Patterns within Neurons

T.N
tnaithani96@gmail.com

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Abstract

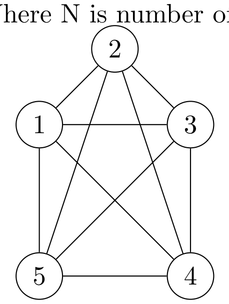
While reading about brain,this problem struck me. How many memories are possible in Brain given N number of neurons?. A memory in brain is a result of neurons fired in a particular sequence.If every pattern of Neuron firing corresponded to a new memory, which can have any functions from playing music to building sentences. How many memories can the brain can have, is it infinite or a finite number.

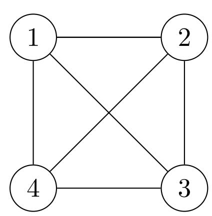
Introduction

The crux of this article is to find a solution to the problem of how many memories can the brain have or how many unique Patterns are possible for a given number of Neurons or Nodes. I would move forward with taking calling Neurons as Nodes. With a given number of Nodes how many connections are possible? Since for any given Number of Nodes we can know total number of edges will be E. Where E is,

$$E = N(N-1)/2$$

Where N is number of Nodes



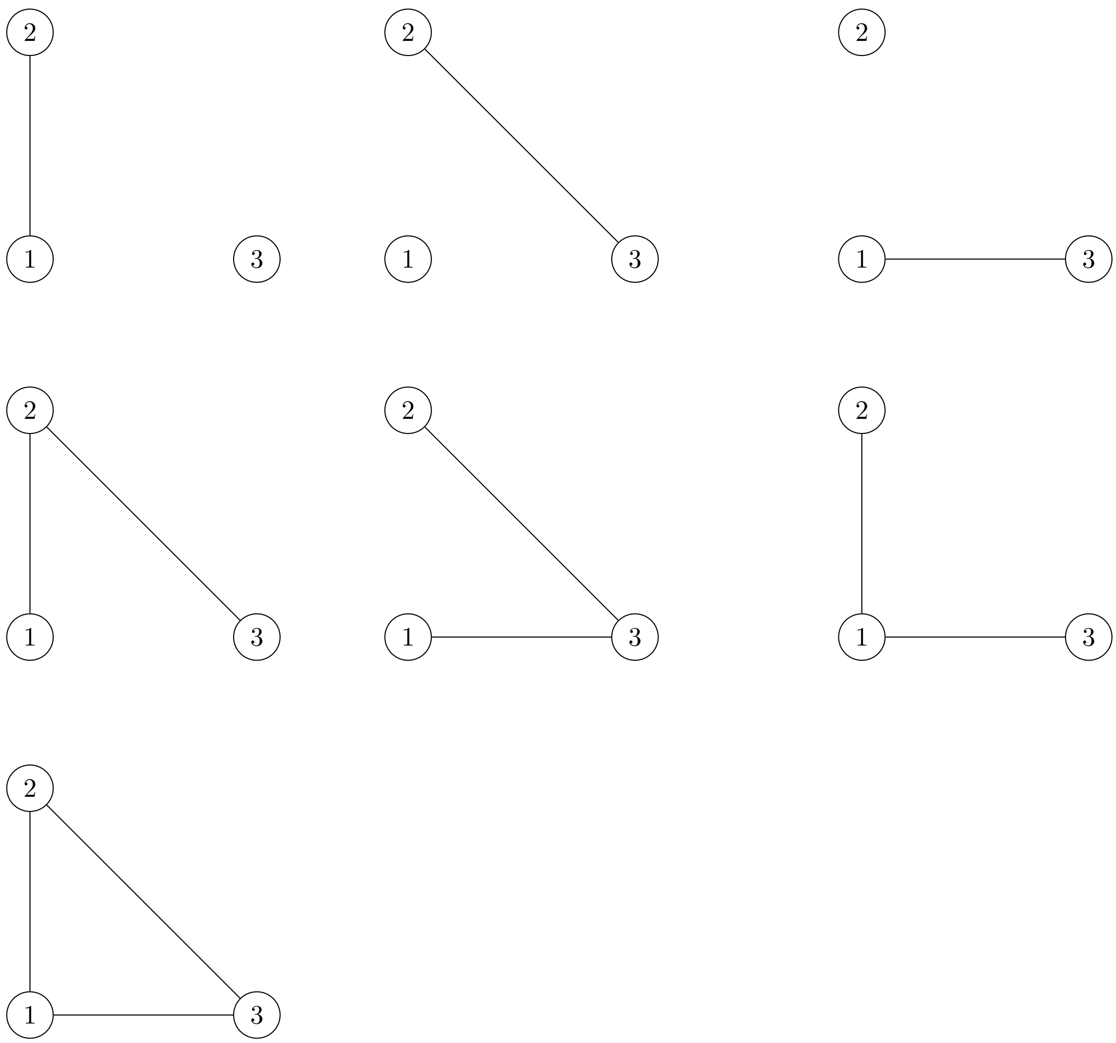


The above examples are connected graphs of 5 and 4 nodes with number of edges: $n(n-1)/2$

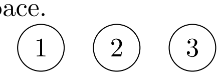
Theorem

Now considering there are N nodes in brain how many unique patterns will be position,Under the condition that we need atleast one active connection between 2 neurons to trigger a specific memory.

Example of patterns in 3 Node system



The above are the patterns formed by a 3 Node system. The aproach we can take while making patterns like these is to consider every Edge as an unique space.



