

# Experimental Resistance Analysis of LSB Steganography Algorithm Variations Against Image Compression and Manipulation

N-Bits Sequential and N-Bits Random LSB Steganography against PNG Compression and 180-degree Rotation

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**Abstract**—In the topic of steganography, especially when the cover object is an image, the LSB (Least Significant Bit) technique is very often used. It offers simplicity and straightforwardness in the way it is implemented. It can be implemented traditionally in which the message we want to hide is embedded sequentially bit by bit into the image's pixels. We can also vary it by using more than one bits per pixel value or embed it on pseudo-random placements. However, one must ask whether it—and its variations—also offers resistance against image compression and/or manipulation should it be open to that risk. This paper aims to provide insights into that very issue by showing results gained after a particular experiment is undertaken to compare the LSB technique variations against PNG compression and 180-degrees rotation.

**Keywords**—*steganography, image, least significant bit, variations, resistance, compression, rotation*

## I. INTRODUCTION

When two or more parties communicate, it is not exactly a novel or strange idea for them to send communications that are not intended for outsiders to see. When such a matter is truly of concern, they usually take particular precautions to ensure that it remains such. One of these measures could be in the form of cryptography. Cryptography involves creating and evaluating methods to protect private messages from unauthorized access, including by the general public. Simply put, the most fundamental challenge that it aims to address is the issue of safeguarding communication within an unsafe medium [1].

Almost any approach that falls under it begins with the conversion of comprehensible and maybe relevant information into an alternate form that is supposedly unreadable and incomprehensible. This initial process is known as encryption, and it involves converting a plain text into something called a cipher text. This cipher text would serve as the actual content of the message that is exchanged in the communication between at least two parties. In a procedure known as

decryption, any authorized recipient would then be able to convert the cipher text back into its original and intelligible/meaningful message using a specific key to perform it [2].

However, this type of techniques may yield a strangely random string of messages in one form or another. This may not be a major issue if we only need to secure a message's true meaning. However, when our primary goal shifts, such as hiding the message regardless of meaningfulness, it can become one. A new strategy can be sought to prevent unwanted parties from detecting the message by virtue of it creating suspicion or arousing curiosity. That is where steganography comes in.

Steganography could refer to any process that involves concealing a hidden message within or on top of an object that is not intrinsically a secret, such as an image. Its principal objective is to conceal and mislead. It differs from cryptography in that the information to be hidden is not jumbled to the point where it is unrecognizable and seems meaningless. That is why it generally promotes the idea of keeping information hidden rather than strictly private [3]. Furthermore, this is why the two can be employed together rather than as substitutes for one another to achieve a more secure way of exchanging information.

Speaking of image steganography in particular, though, one technique that can be employed is the LSB (Least Significant Bit) technique. The general idea of this steganography technique is embedding the binary bit values of the message into the least significant bit values of the pixels found within an image. For example, if the image is of RGB format, then the message bits would be embedded into the red, blue, and green color values of each pixel as the least significant bit of those values [4]. An interesting topic that we can explore is how this LSB steganography techniques would fare if the resulting image after the whole message hiding process is then processed further such as be compressed or be rotated a certain degree.

Looking at how this technique is implemented, it might not perform all that well, but to know for sure, we ought to do an experiment to ascertain whether this hypothesis would be proven right or otherwise.

## II. METHODOLOGY

The first stage in doing this comparison analysis is to create the algorithm that will achieve the functions of the LSB image steganography itself. There will be two major variations of the method implemented. The first of these is the sequential LSB algorithm. This variant considers the image as a two-dimensional array of height  $\times$  width pixels. The height denotes the number of vertical pixels, while the width represents the number of horizontal pixels in the array. To hide the message within the image, it would first be transformed into binary form. Next, one bit is extracted and embedded as the least significant bit of a single color value (R/G/B) from a single pixel in the original image. This would be repeated for each of the three color values, or moved on to the next pixel sequentially as long as a message bit remained. Fig. 1 depicts a summary of the full method in a simple flowchart.

The random LSB algorithm is the second version of the LSB algorithm implemented. As before, this variation on the technique assumes the image as a two-dimensional array of pixels before embedding the message bit values into each pixel's color values. The distinction has to do with the order of the pixel placements where message bits will be put in. If the previous variation handled the embedding sequentially, beginning with the first pixel in the top left corner of the array, this time it is random. A pseudo-random number generator (PNRG) is used. This way, a seed can be used as a key, which can then be used to extract the original message later. Fig. 2 illustrates the essence of this algorithm variation in a simple flowchart.

In addition to these two forms of variations, each variation allows for the use of more than one bit of each of the image's pixel's color values. Let us imagine that a single RGB pixel in the image has the following values: (1110100, 01100011, 00011001). If we only utilize one bit as the least significant bit, the embedding method will look like this: (111010**M**, 0110001**M**, 0001100**M**), with **M** representing a single message bit. However, if we choose two bits of each color value as the least significant bits that can be incorporated, the scheme would now look like this: (11101**MM**, 011000**MM**, 000110**MM**), where each **M** represents a single message bit. This is often used to increase the size of the message that can be hidden within an image at the expense of reducing the image quality even further. It is, however, utilized for experiment's sake to see if it has an effect on resisting the impact of image compression and manipulation upon the message that is hidden within said image.

