GAP INDIAN JOURNAL
OF FORENSICS AND BEHAVIOURAL SCIENCES
(ISSN – 2582-8177)
Globally peer-reviewed and open access journal.

ARTIFICIAL INTELLIGENCE AND SATELLITE IMAGERY: PAVING THE WAY FOR FORENSIC INVESTIGATIONS

Arun Kumar Shukla, Dr. Kapil Kumar

Department of Biochemistry and Forensic Science, University School of Sciences,
Gujarat University, Ahmedabad-380009 (INDIA)
arun_shukla32@yahoo.com

Department of Biochemistry and Forensic Science, University School of Sciences,
Gujarat University, Ahmedabad-380009 (INDIA)
kkforensic@gmail.com

Abstract

Artificial Intelligence (AI) is an indispensable and vital area of modern computer science that can often provide a means of tackling computationally significant problems in a realistic time frame. This area is becoming part and parcel of computing, and it requires the training of machines for the intelligent analysis of large amounts of complex data. Therefore, it is evident that AI is an ideal approach to dealing with many of the problems in forensic science related to the cyber world. On the other hand, Satellite Imagery is becoming crucial as a source of data in many cases. It can even provide real-time information of any location in the world. Hence, this data, otherwise junk, can be converted into a vital source of information that can be accessed on a need-to-know basis.

This paper explores applications of Artificial Intelligence and Satellite Imagery for Forensic Investigations through digital image processing. An attempt has been made to extract information from satellite images using artificial intelligence in different domains of Forensic Science. Additionally, this kind of application paves the way for solving various mysteries of the world. Undoubtedly, Artificial Intelligence and Satellite Imagery are great tools in processing information to manage different spheres.

Keywords: *Artificial Intelligence, Satellite Imagery, Forensic Investigations, Digital Image Processing.*

INTRODUCTION

Artificial Intelligence (AI) is an emerging but very potent tool that is currently being applied to almost all areas of science. It is an important area of modern computer science that can often tackle computationally large or complex problems in a realistic time frame. Since cyber forensics is becoming increasingly important due to the evolution of digital space, there is a need to compute and analyze large amounts of complex data. Many of the current problems in forensic investigations can be solved with application of AI [1].

A large number of images from satellites are available across the world. At present, we can get good resolution and color images from satellites. Cost-effectiveness has also been achieved because many satellites have been launched in space by many countries worldwide. Satellite Images can provide real-time information as well. Image processing is an essential feature of Artificial Intelligence to extract the desired information. As the quality and resolution of satellite images will improve, we will be able to solve many problems in forensic science that are presently a 'Mystery.'

ARTIFICIAL INTELLIGENCE

The idea of inanimate objects coming to life as intelligent beings have been around for a long time. Nevertheless, the beginnings of modern AI can be traced to classical philosophers' attempts to describe human thinking as a symbolic system. John McCarthy gave the term "Artificial Intelligence" in 1956 at a conference at Dartmouth College in Hanover, New Hampshire. First decades of the 21st century witnessed maximum growth in Artificial Intelligence (AI) when it was successfully used for solving many problems in the fields of academia and industry. It was subsequently applied in the application of powerful computer hardware, and also in the collection of big data sets [2].

Artificial intelligence is not human intelligence, but it can be like human thinking and may exceed human intelligence. Since the birth of artificial intelligence, theory and technology have become more and more mature, and the application fields have been expanding. AI has various elements through which the problem solving is carried out effectively based on its scope and complexity. Machine Learning (ML), which is the first step in AI, provides algorithms and training toolkits. It can be viewed as a system that can learn from experience and examples rather than from programming. Deep Learning (DL) combines techniques used to implement Machine

GAP INDIAN JOURNAL
OF FORENSICS AND BEHAVIOURAL SCIENCES
(ISSN – 2582-8177)
Globally peer-reviewed and open access journal.

Learning methods to recognize patterns such as image recognition. First of all, the system identifies the object edges, the structure of the object, object type, and then the object itself. Deep learning attempts to mimic the area of the human brain where thinking occurs [3].

A number of other methods in AI such as Natural Language Processing (NLP), Text Analytics, Biometrics, Robot Process Automation, Natural Language Generation, Speech Recognition, Virtual Agent, etc. are being applied for problem solving in the fields of security, fraud detection, access control, IVRs, Surveillance and data mining. The efficiency of these applications can be enhanced by Artificial Neural Network (ANN) which is an equivalent system as human neurons for decision support system [4].

