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Analysis of the Properties of Smart Theories and Their Revisited Realistic Modeling

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Abstract—In this paper, we have evaluated the image of smartness in theories by means of different examples in different fields. We analyzed the fruitful and uncomfortable aspects of such elegance. This last unaccommodating facet concerns the unreliability of smart theories in the direct management of realistic circumstances. To alleviate this divergence, we have investigated a possible solution adapted to realistic situations. This involved the adjusting of the models offered by the elegant theories. The impact of these modified models was highlighted through a major review. As in the case of elegance in theories, we evaluated the constructive and weak characteristics of the adjusted models.

Keywords— smart theories, unifying, rationalizing, realistic models.

1. Introduction

The base of fundamental theoretical exploration is founded on elegant and coherent theories, which is essential for advanced science for civilization. These theories are generally assigned to autonomous scientific fields. The reliability of a specified theory in a particular principal scientific topic emanates from the occurrence of disregarding diverse smaller significant happenings existent in the actual sphere. Such suggestions compress and enhance the present veracity. These minor occurrences are usually concomitant to the surrounding circumstances and comportment of materials. They are in general governed by extra consequent topics of science. Models based on coherent theories function perfectly in certain circumstances wherever the relative assumptions are in consistency.

As regards the smartness in theories, we have many instances e.g. Newton's second law of motion, Maxwell equations in electromagnetics, Schrödinger equation (quantum superposition states) in quantum mechanics, Bayesian Brain theory in neuroscience… Diverse features can characterize the concerned smartness in theories as rationalizing, generalizing, amalgamating … An illustration of smartness could be seen in one of the famous elegant fused theories: the group of Maxwell equations [1], which integrated three experimental laws found by Gauss, Ampère and Faraday.

The impact of elegance in theories is undisputable. Yet, despite smartness, a theory could be in disagreement with reality. Short time after Francis Crick co-discovered the DNA double helix and shortly earlier to his co- attaining a Nobel Prize, he indicated concerning smartness of theories that [2] the same is not automatically exact for wholly science accomplishments "In biology, it is likely to be elegant and to be incorrect".

In the present paper after examining the perception of elegance of theories through different examples in different fields, we will underline the constructive and uncooperative aspects of such elegance. This last disobliging facet regards the inconstancy of smart theories in treating realistic landscapes. We will discuss then how remedying such conflict. This will be discussed through amending of models provided by elegant theories. As in the case of elegance, we will assess the positive and negative features of the amended models.

2. Theoretical Elegance

Concerning the idea of smartness in theories, when we think about a theory expressing an event comprehensibly and directly, we identify it as elegant. Moreover, a concept easy to comprehend allows accounting for a great quantity of knowledge and satisfying many demands. Therefore, the elegance description as easiness plus more capacity looks just. Such easiness and capability may involve rationalizing, generalizing, amalgamating or simplifying. We will give in the next lines three examples to illustrate such elegance.

2.1. Unifying in Theories

An example of the finest elegant compound theories as mentioned in the introduction is the Maxwell equations. These equations originated by James Clerk Maxwell (1831-1879) embrace a union of three experimental laws found by three of his forerunners. These are Carl Friedrich Gauss (1777-1855), André-Marie Ampère (1775-1836) and Michael Faraday (1791-1867). The association of Maxwell equations was only feasible, as Maxwell perceived how to proceed ahead of the work of his precursors, by introducing into one equation a deficient-link, stated displacement current, whose occurrence guarantees the consistency of the integrated configuration. This displays a considerable feature of the union smartness, [1].

2.2. Universal Constants

A second example concerns the definition of universal constants for the smartness of theories is given for the case of vacuum permeability μ_0.

In magnetostatics, Ampère's theorem makes it possible to determine the value of the magnetic field thanks to the value of electric currents. Coulomb's law expresses, in electrostatics, the force of the electrical interaction between two electrically charged particles. Ampere's theorem is expressed as a function of the vacuum permeability μ_0 and Coulomb's law is as a function of the vacuum permittivity ε_0.

The exact value of the vacuum permeability has been set at $\mu_0=4\pi \times 10^{-7}$ kg m A^{-2} s^{-2} to simplify the expression of Ampère's theorem. This is for a definition of the ampere approved at the General Congress of Weights and Measures of 1948. Thus, we see that the definition of the value of μ_0 was decided only to have an elegant expression of Ampère's theorem.

Since May 20, 2019 a new definition of the ampere, linked to the definition of the elementary charge e, which has been chosen as exact. For this new definition, the value of the permeability has become approximate.

The equations established by Maxwell revealed a propagation speed of electromagnetic waves c as a function of the product $\varepsilon_0 \mu_0$. Therefore, for the approximate value of μ_0 we have an approximate value of ε_0 of defined by:

$\varepsilon_0=1/(\mu_0 \ c^2) \approx 8{,}854\,187\,82 \times 10^{-12}\ A^2\ \ s^4\ \ k\ g^{-1}\ \ m^{-3}$.

