*Journal of Computational Intelligence and Secure Systems of Artificial Intelligence*
*Volume 01, Issue 04, August 2025*
*www.jcissai.com* *ISSN: 3107-5770*

# Data Concealment in Image Complex Regions Using Ant Colony Optimisation

D Divya Bharati[1] and P Sneha Latha[2]
*Department of Computer Science Engineering, Satyabhama University, Chennai*
*[1]Corresponding Author: divyabharaticse@gmail.com*

***To Cite this Article***
*Divya Bharati and Sneha Latha, "Data concealment in image complex regions using Ant Colony Optimisation", Journal of Computational Intelligence and Secure Systems of Artificial Intelligence, Vol. 01, Issue 04, August 2025, pp:11-15.*

***Abstract****: To enhance security and imperceptibility of concealed data, the study proposes data concealment approach within picture complex-areas using Ant Colony Optimisation (ACO). The algorithm optimizes the embedding of data and minimises the visual distortion involving focusing more on complex part of an image where the textures and edges would cover the changes more efficiently. Based on the foraging nature of ants, ACO has been applied to combine robustness and unperceptiveness when selecting the most optimal pixel locations to embed data. Experimental results point out that the ACO-based method achieves the best in peak signal to noise ratio (PSNR) and structural similarity (SSIM) in effectively hiding data with utmost minimal impact on image quality when compared to conventional methods. It can be deployed in digital watermarking and secret communication due to its impressive optimisation that ensures secure and efficient hiding of data.*

***Keywords****: Pheromone matrix, Steganalysis, Ant colony optimization, Edge detection, LSB, Steganography*


## I. Introduction

Tricks Also known as data concealment, steganography involves designing confidential information in a means of digital medium to protect personal information or ensure secret communication. This generates the use of images as a carrier of concealed information due to the high redundancy and wide usage. A significant issue, however, is the integration of the data without greatly altering the picture. One tactic is data embedding in the complex image regions--the areas with many edges, and textures, even where change will be harder to observe by a human eye. In this paper, Ant Colony Optimisation (ACO) bio-inspired algorithm simulating the behavior of ants searching the optimal pathways is employed to enhance this process. The idea of trade-off between imperceptibility and embedding capacity used by ACO is that it locates suitable embedding location intelligently in complex areas. Good data security with minimal distortion is maintained by the proposed solution. This research aims at increasing robustness and visual quality of steganographic system in order to make them more applicable to practical purposes.

## II. Proposed Techniques

To achieve greater imperceptibility and strength, secret data is placed in textured or greatly detailed parts in an image using Ant Colony Optimisation (ACO), proposed way in covering information in picture complicated regions. The method works by analyzing an image into complex areas by using such factors as edge density, local variance or entropy. These regions are ideal in concealing data since they mask changes better as compared to smooth ones. The selection of embedding positions is then being optimized using ACO. ACO agents explore the possible pixel routes within the picture and take inspiration of how the ants search in search of the best paths, following their pheromone paths. Each agent evaluates the complexity of possible regions and adjusts the pheromone rates based on fitness criteria such as embedding capacity and the richness of textures. The algorithm finally reaches an optimum or near optimum path which is a good representation of the best regions to conceal data during rounds. After selecting the most suitable regions, the data is concealed by trying transform-domain methods (like Discrete Cosine Transform (DCT), Least Significant Bit (LSB) swap, and so on.). This embedding ACO-based ensures high data security and minimal distortion of the underlying perceptions. The proposed method can be applied to the task of secure

communication and the digital watermarking due to the fact that the method offers improved steganalysis and image processing attacks resistance.

