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Superiority of the Human Brain over the Computer World in terms of Memory, Network, Retrieval and Processing.

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Abstract: - We live in a world of computers. The computers are becoming more powerful with each generation. We cannot imagine a world without computers today as they are an amazing invention and has become a part of our everyday life. As of today the world's most powerful and the most complex computer is the supercomputer TITAN. But how complex is it? How about the Human Brain? Most of us think that the computers are superior to us and underestimate the Human Brain. Instead ,We do not realize how complex and superior we are to the computer world in reality . The Human Brain is so complexly designed that it cannot even be understood completely .As with this research, there is a detailed comparison between the Human Brain and the Computer world and we will get to know how the Human Brain exceptionally beats the computer world.

I. INTRODUCTION

We live in a world of Computers. As of today the world's best computer is TITAN. But how complex is it??Can it beat the Human brain? The Human brain is such a complex system; it's almost an abstract concept. The study of the Human brain is incredibly important and of great use to the whole mankind. This research proposes a detailed comparison between the computer world and the Human brain. The Memory, Network, Retrieval Process and Processing speed of the Human Brain are all major research topics in Artificial Intelligence. Scientists are yet to completely explore the complex and amazing design of the human brain. In the current generation of the computer, with Image processing, Voice recognition , Robotics, Software Agents and many more, there is no doubt that the Computers are advancing and replacing manual and Analog things in Digital format and processing. There are so many software's which are being developed. But how about a Human Being? Have we ever thought about all the complex things which we process in our everyday life? Our Brain is one unit which does all the things. At an instance we can Talk , Breath , Listen , See , Walk , Move , Imagine, Think, Smile, Touch feel , Smell, Learn , Take Decisions, Creative, Store , Monitor . So much of processing required doing each of this. Who is doing all these things? It's the Human Brain. With an estimated 100 billion neurons and about a trillion synapses per cubic centimeter of cortex, the human brain is arguably the most complex system in the human body and. Yet the human brain remains poorly understood.[1] It is only when we begin to really think about it that the importance of the complexity of our brains, it becomes apparent how much our Brain really does. This research will help us to understand the complexity of the brain and With the end result, we would know how superior the brain is over the computer world is in terms of Memory, Retrieval, Processing and network

II. MEMORY CAPACITY

2.1 The Memory Capacity of the Computer

The computer memory has had great advancement over the years. As with each generation, the Memory Capacity is increasing and the Storage device is decreasing in size. Let us have a look at in general according to the different generations of Computer. Computers have more than one form of memory. We can generally classify them into primary and secondary memory. Primary memory is used as a form of temporary memory for calculation processes and storage of temporary values that need rapid access or updating, the

contents of the primary memory disappear when the power is turned off. Primary memory is important when executing programs, bigger programs require more primary memory. RAM(random access memory), Caches & buffers are just a few examples of primary memory. Secondary memory often comes in the form of hard disks, removable disk drives and tape drives. Secondary memory is used for the storage of most of a system's data, programs and all other permanent data that should stay there even when the power is turned off. As a computer is fed with bigger, smarter programs and more data, it would naturally need more secondary memory to hold them. As of now, the worlds supercomputer **TITAN**'s primary memory is **710 TB** and the Hard Disk is **20 PB**. 1 PB=1024 TB.. The Memory Capacity of the Super Computer is thousand times much more than the Personal Computer. There is no computer now in the world with memory capacity higher than the **TITAN**.

COMPUTER GENERATION	PRIMARY MEMORY	SECONDARY MEMORY
First Generation (1946 - 1956) Vacuum Tubes	Magnetic drum (2 KB)	Punch-card used (Up to 10 GB)
Second Generation (1957 - 1963) Transistors	Magnet core memory (Up to 32 KB)	Magnet tapes used (Up to 40)
Third Generation (1964 - 1979) Integrated Circuits	Semi conductor memory (Up to 2 MB)	Magnetic discs (Up to 100)
Fourth Generation (1980 '- 1990) Very Large Integrated Circuits	Chips (Up to 1GB)	Hard Disc, massive use of Magnetic and optical storage devices (Up to 200 GB)
Fifth Generation (future implementation).	Bio-Chips (Up to 16 GB).	Harddisk ,External Hard disks, Pendrives(Up to 100 TB)
Super Computer TITAN (VSLI chips)	Chips (710 TB)	Chips (10 PB)