However, with minimal use of machine learning and deep learning, the details from digital data and images can be extracted for valuable information.

SATELLITE IMAGERY

The first photography of the earth's surface was carried out by the Explorer II balloon mission in 1935 from 13.7 miles (22 km). The famous Blue Marble photograph of Earth was taken from space in 1972 . Before 1972, satellites were not designed to study or monitor the earth's surface. These were mainly used for military purpose [5]. In 1977, for the first time, the real-time satellite imagery was acquired by the United States KH-11 satellite system. Satellite Imagery was commercialized in 1984 but faced many funding issues. However, in the early 21st-century, satellite imagery became widely available and affordable with easy to use software. Apart from the government agencies, various private companies providing commercial satellite imagery [6].

Satellites are essentially the eyes in the sky. The satellite images are observed as fact. There is no coincidental for error, satellite images deliver data that can be interpreted "first-hand." Perceptible satellite images are equivalent to taking a picture with a regular camera [7]. For this reason, these images are only helpful when the sun is shining on the area to be photographed. There are several sources such as Google Earth, Remote Pixel, NASA earth data search, Sentinel Hub, etc. to get satellite imagery. Out of all these, Not only does Google Earth provide higher resolution satellite imagery at a much higher zoom rate, but it also lets us swivel the camera perspective, view how the location has changed over a timeline, and land down to the ground level to view the landscape topography of an area.

SCOPE

This work was carried out into three blocks, i.e., research, determination of programming software, and feature extraction from processed images for change detection. The focal area of the research was to study the capabilities of AI to enable the extraction of features from images [8].

The second block was to find a suitable programming software for the relatively complex satellite imagery processing due to the seldom availability of apparent contrasting features with a background [9]. Here MATLAB programming software has been used due to its inherent advantages over other programming softwares. With the help of MATLAB, it was possible to carry out image processing with lesser possibility of errors [10].

Because of the high dimensionality of the image data, it is complex and inefficient for the computer to learn from the raw data directly. The effect of collinearity as input variables and the presence of noise degrades the performance of the algorithms to a great extent [11]. Hence, before arriving at a specific image processing technique, all types of image manipulation have been carried out, and discriminative features have been chosen carefully from the input data [12].

This study is focussed on incremental change in historical satellite images of the same altitude, latitude, longitude, and resolution over 15- 20 years [13]. Some issues related to national importance have been covered. Based on these prerequisites, the study of two distinct scenarios from environmental forensics and homeland security has been carried out to prove the relevance of the work.

Scenario-1: Environmental forensics (Deforestation around Nalsarovar bird sanctuary);
Nalsarovar is a famous bird sanctuary in Gujarat. It is a natural lake surrounded by a muddy lagoon and forested area. Green cover in forested areas around Nalsarovar is on the decline. It can be attributed to the illegal cutting of trees and a deforestation trend over the years. An attempt has been made to find out approximate decrease in the forested area over a period of 18 years.

GAP INDIAN JOURNAL
OF FORENSICS AND BEHAVIOURAL SCIENCES
(ISSN – 2582-8177)
Globally peer-reviewed and open access journal.

Scenario-2: Homeland security (Growing Settlements near IB along Tawi river in Jammu);
Jammu, which is a district in J&K state, is situated on the banks of the Tawi river, which flows east to west, and enters Pakistan and further confluences with Chenab. Settlement of migrant Bakarwals (sheepherders) on the banks of the Tawi river near IB has grown over the years. It poses a critical threat to the security of the region due to more accessible options for infiltration.

RESULTS

Digital Image Processing has been used to convert satellite images into digital format and perform operations to improve or extract useful information. It is a collection of functions that extends the MATLAB numeric computing environment [14].

Scenario-1
Images of approximately 200 square km area around Nalsarovar (including the lake) have been stored in the database. Stretch of forest cover around Nalsarovar in May 2002 vis-à-vis January 2020 has compared. One image of each of these two periods has been compared in MATLAB. Along both axes, the values at different places keeping a single reference have been calculated. One image each of May 2002 and January 2020 has been shown here as part of the report. The images have been manipulated by utilising features of MATLAB.

