Noise Cross-Correlation Based Brain Signal Reconstruction:

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Background. Brain signal reconstruction is to reconstruct the certain signal of brain via certain measurement. Brain imaging --reconstruct the brain itself-- is also contained in this category. We usually need to use a device to get certain measurement and reconstruction what we need from them. Typical methods contain MRI, CT[1] PET and EEG. These technics are all extremely powerful with high resolution, so they are popular methods in brain research and diagnostic. However, if we are not interested in reconstructing the whole brain with that high resolution, if we just need a basic level of knowing the structure, for example, we want to use wearable devices to do the measurement and just make predictions and warnings to the brain status. These methods suddenly became useless since they are impossible to become "wearable". The high resolution of these technics make the devices used too large to use in many usual situations. Therefore, we need other ways to do it. A promising method is to use an analog from the geology field: surface-wave tomography. Since the wearable devices can only get bio-signals not much more than noise. We then just use the noise to reconstruct what we need!

Hypothesis. As an analog of the original Science paper [2], the hypothesis is that the noise we measured from each point of our head are correlated with each other, and the structure information of brain is contained in these cross-correlation. We will derive the correlation pattern in theory and find out whether they are correct and detectable in reality. Then we will solve the inverse problem to using the cross-correlation to reconstruct the brain.

Approach. First, we need to collect enough data, we need to convene a lot of volunteer to collect the neuro noise, since we are just measuring the noise, any typical methods like using electrodes over head are fine. But the pattern inside the noise is spread and subtle, we may need a long term for experiments. Then, the method is similar to typical CT approach[1], since the cross correlation between two points on the head depends on the matter between them. However, we need a more procedure to test if these patterns are detectable via measuring only the noise. Then if this is proved, we need to solve the inverse problem and get the algorithm to use the cross-correlation function to reconstruct brain matter density function, just like in CT[1].

Summary. To make brain signal reconstruction in daily life, we need to derive a totally new method. And this noise cross-correlation based approach is promising and worth to be tested. If it's proved, we can change the way people living, and improving life quality since we can notice the pathological changes earlier and easier.

Reference.

[1] Hsieh, Jiang. "Computed tomography: principles, design, artifacts, and recent advances." Bellingham, WA: SPIE, 2009.

[2] Shapiro, Nikolai M., et al. "High-resolution surface-wave tomography from ambient seismic noise." *Science* 307.5715 (2005): 1615-1618.