Pattern Recognition

Qcamp 2019, Experimental Session 20/06/2019

1 Introduction

In Mission 3, we split the incoming beam into two with a beam splitter and project its polarisation with two separate polarisers. The beam intensities were measured with two separate photodetectors, giving voltages from detector 1 and detector 2. From the magnitude of the signals measured, we try to identify the polarisations of the signal from the four possible choices: H, V, D, A.

1.1 Motivation

First, we do a quick recap of the set-up. We have two photodetectors with their own polarisers. All in all, there are three different polarisations to deal with: the polarisation of Alice's photon, and the two polarisers for our photodetectors. Unlike in mission 1, where we calibrated the polarisations between the sending and receiving team, this time we do not calibrate the polarisations. Thus, in principle, the two detectors do not have the same polarisation.

The signal we get would be the voltage readings from both detectors. Since the incoming signals will be one of the four polarisations, we can try to group the data into four groups. This is performed through the K-means clustering algorithm[1]. Long story short, the algothrim sifts through the dataset and group the data into k number of clusters by looking at how close the data are to one another. We use this idea to group the signals into the four possible basis. Unfortunately, it only groups the data but not tell us the polarisation (we need you to figure this out yourselves!).

Task 1 [2 pts] Explain and convince yourselves that you understand the data generated by `key_logger.py`. Write down what you have understood.

Task 2 [2 pts] Of course, the fact that we do not bother with calibration (which is a critical aspect of any experiment) means that it does not impact the results. Argue for why this is the case.

The algorithm allows us to identify 4 unique clusters, but does not identify the polarization. Even if calibrated, we are still unable to identify the exact polarization of the light.

Task 3 [3 pts] A sample of the signal voltage from both detectors is plotted below. Using a 'clustering' algorithm, we identify 5 clusters.

[1] https://www.datascience.com/blog/k-means-clustering

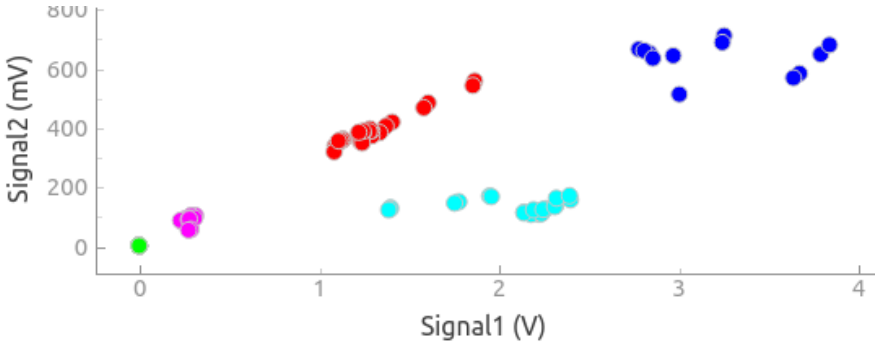

Figure 1: Signals from detectors 1 and 2.

Why are 5 clusters identified, when only 4 polarisations are being measured?

1 cluster corresponds to when both detectors are idle, no incoming signal is detected

Task 4 [3 pts] Why do you think we made the effort to measure the beam using two detectors? Hint: Observe the spread of the signals for each cluster using your answer in Task 3.

If there is only one detector, we will only be able to identify 2 main clusters.