Figure 1: Original image 'nls1' (May 2002)
(Source: Google Earth)

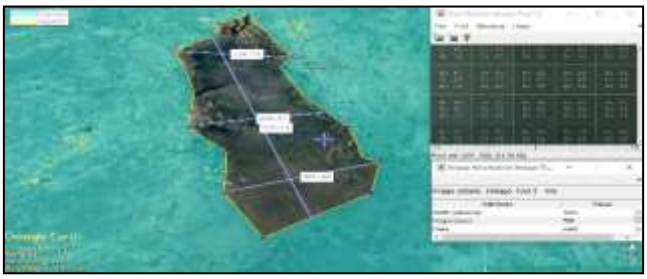

Figure 2: Manipulated image 'nls1_rgb'
(Source: MATLAB simulation)

In the next step, the balance area has been masked by image masking. The stretch of the green cover along the horizontal and vertical axis is marked, measured, and tabulated values [15].

Figure 3: Original image 'nls2' (Jan 2020)
(Source: Google Earth)

GAP INDIAN JOURNAL
OF FORENSICS AND BEHAVIOURAL SCIENCES
(ISSN – 2582-8177)
Globally peer-reviewed and open access journal.

Figure 4: Manipulated image 'nls2_rgb'
(Source: MATLAB simulation)

Table 1 shows the difference in the green cover in both images. The difference in negative quantity represents a size reduction compared to an image taken in May 2002 and January 2020. It represents a deforestation trend. The difference along the horizontal axis is lesser in comparison to the difference along the vertical axis [16].

Image portion	Image 'nls2' (Jan 2020)	Image 'nls1' (May 2002)	Difference
Longitudinal main axis	447.57	528.14	- 80.57
Horizontal top axis	189.11	238.76	- 49.65
Horizontal middle axis	229.79	264.07	- 34.28
Horizontal lower axis	284.49	305.66	- 21.17

Table 1: Reduction in the green cover
(Source: MATLAB data from figure 2 and figure 4)

Scenario-2

50 images of a 9 square km area near IB around Tawi River have been downloaded year-wise, and a database has been created. The region has been kept the same, and images from August 2004 to January 2020 have been stored. Expansion of villages and new houses constructed away from the main village in August 2004 vis-à-vis structures built up to January 2020 has been compared. One image each from August 2004 and January 2020 has been compared in MATLAB to check new artificial features. The analysis has been carried out by the differentiation method [17].

Figure 5: Original image 'jam1' (Jan 2020)
(Source: Google Earth)

Figure 6: Original image 'jam2' (Aug 2004)
(Source: Google Earth)

Before applying and filtering images, a test for correlation between images needs to be carried out to check the similarity between image backgrounds. Subsequently, it helps us to reduce errors occurring due to noise [18].

GAP INDIAN JOURNAL
OF FORENSICS AND BEHAVIOURAL SCIENCES
(ISSN – 2582-8177)
Globally peer-reviewed and open access journal.

Figure 7: Differentiated image 'jam_diff'
(Source: MATLAB simulation)

From the image processing of the above-mentioned raw images, we have reached a point where one can separate the desired features in the images. The additional features are the resultant of the differentiated image [19]. One can apply similar conditions in various image processing problems that we encounter in our daily lives in various related fields of study.

CONCLUSION

Desired features for identification need to be made visible against the background; hence image enhancement has to be carried out. Filtering processes remain achieved only in a small part of an image, mentioned as the region of interest (ROI), which is specified by defining a cover that limits the portion of the image in which the process will occur [20]. The image quality has to be brought up to the quality level at which the feature extraction is more straightforward, and the chances of error are more diminutive. Edge extraction or edge detection need to be applied to separate objects from one another before identifying their contents. Once the relevant objects have been segmented and labeled, their relevant features are extracted and used to classify, compare, cluster, or recognize desired objects [21]. The final corroboration of these forensic investigaton results is done on ground.

Each object-detection subsystem consists of three processing stages: the condition check, the calculation of new specialized features, and the recognition judgment. Specialized feature-extraction programs can also be applied to the selected regions to judge whether or not they are the objects to be located. Feature extraction in the differentiation method in the study is based on the change measurement with the complete dependency on the image processing capability of the software. There is a possibility of error in a scenario where there is a corresponding spatial change in the features present on images. From several iterations, possible error has been reduced [22].

FORENSIC SIGNIFICANCE

One must appreciate that the scope of AI and Satellite Imagery in the field of Forensic Investigations is limitless. It is not only useful for crime detection but also for crime prevention. It is very useful in upgradation from conventional methods to more scientific methods of Forensic investigations [23]. This study after refinement should be able to support forensic techniques already in practice and discuss their merits so that a user can decide which technique, or combination of techniques, is most appropriate for solving of a case [24].