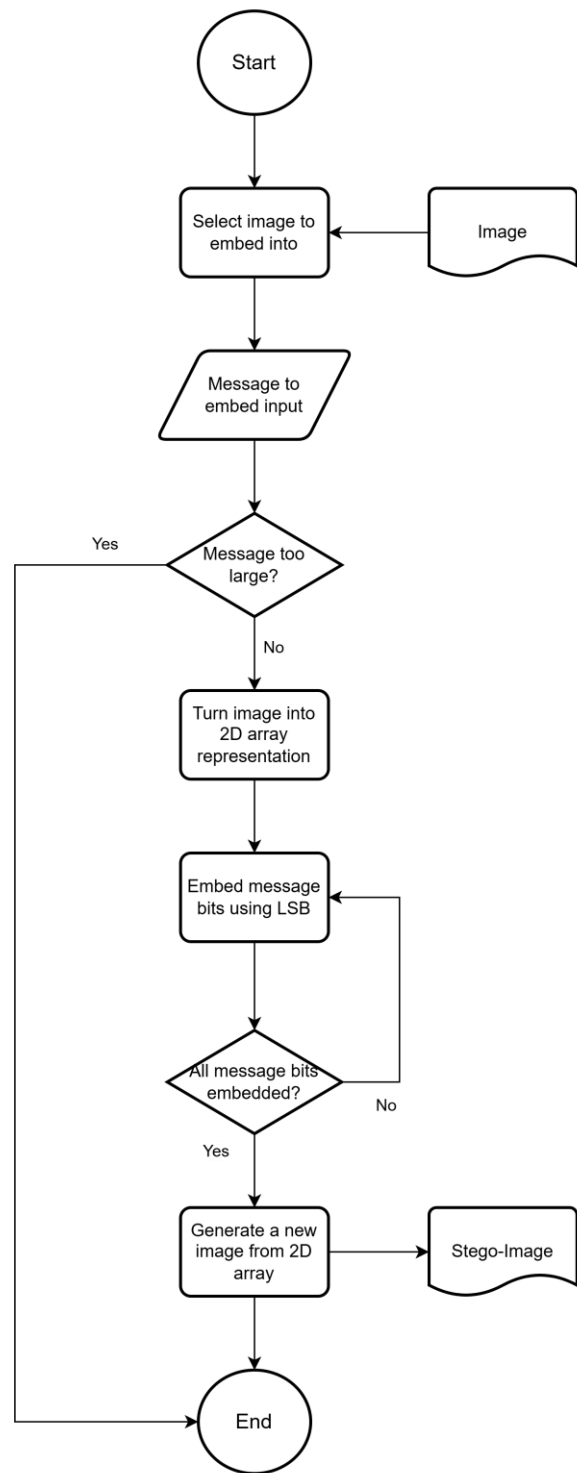


Fig. 1. Simple Flowchart of Sequential LSB Steganography Algorithm

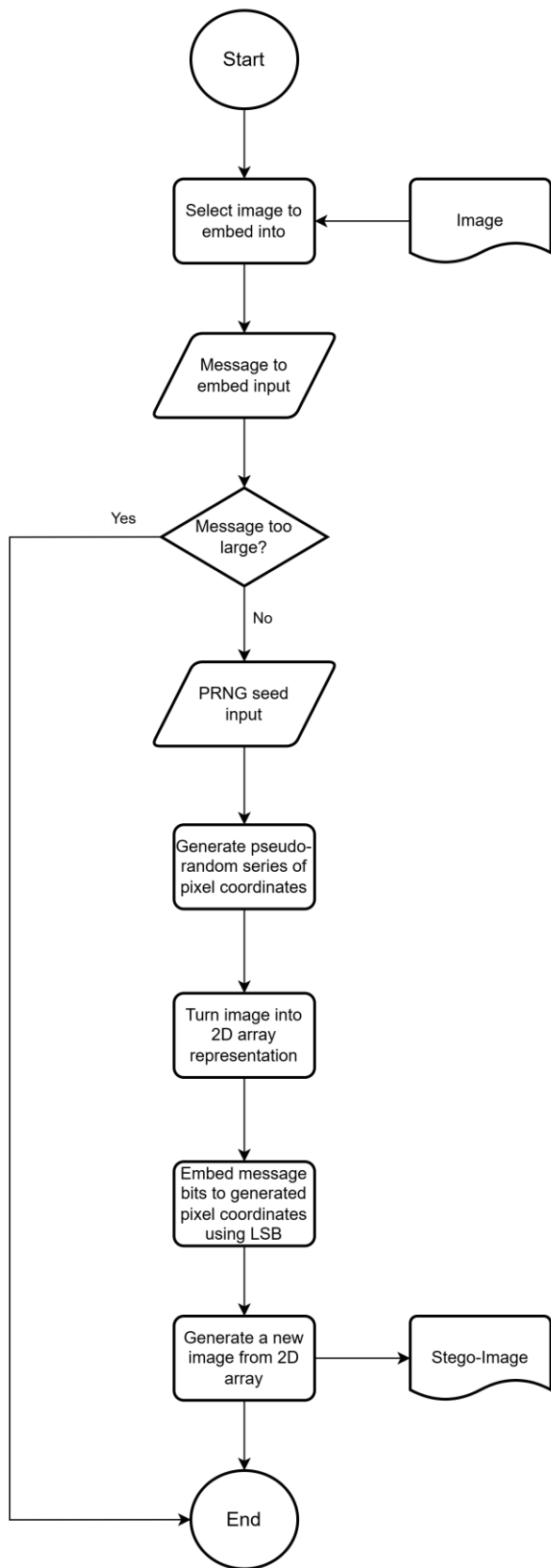


Fig. 2. Simple Flowchart of Random LSB Steganography Algorithm

### III. IMPLEMENTATION

The LSB steganography algorithm as explained in the previous section is implemented using the Python programming language. The main module that includes its primary functions is defined as follows:

```

import os
import random
from PIL import Image

__dirname__ = os.path.dirname(__file__)

path = lambda fname :
os.path.join(__dirname__, "..", "..", "..",
"public", fname)

def max_msg_size(width: int, height: int,
mode: str = "RGB", n_bits: int = 1) -> int:
    return (width * height * (3 if mode ==
"RGB" else 1) * n_bits) // 8

def str_to_bins(message: str) -> str:
    l = "".join([format(ord(c), "08b") for c
in message])

    return l

def embed_bit(v: int, bit: str) -> int:
    v_ = bin(v)[2:]
    v_ = ((8 - len(v_)) * "0") + v_

    if v_[len(v_) - 1] != bit:
        v_ = v_[:len(v_) - 1] + bit

    return int(v_, 2)

def embed_n_bits(v: int, bits: str) -> int:
    v_ = bin(v)[2:]
    v_ = ((8 - len(v_)) * "0") + v_

    if v_[-len(bits):] != bits:
        v_ = v_[:len(v_) - len(bits)] + bits

    return int(v_, 2)
  