2.3 Rationalizing of a Natural Process

The third example regards the biological Bayesian Brain theory in neuroscience. To illustrate the rationalizing aspect of this theory we will summarize its function.

Bayesian strategies for brain actions assess the aptitude of the neural organization to function under situations of uncertainty to come collectively with the finest outcome supported by Bayesian statistics [3]. The theory of Bayesian Brain in neuroscience normally tries to relieve the cognitive aptitudes of the brain established on statistical methods where it is deliberated that the neural construction holds internal probabilistic models adjusted by sensory communication via neural treatment by means of Bayesian probability [4]. It is supposed that Bayesian inference works at the cortical macrocircuits level. These circuits are structured with an organization that designates the classified assemblage of the observable stuffs round us. The brain tutors a model of such items and engenders predictions regarding their sensory input; that is the playacted predictive coding. The overall fonts of the scenery, including items, will be assigned by achievements in areas of the brain nearby to the superior hierarchy. The links from the upper zones to the inferior ones subsequently set into code a model revealing how the prospects enclose objects as well as the forms of these objects. The bottommost level predictions are matched to sensory input and the prediction error is expanded up in the hierarchy. These areas are hierarchically structured such that the lower level conveyed prediction error generates the input of an upper-level region. Simultaneously, the return from the upper-level slice communicates the former convictions for the lower level one. In this circumstance, the prediction error stipulates that the current model has not wholly accounted for the input. Readjusting the next level can enhance correctness and temper the prediction error [5-6]. However, if not, higher-level adjustments are required. Generally, upper levels offer data to inferior ones and ensure inner consistency of presumed sources of sensory input at different levels. This occurs simultaneously at all hierarchical stages. The predictions are conveyed down and their errors are directed back up in a dynamic procedure.

From the last description of the Bayesian Brain theory, we see that the organization of neural system in conditions of uncertainty expresses a real-time matching two-way process. The elegance of the theory embraces a top-down management of observation through minimization of prediction error process. All the levels of the neural assembly enclose probabilistic predictions revised by sensory observed information through neural processing iterative matching.

3. Pluses and Handicaps of Elegance

In general, one can think a theory only founded after validation by observation. Furthermore, such a theory stays valid until divergence with observation. This illustrates the evidence that the theory-observation couple is unavoidably constantly associated. The elegance of a theory does not alter this imperative. We may evoke the famous statement of Richard Phillips Feynman, father of Quantum electrodynamics (Nobel 1965) and one of the firsts proposing Quantum computing, “No matter how beautiful your theory is, No matter how smart you are, No matter if you're famous ...If your theory is not in tune with experience, It is wrong. That's all.”

Moreover, the validation of an elegant theory is as hard as its establishment. This is due to the complexity of experimental conditions concerning the elegance. Such conditions are in fact very far from classical experimental settings. Often one has to develop original apparatus and teste routines.

A typical case illustrating that in spite of elegance a theory could be in conflict with reality and only sophisticated observation permits highlighting such evidence. Short time after Maxwell has advertised his Treatise in 1873, a young scientist has invalidated a part of the Treatise, Edwin Herbert Hall (1855-1938). He has revealed and confirmed in his thesis work, the principle named Hall Effect in 1879. This suggestion reached from observation by experience regards the relation between the force and the current in a conductor immersed in a magnetic field. Maxwell thought this nonexistent. We remark at this point that the elegance owing to mathematical treatment of observed laws has been upgraded because of observation indubitably.

It should be noted that an elegant theory is reputed founded only after validation by an adequate observation. This could be realized by sophisticated experimental sets running in the same idealized conditions postulated in the theory. Furthermore as mentioned before, such a theory stays valid until divergence with observation.

3.1. Reverberations of Elegance

It is undoubtedly evident that elegant theories are essential for humanity. They allow a continuous evolution of knowledge. For example, the theories mentioned in the last paragraphs are a typical illustration of this. Maxwell's equations and the Hall Effect weighed heavily in subsequent research, mainly in restraint relativity and quantum mechanics.

On the other hand, as mentioned above, the development of original devices and test routines for the validation of elegant theories, allows new investigations. It might even lead to new theories by serendipity. This clearly illustrates the symbioses of theoretical and observational items in science.

3.2. Cure for Elegance

Generally, in applications involving quantifiable real systems, elegant theories could be in discrepancy with reality and not each time applicable straightaway. In such circumstances, we need to amend the model fashioned on a theory of a main field, by combining the presumed unimportant fields, neglected for elegance, in an amended model.