Study of satellite imagery of various regions can provide the details of mass disaster sites that have seen the wrath of natural disaster like flood, earthquake, tsunami, volcano eruption, etc. [25]. AI based systems can be used to make best use of 3D GIS technology incorporated in satellite images. This technology significantly reduces the cognition effort needed to interpret the situation and improves the efficiency of the decision making process.

Wildlife crime around the world is on the rise. Though many governments have banned poaching and hunting as sports, still a lot needs to be done on this arena. High resolution satellite imagery can provide up-to-date geospatial data and by use of neural networks processing, reliable statistics can be obtained for monitoring wildlife migrations, habitat mapping and tracking endangered species in remote areas of the world [26].

This study is also useful in locating the outdoor crime scenes which may involve crimes such as mass killing incidents, vehicular crimes, major road and rail incidents, etc [27]. The satellite imagery interpretation is a very potent tool to map even a terror attack site instead of hand-drawn sketches or photographs that probe agencies across the country use to depict a crime scene.

Opportunistic land encroachment is most common for common land, riverside areas, and forest land. To prevent heavy loss of these resources, its monitoring through AI resources and full enforcement must be the rule rather

than the exception. The study is useful in monitoring and forensic analysis carried out to find the portion of land encroachment [28].

In the field of Forensic epidemiology, GIS enabled satellite image data backed up with AI can provide useful information for detection and management of both human and animal diseases outbreaks [29]. The satellite surveillance can be used for monitoring of several environmental factors such as temperature, humidity, wind speed, precipitation, and direction etc. that influences the activity of pathogens, vectors and how their interaction affects human and animal hosts.

Satellite imagery processing with artificial intelligence can be used in identification of various important aspects of life which have been buried under the ground. These can be mass graves, clandestine graves, desert resources, oil spills on sea water or any other thing of historic value. The land, water or air features showing distinction from surroundings can be easily picked by the image processing tool and generate enough evidence for further investigations [30].

This study is also useful for other forensic science related applications which have not been covered in previous sections. It will definitely find a place in the field of forensic anthropology, forensic geophysics, forensic pedology, forensic oceanography, forensic chemistry and others. Satellite images of Infra-red and Microwave ranges taken with Ground Penetrating Radars (GPR) fitted on satellites are useful in forensic hydrology and investigations requiring details of under foliage in forensic ecology [31]. Apart from forensic investigations, the study can be useful in interdisciplinary fields such as homeland security and disaster management.

In the domain of forensic science, the digital images and videos play a significant role in determining fingerprints, identifying criminals and understanding crime scenes. However, due to the presence of a large amount of visual data, the creation of tools to manage or categorize this data have an exceptional importance. The answer to this is an object detection system working in real-time [32].

ACKNOWLEDGMENT

We are thankful to research fellows in the Forensic Science Dept at Gujarat University for their support and discussion towards completing the work.

REFERENCES

[1] D. F. Mitchell, "The use of Artificial Intelligence in digital forensics: An introduction," Digital Evidence and Electronic Signature Law Review, vol. 1, p. 8, 2014.
[2] Chetan Kumar GN, "Artificial Intelligence: Definition, Types, Examples, Technologies," 31 Aug 2018. [Online]. Available: www.medium.com.
[3] J. Liebowitz, "Knowledge management and its link to artificial intelligence,"Expert Systems with Applications,vol.20, no.1,Jan 2001.
[4] Michelle AJ, "Digital Forensics is Ready for its Most Recent Challenge: IoT Forensics," 01 July 2021. [Online]. Available: www. haniahshafi.medium.com.
[5] Shawn Milrad, "Satellite Imagery," in Synoptic Analysis and Forecasting, 2018
[6] K. A. Kelly, "NOAA GOES and POES Satellite," in Satellite Direct Readout Conference, 2004, Dec 06.
[7] M. N. Matsuyama, "A Structural Analysis of Complex Aerial Photographs," Proceedings of the 6th international joint conference on Artificial intelligence, vol. 2, pp. 610-616, Aug 1979.
[8] Hemant D. Tagare, "Medical Image Databases : A Content-based Retrieval Approach," journal of the American Medical Informatics Association, vol. 4, no. 3, pp. 184-198, 1997.
[9] D. A. Maini, "Image Processing Using MATLAB: Basic Operations," 14 March 2019. [Online]. Available: https://www.electronicsforu.com/electronic.
[10] Anonymous, "Image Processing Toolbox," 2020. [Online]. Available: https://in.mathworks.com/products/image.html.
[11] R. W. Rafael C. Gonzalez, "Digital Image Processing," Prentice Hall, 2002, p. 793.
[12] Anonymous, "Process digital images with computer algorithms," [Online]. Available: https://in.mathworks.com/discovery.html.
[13] Mahmut Sinecen, "Digital Image Processing with MATLAB," in Applications in Engineering with MATLAB Concepts, July 2016.
[14] Abdullah, W. Palash, A. Rahman, K. Islam, and A. Alim, "Digital image processing analysis using Matlab, " American Journal of Engineering Research (AJER), vol. 5, no. 12, pp. 2320-0936, 2016.
[15] Abdulrahman and S. Varol, "A Review of Image Segmentation Using MATLAB Environment," 2020 8th International Symposium on Digital Forensics and Security (ISDFS), 2020, pp. 1-5, doi: 10.1109/ISDFS49300.2020.9116191