```

```

def get_pixels(path_to_image: str, n: int):
    image =
Image.open(path_to_image).convert("RGB")
    px = list(image.getdata())
    print(px[:n])

def seq_encode(path_to_image: str, message:
str, n_bits: int = 1):
    image =
Image.open(path_to_image).convert("RGB")
    stego_image = image.copy()
    width, height = image.size

    if max_msg_size(width, height,
n_bits=n_bits) < len(message):
        return print("[Error] Message too
large!")

    msg = str_to_bins(message)
    msg_length = len(msg)
    i = 0

    for h in range(height):
        for w in range(width):
            pixel =
list(stego_image.getpixel((w, h)))

            for r_g_b in range(3):
                if i < msg_length:
                    bits_to_embed =
msg[:n_bits] if len(msg) >= n_bits else msg
                    pixel[r_g_b] =
embed_n_bits(pixel[r_g_b], bits_to_embed)

                    i += len(bits_to_embed)
                    msg = msg[n_bits:]

            stego_image.putpixel((w, h),
tuple(pixel))

            if i >= msg_length:
                break

    if i >= msg_length:
        break

```

```

    new_path = path("stego_" +
path_to_image.split("/")[-1])

    stego_image.save(new_path)

def seq_decode(path_to_image: str,
msg_length: int, n_bits: int = 1):
    image =
Image.open(path_to_image).convert("RGB")
    width, height = image.size

    total_n_bits = msg_length * 8
    remaining_n_bits = msg_length * 8

    msg_bits = ""
    i = 0

    for h in range(height):
        for w in range(width):
            pixel = image.getpixel((w, h))

            for r_g_b in range(3):
                if i < total_n_bits:
                    n_bits_to_extract =
n_bits if remaining_n_bits >= n_bits else
remaining_n_bits

                    v_ =
bin(pixel[r_g_b])[2:]
                    v_ = ((8 - len(v_)) *
"0") + v_

                    msg_bits += v_[-
n_bits_to_extract:]

                    i += n_bits_to_extract
                    remaining_n_bits -=
n_bits_to_extract

            if i >= total_n_bits:
                break

    if i >= total_n_bits:
        break

```

```

msg_bytes = []

for b in range(0, len(msg_bits), 8):
    byte = msg_bits[b:b+8]
    msg_bytes.append(int(byte, 2))

msg = "".join([chr(byte) for byte in
msg_bytes])

return msg

def rand_encode(path_to_image: str, message:
str, seed: int, n_bits: int = 1) -> None:
    image =
Image.open(path_to_image).convert("RGB")
    stego_image = image.copy()
    width, height = image.size

    if max_msg_size(width, height,
n_bits=n_bits) < len(message):
        return print("[Error] Message too
large!")

    msg = str_to_bins(message)
    msg_length = len(msg)
    i = 0

    px = []

    while i < msg_length:
        random.seed(seed+i)
        x = random.randrange(0, width)
        y = random.randrange(0, height)

        while (x, y) in px:
            x = (x + 1) % width
            y = (y + 1) % height

        px.append((x, y))

        pixel = list(stego_image.getpixel((x,
y)))

        for r_g_b in range(3):
            if i < msg_length:

```

```

                bits_to_embed = msg[:n_bits]
if len(msg) >= n_bits else msg
                pixel[r_g_b] =
embed_n_bits(pixel[r_g_b], bits_to_embed)

                i += len(bits_to_embed)
                msg = msg[n_bits:]

        stego_image.putpixel((x, y),
tuple(pixel))

        new_path = path("stego_" +
path_to_image.split("/")[-1])
        stego_image.save(new_path)

def rand_decode(path_to_image: str,
msg_length: int, seed: int, n_bits: int = 1)
-> str:
    image =
Image.open(path_to_image).convert("RGB")
    width, height = image.size

    total_n_bits = msg_length * 8
    remaining_n_bits = msg_length * 8

    msg_bits = ""
    i = 0

    px = []

    while (i < total_n_bits):
        random.seed(seed+i)
        x = random.randrange(0, width)
        y = random.randrange(0, height)

        while (x, y) in px:
            x = (x + 1) % width
            y = (y + 1) % height

        px.append((x, y))

        pixel = list(image.getpixel((x, y)))

        for r_g_b in range(3):

```

```

if i < total_n_bits:
    n_bits_to_extract = n_bits if
remaining_n_bits >= n_bits else
remaining_n_bits

v_ = bin(pixel[r_g_b])[2:]
v_ = ((8 - len(v_)) * "0") +
v_

msg_bits += v_[-
n_bits_to_extract:]

i += n_bits_to_extract
remaining_n_bits -=
n_bits_to_extract

msg_bytes = []

for b in range(0, len(msg_bits), 8):
    byte = msg_bits[b:b+8]
    msg_bytes.append(int(byte, 2))

msg = "".join([chr(byte) for byte in
msg_bytes])

return msg

```

Additionally, the image that would be used in the steganography routine is a PNG image that can be seen in Fig. 3. It has the pixel resolution of 861 (height) × 1024 (width). For this experiment, the message that will be hidden inside of it is the preamble to the Indonesian Republic basic constitution (Pembukaan Undang-Undang Dasar 1945).



Fig. 3. Original Image to use in the Steganography Process

#### IV. RESULTS

The experiment is done a total of 12 times. Four different specific variations of the algorithm is used: single-bit sequential, two-bits sequential, single-bit random, and two-bits random. For each of those four, three different message extractions are done: normal, after PNG compression (using a free online tool), and after rotating the stego-image 180-degrees. Each of the variations' result can be seen in TABLE I, TABLE II, TABLE III, and TABLE IV.