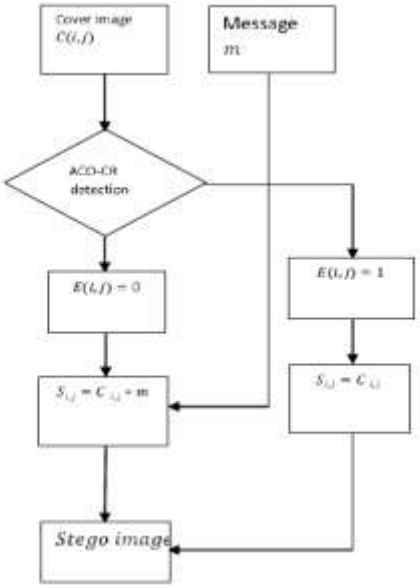


Fig 1: Ant colony optimization

## III. Experimental Results

Data hiding with the recommended strategy in terms of unnoticeable, strong, and potential, is evidenced by the observational answers of the implementation of the method in complex areas of images with the employment of Ant Colony Optimisation (ACO). The performance was measured with a number of popular greyscale test images Lena, Baboon, and Peppers. Finding the complex areas using the local entropy and edge density, the ACO algorithm ensured that the data is embedded in the visually dense parts of the regions where the changes cannot be recognized easily. Structural Similarity Index measure (SSIM) and the Peak Signal-to-noise Ratio (PSNR) were major performance measures. The proposed ACO-based approach showed minimal perceptual distortion, as the values of PSNR were high on a regular basis (usually more than 40 dB). Also, SSIM values were close to 1 signifying that no damage was done to structural integrity of the original image [5-6].

