Embedding Data through Bit-Flipping using Block-Diagonal Partition Pattern (BDPP) in Binary Images

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1. Introduction

Hiding data in binary images is inherently difficult because “flipping” any one pixel may cause the image to be noticeably different to even the human eye. Some earlier “flipping” methods measured the perceived smoothness of a flip on a block 3x3 and would later measure the same smoothness for a larger block of the same image. [2]. While this method of hiding may be sufficient, the hiding capacity can be minimal. For our project, we chose to use Block-Diagonal Partition Pattern (BDPP) to hide data in binary images. The BDPP method of hiding developed and published by Chhajed and Garg in 2023, features a method for checking the suitability of a block of pixels that may expand the possible hiding capacity of a binary image by allowing blocks that may have appeared to be unsuitable to be usable for embedding.

BDPP seeks to embed data at the center of a 3x3 block of pixels by testing if a block is suitable for embedding. The embedding suitability test first represents each block of pixels as a simple binary matrix. It then slices each block diagonally twice leaving four (4) 6-pixel sections, any blocks cut in half are counted as whole blocks. In doing so, the ratio/pair of “1” and “0” is measured. Each section is measured this way, while maintaining a count of ratios/pairs that have occurred. For example, if a section contains four (4) black pixels, and two (2) white pixels, the ratio/pair is said to be 4-2; if another section sliced from the same block is measured to have the same ratio, then the count of 4-2 ratios/pairs would become two (2). Once the counting has completed, the connectivity of a block is measured in horizontal (H), vertical (V), and diagonal (D) directions. A block is said to have connectivity in a direction if there are two (2) or more consecutive values of “1” in that direction. If connectivity is found in a specific direction, then the block’s connectivity is labeled with the appropriate letter HVD. For instance, if a block were to have a matrix whose upper-middle, middle, and right entries were all “1”, then the block would be said to have connectivity in all directions and would therefore be labeled as HVD. However, if the matrix only had the upper-middle, middle, and lower-right entries as “1” then the matrix would only be said to have connectivity in the vertical and diagonal directions and would therefore be labeled as VD. Once this process is complete, the data is embedded by manipulating the center pixel of the block, and the embedding suitability tests are performed once again. Once the embedded block tests are completed, the results are assessed to determine if a block is suitable. For a block to be suitable it must have two (2) or more unique ratios/pairs, as well as a connectivity label of HVD both before and after embedding. If this is true, then the data is embedded onto that block [1]. Once the process has been completed the program should output an altered version of the original cover image with the embedded data. This process can be further visualized in the functional block diagram in Fig.1 below.

The goal of our project is to try to implement a hiding method that is derived from something we learned in class, while not being exactly the same we learned in class. The decision to choose a novel method such as BDPP seemed to fit the criteria for our goal, as we were not able to find very much information outside of the research paper itself.

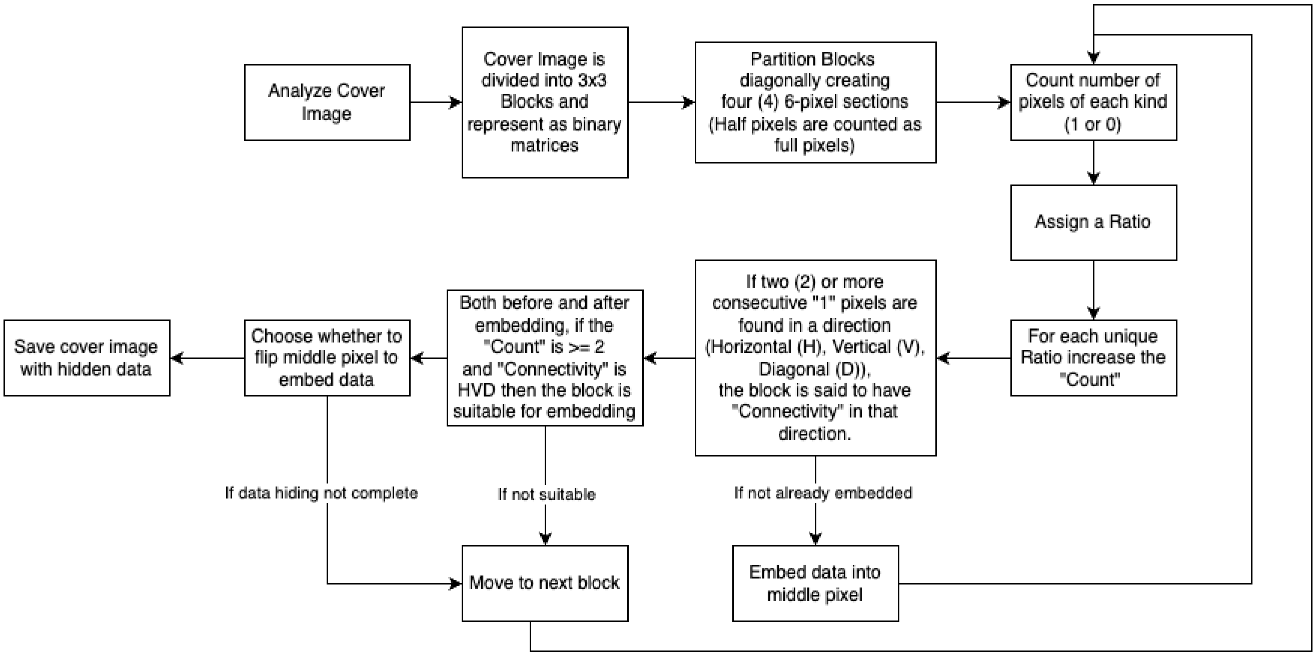
Analyze Cover Image
Cover Image is divided into 3x3 Blocks and represent as binary matrices
Partition Blocks diagonally creating four (4) 6-pixel sections (Half pixels are counted as full pixels)
Count number of pixels of each kind (1 or 0)
Assign a Ratio
For each unique Ratio increase the "Count"
If two (2) or more consecutive "1" pixels are found in a direction (Horizontal (H), Vertical (V), Diagonal (D)), the block is said to have "Connectivity" in that direction.
Both before and after embedding, if the "Count" is >= 2 and "Connectivity" is HVD then the block is suitable for embedding
Choose whether to flip middle pixel to embed data
Save cover image with hidden data
If data hiding not complete
If not suitable
If not already embedded
Move to next block
Embed data into middle pixel

Figure 1. Functional Block Diagram showing the steps for assessing suitability of a block for embedding and the process of embedding data

References

[1] Gyankamal J.Chhajed and Bindu Garg. Hiding data in binary images using block-diagonal partition pattern. *International Journal of Computing and Digital Systems*, 2023. 2

[2] Min Wu and Bede Liu. Data hiding in binary image for authentication and annotation. *IEEE Transactions on Multimedia*, 6(4):528–538, 2004. 2