[16] P. S. Duth and M. M. Deepa, "Color Detection in RGB-modeled Images using MATLAB," International Journal of Engineering & Technology, vol. 7, no. 7, pp. 29-33, May 2018, doi: 10.14419/ijet.v7i2.31.13391.
[17] G. A. Kumar and A. Kusagur, "Evaluation of image denoising techniques a performance perspective," 2016 International Conference on Signal Processing, Communication, Power and Embedded System (SCOPES), 2016, pp. 1836-1839, doi: 10.1109/SCOPES.2016.7955762.
[18] Y. C. Samarawickrama and C. D. Wickramasinghe, "Matlab based automated surface defect detection system for ceremic tiles using image processing," 2017 6th National Conference on Technology and Management (NCTM), 2017, pp. 34-39, doi: 10.1109/NCTM.2017.7872824.
[19] M. I. Ashqer and M. Bikdash, "Parking Lot Space Detection Based on Image Processing," 2019 SoutheastCon, 2019, pp. 1-6, doi: 10.1109/SoutheastCon42311.2019.9020584.
[20] Anonymous, "ROI based processing," 2020. [Online]. Available: https://in.mathworks.com/products/image.html.
[21] Bansal, R. Bajpai, and J. P. Saini, "Simulation of Image Enhancement Techniques Using Matlab," First Asia International Conference on Modelling & Simulation (AMS'07), 2007, pp. 296-301, doi: 10.1109/AMS.2007.92.
[22] E. Leavline, A. Antony, and G. Singh, "On Teaching Digital Image Processing with MATLAB," American Journal of signal processing, vol. 4, no. 1, pp. 7-15, 2014, doi: 10.5923/j.ajsp.20140401.02.
[23] Ankan Bansal, "Zero Shot Object Detection," ECCV Journal, vol. 3, no. 2, 2018.
[24] R. D. Morrison, "Critical Review of Environmental Forensic Techniques," Environmantal Forensics Journal, vol. 1, no. 4, pp. Pages 157-173 , 2000.
[25] Nathaniel A. Raymond, "A New Forensics: Developing Standard Remote Sensing Methodologies to Detect and Document Mass Atrocities," Genocide studies and prevention : An International Journal, vol. 8, no. 3, 2014.
[26] Kuenzer, C.; Ottinger, M.; Wegmann, M.; Guo, H.; Wang, C.; Zhang, J.; Dech, S.; Wikelski, M. Earth observation satellite sensors for biodiversity monitoring: Potentials and bottlenecks. Int. J. Remote Sens. 2014, 35, 6599–6647.
[27] R. Ahuja, "NIA to use satellite images for mapping terror attack sites," 12 September 2016. [Online]. Available: https://www.hindustantimes.com.
[28] Anonymous, "Earth Observation Applications," Department of Space, Indian Space Research Organisation, 2017. Available: www.isro.gov.in/earth-observation.
[29] K. R. Rajeev Singh, "Satellite Imaging and Surveillance of Infectious Diseases," Journal of Tropical diseases, vol. 3, no. 2, Jan 2015.
[30] J. Rogers, "Spy satellites, drones, help experts discover lost city in Iraq founded after Alexander the Great," Fox News, 26 September 2017. [Online]. Available: https://www.foxnews.com/tech.
[31] P.R Sensing, " Active and Passive Remote Sensing, "Remote Sensing of the Environment John R. Jensen (2007) Second Edition Pearson Prentice Hall.
[32] Saxena, A. Samal, and D. Ray, "Vehicle Detection by Image Processing using MATLAB: A Colour based Approach," International Journal of Industrial Electronics and Electrical Engineering, vol. 6, no. 3, pp. 65-67, 2018.