Background for the Brain Wave Cruise Photo Tour

This document supplies background information to understand the meaning of the blue surfaces of the Brain Wave Cruise Photo Tour.

Understanding the brain with copulas

Imagine we could fully understand the brain. Understanding all the intricacies of how the brain works could allow us to cure many diseases like Alzheimer's or Parkinson's. We might also be able to build machines that mimic the brain or even excel at what it is doing so that old science fiction stories on general artificial intelligence finally come true.

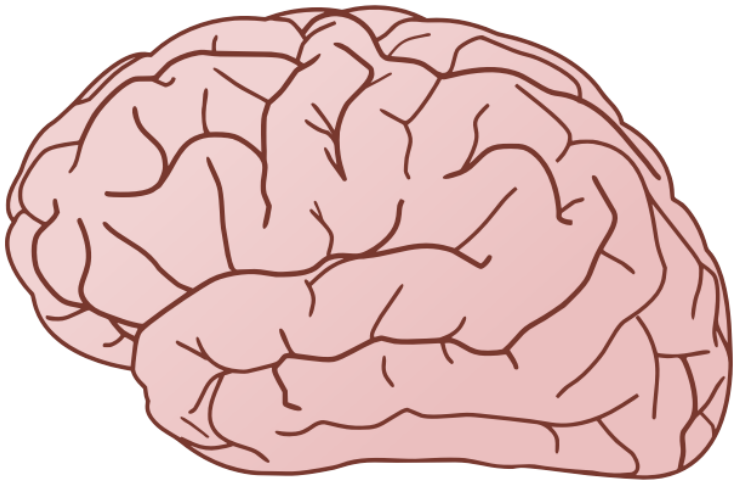

Figure 1: The brain - how can we understand it?

So how do we get there? Well, if we want to understand something, we might start by looking at it. But of course, it is difficult to see what is going on by just looking at the brain. So, when we say looking, we really mean measure: we want to measure brain activity.

People have been measuring brain activity for a very long time using different techniques. These techniques typically measure activity at multiple sites of the brain. Wouldn't it be great if we could combine different measurements to get the big picture? To do so, we need to understand how exactly measurements at different sites are related. Sounds like a difficult problem.

We can take inspiration from a domain that has been looking at interactions for a very long time - and also has been extremely well funded to develop methods for this: Finance itself. Understanding the relations between stock markets is useful for making money. In finance, a common tool to understand relations is the copula. A copula is a representation of how two things are related.

Brain waves in the cruise photo tour

When you start the brain wave cruise photo tour, you will see an animated blue surface. This is a representation of a copula for real brain recordings.

For the brain wave cruise photo tour, brain activities were recorded at multiple sites over time. The copula is showing how two brain measurements interact. Elevations in the surface plot show

stronger coupling than what would be expected by chance if the brain activities at the two measurement sites were independent.

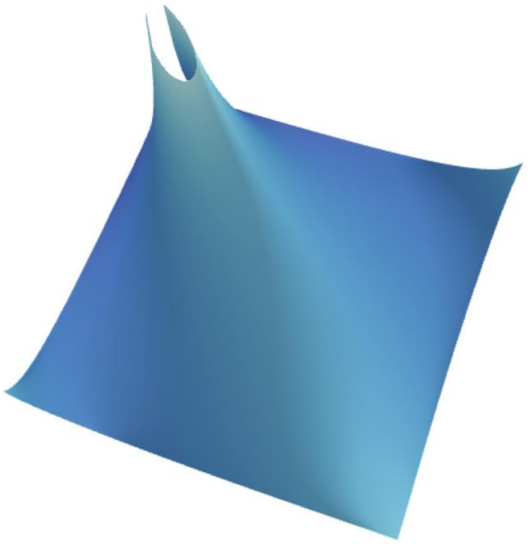

Figure 2: A copula showing the relation between two brain recording sites.

The corners of the base area represent different activity combinations. The top corner means low brain activity at site 1 and low brain activity at site 2, bottom means high activity at site 1 and high activity at site 2, left means low activity at site 1 and high activity at site 2, and right means high activity at site 1 and low activity at site 2.

Elevations along the diagonal from top to bottom mean that brain activities at the two measurement sites act similarly. If one is active, then the other one also tends to be active. On the other hand, elevations along the diagonal from left right to right mean that brain activities act in opposite ways. If one is more active, then the other tends to be less active and vice versa.

For instance, in Figure 2, the large peak in the top corner means that low activity at site 1 together with low activity at site 2 occurred more often than expected by chance. This could indicate that there was a common process decreasing the activity at both sites.

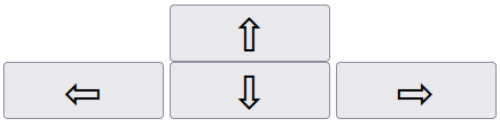

Figure 3: Arrows for brain navigation.

The animation shows how the relation between brain activities at sites 1 and 2 changes over time. By pressing the arrows, you can select different brain recording sites and thereby move within the brain. The animations will change to show the relations of the selected recording sites.

The tool that we built to model these relations is called Copula-GP. For technical details on the tool, check out the Copula-GP project website.