TABLE I. SINGLE-BIT SEQUENTIAL VARIATION RESULT

Extracted Normally	Extracted after Compression	Extracted after 180° Rotation
<p>Bahwa sesungguhnya Kemerdekaan itu ialah hak segala bangsa dan oleh sebab itu, maka penjajahan di atas dunia harus dihapuskan, karena tidak sesuai dengan perikemanusiaan dan perikeadilan.</p> <p>Dan perjuangan pergerakan kemerdekaan Indonesia telah sampailah kepada saat yang berbahagia dengan selamat sentausa mengantarkan rakyat Indonesia ke depan pintu gerbang kemerdekaan Negara Indonesia, yang merdeka, bersatu, berdaulat, adil dan makmur.</p> <p>Atas berkat rahmat Allah Yang Maha Kuasa dan dengan didorongkan oleh keinginan luhur, supaya berkehidupan kebangsaan yang bebas, maka rakyat Indonesia</p>	<p>\$òüÿðIçóÿüþOçóù üóÉ\$üóüäöÿäöÿ\$ó üüÿäþlâyäþIçóIäþI \$òIüÿÿäIäþIÿþOää ðlâyüöÿ\$ÿÈçòIäöÿ äóüäòIüIäIüöÿ\$òü óÉ\$òIäöÿ\$öÿäöüü öÿäþÿ\$ÿÈäöÿÿäòI çäöÿäðIäöÿçöÿ\$ò OäöÿÿÈüöÿäóÈüI äþIäóüäÿIäöÿüöÿ&lt; ÿ\$òOäþäþOäþIäöü çóüäÿÈüäÿIäöOçó ÈüIüöüöÿäðIüóüäð Içóÿäóüüóü\$ÿIäóÉ ääóü\$óÈüþIäóüäóü äÿüäIäþOäþIçóüäÿ ÈüäþÿäöÿääþOäþÿ äòüääIäðIüÿäþÿüO äòIäþO\$ÿIüóüäöÿä öÿ\$óüäIüöüöÿäöÿ\$ óÈüþIüöüäöÿäóüç óüüóüäöÿüóü&lt;Iäó ù\$òIüäÿÿüö\$óÿ\$ò OäÿÈüÿÿäÿüóü\$üü óü\$óÈüþI&lt;óüäOüó ÿçIäþIäöÿçöÿ\$öÿä ÿüÿþOçóÿ\$ÿüäðIç óüüÿüöüöÿ\$þäóü&lt;ü ðIüðIäöüçóüäðäöÿ \$ÿIäöÿçóÈäþIüöÿç IäðIçóÿÿäÿüäðIþ IÿþOçóÉ\$ÿIüóÈüó ÿäþIäöÿçöÿ\$óÿäÿÿ IäðOçóÈüþÿäüóÈä öÿ\$òIäóüäðI\$óüüü ðçäÿÈäþÿüþIçóÈü ðI\$óÿäöÿüöIäOäÿ ÈäðIþIÿþOçóÉ\$ó ÈüþIüóüäþIüþOää ÿIüóü\$òIüÿÿäIüöüð öÿäðIäöÿ\$óIüóüüð Iüöÿäóü\$ðIäóü\$ÿä ÿÿäóüäIäþIüþÿüþI</p>	<p>Üí³4ú } ÷ ß } ÷ Üí³4ú ³4ß } ÷ Üí·Bo³4úí³4ß }³4úó³4ÿÿÿÜíöBo· ÿÿÿBo³4ÜíöÿÿÿÜíö ÿÿÿÜ }³4Bo³4ß }³4ú m ÷ ß } ÷ Üíöüó³4ÿÿÿ Üí³4ú } öüó³4í·Üí·B ó³4Ü } ÷ Üí³4úí³4ß } ÷ Üí·Bo³4úí³4ß }³4úó ³4ÿÿÿÜíöBo·ÿÿÿBo ³4ÜíöÿÿÿÜíöÿÿÿÜ }³4Bo³4ßm ÷ ß } ÷ Üíöüó³4ÿÿÿÜí³4ú } öüó³4í·Üí·Bo³4Ü } ÷ Üí³4úí³4ß } ÷ Üí·Bo ³4úí³4ß }³4úó³4ÿÿÿ ÜíöBo·ÿÿÿBo³4Üíö ÿÿÿÜíöÿÿÿß } öß }· Üó³4ß³4ß } öüí³4ß } ö ÿÿÿBo³4Üí·Bo·Üí· Ü }³4Bo³4Üíöüó³4úí öBo³4úíöüí³4Bo³4úí ·Üí·ÿÿÿüí³4ú }³4ÿÿÿ ÿÜíöüí·ÿÿÿBo·ÿÿÿ üó³4ú }·Bo·Bo³4ú }³4 üó³4Üí·ÿÿÿÜí·Ü } ³4úó·Üí·B } öüíöÿÿÿ üó³4úó·Üí³4ú } öüíö ÿÿÿüó·B }·ÿÿÿß }³4 üíöÿÿÿüí·B }³4ÿÿÿß }³4ÿÿÿüí·B } ÷ üí·Ü í·Üí³4ß }³4úí·ÿÿÿBo ³4ß }³4ß } ÷ Üí³4ú } öü í·ÿÿÿüó³4úó·Üí³4ú } öüíöÿÿÿüó·B }·ÿÿÿ ÿß }³4úíöÿÿÿüí·B } ³4ÿÿÿß }³4ÿÿÿüí·B } } ÷ üí·Üí·Üí³4ß }³4ú í·ÿÿÿBo³4ß }³4ß } ÷ Üí³4ú } öüí·ÿÿÿüó ³4úó·Üí³4ú } öüíöÿÿÿ ÿüó·B }·ÿÿÿß }³4úíö ÿÿÿüí·B }³4ÿÿÿß }³4 ÿÿÿüó³4úí³4ÿ }³4ú m³4úó³4ß } öüó³4ÿÿÿ</p>