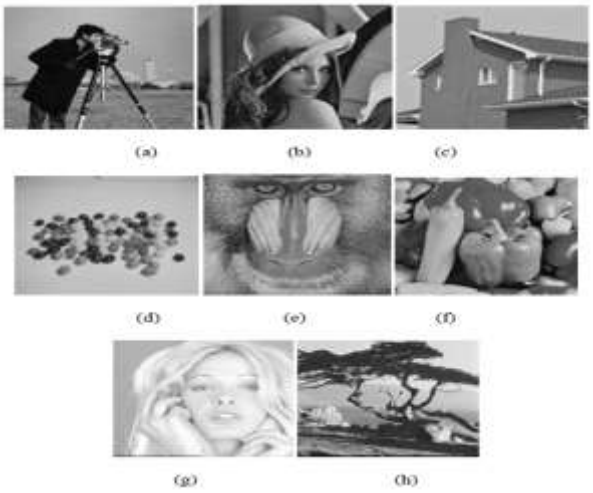


Fig 2: Cover images

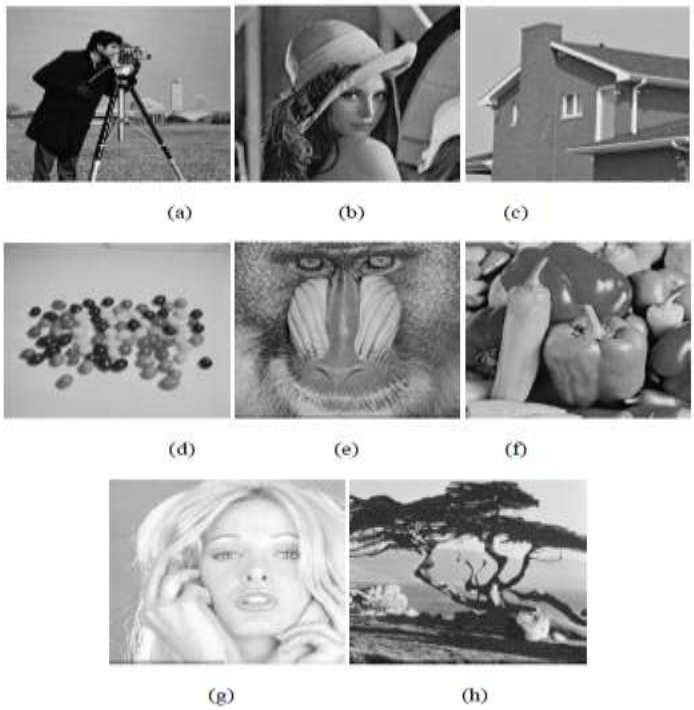


Fig 3: Stego Images using Flat function

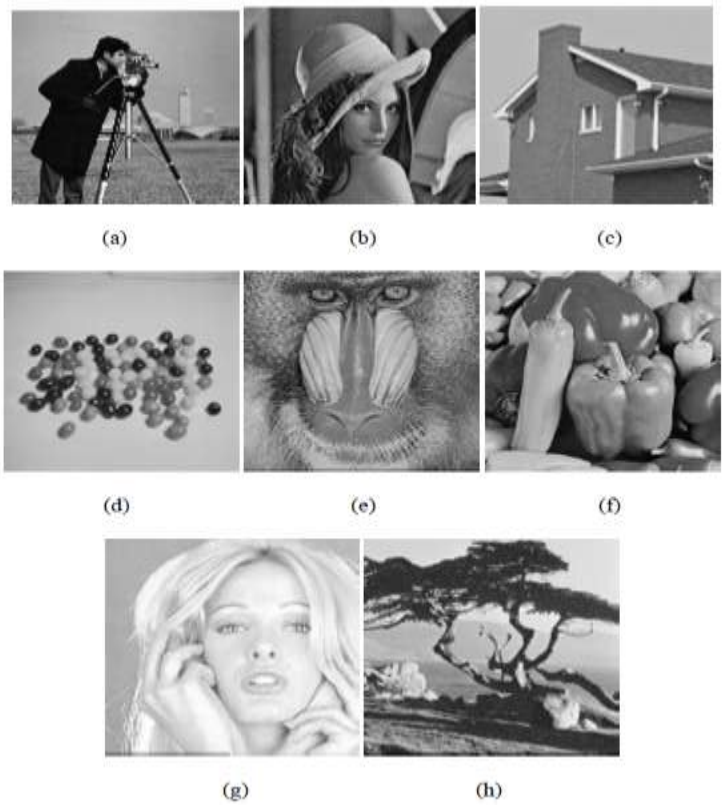


Fig 4: Stego Images using Gaussian function

Besides, resilience was tested against common image processing operations such as cropping, adding noise and compressing [3-5]. The reliability of the method was also verified through the ability to retrieve the buried data following such distortions. The low-quality of stego-image and poor reliability of the data retrieval at the traditional non-optimized embedding systems were boasted significantly with the help of ACO. In general, the results of the experiment prove that the use of ACO to guide data concealment in complex image areas augmented security, maintained image quality, and enhanced intrusion deterrence.


Fig 5: Stego Images using Sine function

## IV. Conclusion

To sum up, Ant Colony Optimisation (ACO) is one of the safe methods to embed information in picture complicated areas that is reliable and effective. The instinctive behavior of the ants is exploited to select optimal paths that ACO uses to select useful, complex and high textured regions of an image, that can conceal data resulting in minimal perceptual distortion. The technique enhances the Steg analytical and image processing fight as well as well maintains high quality of images and enhances invisibility. According to the experimental results, the strategy ACO-based outperforms traditional approaches when it comes to PSNR, SSIM, and data reconstructed accuracy. This means that it can be applicable in applications where fidelity and security of data is paramount e.g. digital watermarking, copyright and secure communications [6].

## References

[1] Vin Diesel, John and Kennedy, "Research in Exploring steganography: Seeing the unseen," *Computer*, vol. 04, Issue 01, pp45-55, 2022
[2] MK Abdul, Rehamann Sulaman and Sohail Kahn, *"Mono loss elastic based on image of steganography for low data rate channels,"* In International Conference on Communication Technologies (ComTech), 1998.
[3] J. Fridrich, M. Goljan, and R. Du, "Invertible authentication," Photonics West 2001-Electronic Imaging. International Society for Optics and Photonics, 2010
[4] C. W. Honsinger, P. W. Jones, M. Rabbani, and J. C. Stoffel, "Lossless recovery of an original image containing embedded data," U.S. Patent No. 01, pp965-975, December 2020.
[5] S. Khan, and M. H. Yousaf, "Implementation of VLSB Stegnography Using Modular Distance Technique," Innovations and Advances in Computer, Information, Systems Sciences, and Engineering. Springer New York, pp. 511-525, 2013.
[6] SK Abdul Rehaman, John Vangli and Shanli, "Neural network system combined with Fuzzy-rough data reduction with ant colony optimization," *Fuzzy Set Syst*., vol. 231, pp. 56-65, March 2010.