2.2 The Memory capacity of the Brain

Memory is our ability to encode, store, retain and subsequently recall information and past experiences in the human brain. It is the sum totals of what we remember, and gives us the capability to learn and adapt from previous experiences as well as to build relationships. It is the ability to remember past experiences, and the power or process of recalling to mind previously learned facts, experiences, impressions, skills and habits. It is the store of things learned and retained from our activity or experience, as evidenced by modification of structure or behavior, or by recall and recognition. The **Neurons** are the living cells which are the storage units in our brain. They are micro organisms that store the information. There are about 100 Billion Neurons in the Brain .The Neuron is comprised of Synapse. There are more than 125 Trillion **Synapse** in our Brain. Even to the minimum, if 1 byte of Information is stored in each 200 Billion Neurons*1= 200 Billion bit of information (10,000 Million MB).But how much of Memory can be Stored in a Neuron? A typical healthy human brain contains about **100 Billion** nerve cells, or neurons, linked to one another via hundreds of trillions of tiny contacts called synapses each Neuron is linked with 1,000 to 100,000 other Neurons through 125 trillion to 10 quadrillion synaptic junctions. In a human, there are more than **125 trillion synapses** just in the cerebral cortex alone.(**René Marois from the Center for Integrative and Cognitive Neurosciences at Vanderbilt Vision Research Center stated)** Each synapse stores information in it. Each Synapse possesses a variable firing threshold which is reduced as the neuron is repeatedly activated. Now to the Minimum, If we assume each Synapse to store 1 bit of Information, then 125 Trillion*1=125 Trillion Bytes of Memory.

The brain has an infinite amount of storage. It was discovered that if the things the average human learns in one year was broke down into 4 minute songs, that it would take 2 billion years to listen to all of them. Considering the song size in megabytes for 4 minutes is 4-6 mb Approximately 1.5 billion terabytes of memory is needed to store 1 years worth of learned things. ***"According to Joe Boney Taking 5 mb as an average to store 4 minutes data as a song, 1503753662.10938 Terabytes of Memory is needed"*** . To figure out how much

you have learned in your life you would simply multiply this number time your age in years.. If somebody lives for 40 years, then till that point the Brain storage capacity would be 60150146484 TB. **In cubic Miles of Bytes-** The memories of computers are measured in terms of their smallest addressable element, called a byte. A byte usually contains eight binary digits. Nerve cells also have an "all or nothing" binary response. If combinatorial codes are remembered by nerve cells, each combination of firing inputs received by a neuron with 100 dendrites could contain 100 binary digits.. A single nerve cell with 100 dendrites can potentially remember that many bytes of singular combinations. Some nerve cells have upto 2,50,000 dendrites! **(2004 Noble Prize Winning Discovery)**

III. NETWORK STRUCTURE

3.1 In the Computer World

There are many types of Topology through which connections are established. The Star, Mesh, Ring and Bus are the commonly used Topologies. The computers are connected through many different devices and Modes. The Satellites, Switches, Routers, Workstations, Hubs and Nodes are connected through different cables and through a Topology. The cabling and wiring to connect so many different computers takes many months or Years. The Network Engineers decide on the Topology to and do the connection. Once the connections are established, they do not change or alter the Topology unless some problem occurs. The Current world population is said to be 7 Billion according to the survey. Even if we consider everybody to have a personal computer, on the whole about 7 Billion computers. Considering all the MNC's and IT companies and all the other companies. On the whole the Number of computers in the world would be about 10 Billion. All the computers are connected through LAN, WAN, MAN and INTERNET. In the Internet world, Computers are connected generally through a Client Server Technology where thousand or Billions of Clients are connected to few Servers. Approximately on the whole there would be about 10 Billion Connections.

3.2 In the Human Brain

Every Neuron is connected to over 10,000 to 1,00,000 other neurons. The number of connections seems less precise, but it is at least several **125 Trillion** connections **(10^{14})** as judged by Marios and Smith and as much as **10^{15}** as judged by Seung. (**That's roughly equal to the number of stars in 1,500 Milky Way galaxies).In a Cubic Millimeter of a Brain- John S. Allen of the Department of Neurology at University of Iowa** stated in one of his paper - The mean total brain volumes found here (1,273.6 cc for men, and 1,131.1 cc for women) .We can take the volume of the brain as 1000cc as a low estimate (which will only over estimate the density of connections). One cubic millimeter is 1/1000 of a cubic centimeter and 1/1000000 (10^{-6}) of the entire volume of the brain. We can scale the total number of connections in the brain (using the high estimate of 10^{15} connections in the brain) then we find that there are 10^{9} connections in a cubic millimeter of the brain. The number of connections in a cubic millimeter of the brain is **10^{9}**. "In a single cubic millimeter of brain tissue, there are some one 100 million synaptic connections between Neurons.".(**Eagleman, David. *Incognito: The Secret Lives of The Brain.* New York: Pantheon Books, 2011**.)