TABLE III. SINGLE-BIT RANDOM VARIATION RESULT

<p>membentuk suatu Pemerintah Negara Indonesia yang melindungi segenap bangsa Indonesia dan seluruh tumpah darah Indonesia dan untuk memajukan kesejahteraan umum, mencerdaskan kehidupan bangsa, dan ikut melaksanakan ketertiban dunia yang berdasarkan kemerdekaan, perdamaian abadi dan keadilan sosial, maka disusunlah Kemerdekaan Kebangsaan Indonesia itu dalam suatu Undang-Undang Dasar Negara Indonesia, yang terbentuk dalam suatu susunan Negara Republik Indonesia yang berkedaulatan rakyat dengan berdasar kepada Ketuhanan Yang Maha Esa, Kemanusiaan yang adil dan beradab, Persatuan Indonesia dan Kerakyatan yang dipimpin oleh hikmat kebijaksanaan dalam Permusyawaratan/ Perwakilan, serta dengan mewujudkan suatu Keadilan sosial bagi seluruh rakyat Indonesia.</p>	<p>aaaaaa-ê«Z<sup>aa</sup>-ê<sup>aa</sup>ç<sup>aa</sup>- ê<sup>a</sup>-ê<sup>aaaaaa</sup>aaaa<sup>aaaa</sup>-ê«Z aaaaaaP<sup>a</sup></p>	<p>ÖyoÖ[öyöyöyöyö Öyéç[öç YoÖyöyöyöyö oÖ[öç[öç[öçYoÖ[öç ç YoÖyéç YoÖYoÖ [öç YoÖyoÖyéçyöy yöyöy[öyoÖ[öç Yo Ö[öç[öç YoÖyoÖy eç[öyoÖ[öçyöyöyöyöy yéyoÖyéç YoÖYo oÖyéç[öyoÖ[öçyöy yöyöyöyöy[öç Yeçyöy yöyöy[öç YoÖyoÖ[öç öyöyöyöyöyöyöy[öç Yo oÖyöyöyöyöyöyöy[öç[ öç[öçYoÖ[öç YoÖyéç YoÖyoÖyéçyöyöyöy[öç YoÖ[öç YoÖ[öç[öç [öçyöyöyöyöyöyöyöy yéç YoÖYoÖyéç[öç öyoÖ[öçyöyöyöyöyöy eç[öç Yeçyöyöyöy[öç ç YoÖyoÖ[öçyöyöyöy yöyoÖyéç[öç YoÖyöy yöyöy[öç YoÖyöyöyöy yöyéyoÖyoÖyoÖyöy öç YoÖyéç YoÖyéçyo Ö[öç[öçyéçyoÖyöyöy yöy[öç Yeç[öçYoÖ yoÖyéç[öç[öç Yo oÖyéçyöyöyöy[öç[öç ç YoÖyoÖyéç Yeç YoÖyoÖ[öçyéçyöyöy yöyYoÖ[öçYoÖ[öçyöy yöyöy</p>
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Extracted Normally	Extracted after Compression	Extracted after 180° Rotation
<p>Bahwa sesungguhnya Kemerdekaan itu ialah hak segala bangsa dan oleh sebab itu, maka penjajahan di atas dunia harus dihapuskan, karena tidak sesuai dengan perikemanusiaan dan perikeadilan.</p> <p>Dan perjuangan pergerakan kemerdekaan Indonesia telah sampailah kepada saat yang berbahagia dengan selamat sentausa mengantarkan rakyat Indonesia ke depan pintu gerbang kemerdekaan Negara Indonesia, yang merdeka, bersatu, berdaulat, adil dan makmur.</p>	<p>²Pýý÷?Öagý÷yüüø &gt;9yóáóíÇüýÖÖýý BýáB'uÖøp&gt;</p> <p>Ççpßtö@=yþúî?ü } Íú÷þ #ç_ÿäy³4çuw ÇüýñøýýGð³4QÝú ää4üî?eýüýýýÏ~wý ù,c</p> <p>8þø?i }çþÇä,7þ÷y× ýø?Qýü!úýýøã&gt; ÖMÁúBéýýü~{ää_ äýýü!ýü[ý×Áý?qý÷ ðÖyã Bþ]z÷y,úýý ð &gt;Bñý³4_ìøý?