Given: An encrypted image.

Target: To recover object information.

Challenges I faced and my approach to solving them:

1. After looking at the encrypted image my first challenge was to understand the image itself and to understand what does the image data represent?

Solution: With a clue that a laser is being used during encryption and some googling I arrived at the conclusion that it is a speckle density pattern. Before arriving at this conclusion, I had performed a basic exploration of the image data. I have attached the code as exploration.py. From this exploration, I could only understand that the intensity distribution is like a Gaussian from the center of the image.

1. How can I get object information from a speckle pattern?

I believe that this is where I spend most of my time and I am still trying to understand the best possible way to solve the problem. After following a few articles, regardless of the experimental setup, the steps to solve the problem were similar. First to get the autocorrelation function (**r\*r**) of the object from the speckle intensity pattern. The autocorrelation function is related to the Fourier transform (**F**) of the object by

**F**(**r\*r**) = | **F(r)**|2.

As in the right side of the above equation is a square of the Fourier transform of the object. Recovering object information from| **F(r)**|2 requires information of the phase and the next step to solving the problem is to retrieve the phase.

1. Finding ways to solve phase retrieval problems.

With no real optical background, while solving this puzzle I got caught in the limbo of vast literature and algorithms. Eventually, I learned that Fineup's hybrid input-output (HIO) approach is one of the popular approaches for these kinds of problems (Ref [1]). Here, I would like to accept that I tried to search for relevant code and I found a couple of repositories in GitHub which focuses on image reconstruction problem and I adapted to this code

<https://github.com/cwgoddard/Image-Reconstruction>.

I must say, I was not getting any satisfying results thus I started looking deeper into the literature. I finally learned that these classical approaches are not suitable for all kinds of situations and the state of the art to solve this problem is to use deep learning models like CNN. I also learned that one may not need to work with the entire image as parts of the image may also provide sufficient information about the object. This is also a way to increase the sample size for CNN models. I am currently at this stage and I am trying to follow Ref [2].

1. J. R. Fineup, Appl. Opt. **21**(15) 2758-2769 (1982).
2. Christopher A. Metzler, Felix Heide, Prasana Rangarajan, Muralidhar Madabhushi Balaji, Aparna Viswanath, Ashok Veeraraghavan, and Richard G. Baraniuk, Optica 7(1) 63-71 (2020)