4. Realistic Modeling

Think about a real objective problem that could be mathematically signified by a given global function, which is the fusion or union of sub-functions, each of which relates to a particular sub-field of science. For the objective of modeling this real problem, it is generally necessary to account for the various aspects related to the sub-functions in the zones corresponding to the global function. In addition, often one sub-area is more involved than the others are; let us call it the main sub-area. In general, we tend to consider this main subdomain solo for modeling. Meanwhile, virtually all theories generally fall under a single area of science. In addition, establishing rational and friendly theories usually requires postulations that distort and idealize the actual context of the investigation. Therefore, the consistency of a theory requires idealized assumptions occurring in an abbreviated main sub-area function. Consequently, the validation of this theory, which allows its foundation, must also be done under these conditions [7].

Therefore, when we model a real situation by soloing the shortened main sub-zone function, the result would often be wrong. This is due to the limitation of the two approximations shown. In such a context, in order to cure this situation, it is necessary to follow an inverse approximation technique, which reintroduces into the model all the abandoned aspects.

4.1 Amended Models

As mentioned before, founded theories point out a key attention to elegance concept. In uses for real schemes, such theories could be in conflict with veracity. In such circumstances, we have to move from elegance to reality reviewing the corresponding committed approximations. We are accordingly inclining to revise the model erected on a main field theory, by connecting the lesser fields in an amended model [8-9]. The context of "cancel out approximation" reintegrating ignored affects into the model evidently performs as a kind of a coupled problem.

4.2. Coupled Problems and Solution Strategy

Generally, coupled problems actions entail solution of mathematical equations governing diverse natural or artificial phenomena corresponding to distinct topics of theoretical sphere. The comportments of these phenomena and their mutual dependence as well as the intimacy of their temporal evolution are wholly linked to the methodology to solve the related ruling equations. In such a procedure, the treatment of the equations could vary widely. Within one limit, the equations are solved almost separately. For the other limit, they are solved completely simultaneously.

Generally, modeling of a realistic device comprises more or less complex characteristics. These involve geometrical character, substance comportment laws and temporal behaviors. Such happening turn into further sharp once implicating coupling of distinct phenomena. In this circumstance, we have to count for different specific treatments, which are more complicated compared to those for simplified devices that can be governed by elegant theories.

Consider the case of electromagnetic systems that governed mainly by the elegant compound theory of the set of Maxwell equations mentioned early. This example permits to illustrate the solution strategy involving the mentioned specific treatments. These electromagnetic systems are present in many societal applications such as mobility, health, safety, communication. They behave not only due to Maxwell equations but generally in four instances: electrical, magnetic, mechanical and thermal. Different examples involving the solution strategy accounting for one or several of these instances could found in the literature. In the circumstance of electromagnetic generally, see e.g. [10-25]. In the circumstance involving with electromagnetic, the mechanical instance, see e.g. [20] [26-28]. In the case comprising the thermal instance, see e.g. [18] [29-31]. In the case of material intrinsic couplings (for smart materials), see e.g. [32-35].

All the coupled models involved in the mentioned studies are supposed validated as in case of smart theories. These validations could be practiced in two successive steps. The primary could be by means of analytical solution applied to simplified structures and behaviors when possible. The second validation that is mandatory has to be done with the help of precise experimental sets. These are less sophisticated than those used for the validation of smart theories. This is because the conditions for running of the sets in the case of realistic models are easier to attain.

4.3 Natures of Models

The amended models mentioned above make it possible to evaluate real phenomena, in natural processes [3-6] or artificial settings [36-40]. The most important task in developing such models is the coupling of different theories considering their postulations and their interdependence. In addition, these theoretical models are generally based on numerical analysis. The improvement of these models requires techniques allowing greater precision, less computer memory, faster calculations and more generalizing functions. Therefore, one important aspect of enhancement of these models is relative to their digital performance.

This could be performed through new mathematical formulations by means of the choice of the most suitable physical variable practiced in the best-acclimatized spatial-temporal behaviors. In addition, one can use innovative algorithms adapted to the considered problems as well as the computation and control available tools.

One of the most difficult aspect in the field of numerical modeling is the capacity to extend investigations to processes possess not well-known mathematical functions or phenomena with random behaviors.

Unlike the elegant theories associated with their sophisticated validation experimental sets, the investigation in numerical modeling does not allow as largescale consequent added continuous inventions.

5. Conclusions

In the present study, we evaluated the concept of elegance in theories. The analysis of the character of these theories has highlighted their beneficial aspect allowing for future research. At the same time, such a character has been found not to be suitable for application on realistic operating systems. We have proposed to take into account the hypotheses idealizing intelligent theories by modifying their models to address realistic situations. These improved models combine the idealized model resulting from the theory with those representing the abandoned phenomena in view of elegance. We have considered the example of electromagnetic systems to illustrate such an approach. A major review of the construction strategies of the improved realistic models in this case was carried out. Analysis of these modified realistic models illustrates their crucial importance in designing real systems for everyday applications. However, in this case, the aspect allowing for future investigations is not as ambitious as in the case of intelligent theories.

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