ýý³Ø</p> <p>Býý }×úqíÍúäýwuñ 7wýGOúÁý÷ ýCÖ÷þvýÏýýçþ£¼ øý}öýý Çü_à~çB »ýý{ý÷ýýäýÁ.ñþø ýäèýúè!üèý }çýñÈ ú</p> <p>ýà:ç~&gt;ýxtyóý8ã³4 áóíýþ&lt;úò!ù }A[Í0s x¼sçüç,Ø£éüq þ:Á ýhýá7÷yèsÁç½÷çð °øwýO÷÷+þäýýý ýþþèü#ü=C{ý?ñþá ÷óíçüÜáý[çCí}Öþ xý_×ýç</p>	<p>íýö?Nñü!&gt;ü©«ýýý çlóo²XýÇ_úýîé?éÍ ã³4:&lt;Í÷þLç</p> <p>ú(&gt;1oßý~þ~?ývÇü Íñäçü_@?áýýþ ýZÍ ýíá÷»÷ý×ç_ù&gt;</p> <p>çB¼éþ{üo÷ ýý¼X ÷íýýçÉývùø~ÝÍBr{ íýýÏýÝýøý÷_þø?þ ý{ú£BüþýBøBý÷iäý ýýB÷öçýíÉð0ñ[ýú Üýýó×í÷ÆéqýþýB ýÏWç[ñ!*oáýäü!× Kþx çý~_ýýýýñøúØç? ýá{ýýýÜçýÄýÁüÍ ÇBýçýÖýñ+ðüüD· ÷ý÷Íñ_ýñÜKB_ýð ÷</p> <p>úçí- Béý³4íðýÝý;üü÷5B ýé?éýñæ{ÆíüBú÷ý ýð×í é?ñ±hýçç×_ýzúú; ýÍüðýá÷UvzÍywø ÁjqþçóçÉ÷÷9è÷÷ ýÜþðþþ/ý_üáóççð Çüáçó~?oýþØ_öy¹ ýÇçíáçðüíüçý"ýý; üüí&lt;ýü_Áüp?ñüð µ;ýçýB?þúý÷Küý ^8&gt;ýýÆ½ðöýBÉ] þ³4Çðçç,éóý³ýäq äýýéç×ÁáLáýÇý ³4ýÍº9cÉç£qgñýñ þýç×;ýç3?÷ýíøüNá _ýññ'ý÷:ýLµýüø· WO~úyç{÷ü}áW ½ý;ýüüGýú8ý03Ç. }áU_Íóýýú÷ýýýð ýüþÍþ=ýýFO_ùøý ýýáç_ÜGqç ýýéýÜ üýí½ýðÍíéýçÜ×Ó Býá~oóðç;?þ÷ÇürÍ /ç_ýÜýÍçýñýüý×ýº ÁwøNýBüý÷ý8ýø wþÖý@_ýBþý÷ýýí þþ¹ð þá}øYáçüýçð u- p¼ý÷?ÍýBýççðwþý ýýléð¼Yí?ýþ&lt;ýð?í þ÷øüþ@íþñBäýÁü ~éüý/-</p>
<p>Atas berkat rahmat Allah Yang Maha Kuasa dan dengan didorongkan oleh keinginan luhur, supaya berkehidupan kebangsaan yang bebas, maka rakyat Indonesia menyatakan dengan ini kemerdekaannya.</p>	<p>Atas berkat rahmat Allah Yang Maha Kuasa dan dengan didorongkan oleh keinginan luhur, supaya berkehidupan kebangsaan yang bebas, maka rakyat Indonesia menyatakan dengan ini kemerdekaannya.</p>	<p>üü-×ýç</p> <p>/WNúóás8çýÄ³4x &gt;ç_ýü }?úxüá-ýðÜí 9÷ácýþúÜ B{ Gñ èÇüü;÷úðýwðç?</p> <p>çÆ~oðYçüñý!}øý ÜýýÉúøÍøÍúþ÷ýü ùçíøç;óAýè÷øýüý Íø</p> <p>öü~yýççýþýýýçøýý Í³ýéúøçqçãNýó{ç- ýéü;[áýóóýðÁÁðç ý- æ?íçwíÉÜýý¼íµÁ óüæãÖ&gt;3ý¼4ýþæþ ýÝç=þþ-úü_ütçíý ¼áècñãþCú }ý?mø ýýý÷&gt;aßaG ñBüsø øüþúðüñþ?Öýüªçý ùç[ýü_øýð_üýè7</p>
<p>Kemudian daripada itu untuk membentuk suatu Pemerintah Negara Indonesia yang melindungi</p>	<p>Kemudian daripada itu untuk membentuk suatu Pemerintah Negara Indonesia yang melindungi</p>	<p>üçí- Béý³4íðýÝý;üü÷5B ýé?éýñæ{ÆíüBú÷ý ýð×í é?ñ±hýçç×_ýzúú; ýÍüðýá÷UvzÍywø ÁjqþçóçÉ÷÷9è÷÷ ýÜþðþþ/ý_üáóççð Çüáçó~?oýþØ_öy¹ ýÇçíáçðüíüçý"ýý; üüí&lt;ýü_Áüp?ñüð µ;ýçýB?þúý÷Küý ^8&gt;ýýÆ½ðöýBÉ] þ³4Çðçç,éóý³ýäq äýýéç×ÁáLáýÇý ³4ýÍº9cÉç£qgñýñ þýç×;ýç3?÷ýíøüNá _ýññ'ý÷:ýLµýüø· WO~úyç{÷ü}áW ½ý;ýüüGýú8ý03Ç. }áU_Íóýýú÷ýýýð ýüþÍþ=ýýFO_ùøý ýýáç_ÜGqç ýýéýÜ üýí½ýðÍíéýçÜ×Ó Býá~oóðç;?þ÷ÇürÍ /ç_ýÜýÍçýñýüý×ýº ÁwøNýBüý÷ý8ýø wþÖý@_ýBþý÷ýýí þþ¹ð þá}øYáçüýçð u- p¼ý÷?ÍýBýççðwþý ýýléð¼Yí?ýþ&lt;ýð?í þ÷øüþ@íþñBäýÁü ~éüý/-</p>