"In a single cubic millimeter of brain tissue, there are some one hundred million synaptic connections between neurons." Pg. 173 ,**Eagleman, David. *Incognito: The Secret Lives of The Brain.* New York: Pantheon Books, 2011**.In the Brain, to the minimum about **125 Trillion** connections are there and they too are connected through a specific pattern. The most surprising thing is that the human brain does not remain connected through a specific Topology. The Structure and Topology keeps changing.. The Topology in the Brain constantly keeps on changing over a period of time. The number of connections in our Brain increases everyday. Whenever we learn something new, new connections are established in our Brain. With everything which we do, new connections are added into the existing connections. Whenever we Listen, See, Smell, learn, read, practice, Millions of new connections is formed. **Millions** of connections in our Brain are established through a certain Topology within few minutes or hours. But in the computer world, it takes so much time and resources even to establish few thousand connections.

IV. INFORMATION RETRIEVAL

4.1 In the Computer World

The Internet works with the **Client Server** Technology. The Server is the actual computer which stores all the information. In the Internet world, the **clients** are connected to the **central server**. When the user gives the Search criteria, the **reques**t is sent to the server and the server processes the request and gets a set of result and sends back those results as **response** back to the client. There are many servers in the computer world. Google, Yahoo is the most popular ones. The **Search Engines** are the ones which perform search throughout the web and gets the result. There are lots of Algorithms which are used to perform search efficiently and to get efficient results. There are many Search Engines which perform the searching. When we use Internet, we do get

result for our search criteria. But how fast and efficient are the results? Like any other system, retrieval systems are susceptible to being evaluated so that users can measure their effectiveness and so acquire trust in them. The field of information retrieval has a critical need for testability. The information retrieval system can be evaluated in terms of many criteria, including execution efficiency, storage efficiency, retrieval effectiveness and the features they offer a user. In an information retrieval system, the retrieved documents will not be exact responses to the request, it will be a set of documents ordered according to the relevance of the request. What needs to be evaluated is how related with the topic of the question the set of documents forming the response is; this is the retrieval effectiveness. A **document** can be considered relevant or non relevant considering two things. to the motives for the need for the information or the degree of knowledge both have of the subject.

4.2 In the Human Brain

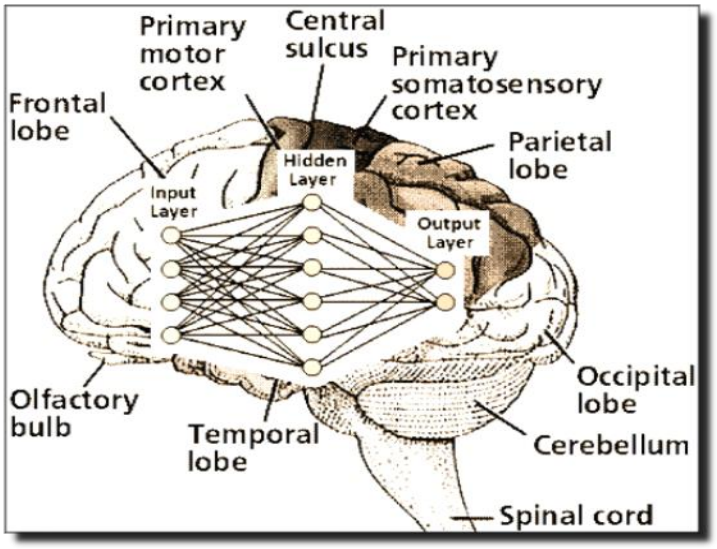
Information Retrieval is to select the information that is relevant and reduces it to a manageable and understandable set. In human brain the information are stored as a very huge content, but during the presentation or retrieval it selects the relevant content and then tries to represent it. There are two types of information retrieval that brain can perform, Basic and compound information retrieval.

