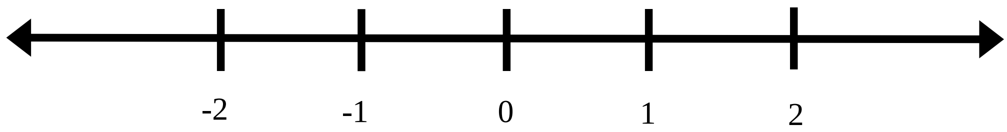
Conditional Probabilities in Exponential Reference Classes

by Sven Nilsen, 2022

In this paper I prove, using a simple one-dimensional model with two choices, that conditional probabilities are modified in an exponential reference class of observers. Furthermore, I also show that the conditional probabilities branching from impossible or unlikely events are well behaved.

Assume that there is a discrete one-dimensional space without bounds. This can be modelled using the integers. At origo, there is a source for an exponential reference class of observers[1]. Instead of giving a specific reference class, the limit is studied, such that one can infer the behaviour of probabilities alone, of finding observers, from the shortest paths to any given position.



The probabilities of finding observers is a function of the path that is 1 for the shortest path from origo to any given position, and 0 for all other paths with the same start and end. It turns out that this path is unique for this particular model, but in principle there could be more than one shortest path. Hence, there is a set of paths which are likely to be observed.

When taking the union of these sets for every position, one gets a probability distribution that is not normalizable, yet is well defined. This is because there is no overlap between the sets, since every path determines which original set it belongs to through its start and end position. One can only talk about probabilities when selecting some position to measure relative to the origo.

However which path an observer takes, it has to proceed along the extensions of its history, such that for every shortest path of length N greater than 0, there is a shortest path of length N-1. Thus, one can view the probability distribution in terms of conditional probabilities.

$P(L) = P(R) = 0.5$ L = “left” R = “right”

$P(L \mid L) = P(R \mid R) = 1$

The reason for these conditional probabilities is that `P(R | L) = P(L | R) = 0` as moving left, followed by right (or vice versa) would cancel and become longer than the shortest path possible, which has length 0. Therefore, as the sum of conditional probabilities for every position must sum up to 1, the only remaining possibility is to continue movement in the same direction.

Since the following equation holds for conditional probabilities:

$P(LL) = P(L \mid L) * P(L)$ $P(RR) = P(R \mid R) * P(R)$

One can infer that:

$P(LL) = P(RR) = 0.5$

This leads to an interesting interpretation of probabilities. What does it mean that an observer has 50% chance of having the path LL or RR? The general distribution of probabilities over the entire space is not normalizable. The intuition is that the observer at the start of origo chooses to go either left or right, but after making this choice, is forced to continue moving in the same direction over time. Hence, the 50% chance of existing at any positive or negative position is summed up to 100% with the corresponding probability of being at the same position, but of opposite sign.

There are some remarkable properties of the paths in such probability distributions. First, the observed paths are as straight as possible. Second, the union of all sets of shortest paths per position cover the entire continuous space. Third, the conditional probabilities are well defined by having alternative paths being cancelled by other paths outside its distribution per position that sums to 1.

I conjecture that every conditional probability is well defined for all discrete continuous spaces. Hence the overall probability distribution is well defined, even though it is not normalizable.

For example, even if the probability `P(LR) = 0`, one can build further conditional probabilities based on it, e.g. `P(R | LR) = 0.5`, since the following branches are a result of self referential repetition of the distribution of observers starting at origo. Therefore, when branching from impossible or unlikely events, the probabilities are still well behaved.

There is also a case where the origo is shifted left or right through impossible or unlikely events. This happens by canceling the path after repeated movements in the same direction, e.g. `LRR`, which can be read as moving right two steps and then left one step. Since the last left step cancels the previous right step, there is no set of shortest paths for any position that contains this path. Hence, the conditional probability is 0 and considered an impossible or unlikely event. Now, having canceled the path, the observer can move either left or right as the direction of movement is undefined. The result is a shift of the origo one step to the right. The reson for this is simple: From the perspective of either one future step left or right, the shortest path, assuming the history `LRR`, is `LLRR` or `RLRR`. Without a bias of choice, each step left or right has equal probability.

Now, one can imagine models where there is bias of choice, so in some sense the conditional probabilities are not well defined. This means the conjecture I made was not true without making any assumptions. However, one can make an assumption that any bias implies introducing well defined probabilities in cases where paths cancel. Plus, when there is no bias, each choice has equal probability to any other choice. Therefore, one can think of the conjecture as true when bias is treated like choice of cordinates. These cordinates are kind of like relativistic curvature of space.

For example, a choice of coordinates is to make a particle move with 100% likelihood in one direction. This implies that in the impossible or unlikely event that its path would cancel at some position, it would continue in the same direction with 100%, but delayed one step in time. Such particles would move close to “speed of light” for that particular kind of physical universe.

Similarly, one can imagine a particle with mass moving with 50% likelihood in either left or right direction. The particle continues moving in the same direction unless the path cancels. When the path cancels, the particle might move in opposite direction, canceling the movement further, but leaving information behind for external observers. Here, the mass is a choice of coordinates at rest relative to the particle.

In either case, the particle moves at “speed of light” at any point in space-time relative to some external observer, but the effect is different depending on which choice of cordinates one views the particle. Therefore, it is likely that observed particles can take on different properties depending on the overall observer selection effect. However, this requires further research.

References:

[1] “Exponential Reference Class”
Sven Nilsen, 2019
https://github.com/advancedresearch/observer_selection_effects/blob/master/papers-wip/exponential-reference-class.pdf