<p>segenap bangsa Indonesia dan seluruh tumpah darah Indonesia dan untuk memajukan kesejahteraan umum, mencerdaskan kehidupan bangsa, dan ikut melaksanakan ketertiban dunia yang berdasarkan kemerdekaan, perdamaian abadi dan keadilan sosial, maka disusunlah Kemerdekaan Kebangsaan Indonesia itu dalam suatu Undang-Undang Dasar Negara Indonesia, yang terbentuk dalam suatu susunan Negara Republik Indonesia yang berkedaulatan rakyat dengan berdasar kepada Ketuhanan Yang Maha Esa, Kemanusiaan yang adil dan beradab, Persatuan Indonesia dan Kerakyatan yang dipimpin oleh hikmat kebijaksanaan dalam Permusyawaratan/Perwakilan, serta dengan mewujudkan suatu Keadilan sosial bagi seluruh rakyat Indonesia.</p>	<p>±ñĪŷÁqwyĪr«'aBn [óyùð¿ÿ£úâpBŪ÷h }pyýý7,ûñý=p ýñŌñA?wÁ/é÷úßp &gt;#ðáöý»-:Í34i/49ý @ýýÇ»~8úýpŪqū ùð9úoø~Hà!';Cøýý ×āýý@;[Ī°÷×¿úýG óĪý·çfĪýüatūqýÆĪū ŪýĪý]úÁB</p> <p>ü»ñ34āĀ½úĪr{áyý3 .&gt;úýĀýýĪýüĀē?āf ýwÇçç'Y»ēýý3÷?é ý&lt; wī~&gt;ýóýāüýð ŪýBý-ú&lt;øŸNØēb ýNý;ýýĀB'Ō-ðð×ā {üüðßçü{úø?B&gt;ú B÷}øúit-ýñ¿psýý± ùĀ3ý× ¿ýD×ýàpýý ñuyüüq¿ò?Ō34»Īwþ þ8Ūwýāñ'zf}_ā</p> <p>wĀ?Īp~?yøñĪýŌH qŹúóĪŌ^ý¼eü×ü? ðq?āþüñ&lt;óýàruýýĪ ýíýüoýàÇü;? üü7; ä_ññL &gt;úñüüý</p>	<p>āóáýšçúðsýŌ¿ùýé ¿Ī P= G-èāÇé- BýĀýüüð' āüW¿;ýý34Ā÷ýāēĀ ü9÷OçýðŌiö×ýŪý _ýĀýBýþĪ·ý34ŹŪŌ ýýšçŸNýóμøý34ýf, þý@¿;ó!2½jwù÷ð÷ ýýýr!4iüýýĀĪæ~Bý ýýĪæ?ýā÷çðýoQøz sÇëqþĀÇçýý×Ī_'</p> <p>ýý?þ?éðŌçýéýùKĪ ý÷Āā</p> <p>gĪ?üýýýŌ_?ý;÷ýŌ çúWëýāāü_öýýýB ½ðýüðāüü×ý@āýý ýfÇý-úāüýā±Ī+ý&lt; {ßçŪúŌB¿ps?Ī?æx  »ðēýþþBü÷āýóÝý ý,wý¿çý-ýĪÇyyý</p> <p>&lt;Lý½ýýóýāýüèĪýu ·¿þý÷ĪĪýiwú÷÷} Wþäö¿ÇýĒ~ýBy? ý¿ ?_ā?B:Ōýçñýþ¿ ý _ý_çēþ;ýýÇý_p! ú×ú }</p> <p>Īý</p>	<p>bangsa dan oleh sebab itu, maka penjajahan di atas dunia harus dihapuskan, karena tidak sesuai dengan perikemanusiaan dan perikeadilan.</p> <p>Dan perjuangan pergerakan kemerdekaan Indonesia telah sampailah kepada saat yang berbahagia dengan selamat sentausa mengantarkan rakyat Indonesia ke depan pintu gerbang kemerdekaan Negara Indonesia, yang merdeka, bersatu, berdaulat, adil dan makmur.</p> <p>Atas berkat rahmat Allah Yang Maha Kuasa dan dengan didorongkan oleh keinginan luhur, supaya berkehidupan kebangsaan yang bebas, maka rakyat Indonesia menyatakan dengan ini kemerdekaannya.</p> <p>Kemudian daripada itu untuk membentuk suatu Pemerintah Negara Indonesia yang melindungi segenap bangsa Indonesia dan seluruh tumpah darah Indonesia dan untuk memajukan kesejahteraan umum,</p>	<p>zT[grá[ðŸo÷YāZE eYeŸeyāýþŸ</p> <p>āeVYk»AYoaÖY WfYø/ùŌnVzŌY Ōü»YW3Ōoý=eA LYUŌñýYmýĪá½Ī e-:VYe\$YiVŌe=g ¿C÷l5iøCĪYøi±eA dýL¿ŌuU!ŸeyAe¿ ZiŌXÁYŌĪ±isþ_ý Īā</p> <p>e'XĪ¿eyĪYi?[ðŌüŌ &lt;~uoŌPāmíýeĪY ZgĪe°çyĪTYeV [ð¿«ðĪŌYc&amp;Yā8" ŌÇuí±oüŌkUgýU f[-Ōý*1¾ŌýŸ-ĪjJU e'Zt;[þ?ñ¿;[2YkĪý ĪY&lt;ýýTu°[ùYSYŌ Ō³ĀĪe,ĪayüŌ[ýŌ YŌ[ð</p> <p>eŌýñßμŌ&gt;ŌYāĪé eu»YeajÇYfĪŌe[ð ŌCŌ-XSýe k*YēYμ[;[ð¿Ÿe u¿ ýYĪjYeŌ[</p> <p>úšýŌŌXŌYYeiz CzYeZd?éé\$[ð¿Yo ŌYn33[X.VXþUk UjX</p> <p>XtŌZýý²¿XBŌSú? ĪíYeVYŌYŌuzCY ¹YgĪr</p> <p>YýDYe¿ZUYñ¿Y UYcVāe³X¹[ðĀŌ¿ YñēšX×lýoBÝeāø þU°YñĒĪ¹YĪĪ</p> <p>oŌYeŌZŸ¿«ðßŌ þĀĀYcĵY¿ŌYŌZ Ā±YifŌu[zPĪāŌ³þ {Yifñ¿XĒT°YŌD ŌeYk¹Ye</p> <p>ZĀZS?Ye¿</p> <p>ZŸ¿ynwUŸXuT?Īj aGYeGwYén¿ZŸ° «ýýĪā</p> <p>bÝN¿ud¹ŪŌ¹U°Ū ŌZiý}eZāXðšWñ ýāýf*YoĀ]JVŸciZ y[ýe Zi?üWYnŌYeeçþý Ō·}oýYñiUj[:'CŌi »?</p>	<p>?^ý76½æ/ŌáčMýŌ NýýýkþíýýŌýó];ý ýŌoĀý}ýýý²;?[ýý _÷þ'Ōý«ð¿2-Ōüß ýkýĪéýkýþ-ĪüŌAn yWŌçýý¿V'9Īý«ú? ý?ýßøgbýSýŌNÝ&gt; BŌ?÷ýĪšóýWŌ;Kð ¿Ō</p> <p>3ý×P¿;ÝŌĪýýh¿BBý ēþ«jðþŌü5Ō»_ý</p> <p>ýŌfýýýý_ýþŌ¿Ō:w āýþ?ýó?Sðwý3ªü? āSýýý×iy_~]=ýV ýŌCĐýĪýüYDf;ýĀ C6ýü«ðŪ4ā-Wýýü ;?RŌü4Ō</p> <p>ýýüüýýýŌ]</p> <p>ēýþmýü=_Ō[ŌðU μŌýāýŌýþCýðýý ýDýýŌýŌýøĀN?ý ūñýý«üŌü&lt;ýýāýü¿ ýŌ?ĀĀŌý'Ō¿;üĀS ýýøCŌýCāeμ</p> <p>?ŌðŪ[ýŪ</p> <p>šq¿¿·ð°[ý:ý7óāýðð ýñ*ýø?YýĒýýZ_p ?SýDýŌMS¿μ_āý Ōð@ĪiøþýþŸĪ÷7 ýýŌ¿Cú÷āñýýý7ýē þ¿;ýýýþý šŌ¿;ýýýýš¿;þŌvð×</p> <p>?ý÷ªLü¿_ēðW[ð'ó ýý÷üªŌzýMEUé, ýYýām½¿XŌ¹:3? Nßýýýýýā8«þýĪēŪ Ōªýýýý[ĀĪýþþ-Ō wú¿;āŌ¿ý9ēýāĪŪ-Đ ĪýýŌüU¿ü=āþĪýéýē ~-šýýĪþýýŌ¿_ýāýĪ ýBýŌýýýý48ßĀPĀ ¿: {?þbcĪ¿7ýþŸ_ýā ýñ«ð¿ðŌā_ýýýþß ĀBŌ¿XuŌCýāýýý ýüēýŌýü?ýŌ÷:ýýē ýŌýýð-ýŌýýμĪQm ŪBýýŌýýüŌýþ=Ōo çKūýñüýPßýĐŌ? ýĪþ?þ_ē4?rª%¿;W úªþĪBý[ýþ&gt;ŌŌýý; ýýýýē</p>
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TABLE IV. TWO-BITS RANDOM VARIATION RESULT