4.2.1 Basic information retrieval

The neural networks of the brain includes nodes, the nodes can be in one or two states. **Active states**: represent ongoing external events and internal mental processes. **Quite states**: represent stored concepts. Making the quite state nodes to activate is known as information retrieval process. Every basic associations has corresponding basic retrieval requests. The basic association 'A is a part of B' has two corresponding retrieval requests: 'Retrieve a part of the given item A', and 'Retrieve an item whose given part is B'. These type of retrieval is known as Basic retrieval.

4.2.2 Compound retrieval information

Related to the basic retrieval requests the compound retrieval requests are of two ways that is nesting and by logical joining. In nesting the given and/or the target are themselves retrieval requests. In logical joining, individual requests are joined together by the logical relationships AND, OR, NOT and delimiters.



4.2.3 Thinking

Thinking is a set of information handling processes that operate on the information structures stored in the brain's memory and on information that flows through the brain. There are different ways of thinking based on request or requirement of oneself. They are problem solving, organizing information's and simulations.

4.2.4 Problem solving

In order to reach a satisfactory solution, the brain has to retrieve information from all the neurons which are needed. Searching takes place over the Billions of Neurons .Out of the 200 Billion neurons, few thousand neurons are activated and the information is said to be retrieved. If nodes are not activated, then there is no solution in memory records. The synaptic changes in modulation are not permanent, ones the solution is found or the retrieval process is abandoned, All the time the activated node will not be a satisfactory solution. The firing node may represent a solution to only a part of the retrieval request. Other mechanism which brain has is

appraising solutions. This mechanism is the part of the thinking process. This makes to feel whether the solution is right or not. After all possible modulations if the solution is not satisfactory then the brain decides to relax the retrieval request. Brain has the ability to construct new concept from the existing one, so that it satisfy the retrieval request. Problem solving may require trial and error iterations. Throughout the iterations, the givens have to remain active, or refreshable, until a satisfactory solution is obtained.

4.2.5 Organizing information

Organizing information is one of the common thinking process. In order make brain useful, information – flow has to be associated with pre-existing concepts. The information-flow may sometime be the result of external stimulation or internal processes. This information-flow is continuous and with this it establishes item parts, class exemplars and temporal associations between the parsed entities and memory records. The organization of information in brain is conscious and unconscious. In familiar situations we are not aware of the work associating with internal representations. Sometimes we are aware of situation, at this time brain try to answer the question.

4.2.6 Creativity

Ability to create and to analyze is one of the most important features of human brain. The brain can also activate nodes that have nothing to do with actual external events, in addition to nodes that fire due to external stimuli. Play-backs of real experiences are by internally activated nodes or it can be new combinations of unrelated experiences. For example, the events which are past can play-back in our mind. Modification can be made during play-back, but the brain simulates if some of the elements were different. After the creation of hypothetical event, it is exposed to the detectors and activators of the brain.. One of the most complicated processes is simulating and analyzing hypothetical events. After the simulation is over, no permanent record of all the intermediary concepts has to be created. The brain has to rely on the working memory to satisfy this requirement. Mirror representations of concepts that exist in short and long term memory are created in working memory. In addition to the mirror concepts, new concepts are defined. The working concept and other concept are detected by detectors and activates brain's activators

The Internet world works with the Client Server Technology. Where all the clients' requests are sent to the central Server. It is only in the Server the Searching takes place. But in the Human Brain, we don't have a central server like wise as the Internet. All 100 Billion Neurons store information in it. All of these individual neurons are like Servers storing the information. Information has to be retrieved from these 100 Billion neurons. But still, because of the processing speed of the brain, the search takes place within few seconds generally. Example: It just takes few milliseconds for a person who is about **50** years to recollect many of the instance which happened in his early childhood or school days. The information and instances stored more than **30- 40 years** before can be recollected within few milliseconds. . The search takes place among 100 Billion neurons and retrieved so quickly. That is the Information Retrieval capacity of the Human Brain. The Computer world even with Client Server technology cannot retrieve information as fast and relevant as the Human Brain.

V. PROCESSING SPEED AND MULTITASKING

5.1 In the Computer

The computers can do many things much faster than Human beings. If we need to calculate the product of 12345*674682, the computer would do within a second but the Human Being will take quite some time. And most of us think that the computers can process information faster than the Brain. With parallel processing and Multiprocessing, the processing speed of computers has increased even more. As of now the Super Computer **TITAN** has the highest processing speed.

