficient image and	90% detection of
Encase Forensic	80%	file analysis	manipulated
FTK files (Forensic	80%	change detection at 60% speed	85% detection of file system
Toolkit)			manipulation
X1 Social Discovery	more than	90% detection of modified social	80% recover modified social
A1 Social Discovery	70%	media posts	media data
Cellebrite UFED	75%	detect images and messages from	95% recover deleted
Cellebrite OFED		mobile devices at 85% speed	
PhotoDNA data	over 90%	detect processed images 95%	identify images and detect
r ilotoDNA data			manipulation 98%

The number of crimes related to digital forensics and changing multimedia data has increased significantly in recent years. Along with the increase in the number of crimes, the effectiveness of software tools used to detect image manipulation and digital manipulation is important, while tools such as EnCase Forensic, FTK, PhotoDNA are highly effective in detecting manipulation of images and documents. These tools effectively help not only in detecting crimes, but also in combating them.

4 Conclusion

As of 2020, accurate data on the number of crimes and strategies to combat them are collected using image manipulation and digital manipulation detection tools. At the same time, technologies and methodologies used in the field of digital analytics have been rapidly developing in recent years and are becoming increasingly relevant in analyzing data from social networks, mobile devices, and other digital sources. This, in turn, provides more effective approaches to combating digital crimes and their consequences.

To prevent and combat cybercrime, it is important to promote innovation in the digital economy and choose the right software tools. In addition, through the analysis of social networks, mobile devices and other digital resources, the ability to detect and prevent the latest crime trends is increasing. This will be an important factor in the efficient use of data and technology, reducing crime growth, and fighting crime.

Reference

- 1. https://www.fbi.govhttps://www.microsoft.com/en-us/security/blog/2020/10/05/photodna-impacting-cyber-crime-and-child-exploitation-with-advanced-technology/).
- 2. https://www.europol.europa.eu.
- 3. V. Oppenheim, R. W. Schafer," Discrete-time Signal Processing", Boston, Massachusetts, USA, 2010, ISBN: 978-0131988421, P. 45-96.
- 4. P. L. Wei, H. H. Li," Multimedia steganography and its analysis", China, 2020, P. 30-45.
- 5. John G. Proakis, Dimitris G. Manolakis, "digital Signal Processing: Principles, Algorithms, and Applications", India, 2014, ISBN: 978-0133750366, P. 200-300.
- 6. Sanjay Sharma," digital Signal Processing: Theory and Practice", New Delhi, India, 2014, ISBN: 978-1107067345, P. 161-218.
- 7. Saeed V. Vaseghi, S. Xie, Advanced Digital Signal Processing and Noise Reduction, Beijing, China, 2011, ISBN: 978-0470661380, P. 45-88.
- 8. Rafael C. Gonzalez, Richard E. Woods, digital Image Processing, Boston, 2017, ISBN: 978-0133356724, P. 155-244.
- 9. R. K. S. Kamaraju, S. S. Prabhakar," detection and mitigation of steganographic attacks", India, 2022, P. 210-225.
- 10.Nihad A. Hassan," Digital Forensics and Cyber Crime", Cham, Germany, 2016, ISBN: 978-3-319-46988-4, P. 33-42.
- 11. Eoghan Casey," Handbook of Digital Forensics and Investigation " Eoghan Casey, Amsterdam, Netherlands, 2011, ISBN: 978-0-12-374266-3, P. 117-128.