Extracted Normally	Extracted after Compression	Extracted after 180° Rotation
Bahwa sesungguhnya Kemerdekaan itu ialah hak segala	XU=ŌYĪg¹Ud;Zi85 UgV5e³Xu¹YjVA^ ÑeYĪZémñj[üŌY nxÇ³9>ŌmüðŌXŌ	üýŌŌoaeýý¿Ź_ýü> \$ŌýýüßĀýŌŌª³iŌ WýŌþýýý

<p>mencerdaskan kehidupan bangsa, dan ikut melaksanakan ketertiban dunia yang berdasarkan kemerdekaan, perdamaian abadi dan keadilan sosial, maka disusunlah Kemerdekaan Kebangsaan Indonesia itu dalam suatu Undang-Undang Dasar Negara Indonesia, yang terbentuk dalam suatu susunan Negara Republik Indonesia yang berkedaulatan rakyat dengan berdasar kepada Ketuhanan Yang Maha Esa, Kemanusiaan yang adil dan beradab, Persatuan Indonesia dan Kerakyatan yang dipimpin oleh hikmat kebijaksanaan dalam Permusyawaratan/Perwakilan, serta dengan mewujudkan suatu Keadilan sosial bagi seluruh rakyat Indonesia.</p>	<p>el°uVýg! ee\$`%â¿â»[õX%[ @UÖpO÷YIBýe¿[ 7zYUoèyèñýéé³Aü 5 fe[9[¥{2e¿YgýX/Ã ýU´yiÖY?Öàõcý× YU¿YêwYJAóOu PájyYl*Ye·UQú</p>	<p>ùÿêþ®«iÖÿpÃÿùl ßþ?:ýB«ðgýýè³ýýT yoáýýDÿù«ýæýú? ýþ?uã?ýÿýý?5#ýó ýý×@ýýüèýýÄüó Nj-à«ýþßüý/ýýO þýý?Ïþ/ýAjýOÜ Y2jAoØüD&amp;Yoø« _ý§ýüü@«üý·õ¿þ DËÿóþÿýýê«»ú¿ Hãý÷ýás«þýâþÿþC ðèþÖVDíýýðýöPð ¿wýê÷I?ªBý·ýÖþ\$? ýóI±Oý«ú@IýöN÷ ýèýðý`7tyýýNU¾ý ðýñDü=æþÖýD?ü èjþyÖ÷ðýßü¿  í÷@Mýðý»ýý·ýý  ùþýýýýËýýä;uPýil WúU4ãýýü  :Býýü7ýý&gt;÷ýÝþC ü~`IõOey3à?à÷oÃ ãöýQD??ýý8íý;ðý[ ýSýúª-ãýýýé³4Ã OýªiøýýÃ°B</p>
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## V. CONCLUSION

As expected, the LSB algorithm is still insufficient when it comes to resisting the effect that image compression and manipulation can have upon the hidden message. This is due to the fact that LSB simply embeds the message bits directly into the pixels. When those pixels' values are altered due to compression or the changing of locations after the whole image is rotated, the message can never be extracted back correctly. It demands that the pixels stay how they were, where they were in order for the hidden message to be extracted properly. However, some adjustments may be able to circumvent it, even if only partly. An example would be implementing an extraction algorithm in which it checks every possible rotational degree and attempts to extract the message from every single one of those possibilities. Yet, it might be too inefficient to implement and a user might benefit more to just opt for a different algorithmic technique altogether if resistance against compression and manipulation is of great concern.

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## PERNYATAAN

Dengan ini saya menyatakan bahwa makalah yang saya tulis ini adalah tulisan saya sendiri, bukan saduran, atau terjemahan dari makalah orang lain, dan bukan plagiasi.

Bandung, 14 Juni 2024



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