5.1.1 Processor Specification

Specific Purpose Processor

5.1.2 Processing speed

TITAN is a Super computer developed by Cray at Oak Ridge National Laboratory. It is composed of 18,688 CPU's and 18,688 GPU's.. The Processing speed of TITAN is **17.59 PetaFlops[30]. A Petaflop is equal to 1000 Trillion Floating Point Instructions per Second. 17.59*1000=17590 Trillion Floating point Instructions per Second.**

5.1.3 Multitasking Ability

With thousands of CPU's and GPU's, the Super computer has reached great leap in processing multiple things at a time. A Super Computer is use for scientific purpose and must handle very large Database and also

do huge amount of Calculations. The Super Computer has 18,688 CPU's and GPU's. Through **Multiprocessing** Multi tasking is done .Many different processors are used to do different Independent Tasks at a time. The Super computer can do many things at a time. Example: The Personal Computers we can listen to songs, work with Microsoft Word, Browse the net, at a time. All of this is done by one processor. In the Super computer, there is thousands of CPU and Multiprocessing ability is thousand times greater. It does exceptional processing with very high speed.

5.2 In the Human Brain

Many of us think that the computers are faster than us in processing as they can perform calculations with greater efficiency and sped unlike us. Its true that the computers does a lot of tasks exceptionally better than the Human Brain. But does that mean that the Brain is not capable of doing all those things which computers are doing better now? What is the reason Brain cannot compete with Computer processing speed in performing calculations and Specific tasks??. Here is the general analysis.