For patterns in row one we are selecting one of the 3 spaces so the patterns that could be formed are $\binom{3}{1}$

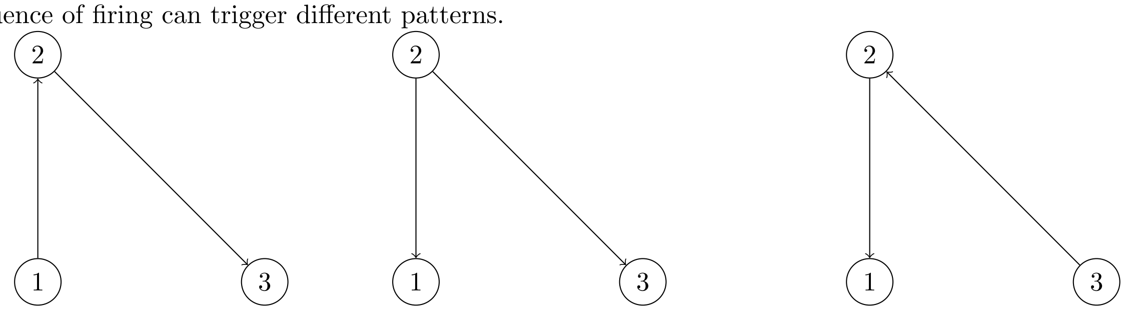
Similarly,Patterns in row 2 are selecting two of 3 unique places so they are $\binom{3}{2}$. So, the total number of Patterns can are

$$patterns = \sum_{x=1}^{3} \binom{3}{x}$$

In the above case we have had 3 unique spaces, What if there are N nodes. The total number of unique spaces for a N node system is $N(N-1)/2$ The new number of patterns are

$$Patterns = \sum_{x=1}^{N(N-1)/2} \binom{N(N-1)/2}{x}$$

The important detail we missed till now is, since these are uniques spaces(Space between 2 nodes/neurons) the 2 differnt directions are possible. Since, The sequence of firing can trigger different patterns.



Even though the patterns have same connections but the direction of each edge makes these 3 different configurations.

Each active edge can have one of the two direction. When taking directions into account the total number of patterns form changes to the following:

$$Patterns = \sum_{x=1}^{N(N-1)/2} \binom{N(N-1)/2}{x} 2^x$$

$$or$$

$$Patterns = \sum_{x=m}^{N(N-1)/2} \binom{N(N-1)/2}{x} 2^x$$

Where m denotes minimum number of active connections threshold for any memory

Conclusion

The answer to how many memories or patterns can be formed in brain with N neurons are:

$$Patterns = \sum_{x=m}^{N(N-1)/2} \binom{N(N-1)/2}{x} 2^x$$

Where m is the minimum connection restraint

This is the total number of patterns, I read that there are 90 Billion neurons in brain so you can calculate the Patterns by putting $N = 90 * 10^9$. Which would given a finite answer though a big one.

Reference

Linear algebra and it's application by Gilbert Strang