Role of constraints in research – demonstration using an example

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We use constraints in our daily life to navigate, to take decisions and to act. But often we neither pay attention to this process nor recognize that we are using constraints to arrive at new solutions. To make this more explicit, here is an example. Imagine that in 1850, a businessman from England was visiting the East India Company office in Calcutta (now Kolkata). He completed his office work during the weekdays. He suddenly decided to visit Bombay (now Mumbai) on a weekend (**Fig.1**). Bombay is a metropolitan city on the western side of India facing Arabian sea. Mumbai has a major port and trade by sea attracted people from many countries to this city, which gave Mumbai the name "Gateway of India". Since offices were closed, our businessman had to get the help of local people around him. They were telling little bit pieces of information about Mumbai. Using a map that does not have the name Bombay on it, he was trying to find and mark the location of Mumbai. Let us see how he is using constraints to figure this out.

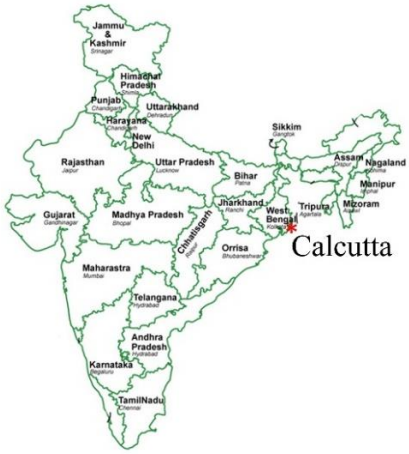

Figure 1. Map of India with Calcutta marked with a red Asterix.

An old, retired navy personnel who worked in Bombay and Madras in his youth told him that both Bombay and Madras are of equal distance from Calcutta. Madras is a major port on the eastern side of India (Constraint 1). So, our businessman took a compass and drew a circle around Calcutta touching Madras. Here it is (**Fig.2**).

Figure 2. Circle touching both Calcutta and Madras.

Then he can look for locations in India through which the drawing goes through. Mumbai can be anywhere along the circumference of this circle. But it touches many locations in India. He needs more clues to find the location. Another person told him that Bombay has a port. So, our businessman inferred that Bombay must be on the banks of a waterbody (sea/ocean) (Constraint 2). This led him to restrict the options to two locations – a place in Gujarat state and a place in Maharashtra state (**Fig.3**).

Figure 3. Circle touching both Calcutta and Madras also touches two other locations that have seashore.

We can now ask, "What was the businessman trying to do?" He was bringing constraints from different observations and using them to narrow down the possibilities to a single solution. Now he needs more information to pinpoint the location to one place. So, he must use constraints from **contrasting** observations to do this. He was not consciously aware that he was looking for constraints.

So, he started asking people about additional features that they have heard about Mumbai. Since there are several languages spoken in India, he enquired about the language commonly spoken by the natives of Bombay. He came to know that it is Marathi (Constraint 3). In the second location, people speak Gujarathi. This allowed him to narrow down the solution to the location that he found in Maharashtra. He met with people who could speak either one of these languages and tried to record in his mind the features of these spoken languages, so that he could confirm when he reached Bombay. He then travelled west according to the drawing on his map. Once he reaches his destination, he will be confirming that it has a port and natives there speak Marathi (**Fig.4**).

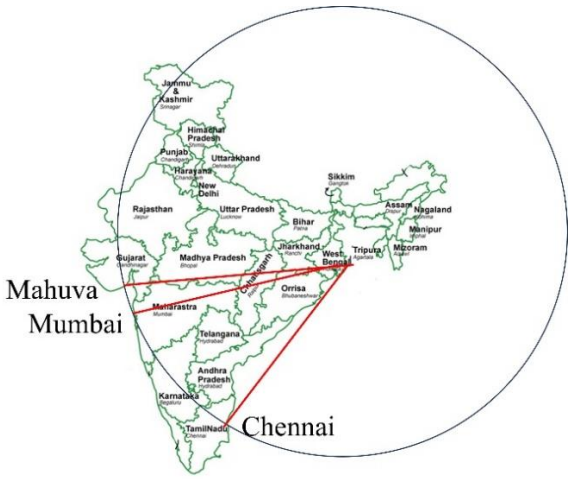

Figure 4. Circle touching both Chennai (Madras) also touches Mahuva and Bombay (2 locations that are on the seashore)

We use constraints from several findings in our daily lives. But we never think about the steps that we take explicitly. In research also, we do the same thing to find solutions to problems. The root principle used to solve a system of linear equations (in linear algebra) is also the same. To find the solution for the brain, the semblance hypothesis also used the same principle. Since there are many findings from different levels of the system, it has been a lengthy process. Certainty about three things gave confidence to proceed **1) Constraints will lead us to the correct solution, 2) Since there are very large number of disparate findings, there can only be one unique solution. The latter allow ruling out wrong solutions. 3) The unique solution is going to be new to us.**

How is this approach different from traditional ones? One common approach in research work is to build a hypothesis based on logically fitting reasoning and intuitions, given a set of findings that are in the neighborhood of a problem. But when we have a system that shows numerous features in different levels, it is not possible for our minds to think of a solution intuitively that can interconnect all those findings. We often call them "hard problems" and often remain helpless. But we have a scientific method that we can use. It is going to be a lengthy, tedious process - enlist constraints from all the findings and arrive at a solution that can satisfy all the constraints. **It is important to note that our intuitive minds are not going to be satisfied by the derived solution.** Anticipating difficulties in convincing others will often pull us backwards even from making any such attempts. But there is hope. Even when our sensory systems cannot sense the eastward rotation of Earth at a speed of 1600km/hour, we came to this conclusion using constraints obtained from observations. Even those of us who have not gone through the constraints that led to the conclusion accept it because we trust science. So, we must continue to remain very optimistic.

When Galileo Galilei used constraints from different findings, he reached an unexpected solution. He would have spent sleepless nights thinking about the consequences of his findings. But the constraints led him to the correct solution & he was confident in his findings. Eventually, he was able to convince the scientific community about his findings. The lesson one learns here is that one must never give up a solution reached by using constraints even to the detriment of one's own comforts. When we enlist all the constraints for difficult problems and reach **a** testable solution, then our threshold to test the predictions made by that solution must be very minimal. Hence, we need to take proactive efforts to undertake verification of the testable predictions made by the solution. This will remain a testament how we valued and nurtured science in our time and most importantly motivate members of the new generation of scientific minds who are watching us!