5.2.1 Processor Specification

General Purpose Processor

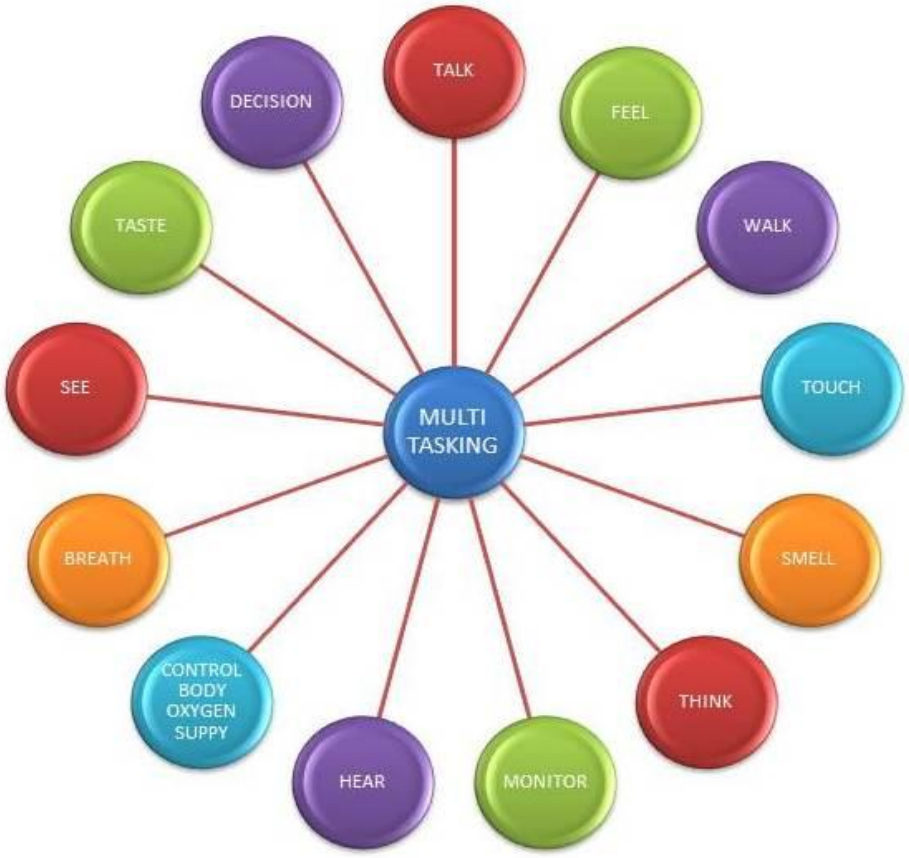
5.2.2 Processing Speed

As we have seen earlier, a human brain has about 100 billion brain cells. Each Neuron Fires information to other neurons in the brain. Although different neurons fire at different speeds, as a rough estimate it is reasonable to estimate that a neuron can fire about once **5 milliseconds**, or about **200 times** a second. The number of cells each neuron is connected to is at least **10,000**.Every time a neuron fires, about **10000** other neurons get information about that firing. If we multiply all this out we get 200 billion neurons X 200 firings per second X 10000 connections per firing = **400 Million Billion** calculations per second. The Retina of our eyes gives us an idea of the Human Brain's capacity. The retina is a nerve tissue in the back of the eyeball which detects lights and sends images to the brain. A human retina has a size of about a centimeter square is half a millimeter thick and is made up of 100 million **neurons**. Scientists say that the retina sends to the brain, particular patches of images indicating light intensity differences which are transported via the **optic nerve**, a million-fiber cable which reaches deep into the brain. Overall, the retina seems to process about ten one-million-point images per second. Because the 1,500 cubic centimeter human brain is about 100,000 times as large as the retina, by simple calculation, we can estimate **the processing power of a average brain to be about 100 million MIPS** (Million computer Instructions Per Second).**A Petaflop is equal to 1000 Trillion Floating Point Instructions per Second. 1000*1000=1000000Trillion Floating point Instructions per Second.** Where as that of the Super computer is 20 Petaflops

5.2.3 Multitasking Ability

The Human Brain has many more things to do other than performing calculations. The brain has to maintain the body temperature, perform breathing action, etc. At an instance we can **Talk** through or mouth, **Breath** through our Nose, **Taste** through our Tongue, **Listen** through or Ears, **See** through our Eyes, **Walk** through our Legs, **Mov**e our hands, **Imagine**, **Think**, **Smile**, **Touch** and **fee**l, **Smell**, maintain the body Temperature, **Learn** Something new, **Take Decisions**, **Creative**, **Store** in memory, **Monitor** all the different parts of our body and much more. Now how much of processing is required for all of this at an instance? In one second, the **Retina** of the eyes sends **Ten one-million-point** images to the brain. This is an example of processing involved only in seeing something through eyes and sending information to the brain and processing. How

about processing required to Smell something, move hands and legs, Ear, Speak, Smile, feel and to do other things? The Human Brain is multitasking all of this at an instance. Can that happen with the Supercomputer? If a Super Computer was fed with the information from a human's senses constantly and asked to process and react to all of them which is processed in the brain, the computer would overload and Crash because it can't react as fast as the brain could and process all the different types of tasks which is done by the brain.. **Unlike computers, processing and memory are performed by the same components in the brain.** Computers process information from memory using CPUs, and then write the results of that processing back to memory. No such distinction exists in the brain. As neurons process information they are also modifying their



synapses – which are they the substrate of memory. As a result, retrieval from memory always slightly alters those memories

