The Uncertainty Principle and the Confusion Matrix

Richard Fiene PhD

Penn State University

December 2023

This abstract will attempt to incorporate Heisenberg's Uncertainty Principle into a Confusion Matrix. The reason for doing this is an attempt to get at the interplay between position and momentum. The Confusion Matrix has been used for decision making for some time now and could be an interesting way to display the Uncertainty Principle based more upon logic and its resultant correlational approach. The Uncertainty Principle describes the relationship between position and momentum. The more accurate you know one, the more blurry the other becomes. This can be depicted in the following Confusion Matrix:

Uncertainty Principle Matrix		Momentum is	Momentum is
		Known (+)	Unknown (-)
Position is	Known (+)	+/+	+/-
Position is	Unknown (-)	-/+	-/-

The above Matrix can be explained in the following way: The Uncertainty Principle is depicted in the +/- and -/+ cells where as we know more about momentum, we know less about position and the more we know about position the less we know about momentum. The +/+ cell is the null cell for the Uncertainty Principle, where one cannot know about both position and momentum equally, this is the essence of the Uncertainty Principle. The -/- cell is where we are unaware of both position and momentum so there is nothing to observe.

The matrix plays out very differently than what is usually the case with the results of most confusion matrices. In the majority of confusion matrices, the diagonal of true positives (+/+) and true negatives (-/-) is the desired result, not false positives (+/-) and negatives (-/+). But in this case with the Uncertainty Principle, the false negative (-/+) is the logical result. Let's look at this from a mathematical point of view in the following matrix substituting (+) and (–) with (A) - (D).

Uncertainty Principle Matrix		Momentum is	Momentum is
		Known (+)	Unknown (-)
Position is	Known (+)	A	B
Position is	Unknown (-)	C	D

Equation demonstrating the correlation based upon above matrix:

$$\phi = \frac{ad - bc}{\sqrt{(a+b)(c+d)(a+c)(b+d)}}$$

$$\phi = \sqrt{\frac{\chi^2}{n}}$$

Hopefully this provides a logical approach to demonstrating the relationship between position and momentum as defined by Heisenberg's Indeterminacy Principle.