Diagram Showing the different things Brain Processes at an Instance

Some Examples of the Sub-Process involved in VISION AND SMELL

VISION and SMELL

VI. ENERRGY CONSUMPTION

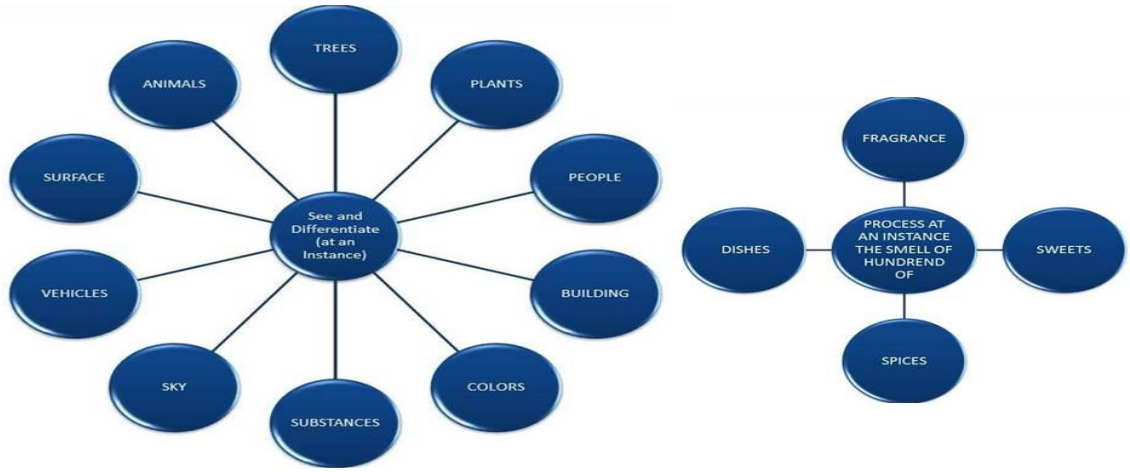
6.1 In the Computer

In order to run a Super computer TITAN, 8.4 Mega Watts of Energy is needed. How much memory is that. It is equal to the energy needed to Light up 8,000 Houses in the United States. With all that, all the resources needed to build 18,868 CPU's and GPU's , The Transistors, Hard disk Network structure and Cabling. Billions of dollars are spent for the Maintenance of the Super computer.

6.2 In the Human Brain

Thought the Human Brain is billion times more powerful than the Super computer and the Computer world, How much energy is needed? . We just need to consume our daily diet routine. The total calories of energy an average man needs in order to be active throughout the day is --- Calories. The Super computer consumes 8.4 Mega Watts of energy where as the Human brain beating the super computer Billions of times still consumes only 1800 calories per day.

We have compared the Human Brain and the Computer world with four most important features the Memory, Network, Processing Speed, Information Retrieval. Now who is Superior ? is it the Human brain or the computer?. There are many reasons why the Brain loses out to computers when we consider Calculations and Computational Jobs. The Brain is made for General purpose and not specifically for computational purpose. In fact the Brain can be even more quicker than the computer if it was special purpose processor. Since it is processing so many complex things like talking, breathing etc …it is less efficient when trying to do a specific job. Where as the computer lack the sensory organs. It cannot sense the smell, feel the touch, cannot hear or see . Even tough, each year computers are becoming more complex it can never be equal to the capacity of the human brain. The human brain has the power to create things, come up with new answers while the computer cannot. The human brain is capable of experiencing emotions and the ability of the five senses. In conclusion, the human brain is more comprehensive than any modern computer.



COMPARISON	COMPUTER WORLD	HUMAN BRAIN
Memory Capacity	20 Petabytes	1000Petabytes
Network Connections	10 Billion	125 Trillion
Processing Speed	20 Petaflops	1000Petaflops
Energy Required	8.4 Mega Watts(Electricity needed to light 8000 House)	1800 Calories /day
Memory Unit	Hard disk and RAM	Neurons
Processing Unit	CPU's and GPU's	Neurons
Compute Nodes	18.879	125 Trillion
Input Output Nodes	512	200 Billion

VII. CONCLUSION

The Human Brain is far more complex than what we can understand. Whatever estimations and values which was given was considering the least value or the minimum value for the Human Brain. There is lot more what we have still not understood . The Memory , Network , Retrieval Process and Processing speed of the Human Brain are all major research topics in Artificial Intelligence . Scientists are yet to explore the complex and amazing design of the human brain. In the current generation of the computer, with Image processing, Voice recognition , Robotics, Software Agents and many more, there is no doubt that the Computers are advancing and replacing manual and Analog things in Digital format and processing. But how about a Human Being. ?. There are so many software's which are being developed. The Voice recognition Software, Image recognition software's, etc. But have we ever thought about all the complex things which we process in our everyday life. Our Brain is one unit which does all the things. At an instance we can **Talk** , **Breath** , **Listen** , **See** , **Walk** , **Mov**e , **Imagine**, **Think**, **Smile**, **Touch fee**l , **Smell**, **Learn** , **Take Decisions**, **Creative**, **Store** , **Monito**r . So much of processing required to do each of this. Who is doing all these things. It's the Human Brain. It is the most complex and the most powerful Software in the world. We Human's have designed so many softwares. There are so many stages involved in developing a Software. Starting from Problem Analysis, Design ,coding, Testing, Maintenance and Implementation. Is it possible for a Software to come into existence by itself without Software Engineers designing it??. Its absolutely imposible. Now how about ourselves and our Brain. We are Billion Billion times more complex and powerful than the computer world. If the computer cannot come into existence by itself without Software Engineers , Designers and Programmers , then how about us being Billion Billion times more than computers? The **Human Brain** is the most powerful Software being developed and designed by an **Intelligent Designer** , **Programmer**, the best **Software Engineer** and the **Master mind** ,**OUR CREATOR**, **GOD**.

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